Perl Programmers Reference Guide

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"There's more than one way to do it."
–– Larry Wall, Author of the Perl Programming Language

Author: Perl5–Porters

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NAME

perl – Practical Extraction and Report Language

SYNOPSIS

perl [**–sTuU**] [**–hv**] [**–V**[:*configvar*]]
[**–cw**] [**–d**[:*debugger*]] [**–D**[*number/list*]]
[**–pna**] [**–F***pattern*] [**–l**[*octal*]] [**–0**[*octal*]]
[**–I***dir*] [**–m**[**–**]*module*] [**–M**[**–**]*'module...'*]
[**–P**] [**–S**] [**–x**[*dir*]]
[**–i**[*extension*]] [**–e** *'command']*
[**—**] [*programfile*] [*argument*]...

For ease of access, the Perl manual has been split up into several sections:

```
perl                Perl overview (this section)
perlfaq             Perl frequently asked questions
perltoc             Perl documentation table of contents
perlbook            Perl book information

perlsyn             Perl syntax
perldata            Perl data structures
perlop              Perl operators and precedence
perlsub             Perl subroutines
perlfunc            Perl builtin functions
perlreftut          Perl references short introduction
perldsc             Perl data structures intro
perlrequick         Perl regular expressions quick start
perlpod             Perl plain old documentation
perlstyle           Perl style guide
perltrap            Perl traps for the unwary

perlrun             Perl execution and options
perldiag            Perl diagnostic messages
perllexwarn         Perl warnings and their control
perldebtut          Perl debugging tutorial
perldebug           Perl debugging

perlvar             Perl predefined variables
perllol             Perl data structures: arrays of arrays
perlopentut         Perl open() tutorial
perlretut           Perl regular expressions tutorial

perlre              Perl regular expressions, the rest of the story
perlref             Perl references, the rest of the story

perlform            Perl formats

perlboot            Perl OO tutorial for beginners
perltoot            Perl OO tutorial, part 1
perltootc           Perl OO tutorial, part 2
perlobj             Perl objects
perlbot             Perl OO tricks and examples
perltie             Perl objects hidden behind simple variables

perlipc             Perl interprocess communication
perlfork            Perl fork() information
perlnumber          Perl number semantics
perlthrtut          Perl threads tutorial
```

perlport	Perl portability guide
perllocale	Perl locale support
perlunicode	Perl unicode support
perlebcdic	Considerations for running Perl on EBCDIC platforms
perlsec	Perl security
perlmod	Perl modules: how they work
perlmodlib	Perl modules: how to write and use
perlmodinstall	Perl modules: how to install from CPAN
perlnewmod	Perl modules: preparing a new module for distribution
perlfaq1	General Questions About Perl
perlfaq2	Obtaining and Learning about Perl
perlfaq3	Programming Tools
perlfaq4	Data Manipulation
perlfaq5	Files and Formats
perlfaq6	Regexes
perlfaq7	Perl Language Issues
perlfaq8	System Interaction
perlfaq9	Networking
perlcompile	Perl compiler suite intro
perlembed	Perl ways to embed perl in your C or C++ application
perldebguts	Perl debugging guts and tips
perlxstut	Perl XS tutorial
perlxs	Perl XS application programming interface
perlguts	Perl internal functions for those doing extensions
perlcall	Perl calling conventions from C
perlutil	utilities packaged with the Perl distribution
perlfilter	Perl source filters
perldbmfilter	Perl DBM filters
perlapi	Perl API listing (autogenerated)
perlintern	Perl internal functions (autogenerated)
perlapio	Perl internal IO abstraction interface
perltodo	Perl things to do
perlhack	Perl hackers guide
perlhist	Perl history records
perldelta	Perl changes since previous version
perl56delta	Perl changes in version 5.6
perl5005delta	Perl changes in version 5.005
perl5004delta	Perl changes in version 5.004
perlaix	Perl notes for AIX
perlamiga	Perl notes for Amiga
perlcygwin	Perl notes for Cygwin
perldos	Perl notes for DOS
perlepoc	Perl notes for EPOC
perlhpux	Perl notes for HP-UX
perlmachten	Perl notes for Power MachTen
perlos2	Perl notes for OS/2
perlos390	Perl notes for OS/390
perlposix-bc	Perl notes for POSIX-BC
perlsolaris	Perl notes for Solaris
perlvms	Perl notes for VMS
perlvos	Perl notes for Stratus VOS

```
perlwin32           Perl notes for Windows
```

(If you're intending to read these straight through for the first time, the suggested order will tend to reduce the number of forward references.)

By default, the manpages listed above are installed in the ***/usr/local/man/*** directory.

Extensive additional documentation for Perl modules is available. The default configuration for perl will place this additional documentation in the ***/usr/local/lib/perl5/man*** directory (or else in the ***man*** subdirectory of the Perl library directory). Some of this additional documentation is distributed standard with Perl, but you'll also find documentation for third-party modules there.

You should be able to view Perl's documentation with your man(1) program by including the proper directories in the appropriate start-up files, or in the MANPATH environment variable. To find out where the configuration has installed the manpages, type:

```
perl -V:man.dir
```

If the directories have a common stem, such as ***/usr/local/man/man1*** and ***/usr/local/man/man3***, you need only to add that stem (***/usr/local/man***) to your man(1) configuration files or your MANPATH environment variable. If they do not share a stem, you'll have to add both stems.

If that doesn't work for some reason, you can still use the supplied ***perldoc*** script to view module information. You might also look into getting a replacement man program.

If something strange has gone wrong with your program and you're not sure where you should look for help, try the **-w** switch first. It will often point out exactly where the trouble is.

DESCRIPTION

Perl is a language optimized for scanning arbitrary text files, extracting information from those text files, and printing reports based on that information. It's also a good language for many system management tasks. The language is intended to be practical (easy to use, efficient, complete) rather than beautiful (tiny, elegant, minimal).

Perl combines (in the author's opinion, anyway) some of the best features of C, **sed**, **awk**, and **sh**, so people familiar with those languages should have little difficulty with it. (Language historians will also note some vestiges of **csh**, Pascal, and even BASIC-PLUS.) Expression syntax corresponds closely to C expression syntax. Unlike most Unix utilities, Perl does not arbitrarily limit the size of your data—if you've got the memory, Perl can slurp in your whole file as a single string. Recursion is of unlimited depth. And the tables used by hashes (sometimes called "associative arrays") grow as necessary to prevent degraded performance. Perl can use sophisticated pattern matching techniques to scan large amounts of data quickly. Although optimized for scanning text, Perl can also deal with binary data, and can make dbm files look like hashes. Setuid Perl scripts are safer than C programs through a dataflow tracing mechanism that prevents many stupid security holes.

If you have a problem that would ordinarily use **sed** or **awk** or **sh**, but it exceeds their capabilities or must run a little faster, and you don't want to write the silly thing in C, then Perl may be for you. There are also translators to turn your **sed** and **awk** scripts into Perl scripts.

But wait, there's more...

Begun in 1993 (see *perlhist*), Perl version 5 is nearly a complete rewrite that provides the following additional benefits:

- modularity and reusability using innumerable modules

  Described in *perlmod*, *perlmodlib*, and *perlmodinstall*.

- embeddable and extensible

  Described in *perlembed*, *perlxstut*, *perlxs*, *perlcall*, *perlguts*, and *xsubpp*.

- roll–your–own magic variables (including multiple simultaneous DBM implementations)
  Described in *perltie* and *AnyDBM_File*.
- subroutines can now be overridden, autoloaded, and prototyped
  Described in *perlsub*.
- arbitrarily nested data structures and anonymous functions
  Described in *perlreftut*, *perlref*, *perldsc*, and *perllol*.
- object–oriented programming
  Described in *perlobj*, *perltoot*, and *perlbot*.
- compilability into C code or Perl bytecode
  Described in *B* and *B::Bytecode*.
- support for light–weight processes (threads)
  Described in *perlthrtut* and *Thread*.
- support for internationalization, localization, and Unicode
  Described in *perllocale* and *utf8*.
- lexical scoping
  Described in *perlsub*.
- regular expression enhancements
  Described in *perlre*, with additional examples in *perlop*.
- enhanced debugger and interactive Perl environment, with integrated editor support
  Described in *perldebug*.
- POSIX 1003.1 compliant library
  Described in *POSIX*.

Okay, that's *definitely* enough hype.

AVAILABILITY

Perl is available for most operating systems, including virtually all Unix–like platforms. See *Supported Platforms in perlport* for a listing.

ENVIRONMENT

See *perlrun*.

AUTHOR

Larry Wall <larry@wall.org, with the help of oodles of other folks.

If your Perl success stories and testimonials may be of help to others who wish to advocate the use of Perl in their applications, or if you wish to simply express your gratitude to Larry and the Perl developers, please write to perl–thanks@perl.org .

FILES

```
"@INC"                locations of perl libraries
```

SEE ALSO

```
a2p    awk to perl translator
s2p    sed to perl translator

http://www.perl.com/       the Perl Home Page
http://www.perl.com/CPAN   the Comprehensive Perl Archive
```

DIAGNOSTICS

The `use warnings` pragma (and the **−w** switch) produces some lovely diagnostics.

See *perldiag* for explanations of all Perl's diagnostics. The `use diagnostics` pragma automatically turns Perl's normally terse warnings and errors into these longer forms.

Compilation errors will tell you the line number of the error, with an indication of the next token or token type that was to be examined. (In a script passed to Perl via **−e** switches, each **−e** is counted as one line.)

Setuid scripts have additional constraints that can produce error messages such as "Insecure dependency". See *perlsec*.

Did we mention that you should definitely consider using the **−w** switch?

BUGS

The **−w** switch is not mandatory.

Perl is at the mercy of your machine's definitions of various operations such as type casting, `atof()`, and floating−point output with `sprintf()`.

If your stdio requires a seek or eof between reads and writes on a particular stream, so does Perl. (This doesn't apply to `sysread()` and `syswrite()`.)

While none of the built−in data types have any arbitrary size limits (apart from memory size), there are still a few arbitrary limits: a given variable name may not be longer than 251 characters. Line numbers displayed by diagnostics are internally stored as short integers, so they are limited to a maximum of 65535 (higher numbers usually being affected by wraparound).

You may mail your bug reports (be sure to include full configuration information as output by the myconfig program in the perl source tree, or by `perl -V`) to perlbug@perl.org . If you've succeeded in compiling perl, the **perlbug** script in the ***utils/*** subdirectory can be used to help mail in a bug report.

Perl actually stands for Pathologically Eclectic Rubbish Lister, but don't tell anyone I said that.

NOTES

The Perl motto is "There's more than one way to do it." Divining how many more is left as an exercise to the reader.

The three principal virtues of a programmer are Laziness, Impatience, and Hubris. See the Camel Book for why.

NAME

perldelta – what's new for perl5.004

DESCRIPTION

This document describes differences between the 5.003 release (as documented in *Programming Perl*, second edition—the Camel Book) and this one.

Supported Environments

Perl5.004 builds out of the box on Unix, Plan 9, LynxOS, VMS, OS/2, QNX, AmigaOS, and Windows NT. Perl runs on Windows 95 as well, but it cannot be built there, for lack of a reasonable command interpreter.

Core Changes

Most importantly, many bugs were fixed, including several security problems. See the ***Changes*** file in the distribution for details.

List assignment to %ENV works

`%ENV = ()` and `%ENV = @list` now work as expected (except on VMS where it generates a fatal error).

Change to "Can't locate Foo.pm in @INC" error

The error "Can't locate Foo.pm in @INC" now lists the contents of @INC for easier debugging.

Compilation option: Binary compatibility with 5.003

There is a new Configure question that asks if you want to maintain binary compatibility with Perl 5.003. If you choose binary compatibility, you do not have to recompile your extensions, but you might have symbol conflicts if you embed Perl in another application, just as in the 5.003 release. By default, binary compatibility is preserved at the expense of symbol table pollution.

`$PERL5OPT` environment variable

You may now put Perl options in the `$PERL5OPT` environment variable. Unless Perl is running with taint checks, it will interpret this variable as if its contents had appeared on a "#!perl" line at the beginning of your script, except that hyphens are optional. PERL5OPT may only be used to set the following switches: **–[DIMUdmw]**.

Limitations on –M, –m, and –T options

The `–M` and `–m` options are no longer allowed on the `#!` line of a script. If a script needs a module, it should invoke it with the `use` pragma.

The **–T** option is also forbidden on the `#!` line of a script, unless it was present on the Perl command line. Due to the way `#!` works, this usually means that **–T** must be in the first argument. Thus:

```
#!/usr/bin/perl -T -w
```

will probably work for an executable script invoked as `scriptname`, while:

```
#!/usr/bin/perl -w -T
```

will probably fail under the same conditions. (Non–Unix systems will probably not follow this rule.) But `perl scriptname` is guaranteed to fail, since then there is no chance of **–T** being found on the command line before it is found on the `#!` line.

More precise warnings

If you removed the **–w** option from your Perl 5.003 scripts because it made Perl too verbose, we recommend that you try putting it back when you upgrade to Perl 5.004. Each new perl version tends to remove some undesirable warnings, while adding new warnings that may catch bugs in your scripts.

Deprecated: Inherited `AUTOLOAD` for non–methods

Before Perl 5.004, `AUTOLOAD` functions were looked up as methods (using the `@ISA` hierarchy), even when the function to be autoloaded was called as a plain function (e.g. `Foo::bar()`), not a method (e.g. `<`

`Foo-bar()` or `< $obj-bar() >`).

Perl 5.005 will use method lookup only for methods' `AUTOLOAD`s. However, there is a significant base of existing code that may be using the old behavior. So, as an interim step, Perl 5.004 issues an optional warning when a non-method uses an inherited `AUTOLOAD`.

The simple rule is: Inheritance will not work when autoloading non-methods. The simple fix for old code is: In any module that used to depend on inheriting `AUTOLOAD` for non-methods from a base class named `BaseClass`, execute `*AUTOLOAD = \&BaseClass::AUTOLOAD` during startup.

Previously deprecated %OVERLOAD is no longer usable

Using %OVERLOAD to define overloading was deprecated in 5.003. Overloading is now defined using the overload pragma. %OVERLOAD is still used internally but should not be used by Perl scripts. See *overload* for more details.

Subroutine arguments created only when they're modified

In Perl 5.004, nonexistent array and hash elements used as subroutine parameters are brought into existence only if they are actually assigned to (via `@_`).

Earlier versions of Perl vary in their handling of such arguments. Perl versions 5.002 and 5.003 always brought them into existence. Perl versions 5.000 and 5.001 brought them into existence only if they were not the first argument (which was almost certainly a bug). Earlier versions of Perl never brought them into existence.

For example, given this code:

```
undef @a; undef %a;
sub show { print $_[0] };
sub change { $_[0]++ };
show($a[2]);
change($a{b});
```

After this code executes in Perl 5.004, `$a{b}` exists but `$a[2]` does not. In Perl 5.002 and 5.003, both `$a{b}` and `$a[2]` would have existed (but `$a[2]`'s value would have been undefined).

Group vector changeable with `$)`

The `$)` special variable has always (well, in Perl 5, at least) reflected not only the current effective group, but also the group list as returned by the `getgroups()` C function (if there is one). However, until this release, there has not been a way to call the `setgroups()` C function from Perl.

In Perl 5.004, assigning to `$)` is exactly symmetrical with examining it: The first number in its string value is used as the effective gid; if there are any numbers after the first one, they are passed to the `setgroups()` C function (if there is one).

Fixed parsing of `$$<digit`, `&$<digit`, etc.

Perl versions before 5.004 misinterpreted any type marker followed by `"$"` and a digit. For example, `"$$0"` was incorrectly taken to mean `"${$}0"` instead of `"${$0}"`. This bug is (mostly) fixed in Perl 5.004.

However, the developers of Perl 5.004 could not fix this bug completely, because at least two widely-used modules depend on the old meaning of `"$$0"` in a string. So Perl 5.004 still interprets `"$$<digit"` in the old (broken) way inside strings; but it generates this message as a warning. And in Perl 5.005, this special treatment will cease.

Fixed localization of `$<digit`, `$&`, etc.

Perl versions before 5.004 did not always properly localize the regex-related special variables. Perl 5.004 does localize them, as the documentation has always said it should. This may result in `$1`, `$2`, etc. no longer being set where existing programs use them.

No resetting of `$.` on implicit close

The documentation for Perl 5.0 has always stated that `$.` is *not* reset when an already−open file handle is reopened with no intervening call to `close`. Due to a bug, perl versions 5.000 through 5.003 *did* reset `$.` under that circumstance; Perl 5.004 does not.

`wantarray` may return undef

The `wantarray` operator returns true if a subroutine is expected to return a list, and false otherwise. In Perl 5.004, `wantarray` can also return the undefined value if a subroutine's return value will not be used at all, which allows subroutines to avoid a time−consuming calculation of a return value if it isn't going to be used.

`eval EXPR` determines value of EXPR in scalar context

Perl (version 5) used to determine the value of EXPR inconsistently, sometimes incorrectly using the surrounding context for the determination. Now, the value of EXPR (before being parsed by eval) is always determined in a scalar context. Once parsed, it is executed as before, by providing the context that the scope surrounding the eval provided. This change makes the behavior Perl4 compatible, besides fixing bugs resulting from the inconsistent behavior. This program:

```
@a = qw(time now is time);
print eval @a;
print '|', scalar eval @a;
```

used to print something like "timenowis881399109|4", but now (and in perl4) prints "4|4".

Changes to tainting checks

A bug in previous versions may have failed to detect some insecure conditions when taint checks are turned on. (Taint checks are used in setuid or setgid scripts, or when explicitly turned on with the `-T` invocation option.) Although it's unlikely, this may cause a previously−working script to now fail — which should be construed as a blessing, since that indicates a potentially−serious security hole was just plugged.

The new restrictions when tainting include:

No `glob()` or <*

These operators may spawn the C shell (csh), which cannot be made safe. This restriction will be lifted in a future version of Perl when globbing is implemented without the use of an external program.

No spawning if tainted `$CDPATH, $ENV, $BASH_ENV`

These environment variables may alter the behavior of spawned programs (especially shells) in ways that subvert security. So now they are treated as dangerous, in the manner of `$IFS` and `$PATH`.

No spawning if tainted `$TERM` doesn't look like a terminal name

Some termcap libraries do unsafe things with `$TERM`. However, it would be unnecessarily harsh to treat all `$TERM` values as unsafe, since only shell metacharacters can cause trouble in `$TERM`. So a tainted `$TERM` is considered to be safe if it contains only alphanumerics, underscores, dashes, and colons, and unsafe if it contains other characters (including whitespace).

New Opcode module and revised Safe module

A new Opcode module supports the creation, manipulation and application of opcode masks. The revised Safe module has a new API and is implemented using the new Opcode module. Please read the new Opcode and Safe documentation.

Embedding improvements

In older versions of Perl it was not possible to create more than one Perl interpreter instance inside a single process without leaking like a sieve and/or crashing. The bugs that caused this behavior have all been fixed. However, you still must take care when embedding Perl in a C program. See the updated perlembed manpage for tips on how to manage your interpreters.

Internal change: FileHandle class based on IO::* classes

File handles are now stored internally as type IO::Handle. The FileHandle module is still supported for backwards compatibility, but it is now merely a front end to the IO::* modules — specifically, IO::Handle, IO::Seekable, and IO::File. We suggest, but do not require, that you use the IO::* modules in new code.

In harmony with this change, `*GLOB{FILEHANDLE}` is now just a backward-compatible synonym for `*GLOB{IO}`.

Internal change: PerlIO abstraction interface

It is now possible to build Perl with AT&T's sfio IO package instead of stdio. See *perlapio* for more details, and the ***INSTALL*** file for how to use it.

New and changed syntax

`$coderef-`(PARAMS)

A subroutine reference may now be suffixed with an arrow and a (possibly empty) parameter list. This syntax denotes a call of the referenced subroutine, with the given parameters (if any).

This new syntax follows the pattern of `< $hashref-{FOO}` and `< $aryref-[$foo]` : You may now write `&$subref($foo)` as `< $subref-($foo)` . All these arrow terms may be chained; thus, `< &{$table-{FOO}}($bar)` may now be written `< $table-{FOO}-`($bar) .

New and changed builtin constants

__PACKAGE__

The current package name at compile time, or the undefined value if there is no current package (due to a `package;` directive). Like `__FILE__` and `__LINE__`, `__PACKAGE__` does *not* interpolate into strings.

New and changed builtin variables

`$^E` Extended error message on some platforms. (Also known as `$EXTENDED_OS_ERROR` if you `use English`).

`$^H` The current set of syntax checks enabled by `use strict`. See the documentation of `strict` for more details. Not actually new, but newly documented. Because it is intended for internal use by Perl core components, there is no `use English` long name for this variable.

`$^M` By default, running out of memory it is not trappable. However, if compiled for this, Perl may use the contents of `$^M` as an emergency pool after `die()`ing with this message. Suppose that your Perl were compiled with -DPERL_EMERGENCY_SBRK and used Perl's malloc. Then

```
$^M = 'a' x (1<<16);
```

would allocate a 64K buffer for use when in emergency. See the ***INSTALL*** file for information on how to enable this option. As a disincentive to casual use of this advanced feature, there is no `use English` long name for this variable.

New and changed builtin functions

delete on slices

This now works. (e.g. `delete @ENV{'PATH', 'MANPATH'}`)

flock

is now supported on more platforms, prefers fcntl to lockf when emulating, and always flushes before (un)locking.

printf and sprintf

Perl now implements these functions itself; it doesn't use the C library function `sprintf()` any more, except for floating-point numbers, and even then only known flags are allowed. As a result, it is now possible to know which conversions and flags will work, and what they will do.

The new conversions in Perl's `sprintf()` are:

```
%i   a synonym for %d
%p   a pointer (the address of the Perl value, in hexadecimal)
%n   special: *stores* the number of characters output so far
     into the next variable in the parameter list
```

The new flags that go between the `%` and the conversion are:

```
#    prefix octal with "0", hex with "0x"
h    interpret integer as C type "short" or "unsigned short"
V    interpret integer as Perl's standard integer type
```

Also, where a number would appear in the flags, an asterisk ("*") may be used instead, in which case Perl uses the next item in the parameter list as the given number (that is, as the field width or precision). If a field width obtained through "*" is negative, it has the same effect as the '–' flag: left–justification.

See *sprintf* for a complete list of conversion and flags.

keys as an lvalue

As an lvalue, `keys` allows you to increase the number of hash buckets allocated for the given hash. This can gain you a measure of efficiency if you know the hash is going to get big. (This is similar to pre–extending an array by assigning a larger number to `$#array.)` If you say

```
keys %hash = 200;
```

then `%hash` will have at least 200 buckets allocated for it. These buckets will be retained even if you do `%hash = ()`; use `undef %hash` if you want to free the storage while `%hash` is still in scope. You can't shrink the number of buckets allocated for the hash using `keys` in this way (but you needn't worry about doing this by accident, as trying has no effect).

`my()` in Control Structures

You can now use `my()` (with or without the parentheses) in the control expressions of control structures such as:

```
while (defined(my $line = <>)) {
    $line = lc $line;
} continue {
    print $line;
}

if ((my $answer = <STDIN>) =~ /^y(es)?$/i) {
    user_agrees();
} elsif ($answer =~ /^n(o)?$/i) {
    user_disagrees();
} else {
    chomp $answer;
    die "'$answer' is neither 'yes' nor 'no'";
}
```

Also, you can declare a foreach loop control variable as lexical by preceding it with the word "my". For example, in:

```
foreach my $i (1, 2, 3) {
    some_function();
}
```

`$i` is a lexical variable, and the scope of `$i` extends to the end of the loop, but not beyond it.

Note that you still cannot use `my()` on global punctuation variables such as `$_` and the like.

`pack()` and `unpack()`

A new format 'w' represents a BER compressed integer (as defined in ASN.1). Its format is a sequence of one or more bytes, each of which provides seven bits of the total value, with the most significant first. Bit eight of each byte is set, except for the last byte, in which bit eight is clear.

If 'p' or 'P' are given undef as values, they now generate a NULL pointer.

Both `pack()` and `unpack()` now fail when their templates contain invalid types. (Invalid types used to be ignored.)

`sysseek()`

The new `sysseek()` operator is a variant of `seek()` that sets and gets the file's system read/write position, using the lseek(2) system call. It is the only reliable way to seek before using `sysread()` or `syswrite()`. Its return value is the new position, or the undefined value on failure.

use VERSION

If the first argument to `use` is a number, it is treated as a version number instead of a module name. If the version of the Perl interpreter is less than VERSION, then an error message is printed and Perl exits immediately. Because `use` occurs at compile time, this check happens immediately during the compilation process, unlike `require VERSION`, which waits until runtime for the check. This is often useful if you need to check the current Perl version before `use`ing library modules which have changed in incompatible ways from older versions of Perl. (We try not to do this more than we have to.)

use Module VERSION LIST

If the VERSION argument is present between Module and LIST, then the `use` will call the VERSION method in class Module with the given version as an argument. The default VERSION method, inherited from the UNIVERSAL class, croaks if the given version is larger than the value of the variable `$Module::VERSION`. (Note that there is not a comma after VERSION!)

This version-checking mechanism is similar to the one currently used in the Exporter module, but it is faster and can be used with modules that don't use the Exporter. It is the recommended method for new code.

prototype(FUNCTION)

Returns the prototype of a function as a string (or `undef` if the function has no prototype). FUNCTION is a reference to or the name of the function whose prototype you want to retrieve. (Not actually new; just never documented before.)

srand

The default seed for `srand`, which used to be `time`, has been changed. Now it's a heady mix of difficult-to-predict system-dependent values, which should be sufficient for most everyday purposes.

Previous to version 5.004, calling `rand` without first calling `srand` would yield the same sequence of random numbers on most or all machines. Now, when perl sees that you're calling `rand` and haven't yet called `srand`, it calls `srand` with the default seed. You should still call `srand` manually if your code might ever be run on a pre-5.004 system, of course, or if you want a seed other than the default.

`$_` as Default

Functions documented in the Camel to default to `$_` now in fact do, and all those that do are so documented in *perlfunc*.

`m//gc` does not reset search position on failure

The `m//g` match iteration construct has always reset its target string's search position (which is visible through the `pos` operator) when a match fails; as a result, the next `m//g` match after a failure starts again at the beginning of the string. With Perl 5.004, this reset may be disabled by adding the "c" (for "continue") modifier, i.e. `m//gc`. This feature, in conjunction with the `\G` zero-width assertion, makes it possible to chain matches together. See *perlop* and *perlre*.

m//x ignores whitespace before ?*+{}

The m//x construct has always been intended to ignore all unescaped whitespace. However, before Perl 5.004, whitespace had the effect of escaping repeat modifiers like "*" or "?"; for example, /a *b/x was (mis)interpreted as /a*b/x. This bug has been fixed in 5.004.

nested sub{} closures work now

Prior to the 5.004 release, nested anonymous functions didn't work right. They do now.

formats work right on changing lexicals

Just like anonymous functions that contain lexical variables that change (like a lexical index variable for a foreach loop), formats now work properly. For example, this silently failed before (printed only zeros), but is fine now:

```
my $i;
foreach $i ( 1 .. 10 ) {
    write;
}
format =
    my i is @#
    $i
.
```

However, it still fails (without a warning) if the foreach is within a subroutine:

```
my $i;
sub foo {
  foreach $i ( 1 .. 10 ) {
    write;
  }
}
foo;
format =
    my i is @#
    $i
.
```

New builtin methods

The UNIVERSAL package automatically contains the following methods that are inherited by all other classes:

isa(CLASS)

isa returns *true* if its object is blessed into a subclass of CLASS

isa is also exportable and can be called as a sub with two arguments. This allows the ability to check what a reference points to. Example:

```
use UNIVERSAL qw(isa);

if(isa($ref, 'ARRAY')) {
   ...
}
```

can(METHOD)

can checks to see if its object has a method called METHOD, if it does then a reference to the sub is returned; if it does not then *undef* is returned.

VERSION([NEED])

VERSION returns the version number of the class (package). If the NEED argument is given then it will check that the current version (as defined by the $VERSION variable in the given package) not

less than NEED; it will die if this is not the case. This method is normally called as a class method. This method is called automatically by the `VERSION` form of `use`.

```
use A 1.2 qw(some imported subs);
# implies:
A->VERSION(1.2);
```

NOTE: `can` directly uses Perl's internal code for method lookup, and `isa` uses a very similar method and caching strategy. This may cause strange effects if the Perl code dynamically changes @ISA in any package.

You may add other methods to the UNIVERSAL class via Perl or XS code. You do not need to `use UNIVERSAL` in order to make these methods available to your program. This is necessary only if you wish to have `isa` available as a plain subroutine in the current package.

TIEHANDLE now supported

See *perltie* for other kinds of `tie()`s.

TIEHANDLE classname, LIST

This is the constructor for the class. That means it is expected to return an object of some sort. The reference can be used to hold some internal information.

```
sub TIEHANDLE {
    print "<shout>\n";
    my $i;
    return bless \$i, shift;
}
```

PRINT this, LIST

This method will be triggered every time the tied handle is printed to. Beyond its self reference it also expects the list that was passed to the print function.

```
sub PRINT {
    $r = shift;
    $$r++;
    return print join( $, => map {uc} @_), $\;
}
```

PRINTF this, LIST

This method will be triggered every time the tied handle is printed to with the `printf()` function. Beyond its self reference it also expects the format and list that was passed to the printf function.

```
sub PRINTF {
    shift;
      my $fmt = shift;
    print sprintf($fmt, @_)."\n";
}
```

READ this LIST

This method will be called when the handle is read from via the `read` or `sysread` functions.

```
sub READ {
    $r = shift;
    my($buf,$len,$offset) = @_;
    print "READ called, \$buf=$buf, \$len=$len, \$offset=$offset";
}
```

READLINE this

This method will be called when the handle is read from. The method should return undef when there is no more data.

```
sub READLINE {
    $r = shift;
    return "PRINT called $$r times\n"
}
```

GETC this

This method will be called when the `getc` function is called.

```
sub GETC { print "Don't GETC, Get Perl"; return "a"; }
```

DESTROY this

As with the other types of ties, this method will be called when the tied handle is about to be destroyed. This is useful for debugging and possibly for cleaning up.

```
sub DESTROY {
    print "</shout>\n";
}
```

Malloc enhancements

If perl is compiled with the malloc included with the perl distribution (that is, if `perl -V:d_mymalloc` is 'define') then you can print memory statistics at runtime by running Perl thusly:

```
env PERL_DEBUG_MSTATS=2 perl your_script_here
```

The value of 2 means to print statistics after compilation and on exit; with a value of 1, the statistics are printed only on exit. (If you want the statistics at an arbitrary time, you'll need to install the optional module Devel::Peek.)

Three new compilation flags are recognized by malloc.c. (They have no effect if perl is compiled with system `malloc()`.)

–DPERL_EMERGENCY_SBRK

If this macro is defined, running out of memory need not be a fatal error: a memory pool can allocated by assigning to the special variable `$^M`. See *"$^M"*.

–DPACK_MALLOC

Perl memory allocation is by bucket with sizes close to powers of two. Because of these malloc overhead may be big, especially for data of size exactly a power of two. If `PACK_MALLOC` is defined, perl uses a slightly different algorithm for small allocations (up to 64 bytes long), which makes it possible to have overhead down to 1 byte for allocations which are powers of two (and appear quite often).

Expected memory savings (with 8–byte alignment in `alignbytes`) is about 20% for typical Perl usage. Expected slowdown due to additional malloc overhead is in fractions of a percent (hard to measure, because of the effect of saved memory on speed).

–DTWO_POT_OPTIMIZE

Similarly to `PACK_MALLOC`, this macro improves allocations of data with size close to a power of two; but this works for big allocations (starting with 16K by default). Such allocations are typical for big hashes and special–purpose scripts, especially image processing.

On recent systems, the fact that perl requires 2M from system for 1M allocation will not affect speed of execution, since the tail of such a chunk is not going to be touched (and thus will not require real memory). However, it may result in a premature out–of–memory error. So if you will be manipulating very large blocks with sizes close to powers of two, it would be wise to define this macro.

Expected saving of memory is 0–100% (100% in applications which require most memory in such 2**n chunks); expected slowdown is negligible.

Miscellaneous efficiency enhancements

Functions that have an empty prototype and that do nothing but return a fixed value are now inlined (e.g. `sub PI () { 3.14159 }`).

Each unique hash key is only allocated once, no matter how many hashes have an entry with that key. So even if you have 100 copies of the same hash, the hash keys never have to be reallocated.

Support for More Operating Systems

Support for the following operating systems is new in Perl 5.004.

Win32

Perl 5.004 now includes support for building a "native" perl under Windows NT, using the Microsoft Visual C++ compiler (versions 2.0 and above) or the Borland C++ compiler (versions 5.02 and above). The resulting perl can be used under Windows 95 (if it is installed in the same directory locations as it got installed in Windows NT). This port includes support for perl extension building tools like *MakeMaker* and *h2xs*, so that many extensions available on the Comprehensive Perl Archive Network (CPAN) can now be readily built under Windows NT. See http://www.perl.com/ for more information on CPAN and ***README.win32*** in the perl distribution for more details on how to get started with building this port.

There is also support for building perl under the Cygwin32 environment. Cygwin32 is a set of GNU tools that make it possible to compile and run many Unix programs under Windows NT by providing a mostly Unix-like interface for compilation and execution. See ***README.cygwin32*** in the perl distribution for more details on this port and how to obtain the Cygwin32 toolkit.

Plan 9

See ***README.plan9*** in the perl distribution.

QNX

See ***README.qnx*** in the perl distribution.

AmigaOS

See ***README.amigaos*** in the perl distribution.

Pragmata

Six new pragmatic modules exist:

use autouse MODULE = qw(sub1 sub2 sub3)

Defers `require MODULE` until someone calls one of the specified subroutines (which must be exported by MODULE). This pragma should be used with caution, and only when necessary.

use blib
use blib 'dir'

Looks for MakeMaker-like *'blib'* directory structure starting in *dir* (or current directory) and working back up to five levels of parent directories.

Intended for use on command line with **-M** option as a way of testing arbitrary scripts against an uninstalled version of a package.

use constant NAME = VALUE

Provides a convenient interface for creating compile-time constants, See *Constant Functions in perlsub*.

use locale

Tells the compiler to enable (or disable) the use of POSIX locales for builtin operations.

When `use locale` is in effect, the current LC_CTYPE locale is used for regular expressions and case mapping; LC_COLLATE for string ordering; and LC_NUMERIC for numeric formatting in printf and sprintf (but **not** in print). LC_NUMERIC is always used in write, since lexical scoping of formats is problematic at best.

Each `use locale` or `no locale` affects statements to the end of the enclosing BLOCK or, if not inside a BLOCK, to the end of the current file. Locales can be switched and queried with `POSIX::setlocale()`.

See *perllocale* for more information.

use ops

Disable unsafe opcodes, or any named opcodes, when compiling Perl code.

use vmsish

Enable VMS−specific language features. Currently, there are three VMS−specific features available: ‘status‘, which makes `$?` and `system` return genuine VMS status values instead of emulating POSIX; ‘exit‘, which makes `exit` take a genuine VMS status value instead of assuming that `exit 1` is an error; and ‘time‘, which makes all times relative to the local time zone, in the VMS tradition.

Modules

Required Updates

Though Perl 5.004 is compatible with almost all modules that work with Perl 5.003, there are a few exceptions:

```
Module   Required Version for Perl 5.004
------   -------------------------------
Filter   Filter-1.12
LWP      libwww-perl-5.08
Tk       Tk400.202 (-w makes noise)
```

Also, the majordomo mailing list program, version 1.94.1, doesn‘t work with Perl 5.004 (nor with perl 4), because it executes an invalid regular expression. This bug is fixed in majordomo version 1.94.2.

Installation directories

The *installperl* script now places the Perl source files for extensions in the architecture−specific library directory, which is where the shared libraries for extensions have always been. This change is intended to allow administrators to keep the Perl 5.004 library directory unchanged from a previous version, without running the risk of binary incompatibility between extensions’ Perl source and shared libraries.

Module information summary

Brand new modules, arranged by topic rather than strictly alphabetically:

```
CGI.pm                Web server interface ("Common Gateway Interface")
CGI/Apache.pm         Support for Apache's Perl module
CGI/Carp.pm           Log server errors with helpful context
CGI/Fast.pm           Support for FastCGI (persistent server process)
CGI/Push.pm           Support for server push
CGI/Switch.pm         Simple interface for multiple server types

CPAN                  Interface to Comprehensive Perl Archive Network
CPAN::FirstTime       Utility for creating CPAN configuration file
CPAN::Nox             Runs CPAN while avoiding compiled extensions

IO.pm                 Top-level interface to IO::* classes
IO/File.pm            IO::File extension Perl module
IO/Handle.pm          IO::Handle extension Perl module
IO/Pipe.pm            IO::Pipe extension Perl module
IO/Seekable.pm        IO::Seekable extension Perl module
IO/Select.pm          IO::Select extension Perl module
IO/Socket.pm          IO::Socket extension Perl module

Opcode.pm             Disable named opcodes when compiling Perl code
```

```
ExtUtils/Embed.pm    Utilities for embedding Perl in C programs
ExtUtils/testlib.pm  Fixes up @INC to use just-built extension

FindBin.pm           Find path of currently executing program

Class/Struct.pm      Declare struct-like datatypes as Perl classes
File/stat.pm         By-name interface to Perl's builtin stat
Net/hostent.pm       By-name interface to Perl's builtin gethost*
Net/netent.pm        By-name interface to Perl's builtin getnet*
Net/protoent.pm      By-name interface to Perl's builtin getproto*
Net/servent.pm       By-name interface to Perl's builtin getserv*
Time/gmtime.pm       By-name interface to Perl's builtin gmtime
Time/localtime.pm    By-name interface to Perl's builtin localtime
Time/tm.pm           Internal object for Time::{gm,local}time
User/grent.pm        By-name interface to Perl's builtin getgr*
User/pwent.pm        By-name interface to Perl's builtin getpw*

Tie/RefHash.pm       Base class for tied hashes with references as keys

UNIVERSAL.pm         Base class for *ALL* classes
```

Fcntl

New constants in the existing Fcntl modules are now supported, provided that your operating system happens to support them:

```
F_GETOWN F_SETOWN
O_ASYNC O_DEFER O_DSYNC O_FSYNC O_SYNC
O_EXLOCK O_SHLOCK
```

These constants are intended for use with the Perl operators `sysopen()` and `fcntl()` and the basic database modules like SDBM_File. For the exact meaning of these and other Fcntl constants please refer to your operating system's documentation for `fcntl()` and `open()`.

In addition, the Fcntl module now provides these constants for use with the Perl operator `flock()`:

```
LOCK_SH LOCK_EX LOCK_NB LOCK_UN
```

These constants are defined in all environments (because where there is no `flock()` system call, Perl emulates it). However, for historical reasons, these constants are not exported unless they are explicitly requested with the ":flock" tag (e.g. `use Fcntl ':flock'`).

IO

The IO module provides a simple mechanism to load all the IO modules at one go. Currently this includes:

```
IO::Handle
IO::Seekable
IO::File
IO::Pipe
IO::Socket
```

For more information on any of these modules, please see its respective documentation.

Math::Complex

The Math::Complex module has been totally rewritten, and now supports more operations. These are overloaded:

```
+ - * / ** <=> neg ~ abs sqrt exp log sin cos atan2 "" (stringify)
```

And these functions are now exported:

```
pi i Re Im arg
log10 logn ln cbrt root
```

```
tan
csc sec cot
asin acos atan
acsc asec acot
sinh cosh tanh
csch sech coth
asinh acosh atanh
acsch asech acoth
cplx cplxe
```

Math::Trig

This new module provides a simpler interface to parts of Math::Complex for those who need trigonometric functions only for real numbers.

DB_File

There have been quite a few changes made to DB_File. Here are a few of the highlights:

- Fixed a handful of bugs.
- By public demand, added support for the standard hash function `exists()`.
- Made it compatible with Berkeley DB 1.86.
- Made negative subscripts work with RECNO interface.
- Changed the default flags from O_RDWR to O_CREAT|O_RDWR and the default mode from 0640 to 0666.
- Made DB_File automatically import the `open()` constants (O_RDWR, O_CREAT etc.) from Fcntl, if available.
- Updated documentation.

Refer to the HISTORY section in DB_File.pm for a complete list of changes. Everything after DB_File 1.01 has been added since 5.003.

Net::Ping

Major rewrite – support added for both udp echo and real icmp pings.

Object–oriented overrides for builtin operators

Many of the Perl builtins returning lists now have object–oriented overrides. These are:

```
File::stat
Net::hostent
Net::netent
Net::protoent
Net::servent
Time::gmtime
Time::localtime
User::grent
User::pwent
```

For example, you can now say

```
use File::stat;
use User::pwent;
$his = (stat($filename)->st_uid == pwent($whoever)->pw_uid);
```

Utility Changes

pod2html

Sends converted HTML to standard output

The *pod2html* utility included with Perl 5.004 is entirely new. By default, it sends the converted HTML to its standard output, instead of writing it to a file like Perl 5.003's *pod2html* did. Use the **—outfile=FILENAME** option to write to a file.

xsubpp

`void` XSUBs now default to returning nothing

Due to a documentation/implementation bug in previous versions of Perl, XSUBs with a return type of `void` have actually been returning one value. Usually that value was the GV for the XSUB, but sometimes it was some already freed or reused value, which would sometimes lead to program failure.

In Perl 5.004, if an XSUB is declared as returning `void`, it actually returns no value, i.e. an empty list (though there is a backward–compatibility exception; see below). If your XSUB really does return an SV, you should give it a return type of `SV *`.

For backward compatibility, *xsubpp* tries to guess whether a `void` XSUB is really `void` or if it wants to return an `SV *`. It does so by examining the text of the XSUB: if *xsubpp* finds what looks like an assignment to `ST(0)`, it assumes that the XSUB's return type is really `SV *`.

C Language API Changes

`gv_fetchmethod` and `perl_call_sv`

The `gv_fetchmethod` function finds a method for an object, just like in Perl 5.003. The GV it returns may be a method cache entry. However, in Perl 5.004, method cache entries are not visible to users; therefore, they can no longer be passed directly to `perl_call_sv`. Instead, you should use the `GvCV` macro on the GV to extract its CV, and pass the CV to `perl_call_sv`.

The most likely symptom of passing the result of `gv_fetchmethod` to `perl_call_sv` is Perl's producing an "Undefined subroutine called" error on the *second* call to a given method (since there is no cache on the first call).

`perl_eval_pv`

A new function handy for eval'ing strings of Perl code inside C code. This function returns the value from the eval statement, which can be used instead of fetching globals from the symbol table. See *perlguts*, *perlembed* and *perlcall* for details and examples.

Extended API for manipulating hashes

Internal handling of hash keys has changed. The old hashtable API is still fully supported, and will likely remain so. The additions to the API allow passing keys as `SV*`s, so that `tied` hashes can be given real scalars as keys rather than plain strings (nontied hashes still can only use strings as keys). New extensions must use the new hash access functions and macros if they wish to use `SV*` keys. These additions also make it feasible to manipulate `HE*`s (hash entries), which can be more efficient. See *perlguts* for details.

Documentation Changes

Many of the base and library pods were updated. These new pods are included in section 1:

perldelta

This document.

perlfaq

Frequently asked questions.

perllocale

Locale support (internationalization and localization).

perltoot

Tutorial on Perl OO programming.

perlapio

Perl internal IO abstraction interface.

perlmodlib

Perl module library and recommended practice for module creation. Extracted from *perlmod* (which is much smaller as a result).

perldebug

Although not new, this has been massively updated.

perlsec

Although not new, this has been massively updated.

New Diagnostics

Several new conditions will trigger warnings that were silent before. Some only affect certain platforms. The following new warnings and errors outline these. These messages are classified as follows (listed in increasing order of desperation):

```
(W) A warning (optional).
(D) A deprecation (optional).
(S) A severe warning (mandatory).
(F) A fatal error (trappable).
(P) An internal error you should never see (trappable).
(X) A very fatal error (nontrappable).
(A) An alien error message (not generated by Perl).
```

"my" variable %s masks earlier declaration in same scope

(W) A lexical variable has been redeclared in the same scope, effectively eliminating all access to the previous instance. This is almost always a typographical error. Note that the earlier variable will still exist until the end of the scope or until all closure referents to it are destroyed.

%s argument is not a HASH element or slice

(F) The argument to `delete()` must be either a hash element, such as

```
$foo{$bar}
$ref->[12]->{"susie"}
```

or a hash slice, such as

```
@foo{$bar, $baz, $xyzzy}
@{$ref->[12]}{"susie", "queue"}
```

Allocation too large: %lx

(X) You can't allocate more than 64K on an MS-DOS machine.

Allocation too large

(F) You can't allocate more than 2^31+"small amount" bytes.

Applying %s to %s will act on scalar(%s)

(W) The pattern match (//), substitution (s///), and transliteration (tr///) operators work on scalar values. If you apply one of them to an array or a hash, it will convert the array or hash to a scalar value — the length of an array, or the population info of a hash — and then work on that scalar value. This is probably not what you meant to do. See *grep* and *map* for alternatives.

Attempt to free nonexistent shared string

(P) Perl maintains a reference counted internal table of strings to optimize the storage and access of hash keys and other strings. This indicates someone tried to decrement the reference count of a string that can no longer be found in the table.

Attempt to use reference as lvalue in substr

(W) You supplied a reference as the first argument to `substr()` used as an lvalue, which is pretty strange. Perhaps you forgot to dereference it first. See *substr*.

Bareword "%s" refers to nonexistent package

(W) You used a qualified bareword of the form `Foo::`, but the compiler saw no other uses of that namespace before that point. Perhaps you need to predeclare a package?

Can't redefine active sort subroutine %s

(F) Perl optimizes the internal handling of sort subroutines and keeps pointers into them. You tried to redefine one such sort subroutine when it was currently active, which is not allowed. If you really want to do this, you should write `sort { &func } @x` instead of `sort func @x`.

Can't use bareword ("%s") as %s ref while "strict refs" in use

(F) Only hard references are allowed by "strict refs". Symbolic references are disallowed. See *perlref*.

Cannot resolve method `%s' overloading `%s' in package `%s'

(P) Internal error trying to resolve overloading specified by a method name (as opposed to a subroutine reference).

Constant subroutine %s redefined

(S) You redefined a subroutine which had previously been eligible for inlining. See *Constant Functions in perlsub* for commentary and workarounds.

Constant subroutine %s undefined

(S) You undefined a subroutine which had previously been eligible for inlining. See *Constant Functions in perlsub* for commentary and workarounds.

Copy method did not return a reference

(F) The method which overloads "=" is buggy. See *Copy Constructor*.

Died

(F) You passed `die()` an empty string (the equivalent of `die ""`) or you called it with no args and both `$@` and `$_` were empty.

Exiting pseudo-block via %s

(W) You are exiting a rather special block construct (like a sort block or subroutine) by unconventional means, such as a goto, or a loop control statement. See *sort*.

Identifier too long

(F) Perl limits identifiers (names for variables, functions, etc.) to 252 characters for simple names, somewhat more for compound names (like `$A::B)`. You've exceeded Perl's limits. Future versions of Perl are likely to eliminate these arbitrary limitations.

Illegal character %s (carriage return)

(F) A carriage return character was found in the input. This is an error, and not a warning, because carriage return characters can break multi-line strings, including here documents (e.g., `print <<EOF;`).

Illegal switch in PERL5OPT: %s

(X) The PERL5OPT environment variable may only be used to set the following switches: **-[DIMUdmw]**.

Integer overflow in hex number

(S) The literal hex number you have specified is too big for your architecture. On a 32-bit architecture the largest hex literal is 0xFFFFFFFF.

Integer overflow in octal number

(S) The literal octal number you have specified is too big for your architecture. On a 32−bit architecture the largest octal literal is 037777777777.

internal error: glob failed

(P) Something went wrong with the external program(s) used for `glob` and `< <*.c`. This may mean that your csh (C shell) is broken. If so, you should change all of the csh−related variables in config.sh: If you have tcsh, make the variables refer to it as if it were csh (e.g. `full_csh='/usr/bin/tcsh'`); otherwise, make them all empty (except that `d_csh` should be `'undef'`) so that Perl will think csh is missing. In either case, after editing config.sh, run `./Configure -S` and rebuild Perl.

Invalid conversion in %s: "%s"

(W) Perl does not understand the given format conversion. See *sprintf*.

Invalid type in pack: '%s'

(F) The given character is not a valid pack type. See *pack*.

Invalid type in unpack: '%s'

(F) The given character is not a valid unpack type. See *unpack*.

Name "%s::%s" used only once: possible typo

(W) Typographical errors often show up as unique variable names. If you had a good reason for having a unique name, then just mention it again somehow to suppress the message (the `use vars` pragma is provided for just this purpose).

Null picture in formline

(F) The first argument to formline must be a valid format picture specification. It was found to be empty, which probably means you supplied it an uninitialized value. See *perlform*.

Offset outside string

(F) You tried to do a read/write/send/recv operation with an offset pointing outside the buffer. This is difficult to imagine. The sole exception to this is that `sysread()`ing past the buffer will extend the buffer and zero pad the new area.

Out of memory!

(X|F) The `malloc()` function returned 0, indicating there was insufficient remaining memory (or virtual memory) to satisfy the request.

The request was judged to be small, so the possibility to trap it depends on the way Perl was compiled. By default it is not trappable. However, if compiled for this, Perl may use the contents of `$^M` as an emergency pool after `die()`ing with this message. In this case the error is trappable *once*.

Out of memory during request for %s

(F) The `malloc()` function returned 0, indicating there was insufficient remaining memory (or virtual memory) to satisfy the request. However, the request was judged large enough (compile−time default is 64K), so a possibility to shut down by trapping this error is granted.

panic: frexp

(P) The library function `frexp()` failed, making printf("%f") impossible.

Possible attempt to put comments in `qw()` list

(W) `qw()` lists contain items separated by whitespace; as with literal strings, comment characters are not ignored, but are instead treated as literal data. (You may have used different delimiters than the parentheses shown here; braces are also frequently used.)

You probably wrote something like this:

```
@list = qw(
    a # a comment
    b # another comment
);
```

when you should have written this:

```
@list = qw(
    a
    b
);
```

If you really want comments, build your list the old–fashioned way, with quotes and commas:

```
@list = (
    'a',    # a comment
    'b',    # another comment
);
```

Possible attempt to separate words with commas

(W) `qw()` lists contain items separated by whitespace; therefore commas aren't needed to separate the items. (You may have used different delimiters than the parentheses shown here; braces are also frequently used.)

You probably wrote something like this:

```
qw! a, b, c !;
```

which puts literal commas into some of the list items. Write it without commas if you don't want them to appear in your data:

```
qw! a b c !;
```

Scalar value @%s{%s} better written as `$%s{%s}`

(W) You've used a hash slice (indicated by @) to select a single element of a hash. Generally it's better to ask for a scalar value (indicated by `$`) . The difference is that `$foo{&bar}` always behaves like a scalar, both when assigning to it and when evaluating its argument, while `@foo{&bar}` behaves like a list when you assign to it, and provides a list context to its subscript, which can do weird things if you're expecting only one subscript.

Stub found while resolving method '%s' overloading '%s' in package '%s'

(P) Overloading resolution over @ISA tree may be broken by importing stubs. Stubs should never be implicitly created, but explicit calls to `can` may break this.

Too late for "**–T**" option

(X) The #! line (or local equivalent) in a Perl script contains the **–T** option, but Perl was not invoked with **–T** in its argument list. This is an error because, by the time Perl discovers a **–T** in a script, it's too late to properly taint everything from the environment. So Perl gives up.

untie attempted while %d inner references still exist

(W) A copy of the object returned from `tie` (or `tied`) was still valid when `untie` was called.

Unrecognized character %s

(F) The Perl parser has no idea what to do with the specified character in your Perl script (or eval). Perhaps you tried to run a compressed script, a binary program, or a directory as a Perl program.

Unsupported function fork

(F) Your version of executable does not support forking.

Note that under some systems, like OS/2, there may be different flavors of Perl executables, some of which may support fork, some not. Try changing the name you call Perl by to `perl_`, `perl__`, and

so on.

Use of "$$<digit" to mean "${$}<digit" is deprecated

(D) Perl versions before 5.004 misinterpreted any type marker followed by "$" and a digit. For example, "$$0" was incorrectly taken to mean "${$}0" instead of "${$0}". This bug is (mostly) fixed in Perl 5.004.

However, the developers of Perl 5.004 could not fix this bug completely, because at least two widely–used modules depend on the old meaning of "$$0" in a string. So Perl 5.004 still interprets "$$<digit" in the old (broken) way inside strings; but it generates this message as a warning. And in Perl 5.005, this special treatment will cease.

Value of %s can be "0"; test with defined()

(W) In a conditional expression, you used <HANDLE, <* (glob), each(), or readdir() as a boolean value. Each of these constructs can return a value of "0"; that would make the conditional expression false, which is probably not what you intended. When using these constructs in conditional expressions, test their values with the defined operator.

Variable "%s" may be unavailable

(W) An inner (nested) *anonymous* subroutine is inside a *named* subroutine, and outside that is another subroutine; and the anonymous (innermost) subroutine is referencing a lexical variable defined in the outermost subroutine. For example:

```
sub outermost { my $a; sub middle { sub { $a } } }
```

If the anonymous subroutine is called or referenced (directly or indirectly) from the outermost subroutine, it will share the variable as you would expect. But if the anonymous subroutine is called or referenced when the outermost subroutine is not active, it will see the value of the shared variable as it was before and during the *first* call to the outermost subroutine, which is probably not what you want.

In these circumstances, it is usually best to make the middle subroutine anonymous, using the sub {} syntax. Perl has specific support for shared variables in nested anonymous subroutines; a named subroutine in between interferes with this feature.

Variable "%s" will not stay shared

(W) An inner (nested) *named* subroutine is referencing a lexical variable defined in an outer subroutine.

When the inner subroutine is called, it will probably see the value of the outer subroutine's variable as it was before and during the *first* call to the outer subroutine; in this case, after the first call to the outer subroutine is complete, the inner and outer subroutines will no longer share a common value for the variable. In other words, the variable will no longer be shared.

Furthermore, if the outer subroutine is anonymous and references a lexical variable outside itself, then the outer and inner subroutines will *never* share the given variable.

This problem can usually be solved by making the inner subroutine anonymous, using the sub {} syntax. When inner anonymous subs that reference variables in outer subroutines are called or referenced, they are automatically rebound to the current values of such variables.

Warning: something's wrong

(W) You passed warn() an empty string (the equivalent of warn "") or you called it with no args and $_ was empty.

Ill–formed logical name |%s| in prime_env_iter

(W) A warning peculiar to VMS. A logical name was encountered when preparing to iterate over %ENV which violates the syntactic rules governing logical names. Since it cannot be translated normally, it is skipped, and will not appear in %ENV. This may be a benign occurrence, as some software packages might directly modify logical name tables and introduce nonstandard names, or it

may indicate that a logical name table has been corrupted.

Got an error from DosAllocMem

(P) An error peculiar to OS/2. Most probably you're using an obsolete version of Perl, and this should not happen anyway.

Malformed PERLLIB_PREFIX

(F) An error peculiar to OS/2. PERLLIB_PREFIX should be of the form

```
prefix1;prefix2
```

or

```
prefix1 prefix2
```

with nonempty prefix1 and prefix2. If `prefix1` is indeed a prefix of a builtin library search path, prefix2 is substituted. The error may appear if components are not found, or are too long. See "PERLLIB_PREFIX" in ***README.os2***.

PERL_SH_DIR too long

(F) An error peculiar to OS/2. PERL_SH_DIR is the directory to find the `sh`-shell in. See "PERL_SH_DIR" in ***README.os2***.

Process terminated by SIG%s

(W) This is a standard message issued by OS/2 applications, while *nix applications die in silence. It is considered a feature of the OS/2 port. One can easily disable this by appropriate sighandlers, see *Signals in perlipc*. See also "Process terminated by SIGTERM/SIGINT" in ***README.os2***.

BUGS

If you find what you think is a bug, you might check the headers of recently posted articles in the comp.lang.perl.misc newsgroup. There may also be information at http://www.perl.com/perl/, the Perl Home Page.

If you believe you have an unreported bug, please run the **perlbug** program included with your release. Make sure you trim your bug down to a tiny but sufficient test case. Your bug report, along with the output of `perl -V`, will be sent off to ***<perlbug@perl.com>*** to be analysed by the Perl porting team.

SEE ALSO

The ***Changes*** file for exhaustive details on what changed.

The ***INSTALL*** file for how to build Perl. This file has been significantly updated for 5.004, so even veteran users should look through it.

The ***README*** file for general stuff.

The ***Copying*** file for copyright information.

HISTORY

Constructed by Tom Christiansen, grabbing material with permission from innumerable contributors, with kibitzing by more than a few Perl porters.

Last update: Wed May 14 11:14:09 EDT 1997

NAME

perldelta – what's new for perl5.005

DESCRIPTION

This document describes differences between the 5.004 release and this one.

About the new versioning system

Perl is now developed on two tracks: a maintenance track that makes small, safe updates to released production versions with emphasis on compatibility; and a development track that pursues more aggressive evolution. Maintenance releases (which should be considered production quality) have subversion numbers that run from `1` to `49`, and development releases (which should be considered "alpha" quality) run from `50` to `99`.

Perl 5.005 is the combined product of the new dual-track development scheme.

Incompatible Changes

WARNING: This version is not binary compatible with Perl 5.004.

Starting with Perl 5.004_50 there were many deep and far-reaching changes to the language internals. If you have dynamically loaded extensions that you built under perl 5.003 or 5.004, you can continue to use them with 5.004, but you will need to rebuild and reinstall those extensions to use them 5.005. See ***INSTALL*** for detailed instructions on how to upgrade.

Default installation structure has changed

The new Configure defaults are designed to allow a smooth upgrade from 5.004 to 5.005, but you should read ***INSTALL*** for a detailed discussion of the changes in order to adapt them to your system.

Perl Source Compatibility

When none of the experimental features are enabled, there should be very few user-visible Perl source compatibility issues.

If threads are enabled, then some caveats apply. `@_` and `$_` become lexical variables. The effect of this should be largely transparent to the user, but there are some boundary conditions under which user will need to be aware of the issues. For example, `local(@_)` results in a "Can't localize lexical variable @_ ..." message. This may be enabled in a future version.

Some new keywords have been introduced. These are generally expected to have very little impact on compatibility. See *New `INIT` keyword*, *New `lock` keyword*, and `/` operator.

Certain barewords are now reserved. Use of these will provoke a warning if you have asked for them with the `-w` switch. See *`our` is now a reserved word*.

C Source Compatibility

There have been a large number of changes in the internals to support the new features in this release.

Core sources now require ANSI C compiler

An ANSI C compiler is now **required** to build perl. See ***INSTALL***.

All Perl global variables must now be referenced with an explicit prefix

All Perl global variables that are visible for use by extensions now have a `PL_` prefix. New extensions should `not` refer to perl globals by their unqualified names. To preserve sanity, we provide limited backward compatibility for globals that are being widely used like `sv_undef` and `na` (which should now be written as `PL_sv_undef`, `PL_na` etc.)

If you find that your XS extension does not compile anymore because a perl global is not visible, try adding a `PL_` prefix to the global and rebuild.

It is strongly recommended that all functions in the Perl API that don't begin with `perl` be referenced with a `Perl_` prefix. The bare function names without the `Perl_` prefix are supported with macros, but this support may cease in a future release.

See *API LISTING in perlguts*.

Enabling threads has source compatibility issues

Perl built with threading enabled requires extensions to use the new `dTHR` macro to initialize the handle to access per−thread data. If you see a compiler error that talks about the variable `thr` not being declared (when building a module that has XS code), you need to add `dTHR;` at the beginning of the block that elicited the error.

The API function `perl_get_sv("@",FALSE)` should be used instead of directly accessing perl globals as `GvSV(errgv)`. The API call is backward compatible with existing perls and provides source compatibility with threading is enabled.

See *"C Source Compatibility"* for more information.

Binary Compatibility

This version is NOT binary compatible with older versions. All extensions will need to be recompiled. Further binaries built with threads enabled are incompatible with binaries built without. This should largely be transparent to the user, as all binary incompatible configurations have their own unique architecture name, and extension binaries get installed at unique locations. This allows coexistence of several configurations in the same directory hierarchy. See ***INSTALL***.

Security fixes may affect compatibility

A few taint leaks and taint omissions have been corrected. This may lead to "failure" of scripts that used to work with older versions. Compiling with −DINCOMPLETE_TAINTS provides a perl with minimal amounts of changes to the tainting behavior. But note that the resulting perl will have known insecurities.

Oneliners with the `−e` switch do not create temporary files anymore.

Relaxed new mandatory warnings introduced in 5.004

Many new warnings that were introduced in 5.004 have been made optional. Some of these warnings are still present, but perl's new features make them less often a problem. See *New Diagnostics*.

Licensing

Perl has a new Social Contract for contributors. See ***Porting/Contract***.

The license included in much of the Perl documentation has changed. Most of the Perl documentation was previously under the implicit GNU General Public License or the Artistic License (at the user's choice). Now much of the documentation unambiguously states the terms under which it may be distributed. Those terms are in general much less restrictive than the GNU GPL. See *perl* and the individual perl man pages listed therein.

Core Changes

Threads

WARNING: Threading is considered an **experimental** feature. Details of the implementation may change without notice. There are known limitations and some bugs. These are expected to be fixed in future versions.

See ***README.threads***.

Compiler

WARNING: The Compiler and related tools are considered **experimental**. Features may change without notice, and there are known limitations and bugs. Since the compiler is fully external to perl, the default configuration will build and install it.

The Compiler produces three different types of transformations of a perl program. The C backend generates C code that captures perl's state just before execution begins. It eliminates the compile−time overheads of the regular perl interpreter, but the run−time performance remains comparatively the same. The CC backend generates optimized C code equivalent to the code path at run−time. The CC backend has greater potential for big optimizations, but only a few optimizations are implemented currently. The Bytecode backend

generates a platform independent bytecode representation of the interpreter's state just before execution. Thus, the Bytecode back end also eliminates much of the compilation overhead of the interpreter.

The compiler comes with several valuable utilities.

`B::Lint` is an experimental module to detect and warn about suspicious code, especially the cases that the `-w` switch does not detect.

`B::Deparse` can be used to demystify perl code, and understand how perl optimizes certain constructs.

`B::Xref` generates cross reference reports of all definition and use of variables, subroutines and formats in a program.

`B::Showlex` show the lexical variables used by a subroutine or file at a glance.

`perlcc` is a simple frontend for compiling perl.

See `ext/B/README`, *B*, and the respective compiler modules.

Regular Expressions

Perl's regular expression engine has been seriously overhauled, and many new constructs are supported. Several bugs have been fixed.

Here is an itemized summary:

Many new and improved optimizations

Changes in the RE engine:

```
Unneeded nodes removed;
Substrings merged together;
New types of nodes to process (SUBEXPR)* and similar expressions
    quickly, used if the SUBEXPR has no side effects and matches
    strings of the same length;
Better optimizations by lookup for constant substrings;
Better search for constants substrings anchored by $ ;
```

Changes in Perl code using RE engine:

```
More optimizations to s/longer/short/;
study() was not working;
/blah/ may be optimized to an analogue of index() if $& $` $' not seen;
Unneeded copying of matched-against string removed;
Only matched part of the string is copying if $` $' were not seen;
```

Many bug fixes

Note that only the major bug fixes are listed here. See ***Changes*** for others.

```
Backtracking might not restore start of $3.
No feedback if max count for * or + on "complex" subexpression
    was reached, similarly (but at compile time) for {3,34567}
Primitive restrictions on max count introduced to decrease a
    possibility of a segfault;
(ZERO-LENGTH)* could segfault;
(ZERO-LENGTH)* was prohibited;
Long REs were not allowed;
/RE/g could skip matches at the same position after a
  zero-length match;
```

New regular expression constructs

The following new syntax elements are supported:

```
(?<=RE)
```

```
(?<!RE)
(?{ CODE })
(?i-x)
(?i:RE)
(?(COND)YES_RE|NO_RE)
(?>RE)
\z
```

New operator for precompiled regular expressions

See / operator.

Other improvements

```
Better debugging output (possibly with colors),
    even from non-debugging Perl;
RE engine code now looks like C, not like assembler;
Behaviour of RE modifiable by 'use re' directive;
Improved documentation;
Test suite significantly extended;
Syntax [:^upper:] etc., reserved inside character classes;
```

Incompatible changes

```
(?i) localized inside enclosing group;
$( is not interpolated into RE any more;
/RE/g may match at the same position (with non-zero length)
    after a zero-length match (bug fix).
```

See *perlre* and *perlop*.

Improved `malloc()`

See banner at the beginning of `malloc.c` for details.

Quicksort is internally implemented

Perl now contains its own highly optimized `qsort()` routine. The new `qsort()` is resistant to inconsistent comparison functions, so Perl's `sort()` will not provoke coredumps any more when given poorly written sort subroutines. (Some C library `qsort()`s that were being used before used to have this problem.) In our testing, the new `qsort()` required the minimal number of pair-wise compares on average, among all known `qsort()` implementations.

See `perlfunc/sort`.

Reliable signals

Perl's signal handling is susceptible to random crashes, because signals arrive asynchronously, and the Perl runtime is not reentrant at arbitrary times.

However, one experimental implementation of reliable signals is available when threads are enabled. See `Thread::Signal`. Also see ***INSTALL*** for how to build a Perl capable of threads.

Reliable stack pointers

The internals now reallocate the perl stack only at predictable times. In particular, magic calls never trigger reallocations of the stack, because all reentrancy of the runtime is handled using a "stack of stacks". This should improve reliability of cached stack pointers in the internals and in XSUBs.

More generous treatment of carriage returns

Perl used to complain if it encountered literal carriage returns in scripts. Now they are mostly treated like whitespace within program text. Inside string literals and here documents, literal carriage returns are ignored if they occur paired with linefeeds, or get interpreted as whitespace if they stand alone. This behavior means that literal carriage returns in files should be avoided. You can get the older, more compatible (but less generous) behavior by defining the preprocessor symbol `PERL_STRICT_CR` when building perl. Of

course, all this has nothing whatever to do with how escapes like `\r` are handled within strings.

Note that this doesn't somehow magically allow you to keep all text files in DOS format. The generous treatment only applies to files that perl itself parses. If your C compiler doesn't allow carriage returns in files, you may still be unable to build modules that need a C compiler.

Memory leaks

`substr`, `pos` and `vec` don't leak memory anymore when used in lvalue context. Many small leaks that impacted applications that embed multiple interpreters have been fixed.

Better support for multiple interpreters

The build–time option `–DMULTIPLICITY` has had many of the details reworked. Some previously global variables that should have been per–interpreter now are. With care, this allows interpreters to call each other. See the `PerlInterp` extension on CPAN.

Behavior of `local()` on array and hash elements is now well–defined

See *"Temporary Values via `local()`"*.

`%!` is transparently tied to the *Errno* module

See *perlvar*, and *Errno*.

Pseudo–hashes are supported

See *perlref*.

`EXPR foreach EXPR` is supported

See *perlsyn*.

Keywords can be globally overridden

See *perlsub*.

`$^E` is meaningful on Win32

See *perlvar*.

`foreach (1..1000000)` optimized

`foreach (1..1000000)` is now optimized into a counting loop. It does not try to allocate a 1000000–size list anymore.

`Foo::` can be used as implicitly quoted package name

Barewords caused unintuitive behavior when a subroutine with the same name as a package happened to be defined. Thus, `new Foo @args`, use the result of the call to `Foo()` instead of `Foo` being treated as a literal. The recommended way to write barewords in the indirect object slot is `new Foo:: @args`. Note that the method `new()` is called with a first argument of `Foo`, not `Foo::` when you do that.

`exists $Foo::{Bar::}` tests existence of a package

It was impossible to test for the existence of a package without actually creating it before. Now `exists $Foo::{Bar::}` can be used to test if the `Foo::Bar` namespace has been created.

Better locale support

See *perllocale*.

Experimental support for 64–bit platforms

Perl5 has always had 64–bit support on systems with 64–bit longs. Starting with 5.005, the beginnings of experimental support for systems with 32–bit long and 64–bit 'long long' integers has been added. If you add –DUSE_LONG_LONG to your ccflags in config.sh (or manually define it in perl.h) then perl will be built with 'long long' support. There will be many compiler warnings, and the resultant perl may not work on all systems. There are many other issues related to third–party extensions and libraries. This option exists to allow people to work on those issues.

`prototype()` returns useful results on builtins

See *prototype*.

Extended support for exception handling

`die()` now accepts a reference value, and `$@` gets set to that value in exception traps. This makes it possible to propagate exception objects. This is an undocumented **experimental** feature.

Re-blessing in `DESTROY()` supported for chaining `DESTROY()` methods

See *Destructors*.

All `printf` format conversions are handled internally

See *printf*.

New `INIT` keyword

`INIT` subs are like `BEGIN` and `END`, but they get run just before the perl runtime begins execution. e.g., the Perl Compiler makes use of `INIT` blocks to initialize and resolve pointers to XSUBs.

New `lock` keyword

The `lock` keyword is the fundamental synchronization primitive in threaded perl. When threads are not enabled, it is currently a noop.

To minimize impact on source compatibility this keyword is "weak", i.e., any user-defined subroutine of the same name overrides it, unless a `use Thread` has been seen.

New `qr//` operator

The `qr//` operator, which is syntactically similar to the other quote-like operators, is used to create precompiled regular expressions. This compiled form can now be explicitly passed around in variables, and interpolated in other regular expressions. See *perlop*.

`our` is now a reserved word

Calling a subroutine with the name `our` will now provoke a warning when using the `-w` switch.

Tied arrays are now fully supported

See *Tie::Array*.

Tied handles support is better

Several missing hooks have been added. There is also a new base class for TIEARRAY implementations. See *Tie::Array*.

4th argument to substr

`substr()` can now both return and replace in one operation. The optional 4th argument is the replacement string. See *substr*.

Negative LENGTH argument to splice

`splice()` with a negative LENGTH argument now work similar to what the LENGTH did for `substr()`. Previously a negative LENGTH was treated as 0. See *splice*.

Magic lvalues are now more magical

When you say something like `substr($x, 5) = "hi"`, the scalar returned by `substr()` is special, in that any modifications to it affect `$x`. (This is called a 'magic lvalue' because an 'lvalue' is something on the left side of an assignment.) Normally, this is exactly what you would expect to happen, but Perl uses the same magic if you use `substr()`, `pos()`, or `vec()` in a context where they might be modified, like taking a reference with \ or as an argument to a sub that modifies `@_`. In previous versions, this 'magic' only went one way, but now changes to the scalar the magic refers to (`$x` in the above example) affect the magic lvalue too. For instance, this code now acts differently:

```
$x = "hello";
sub printit {
```

```
    $x = "g'bye";
    print $_[0], "\n";
}
printit(substr($x, 0, 5));
```

In previous versions, this would print "hello", but it now prints "g'bye".

< now reads in records

If `$/` is a reference to an integer, or a scalar that holds an integer, < will read in records instead of lines. For more info, see *$/*.

Supported Platforms

Configure has many incremental improvements. Site–wide policy for building perl can now be made persistent, via Policy.sh. Configure also records the command–line arguments used in ***config.sh***.

New Platforms

BeOS is now supported. See ***README.beos***.

DOS is now supported under the DJGPP tools. See ***README.dos*** (installed as *perldos* on some systems).

MiNT is now supported. See ***README.mint***.

MPE/iX is now supported. See ***README.mpeix***.

MVS (aka OS390, aka Open Edition) is now supported. See ***README.os390*** (installed as *perlos390* on some systems).

Stratus VOS is now supported. See ***README.vos***.

Changes in existing support

Win32 support has been vastly enhanced. Support for Perl Object, a C++ encapsulation of Perl. GCC and EGCS are now supported on Win32. See ***README.win32***, aka *perlwin32*.

VMS configuration system has been rewritten. See ***README.vms*** (installed as *README_vms* on some systems).

The hints files for most Unix platforms have seen incremental improvements.

Modules and Pragmata

New Modules

B Perl compiler and tools. See *B*.

Data::Dumper

A module to pretty print Perl data. See *Data::Dumper*.

Dumpvalue

A module to dump perl values to the screen. See *Dumpvalue*.

Errno

A module to look up errors more conveniently. See *Errno*.

File::Spec

A portable API for file operations.

ExtUtils::Installed

Query and manage installed modules.

ExtUtils::Packlist

Manipulate .packlist files.

Fatal

Make functions/builtins succeed or die.

IPC::SysV

Constants and other support infrastructure for System V IPC operations in perl.

Test

A framework for writing testsuites.

Tie::Array

Base class for tied arrays.

Tie::Handle

Base class for tied handles.

Thread

Perl thread creation, manipulation, and support.

attrs

Set subroutine attributes.

fields

Compile−time class fields.

re Various pragmata to control behavior of regular expressions.

Changes in existing modules

Benchmark

You can now run tests for *x* seconds instead of guessing the right number of tests to run.

Carp

Carp has a new function `cluck()`. `cluck()` warns, like `carp()`, but also adds a stack backtrace to the error message, like `confess()`.

CGI CGI has been updated to version 2.42.

Fcntl

More Fcntl constants added: F_SETLK64, F_SETLKW64, O_LARGEFILE for large (more than 4G) file access (the 64−bit support is not yet working, though, so no need to get overly excited), Free/Net/OpenBSD locking behaviour flags F_FLOCK, F_POSIX, Linux F_SHLCK, and O_ACCMODE: the mask of O_RDONLY, O_WRONLY, and O_RDWR.

Math::Complex

The accessors methods Re, Im, arg, abs, rho, theta, methods can `($z−Re())` now also act as mutators (`$z−Re(3)`).

Math::Trig

A little bit of radial trigonometry (cylindrical and spherical) added, for example the great circle distance.

POSIX

POSIX now has its own platform−specific hints files.

DB_File

DB_File supports version 2.x of Berkeley DB. See `ext/DB_File/Changes`.

MakeMaker

MakeMaker now supports writing empty makefiles, provides a way to specify that site `umask()` policy should be honored. There is also better support for manipulation of .packlist files, and getting

information about installed modules.

Extensions that have both architecture–dependent and architecture–independent files are now always installed completely in the architecture–dependent locations. Previously, the shareable parts were shared both across architectures and across perl versions and were therefore liable to be overwritten with newer versions that might have subtle incompatibilities.

CPAN

See <perlmodinstall and *CPAN*.

Cwd

Cwd::cwd is faster on most platforms.

Benchmark

Keeps better time.

Utility Changes

`h2ph` and related utilities have been vastly overhauled.

`perlcc`, a new experimental front end for the compiler is available.

The crude GNU `configure` emulator is now called `configure.gnu` to avoid trampling on `Configure` under case–insensitive filesystems.

`perldoc` used to be rather slow. The slower features are now optional. In particular, case–insensitive searches need the `–i` switch, and recursive searches need `–r`. You can set these switches in the `PERLDOC` environment variable to get the old behavior.

Documentation Changes

Config.pm now has a glossary of variables.

Porting/patching.pod has detailed instructions on how to create and submit patches for perl.

perlport specifies guidelines on how to write portably.

perlmodinstall describes how to fetch and install modules from `CPAN` sites.

Some more Perl traps are documented now. See *perltrap*.

perlopentut gives a tutorial on using `open()`.

perlreftut gives a tutorial on references.

perlthrtut gives a tutorial on threads.

New Diagnostics

Ambiguous call resolved as `CORE::%s()`, qualify as such or use `&`

(W) A subroutine you have declared has the same name as a Perl keyword, and you have used the name without qualification for calling one or the other. Perl decided to call the builtin because the subroutine is not imported.

To force interpretation as a subroutine call, either put an ampersand before the subroutine name, or qualify the name with its package. Alternatively, you can import the subroutine (or pretend that it's imported with the `use subs` pragma).

To silently interpret it as the Perl operator, use the `CORE::` prefix on the operator (e.g. `CORE::log($x)`) or by declaring the subroutine to be an object method (see *attrs*).

Bad index while coercing array into hash

(F) The index looked up in the hash found as the 0'th element of a pseudo–hash is not legal. Index values must be at 1 or greater. See *perlref*.

Bareword "%s" refers to nonexistent package

(W) You used a qualified bareword of the form `Foo::`, but the compiler saw no other uses of that namespace before that point. Perhaps you need to predeclare a package?

Can't call method "%s" on an undefined value

(F) You used the syntax of a method call, but the slot filled by the object reference or package name contains an undefined value. Something like this will reproduce the error:

```
$BADREF = 42;
process $BADREF 1,2,3;
$BADREF->process(1,2,3);
```

Can't check filesystem of script "%s" for nosuid

(P) For some reason you can't check the filesystem of the script for nosuid.

Can't coerce array into hash

(F) You used an array where a hash was expected, but the array has no information on how to map from keys to array indices. You can do that only with arrays that have a hash reference at index 0.

Can't goto subroutine from an eval-string

(F) The "goto subroutine" call can't be used to jump out of an eval "string". (You can use it to jump out of an eval {BLOCK}, but you probably don't want to.)

Can't localize pseudo-hash element

(F) You said something like `< local $ar-{'key'}` , where `$ar` is a reference to a pseudo-hash. That hasn't been implemented yet, but you can get a similar effect by localizing the corresponding array element directly — `< local $ar-[$ar-[0]{'key'}]` .

Can't use %%! because Errno.pm is not available

(F) The first time the %! hash is used, perl automatically loads the Errno.pm module. The Errno module is expected to tie the %! hash to provide symbolic names for `$!` errno values.

Cannot find an opnumber for "%s"

(F) A string of a form `CORE::word` was given to `prototype()`, but there is no builtin with the name `word`.

Character class syntax [. .] is reserved for future extensions

(W) Within regular expression character classes ([]) the syntax beginning with "[." and ending with ".]" is reserved for future extensions. If you need to represent those character sequences inside a regular expression character class, just quote the square brackets with the backslash: "\[." and ".\]".

Character class syntax [: :] is reserved for future extensions

(W) Within regular expression character classes ([]) the syntax beginning with "[:" and ending with ":]" is reserved for future extensions. If you need to represent those character sequences inside a regular expression character class, just quote the square brackets with the backslash: "\[:" and ":\]".

Character class syntax [= =] is reserved for future extensions

(W) Within regular expression character classes ([]) the syntax beginning with "[=" and ending with "=]" is reserved for future extensions. If you need to represent those character sequences inside a regular expression character class, just quote the square brackets with the backslash: "\[=" and "=\]".

%s: Eval-group in insecure regular expression

(F) Perl detected tainted data when trying to compile a regular expression that contains the `(?{ ... })` zero-width assertion, which is unsafe. See *(?{ code })*, and *perlsec*.

%s: Eval-group not allowed, use re 'eval'

(F) A regular expression contained the `(?{ ... })` zero-width assertion, but that construct is only allowed when the `use re 'eval'` pragma is in effect. See *(?{ code })*.

%s: Eval–group not allowed at run time

(F) Perl tried to compile a regular expression containing the `(?{ ... })` zero–width assertion at run time, as it would when the pattern contains interpolated values. Since that is a security risk, it is not allowed. If you insist, you may still do this by explicitly building the pattern from an interpolated string at run time and using that in an `eval()`. See *(?{ code })*.

Explicit blessing to '' (assuming package main)

(W) You are blessing a reference to a zero length string. This has the effect of blessing the reference into the package main. This is usually not what you want. Consider providing a default target package, e.g. bless($ref, $p || 'MyPackage');

Illegal hex digit ignored

(W) You may have tried to use a character other than 0 – 9 or A – F in a hexadecimal number. Interpretation of the hexadecimal number stopped before the illegal character.

No such array field

(F) You tried to access an array as a hash, but the field name used is not defined. The hash at index 0 should map all valid field names to array indices for that to work.

No such field "%s" in variable %s of type %s

(F) You tried to access a field of a typed variable where the type does not know about the field name. The field names are looked up in the %FIELDS hash in the type package at compile time. The %FIELDS hash is usually set up with the 'fields' pragma.

Out of memory during ridiculously large request

(F) You can't allocate more than 2^31+"small amount" bytes. This error is most likely to be caused by a typo in the Perl program. e.g., `$arr[time]` instead of `$arr[$time]`.

Range iterator outside integer range

(F) One (or both) of the numeric arguments to the range operator ".." are outside the range which can be represented by integers internally. One possible workaround is to force Perl to use magical string increment by prepending "0" to your numbers.

Recursive inheritance detected while looking for method '%s' in package '%s'

(F) More than 100 levels of inheritance were encountered while invoking a method. Probably indicates an unintended loop in your inheritance hierarchy.

Reference found where even–sized list expected

(W) You gave a single reference where Perl was expecting a list with an even number of elements (for assignment to a hash). This usually means that you used the anon hash constructor when you meant to use parens. In any case, a hash requires key/value **pairs**.

```
%hash = { one => 1, two => 2, };    # WRONG
%hash = [ qw/ an anon array / ];    # WRONG
%hash = ( one => 1, two => 2, );    # right
%hash = qw( one 1 two 2 );                  # also fine
```

Undefined value assigned to typeglob

(W) An undefined value was assigned to a typeglob, a la `*foo = undef`. This does nothing. It's possible that you really mean `undef *foo`.

Use of reserved word "%s" is deprecated

(D) The indicated bareword is a reserved word. Future versions of perl may use it as a keyword, so you're better off either explicitly quoting the word in a manner appropriate for its context of use, or using a different name altogether. The warning can be suppressed for subroutine names by either adding a `&` prefix, or using a package qualifier, e.g. `&our()`, or `Foo::our()`.

perl: warning: Setting locale failed.

(S) The whole warning message will look something like:

```
perl: warning: Setting locale failed.
perl: warning: Please check that your locale settings:
        LC_ALL = "En_US",
        LANG = (unset)
    are supported and installed on your system.
perl: warning: Falling back to the standard locale ("C").
```

Exactly what were the failed locale settings varies. In the above the settings were that the LC_ALL was "En_US" and the LANG had no value. This error means that Perl detected that you and/or your system administrator have set up the so−called variable system but Perl could not use those settings. This was not dead serious, fortunately: there is a "default locale" called "C" that Perl can and will use, the script will be run. Before you really fix the problem, however, you will get the same error message each time you run Perl. How to really fix the problem can be found in *LOCALE PROBLEMS in perllocale*.

Obsolete Diagnostics

Can't `mktemp()`

(F) The `mktemp()` routine failed for some reason while trying to process a **−e** switch. Maybe your /tmp partition is full, or clobbered.

Removed because **−e** doesn't use temporary files any more.

Can't write to temp file for **−e**: %s

(F) The write routine failed for some reason while trying to process a **−e** switch. Maybe your /tmp partition is full, or clobbered.

Removed because **−e** doesn't use temporary files any more.

Cannot open temporary file

(F) The create routine failed for some reason while trying to process a **−e** switch. Maybe your /tmp partition is full, or clobbered.

Removed because **−e** doesn't use temporary files any more.

regexp too big

(F) The current implementation of regular expressions uses shorts as address offsets within a string. Unfortunately this means that if the regular expression compiles to longer than 32767, it'll blow up. Usually when you want a regular expression this big, there is a better way to do it with multiple statements. See *perlre*.

Configuration Changes

You can use "Configure −Uinstallusrbinperl" which causes installperl to skip installing perl also as /usr/bin/perl. This is useful if you prefer not to modify /usr/bin for some reason or another but harmful because many scripts assume to find Perl in /usr/bin/perl.

BUGS

If you find what you think is a bug, you might check the headers of recently posted articles in the comp.lang.perl.misc newsgroup. There may also be information at http://www.perl.com/perl/, the Perl Home Page.

If you believe you have an unreported bug, please run the **perlbug** program included with your release. Make sure you trim your bug down to a tiny but sufficient test case. Your bug report, along with the output of `perl -V`, will be sent off to ***<perlbug@perl.com>*** to be analysed by the Perl porting team.

SEE ALSO

The ***Changes*** file for exhaustive details on what changed.

The ***INSTALL*** file for how to build Perl.

The ***README*** file for general stuff.

The ***Artistic*** and ***Copying*** files for copyright information.

HISTORY

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Send omissions or corrections to ***<perlbug@perl.com***.

NAME

perldelta – what's new for perl v5.6.0

DESCRIPTION

This document describes differences between the 5.005 release and the 5.6.0 release.

Core Enhancements

Interpreter cloning, threads, and concurrency

Perl 5.6.0 introduces the beginnings of support for running multiple interpreters concurrently in different threads. In conjunction with the `perl_clone()` API call, which can be used to selectively duplicate the state of any given interpreter, it is possible to compile a piece of code once in an interpreter, clone that interpreter one or more times, and run all the resulting interpreters in distinct threads.

On the Windows platform, this feature is used to emulate `fork()` at the interpreter level. See *perlfork* for details about that.

This feature is still in evolution. It is eventually meant to be used to selectively clone a subroutine and data reachable from that subroutine in a separate interpreter and run the cloned subroutine in a separate thread. Since there is no shared data between the interpreters, little or no locking will be needed (unless parts of the symbol table are explicitly shared). This is obviously intended to be an easy–to–use replacement for the existing threads support.

Support for cloning interpreters and interpreter concurrency can be enabled using the –Dusethreads Configure option (see win32/Makefile for how to enable it on Windows.) The resulting perl executable will be functionally identical to one that was built with –Dmultiplicity, but the `perl_clone()` API call will only be available in the former.

–Dusethreads enables the cpp macro USE_ITHREADS by default, which in turn enables Perl source code changes that provide a clear separation between the op tree and the data it operates with. The former is immutable, and can therefore be shared between an interpreter and all of its clones, while the latter is considered local to each interpreter, and is therefore copied for each clone.

Note that building Perl with the –Dusemultiplicity Configure option is adequate if you wish to run multiple **independent** interpreters concurrently in different threads. –Dusethreads only provides the additional functionality of the `perl_clone()` API call and other support for running **cloned** interpreters concurrently.

```
NOTE: This is an experimental feature.  Implementation details are
subject to change.
```

Lexically scoped warning categories

You can now control the granularity of warnings emitted by perl at a finer level using the `use warnings` pragma. *warnings* and *perllexwarn* have copious documentation on this feature.

Unicode and UTF–8 support

Perl now uses UTF–8 as its internal representation for character strings. The `utf8` and `bytes` pragmas are used to control this support in the current lexical scope. See *perlunicode*, *utf8* and *bytes* for more information.

This feature is expected to evolve quickly to support some form of I/O disciplines that can be used to specify the kind of input and output data (bytes or characters). Until that happens, additional modules from CPAN will be needed to complete the toolkit for dealing with Unicode.

```
NOTE: This should be considered an experimental feature.  Implementation
details are subject to change.
```

Support for interpolating named characters

The new \N escape interpolates named characters within strings. For example, "Hi! \N{WHITE SMILING FACE}" evaluates to a string with a unicode smiley face at the end.

"our" declarations

An "our" declaration introduces a value that can be best understood as a lexically scoped symbolic alias to a global variable in the package that was current where the variable was declared. This is mostly useful as an alternative to the vars pragma, but also provides the opportunity to introduce typing and other attributes for such variables. See *our*.

Support for strings represented as a vector of ordinals

Literals of the form v1.2.3.4 are now parsed as a string composed of characters with the specified ordinals. This is an alternative, more readable way to construct (possibly unicode) strings instead of interpolating characters, as in "\x{1}\x{2}\x{3}\x{4}". The leading v may be omitted if there are more than two ordinals, so 1.2.3 is parsed the same as v1.2.3.

Strings written in this form are also useful to represent version "numbers". It is easy to compare such version "numbers" (which are really just plain strings) using any of the usual string comparison operators eq, ne, lt, gt, etc., or perform bitwise string operations on them using |, &, etc.

In conjunction with the new $^V magic variable (which contains the perl version as a string), such literals can be used as a readable way to check if you're running a particular version of Perl:

```
# this will parse in older versions of Perl also
if ($^V and $^V gt v5.6.0) {
    # new features supported
}
```

require and use also have some special magic to support such literals. They will be interpreted as a version rather than as a module name:

```
require v5.6.0;             # croak if $^V lt v5.6.0
use v5.6.0;                 # same, but croaks at compile-time
```

Alternatively, the v may be omitted if there is more than one dot:

```
require 5.6.0;
use 5.6.0;
```

Also, sprintf and printf support the Perl-specific format flag %v to print ordinals of characters in arbitrary strings:

```
printf "v%vd", $^V;         # prints current version, such as "v5.5.650"
printf "%*vX", ":", $addr;  # formats IPv6 address
printf "%*vb", " ", $bits;  # displays bitstring
```

See *Scalar value constructors in perldata* for additional information.

Improved Perl version numbering system

Beginning with Perl version 5.6.0, the version number convention has been changed to a "dotted integer" scheme that is more commonly found in open source projects.

Maintenance versions of v5.6.0 will be released as v5.6.1, v5.6.2 etc. The next development series following v5.6.0 will be numbered v5.7.x, beginning with v5.7.0, and the next major production release following v5.6.0 will be v5.8.0.

The English module now sets $PERL_VERSION to $^V (a string value) rather than $] (a numeric value). (This is a potential incompatibility. Send us a report via perlbug if you are affected by this.)

The v1.2.3 syntax is also now legal in Perl. See *Support for strings represented as a vector of ordinals* for more on that.

To cope with the new versioning system's use of at least three significant digits for each version component, the method used for incrementing the subversion number has also changed slightly. We assume that versions older than v5.6.0 have been incrementing the subversion component in multiples of 10. Versions after v5.6.0 will increment them by 1. Thus, using the new notation, 5.005_03 is the "same" as v5.5.30, and the first maintenance version following v5.6.0 will be v5.6.1 (which should be read as being equivalent to a floating point value of 5.006_001 in the older format, stored in `$]`).

New syntax for declaring subroutine attributes

Formerly, if you wanted to mark a subroutine as being a method call or as requiring an automatic `lock()` when it is entered, you had to declare that with a `use attrs` pragma in the body of the subroutine. That can now be accomplished with declaration syntax, like this:

```
sub mymethod : locked method ;
...
sub mymethod : locked method {
    ...
}

sub othermethod :locked :method ;
...
sub othermethod :locked :method {
    ...
}
```

(Note how only the first `:` is mandatory, and whitespace surrounding the `:` is optional.)

AutoSplit.pm and ***SelfLoader.pm*** have been updated to keep the attributes with the stubs they provide. See *attributes*.

File and directory handles can be autovivified

Similar to how constructs such as `< $x-[0]` autovivify a reference, handle constructors (`open()`, `opendir()`, `pipe()`, `socketpair()`, `sysopen()`, `socket()`, and `accept()`) now autovivify a file or directory handle if the handle passed to them is an uninitialized scalar variable. This allows the constructs such as `open(my $fh, ...)` and `open(local $fh,...)` to be used to create filehandles that will conveniently be closed automatically when the scope ends, provided there are no other references to them. This largely eliminates the need for typeglobs when opening filehandles that must be passed around, as in the following example:

```
sub myopen {
    open my $fh, "@_"
         or die "Can't open '@_': $!";
    return $fh;
}

{
    my $f = myopen("</etc/motd");
    print <$f>;
    # $f implicitly closed here
}
```

`open()` with more than two arguments

If `open()` is passed three arguments instead of two, the second argument is used as the mode and the third argument is taken to be the file name. This is primarily useful for protecting against unintended magic behavior of the traditional two-argument form. See *open*.

64-bit support

Any platform that has 64-bit integers either

```
    (1) natively as longs or ints
```

```
        (2) via special compiler flags
        (3) using long long or int64_t
```

is able to use "quads" (64–bit integers) as follows:

- constants (decimal, hexadecimal, octal, binary) in the code
- arguments to `oct()` and `hex()`
- arguments to `print()`, `printf()` and `sprintf()` (flag prefixes ll, L, q)
- printed as such
- `pack()` and `unpack()` "q" and "Q" formats
- in basic arithmetics: + – * / % (NOTE: operating close to the limits of the integer values may produce surprising results)
- in bit arithmetics: & | ^ ~ << (NOTE: these used to be forced to be 32 bits wide but now operate on the full native width.)
- `vec()`

Note that unless you have the case (a) you will have to configure and compile Perl using the –Duse64bitint Configure flag.

```
NOTE: The Configure flags -Duselonglong and -Duse64bits have been
deprecated.  Use -Duse64bitint instead.
```

There are actually two modes of 64–bitness: the first one is achieved using Configure –Duse64bitint and the second one using Configure –Duse64bitall. The difference is that the first one is minimal and the second one maximal. The first works in more places than the second.

The `use64bitint` does only as much as is required to get 64–bit integers into Perl (this may mean, for example, using "long longs") while your memory may still be limited to 2 gigabytes (because your pointers could still be 32–bit). Note that the name `64bitint` does not imply that your C compiler will be using 64–bit `int`s (it might, but it doesn't have to): the `use64bitint` means that you will be able to have 64 bits wide scalar values.

The `use64bitall` goes all the way by attempting to switch also integers (if it can), longs (and pointers) to being 64–bit. This may create an even more binary incompatible Perl than –Duse64bitint: the resulting executable may not run at all in a 32–bit box, or you may have to reboot/reconfigure/rebuild your operating system to be 64–bit aware.

Natively 64–bit systems like Alpha and Cray need neither –Duse64bitint nor –Duse64bitall.

Last but not least: note that due to Perl's habit of always using floating point numbers, the quads are still not true integers. When quads overflow their limits (0...18_446_744_073_709_551_615 unsigned, –9_223_372_036_854_775_808...9_223_372_036_854_775_807 signed), they are silently promoted to floating point numbers, after which they will start losing precision (in their lower digits).

```
NOTE: 64-bit support is still experimental on most platforms.
Existing support only covers the LP64 data model.  In particular, the
LLP64 data model is not yet supported.  64-bit libraries and system
APIs on many platforms have not stabilized--your mileage may vary.
```

Large file support

If you have filesystems that support "large files" (files larger than 2 gigabytes), you may now also be able to create and access them from Perl.

```
NOTE: The default action is to enable large file support, if
available on the platform.
```

If the large file support is on, and you have a Fcntl constant O_LARGEFILE, the O_LARGEFILE is

automatically added to the flags of `sysopen()`.

Beware that unless your filesystem also supports "sparse files" seeking to umpteen petabytes may be inadvisable.

Note that in addition to requiring a proper file system to do large files you may also need to adjust your per−process (or your per−system, or per−process−group, or per−user−group) maximum filesize limits before running Perl scripts that try to handle large files, especially if you intend to write such files.

Finally, in addition to your process/process group maximum filesize limits, you may have quota limits on your filesystems that stop you (your user id or your user group id) from using large files.

Adjusting your process/user/group/file system/operating system limits is outside the scope of Perl core language. For process limits, you may try increasing the limits using your shell's limits/limit/ulimit command before running Perl. The BSD::Resource extension (not included with the standard Perl distribution) may also be of use, it offers the getrlimit/setrlimit interface that can be used to adjust process resource usage limits, including the maximum filesize limit.

Long doubles

In some systems you may be able to use long doubles to enhance the range and precision of your double precision floating point numbers (that is, Perl's numbers). Use Configure −Duselongdouble to enable this support (if it is available).

"more bits"

You can "Configure −Dusemorebits" to turn on both the 64−bit support and the long double support.

Enhanced support for `sort()` subroutines

Perl subroutines with a prototype of `($$)`, and XSUBs in general, can now be used as sort subroutines. In either case, the two elements to be compared are passed as normal parameters in `@_`. See *sort*.

For unprototyped sort subroutines, the historical behavior of passing the elements to be compared as the global variables `$a` and `$b` remains unchanged.

`sort $coderef @foo` allowed

`sort()` did not accept a subroutine reference as the comparison function in earlier versions. This is now permitted.

File globbing implemented internally

Perl now uses the File::Glob implementation of the `glob()` operator automatically. This avoids using an external csh process and the problems associated with it.

```
NOTE: This is currently an experimental feature.  Interfaces and
implementation are subject to change.
```

Support for CHECK blocks

In addition to `BEGIN`, `INIT`, `END`, `DESTROY` and `AUTOLOAD`, subroutines named `CHECK` are now special. These are queued up during compilation and behave similar to END blocks, except they are called at the end of compilation rather than at the end of execution. They cannot be called directly.

POSIX character class syntax [: :] supported

For example to match alphabetic characters use /[[:alpha:]]/. See *perlre* for details.

Better pseudo−random number generator

In 5.005_0x and earlier, perl's `rand()` function used the C library rand(3) function. As of 5.005_52, Configure tests for `drand48()`, `random()`, and `rand()` (in that order) and picks the first one it finds.

These changes should result in better random numbers from `rand()`.

Improved `qw//` operator

The `qw//` operator is now evaluated at compile time into a true list instead of being replaced with a run time call to `split()`. This removes the confusing misbehaviour of `qw//` in scalar context, which had inherited that behaviour from `split()`.

Thus:

```
$foo = ($bar) = qw(a b c); print "$foo|$bar\n";
```

now correctly prints "3|a", instead of "2|a".

Better worst-case behavior of hashes

Small changes in the hashing algorithm have been implemented in order to improve the distribution of lower order bits in the hashed value. This is expected to yield better performance on keys that are repeated sequences.

`pack()` format 'Z' supported

The new format type 'Z' is useful for packing and unpacking null-terminated strings. See *pack in perlfunc*.

`pack()` format modifier '!' supported

The new format type modifier '!' is useful for packing and unpacking native shorts, ints, and longs. See *pack in perlfunc*.

`pack()` and `unpack()` support counted strings

The template character '/' can be used to specify a counted string type to be packed or unpacked. See *pack in perlfunc*.

Comments in `pack()` templates

The '#' character in a template introduces a comment up to end of the line. This facilitates documentation of `pack()` templates.

Weak references

In previous versions of Perl, you couldn't cache objects so as to allow them to be deleted if the last reference from outside the cache is deleted. The reference in the cache would hold a reference count on the object and the objects would never be destroyed.

Another familiar problem is with circular references. When an object references itself, its reference count would never go down to zero, and it would not get destroyed until the program is about to exit.

Weak references solve this by allowing you to "weaken" any reference, that is, make it not count towards the reference count. When the last non-weak reference to an object is deleted, the object is destroyed and all the weak references to the object are automatically undef-ed.

To use this feature, you need the WeakRef package from CPAN, which contains additional documentation.

```
NOTE: This is an experimental feature.  Details are subject to change.
```

Binary numbers supported

Binary numbers are now supported as literals, in s?printf formats, and `oct()`:

```
$answer = 0b101010;
printf "The answer is: %b\n", oct("0b101010");
```

Lvalue subroutines

Subroutines can now return modifiable lvalues. See *Lvalue subroutines in perlsub*.

```
NOTE: This is an experimental feature.  Details are subject to change.
```

Some arrows may be omitted in calls through references

Perl now allows the arrow to be omitted in many constructs involving subroutine calls through references. For example, `< $foo[10]->('foo')` may now be written `$foo[10]('foo')`. This is rather similar

to how the arrow may be omitted from `< $foo[10]->{'foo'}`. Note however, that the arrow is still required for `< foo(10)->('bar')`.

Boolean assignment operators are legal lvalues

Constructs such as `($a ||= 2) += 1` are now allowed.

`exists()` is supported on subroutine names

The `exists()` builtin now works on subroutine names. A subroutine is considered to exist if it has been declared (even if implicitly). See *exists* for examples.

`exists()` and `delete()` are supported on array elements

The `exists()` and `delete()` builtins now work on simple arrays as well. The behavior is similar to that on hash elements.

`exists()` can be used to check whether an array element has been initialized. This avoids autovivifying array elements that don't exist. If the array is tied, the `EXISTS()` method in the corresponding tied package will be invoked.

`delete()` may be used to remove an element from the array and return it. The array element at that position returns to its uninitialized state, so that testing for the same element with `exists()` will return false. If the element happens to be the one at the end, the size of the array also shrinks up to the highest element that tests true for `exists()`, or 0 if none such is found. If the array is tied, the `DELETE()` method in the corresponding tied package will be invoked.

See *exists* and *delete* for examples.

Pseudo-hashes work better

Dereferencing some types of reference values in a pseudo-hash, such as `< $ph->{foo}[1]`, was accidentally disallowed. This has been corrected.

When applied to a pseudo-hash element, `exists()` now reports whether the specified value exists, not merely if the key is valid.

`delete()` now works on pseudo-hashes. When given a pseudo-hash element or slice it deletes the values corresponding to the keys (but not the keys themselves). See *Pseudo-hashes: Using an array as a hash in perlref*.

Pseudo-hash slices with constant keys are now optimized to array lookups at compile-time.

List assignments to pseudo-hash slices are now supported.

The `fields` pragma now provides ways to create pseudo-hashes, via `fields::new()` and `fields::phash()`. See *fields*.

```
NOTE: The pseudo-hash data type continues to be experimental.
Limiting oneself to the interface elements provided by the
fields pragma will provide protection from any future changes.
```

Automatic flushing of output buffers

`fork()`, `exec()`, `system()`, qx//, and pipe `open()`s now flush buffers of all files opened for output when the operation was attempted. This mostly eliminates confusing buffering mishaps suffered by users unaware of how Perl internally handles I/O.

This is not supported on some platforms like Solaris where a suitably correct implementation of fflush(NULL) isn't available.

Better diagnostics on meaningless filehandle operations

Constructs such as `< open(<FH)` and `< close(<FH)` are compile time errors. Attempting to read from filehandles that were opened only for writing will now produce warnings (just as writing to read-only filehandles does).

Where possible, buffered data discarded from duped input filehandle

`< open(NEW, "<&OLD")` now attempts to discard any data that was previously read and buffered in `OLD` before duping the handle. On platforms where doing this is allowed, the next read operation on `NEW` will return the same data as the corresponding operation on `OLD`. Formerly, it would have returned the data from the start of the following disk block instead.

`eof()` has the same old magic as <

`eof()` would return true if no attempt to read from `< <` had yet been made. `eof()` has been changed to have a little magic of its own, it now opens the `< <` files.

`binmode()` can be used to set :crlf and :raw modes

`binmode()` now accepts a second argument that specifies a discipline for the handle in question. The two pseudo-disciplines ":raw" and ":crlf" are currently supported on DOS-derivative platforms. See *binmode in perlfunc* and *open*.

`-T` filetest recognizes UTF-8 encoded files as "text"

The algorithm used for the `-T` filetest has been enhanced to correctly identify UTF-8 content as "text".

`system()`, backticks and pipe open now reflect `exec()` failure

On Unix and similar platforms, `system()`, `qx()` and open(FOO, "cmd |") etc., are implemented via `fork()` and `exec()`. When the underlying `exec()` fails, earlier versions did not report the error properly, since the `exec()` happened to be in a different process.

The child process now communicates with the parent about the error in launching the external command, which allows these constructs to return with their usual error value and set `$!`.

Improved diagnostics

Line numbers are no longer suppressed (under most likely circumstances) during the global destruction phase.

Diagnostics emitted from code running in threads other than the main thread are now accompanied by the thread ID.

Embedded null characters in diagnostics now actually show up. They used to truncate the message in prior versions.

`$foo::a` and `$foo::b` are now exempt from "possible typo" warnings only if `sort()` is encountered in package `foo`.

Unrecognized alphabetic escapes encountered when parsing quote constructs now generate a warning, since they may take on new semantics in later versions of Perl.

Many diagnostics now report the internal operation in which the warning was provoked, like so:

```
Use of uninitialized value in concatenation (.) at (eval 1) line 1.
Use of uninitialized value in print at (eval 1) line 1.
```

Diagnostics that occur within eval may also report the file and line number where the eval is located, in addition to the eval sequence number and the line number within the evaluated text itself. For example:

```
Not enough arguments for scalar at (eval 4)[newlib/perl5db.pl:1411] line 2, at EO
```

Diagnostics follow STDERR

Diagnostic output now goes to whichever file the `STDERR` handle is pointing at, instead of always going to the underlying C runtime library's `stderr`.

More consistent close-on-exec behavior

On systems that support a close-on-exec flag on filehandles, the flag is now set for any handles created by `pipe()`, `socketpair()`, `socket()`, and `accept()`, if that is warranted by the value of `$^F` that may be in effect. Earlier versions neglected to set the flag for handles created with these operators. See *pipe*,

socketpair, *socket*, *accept*, and *$^F*.

`syswrite()` ease-of-use

The length argument of `syswrite()` has become optional.

Better syntax checks on parenthesized unary operators

Expressions such as:

```
print defined(&foo,&bar,&baz);
print uc("foo","bar","baz");
undef($foo,&bar);
```

used to be accidentally allowed in earlier versions, and produced unpredictable behaviour. Some produced ancillary warnings when used in this way; others silently did the wrong thing.

The parenthesized forms of most unary operators that expect a single argument now ensure that they are not called with more than one argument, making the cases shown above syntax errors. The usual behaviour of:

```
print defined &foo, &bar, &baz;
print uc "foo", "bar", "baz";
undef $foo, &bar;
```

remains unchanged. See *perlop*.

Bit operators support full native integer width

The bit operators (`& | ^ ~ << `) now operate on the full native integral width (the exact size of which is available in `$Config{ivsize}`). For example, if your platform is either natively 64-bit or if Perl has been configured to use 64-bit integers, these operations apply to 8 bytes (as opposed to 4 bytes on 32-bit platforms). For portability, be sure to mask off the excess bits in the result of unary `~`, e.g., `~$x & 0xffffffff`.

Improved security features

More potentially unsafe operations taint their results for improved security.

The `passwd` and `shell` fields returned by the `getpwent()`, `getpwnam()`, and `getpwuid()` are now tainted, because the user can affect their own encrypted password and login shell.

The variable modified by `shmread()`, and messages returned by `msgrcv()` (and its object-oriented interface IPC::SysV::Msg::rcv) are also tainted, because other untrusted processes can modify messages and shared memory segments for their own nefarious purposes.

More functional bareword prototype (*)

Bareword prototypes have been rationalized to enable them to be used to override builtins that accept barewords and interpret them in a special way, such as `require` or `do`.

Arguments prototyped as `*` will now be visible within the subroutine as either a simple scalar or as a reference to a typeglob. See *Prototypes*.

`require` and `do` may be overridden

`require` and `do 'file'` operations may be overridden locally by importing subroutines of the same name into the current package (or globally by importing them into the CORE::GLOBAL:: namespace). Overriding `require` will also affect `use`, provided the override is visible at compile-time. See *Overriding Built-in Functions in perlsub*.

`$^X` variables may now have names longer than one character

Formerly, `$^X` was synonymous with `${"\cX"}`, but `$^XY` was a syntax error. Now variable names that begin with a control character may be arbitrarily long. However, for compatibility reasons, these variables *must* be written with explicit braces, as `${^XY}` for example. `${^XYZ}` is synonymous with `${"\cXYZ"}`. Variable names with more than one control character, such as `${^XY^Z}`, are illegal.

The old syntax has not changed. As before, '^X' may be either a literal control-X character or the

two–character sequence ‘caret’ plus ‘X’. When braces are omitted, the variable name stops after the control character. Thus `"$^XYZ"` continues to be synonymous with `$^X . "YZ"` as before.

As before, lexical variables may not have names beginning with control characters. As before, variables whose names begin with a control character are always forced to be in package ‘main’. All such variables are reserved for future extensions, except those that begin with `^_`, which may be used by user programs and are guaranteed not to acquire special meaning in any future version of Perl.

New variable `$^C` reflects `-c` switch

`$^C` has a boolean value that reflects whether perl is being run in compile–only mode (i.e. via the `-c` switch). Since BEGIN blocks are executed under such conditions, this variable enables perl code to determine whether actions that make sense only during normal running are warranted. See *perlvar*.

New variable `$^V` contains Perl version as a string

`$^V` contains the Perl version number as a string composed of characters whose ordinals match the version numbers, i.e. v5.6.0. This may be used in string comparisons.

See `Support for strings represented as a vector of ordinals` for an example.

Optional Y2K warnings

If Perl is built with the cpp macro `PERL_Y2KWARN` defined, it emits optional warnings when concatenating the number 19 with another number.

This behavior must be specifically enabled when running Configure. See ***INSTALL*** and ***README.Y2K***.

Arrays now always interpolate into double–quoted strings

In double–quoted strings, arrays now interpolate, no matter what. The behavior in earlier versions of perl 5 was that arrays would interpolate into strings if the array had been mentioned before the string was compiled, and otherwise Perl would raise a fatal compile–time error. In versions 5.000 through 5.003, the error was

```
Literal @example now requires backslash
```

In versions 5.004_01 through 5.6.0, the error was

```
In string, @example now must be written as \@example
```

The idea here was to get people into the habit of writing `"fred\@example.com"` when they wanted a literal `@` sign, just as they have always written `"Give me back my \$5"` when they wanted a literal `$` sign.

Starting with 5.6.1, when Perl now sees an `@` sign in a double–quoted string, it *always* attempts to interpolate an array, regardless of whether or not the array has been used or declared already. The fatal error has been downgraded to an optional warning:

```
Possible unintended interpolation of @example in string
```

This warns you that `"fred@example.com"` is going to turn into `fred.com` if you don‘t backslash the `@`. See http://www.plover.com/~mjd/perl/at–error.html for more details about the history here.

Modules and Pragmata

Modules

attributes

While used internally by Perl as a pragma, this module also provides a way to fetch subroutine and variable attributes. See *attributes*.

B The Perl Compiler suite has been extensively reworked for this release. More of the standard Perl testsuite passes when run under the Compiler, but there is still a significant way to go to achieve production quality compiled executables.

```
NOTE: The Compiler suite remains highly experimental.  The
generated code may not be correct, even when it manages to execute
```

```
without errors.
```

Benchmark

Overall, Benchmark results exhibit lower average error and better timing accuracy.

You can now run tests for *n* seconds instead of guessing the right number of tests to run: e.g., timethese(−5, ...) will run each code for at least 5 CPU seconds. Zero as the "number of repetitions" means "for at least 3 CPU seconds". The output format has also changed. For example:

```
use Benchmark;$x=3;timethese(-5,{a=>sub{$x*$x},b=>sub{$x**2}})
```

will now output something like this:

```
Benchmark: running a, b, each for at least 5 CPU seconds...
         a:  5 wallclock secs ( 5.77 usr +  0.00 sys =  5.77 CPU) @ 200551.91/
         b:  4 wallclock secs ( 5.00 usr +  0.02 sys =  5.02 CPU) @ 159605.18/
```

New features: "each for at least N CPU seconds...", "wallclock secs", and the "@ operations/CPU second (n=operations)".

`timethese()` now returns a reference to a hash of Benchmark objects containing the test results, keyed on the names of the tests.

`timethis()` now returns the iterations field in the Benchmark result object instead of 0.

`timethese()`, `timethis()`, and the new `cmpthese()` (see below) can also take a format specifier of 'none' to suppress output.

A new function `countit()` is just like `timeit()` except that it takes a TIME instead of a COUNT.

A new function `cmpthese()` prints a chart comparing the results of each test returned from a `timethese()` call. For each possible pair of tests, the percentage speed difference (iters/sec or seconds/iter) is shown.

For other details, see *Benchmark*.

ByteLoader

The ByteLoader is a dedicated extension to generate and run Perl bytecode. See *ByteLoader*.

constant

References can now be used.

The new version also allows a leading underscore in constant names, but disallows a double leading underscore (as in "__LINE__"). Some other names are disallowed or warned against, including BEGIN, END, etc. Some names which were forced into main:: used to fail silently in some cases; now they're fatal (outside of main::) and an optional warning (inside of main::). The ability to detect whether a constant had been set with a given name has been added.

See *constant*.

charnames

This pragma implements the `\N` string escape. See *charnames*.

Data::Dumper

A `Maxdepth` setting can be specified to avoid venturing too deeply into deep data structures. See *Data::Dumper*.

The XSUB implementation of `Dump()` is now automatically called if the `Useqq` setting is not in use.

Dumping `qr//` objects works correctly.

DB DB is an experimental module that exposes a clean abstraction to Perl's debugging API.

DB_File

DB_File can now be built with Berkeley DB versions 1, 2 or 3. See ext/DB_File/Changes.

Devel::DProf

Devel::DProf, a Perl source code profiler has been added. See *Devel::DProf* and *dprofpp*.

Devel::Peek

The Devel::Peek module provides access to the internal representation of Perl variables and data. It is a data debugging tool for the XS programmer.

Dumpvalue

The Dumpvalue module provides screen dumps of Perl data.

DynaLoader

DynaLoader now supports a dl_unload_file() function on platforms that support unloading shared objects using dlclose().

Perl can also optionally arrange to unload all extension shared objects loaded by Perl. To enable this, build Perl with the Configure option -Accflags=-DDL_UNLOAD_ALL_AT_EXIT. (This maybe useful if you are using Apache with mod_perl.)

English

$PERL_VERSION now stands for $^V (a string value) rather than for $] (a numeric value).

Env Env now supports accessing environment variables like PATH as array variables.

Fcntl

More Fcntl constants added: F_SETLK64, F_SETLKW64, O_LARGEFILE for large file (more than 4GB) access (NOTE: the O_LARGEFILE is automatically added to sysopen() flags if large file support has been configured, as is the default), Free/Net/OpenBSD locking behaviour flags F_FLOCK, F_POSIX, Linux F_SHLCK, and O_ACCMODE: the combined mask of O_RDONLY, O_WRONLY, and O_RDWR. The seek()/sysseek() constants SEEK_SET, SEEK_CUR, and SEEK_END are available via the :seek tag. The chmod()/stat() S_IF* constants and S_IS* functions are available via the :mode tag.

File::Compare

A compare_text() function has been added, which allows custom comparison functions. See *File::Compare*.

File::Find

File::Find now works correctly when the wanted() function is either autoloaded or is a symbolic reference.

A bug that caused File::Find to lose track of the working directory when pruning top-level directories has been fixed.

File::Find now also supports several other options to control its behavior. It can follow symbolic links if the follow option is specified. Enabling the no_chdir option will make File::Find skip changing the current directory when walking directories. The untaint flag can be useful when running with taint checks enabled.

See *File::Find*.

File::Glob

This extension implements BSD-style file globbing. By default, it will also be used for the internal implementation of the glob() operator. See *File::Glob*.

File::Spec

New methods have been added to the File::Spec module: `devnull()` returns the name of the null device (/dev/null on Unix) and `tmpdir()` the name of the temp directory (normally /tmp on Unix). There are now also methods to convert between absolute and relative filenames: `abs2rel()` and `rel2abs()`. For compatibility with operating systems that specify volume names in file paths, the `splitpath()`, `splitdir()`, and `catdir()` methods have been added.

File::Spec::Functions

The new File::Spec::Functions modules provides a function interface to the File::Spec module. Allows shorthand

```
$fullname = catfile($dir1, $dir2, $file);
```

instead of

```
$fullname = File::Spec->catfile($dir1, $dir2, $file);
```

Getopt::Long

Getopt::Long licensing has changed to allow the Perl Artistic License as well as the GPL. It used to be GPL only, which got in the way of non–GPL applications that wanted to use Getopt::Long.

Getopt::Long encourages the use of Pod::Usage to produce help messages. For example:

```
use Getopt::Long;
use Pod::Usage;
my $man = 0;
my $help = 0;
GetOptions('help|?' => \$help, man => \$man) or pod2usage(2);
pod2usage(1) if $help;
pod2usage(-exitstatus => 0, -verbose => 2) if $man;

__END__

=head1 NAME

sample - Using GetOpt::Long and Pod::Usage

=head1 SYNOPSIS

sample [options] [file ...]

 Options:
   -help            brief help message
   -man             full documentation

=head1 OPTIONS

=over 8

=item B<-help>

Print a brief help message and exits.

=item B<-man>

Prints the manual page and exits.

=back

=head1 DESCRIPTION

B<This program> will read the given input file(s) and do something
useful with the contents thereof.
```

```
=cut
```

See *Pod::Usage* for details.

A bug that prevented the non-option call-back < from being specified as the first argument has been fixed.

To specify the characters < and as option starters, use <. Note, however, that changing option starters is strongly deprecated.

IO `write()` and `syswrite()` will now accept a single-argument form of the call, for consistency with Perl's `syswrite()`.

You can now create a TCP-based IO::Socket::INET without forcing a connect attempt. This allows you to configure its options (like making it non-blocking) and then call `connect()` manually.

A bug that prevented the `IO::Socket::protocol()` accessor from ever returning the correct value has been corrected.

IO::Socket::connect now uses non-blocking IO instead of `alarm()` to do connect timeouts.

IO::Socket::accept now uses `select()` instead of `alarm()` for doing timeouts.

IO::Socket::INET-new now sets `$!` correctly on failure. `$@` is still set for backwards compatibility.

JPL Java Perl Lingo is now distributed with Perl. See jpl/README for more information.

lib `use lib` now weeds out any trailing duplicate entries. `no lib` removes all named entries.

Math::BigInt

The bitwise operations `<< <<` , `<<` , `&`, `|`, and ~ are now supported on bigints.

Math::Complex

The accessor methods Re, Im, arg, abs, rho, and theta can now also act as mutators (accessor `$z-Re()`, mutator `$z-Re(3)`).

The class method `display_format` and the corresponding object method `display_format`, in addition to accepting just one argument, now can also accept a parameter hash. Recognized keys of a parameter hash are `"style"`, which corresponds to the old one parameter case, and two new parameters: `"format"`, which is a `printf()`-style format string (defaults usually to `"%.15g"`, you can revert to the default by setting the format string to `undef`) used for both parts of a complex number, and `"polar_pretty_print"` (defaults to true), which controls whether an attempt is made to try to recognize small multiples and rationals of pi (2pi, pi/2) at the argument (angle) of a polar complex number.

The potentially disruptive change is that in list context both methods now *return the parameter hash*, instead of only the value of the `"style"` parameter.

Math::Trig

A little bit of radial trigonometry (cylindrical and spherical), radial coordinate conversions, and the great circle distance were added.

Pod::Parser, Pod::InputObjects

Pod::Parser is a base class for parsing and selecting sections of pod documentation from an input stream. This module takes care of identifying pod paragraphs and commands in the input and hands off the parsed paragraphs and commands to user-defined methods which are free to interpret or translate them as they see fit.

Pod::InputObjects defines some input objects needed by Pod::Parser, and for advanced users of Pod::Parser that need more about a command besides its name and text.

As of release 5.6.0 of Perl, Pod::Parser is now the officially sanctioned "base parser code" recommended for use by all pod2xxx translators. Pod::Text (pod2text) and Pod::Man (pod2man) have

already been converted to use Pod::Parser and efforts to convert Pod::HTML (pod2html) are already underway. For any questions or comments about pod parsing and translating issues and utilities, please use the pod-people@perl.org mailing list.

For further information, please see *Pod::Parser* and *Pod::InputObjects*.

Pod::Checker, podchecker

This utility checks pod files for correct syntax, according to *perlpod*. Obvious errors are flagged as such, while warnings are printed for mistakes that can be handled gracefully. The checklist is not complete yet. See *Pod::Checker*.

Pod::ParseUtils, Pod::Find

These modules provide a set of gizmos that are useful mainly for pod translators.
Pod::Find|Pod::Find traverses directory structures and returns found pod files, along with their canonical names (like `File::Spec::Unix`). *Pod::ParseUtils|Pod::ParseUtils* contains **Pod::List** (useful for storing pod list information), **Pod::Hyperlink** (for parsing the contents of `L<>` sequences) and **Pod::Cache** (for caching information about pod files, e.g., link nodes).

Pod::Select, podselect

Pod::Select is a subclass of Pod::Parser which provides a function named `"podselect()"` to filter out user-specified sections of raw pod documentation from an input stream. podselect is a script that provides access to Pod::Select from other scripts to be used as a filter. See *Pod::Select*.

Pod::Usage, pod2usage

Pod::Usage provides the function `"pod2usage()"` to print usage messages for a Perl script based on its embedded pod documentation. The `pod2usage()` function is generally useful to all script authors since it lets them write and maintain a single source (the pods) for documentation, thus removing the need to create and maintain redundant usage message text consisting of information already in the pods.

There is also a pod2usage script which can be used from other kinds of scripts to print usage messages from pods (even for non-Perl scripts with pods embedded in comments).

For details and examples, please see *Pod::Usage*.

Pod::Text and Pod::Man

Pod::Text has been rewritten to use Pod::Parser. While `pod2text()` is still available for backwards compatibility, the module now has a new preferred interface. See *Pod::Text* for the details. The new Pod::Text module is easily subclassed for tweaks to the output, and two such subclasses (Pod::Text::Termcap for man-page-style bold and underlining using termcap information, and Pod::Text::Color for markup with ANSI color sequences) are now standard.

pod2man has been turned into a module, Pod::Man, which also uses Pod::Parser. In the process, several outstanding bugs related to quotes in section headers, quoting of code escapes, and nested lists have been fixed. pod2man is now a wrapper script around this module.

SDBM_File

An EXISTS method has been added to this module (and `sdbm_exists()` has been added to the underlying sdbm library), so one can now call exists on an SDBM_File tied hash and get the correct result, rather than a runtime error.

A bug that may have caused data loss when more than one disk block happens to be read from the database in a single `FETCH()` has been fixed.

Sys::Syslog

Sys::Syslog now uses XSUBs to access facilities from syslog.h so it no longer requires syslog.ph to exist.

Sys::Hostname

Sys::Hostname now uses XSUBs to call the C library's `gethostname()` or `uname()` if they exist.

Term::ANSIColor

Term::ANSIColor is a very simple module to provide easy and readable access to the ANSI color and highlighting escape sequences, supported by most ANSI terminal emulators. It is now included standard.

Time::Local

The `timelocal()` and `timegm()` functions used to silently return bogus results when the date fell outside the machine's integer range. They now consistently `croak()` if the date falls in an unsupported range.

Win32

The error return value in list context has been changed for all functions that return a list of values. Previously these functions returned a list with a single element `undef` if an error occurred. Now these functions return the empty list in these situations. This applies to the following functions:

```
Win32::FsType
Win32::GetOSVersion
```

The remaining functions are unchanged and continue to return `undef` on error even in list context.

The Win32::SetLastError(ERROR) function has been added as a complement to the `Win32::GetLastError()` function.

The new Win32::GetFullPathName(FILENAME) returns the full absolute pathname for FILENAME in scalar context. In list context it returns a two-element list containing the fully qualified directory name and the filename. See *Win32*.

XSLoader

The XSLoader extension is a simpler alternative to DynaLoader. See *XSLoader*.

DBM Filters

A new feature called "DBM Filters" has been added to all the DBM modules—DB_File, GDBM_File, NDBM_File, ODBM_File, and SDBM_File. DBM Filters add four new methods to each DBM module:

```
filter_store_key
filter_store_value
filter_fetch_key
filter_fetch_value
```

These can be used to filter key-value pairs before the pairs are written to the database or just after they are read from the database. See *perldbmfilter* for further information.

Pragmata

`use attrs` is now obsolete, and is only provided for backward-compatibility. It's been replaced by the `sub : attributes` syntax. See *Subroutine Attributes in perlsub* and *attributes*.

Lexical warnings pragma, `use warnings;`, to control optional warnings. See *perllexwarn*.

`use filetest` to control the behaviour of filetests (`-r -w` ...). Currently only one subpragma implemented, "use filetest 'access';", that uses access(2) or equivalent to check permissions instead of using stat(2) as usual. This matters in filesystems where there are ACLs (access control lists): the stat(2) might lie, but access(2) knows better.

The `open` pragma can be used to specify default disciplines for handle constructors (e.g. `open()`) and for qx//. The two pseudo-disciplines `:raw` and `:crlf` are currently supported on DOS-derivative platforms (i.e. where binmode is not a no-op). See also */"binmode() can be used to set :crlf and*

`:raw modes".`

Utility Changes

dprofpp

`dprofpp` is used to display profile data generated using `Devel::DProf`. See *dprofpp*.

find2perl

The `find2perl` utility now uses the enhanced features of the File::Find module. The –depth and –follow options are supported. Pod documentation is also included in the script.

h2xs

The `h2xs` tool can now work in conjunction with `C::Scan` (available from CPAN) to automatically parse real–life header files. The `–M`, `–a`, `–k`, and `–o` options are new.

perlcc

`perlcc` now supports the C and Bytecode backends. By default, it generates output from the simple C backend rather than the optimized C backend.

Support for non–Unix platforms has been improved.

perldoc

`perldoc` has been reworked to avoid possible security holes. It will not by default let itself be run as the superuser, but you may still use the **–U** switch to try to make it drop privileges first.

The Perl Debugger

Many bug fixes and enhancements were added to ***perl5db.pl***, the Perl debugger. The help documentation was rearranged. New commands include `< < ?` , `< ?` , and `< { ?` to list out current actions, `man` *`docpage`* to run your doc viewer on some perl docset, and support for quoted options. The help information was rearranged, and should be viewable once again if you're using **less** as your pager. A serious security hole was plugged—you should immediately remove all older versions of the Perl debugger as installed in previous releases, all the way back to perl3, from your system to avoid being bitten by this.

Improved Documentation

Many of the platform–specific README files are now part of the perl installation. See *perl* for the complete list.

perlapi.pod

The official list of public Perl API functions.

perlboot.pod

A tutorial for beginners on object–oriented Perl.

perlcompile.pod

An introduction to using the Perl Compiler suite.

perldbmfilter.pod

A howto document on using the DBM filter facility.

perldebug.pod

All material unrelated to running the Perl debugger, plus all low–level guts–like details that risked crushing the casual user of the debugger, have been relocated from the old manpage to the next entry below.

perldebguts.pod

This new manpage contains excessively low–level material not related to the Perl debugger, but slightly related to debugging Perl itself. It also contains some arcane internal details of how the debugging process works that may only be of interest to developers of Perl debuggers.

perlfork.pod

Notes on the `fork()` emulation currently available for the Windows platform.

perlfilter.pod

An introduction to writing Perl source filters.

perlhack.pod

Some guidelines for hacking the Perl source code.

perlintern.pod

A list of internal functions in the Perl source code. (List is currently empty.)

perllexwarn.pod

Introduction and reference information about lexically scoped warning categories.

perlnumber.pod

Detailed information about numbers as they are represented in Perl.

perlopentut.pod

A tutorial on using `open()` effectively.

perlreftut.pod

A tutorial that introduces the essentials of references.

perltootc.pod

A tutorial on managing class data for object modules.

perltodo.pod

Discussion of the most often wanted features that may someday be supported in Perl.

perlunicode.pod

An introduction to Unicode support features in Perl.

Performance enhancements

Simple `sort()` using { `$a <= $b` } and the like are optimized

Many common `sort()` operations using a simple inlined block are now optimized for faster performance.

Optimized assignments to lexical variables

Certain operations in the RHS of assignment statements have been optimized to directly set the lexical variable on the LHS, eliminating redundant copying overheads.

Faster subroutine calls

Minor changes in how subroutine calls are handled internally provide marginal improvements in performance.

`delete()`, `each()`, `values()` and hash iteration are faster

The hash values returned by `delete()`, `each()`, `values()` and hashes in a list context are the actual values in the hash, instead of copies. This results in significantly better performance, because it eliminates needless copying in most situations.

Installation and Configuration Improvements

–Dusethreads means something different

The –Dusethreads flag now enables the experimental interpreter–based thread support by default. To get the flavor of experimental threads that was in 5.005 instead, you need to run Configure with "–Dusethreads –Duse5005threads".

As of v5.6.0, interpreter–threads support is still lacking a way to create new threads from Perl (i.e., `use Thread;` will not work with interpreter threads). `use Thread;` continues to be available when you

specify the –Duse5005threads option to Configure, bugs and all.

```
NOTE: Support for threads continues to be an experimental feature.
Interfaces and implementation are subject to sudden and drastic changes.
```

New Configure flags

The following new flags may be enabled on the Configure command line by running Configure with `–Dflag`.

```
usemultiplicity
usethreads useithreads      (new interpreter threads: no Perl API yet)
usethreads use5005threads   (threads as they were in 5.005)

use64bitint                 (equal to now deprecated 'use64bits')
use64bitall

uselongdouble
usemorebits
uselargefiles
usesocks                    (only SOCKS v5 supported)
```

Threadedness and 64–bitness now more daring

The Configure options enabling the use of threads and the use of 64–bitness are now more daring in the sense that they no more have an explicit list of operating systems of known threads/64–bit capabilities. In other words: if your operating system has the necessary APIs and datatypes, you should be able just to go ahead and use them, for threads by Configure –Dusethreads, and for 64 bits either explicitly by Configure –Duse64bitint or implicitly if your system has 64–bit wide datatypes. See also *"64–bit support"*.

Long Doubles

Some platforms have "long doubles", floating point numbers of even larger range than ordinary "doubles". To enable using long doubles for Perl's scalars, use –Duselongdouble.

–Dusemorebits

You can enable both –Duse64bitint and –Duselongdouble with –Dusemorebits. See also *"64–bit support"*.

–Duselargefiles

Some platforms support system APIs that are capable of handling large files (typically, files larger than two gigabytes). Perl will try to use these APIs if you ask for –Duselargefiles.

See *"Large file support"* for more information.

installusrbinperl

You can use "Configure –Uinstallusrbinperl" which causes installperl to skip installing perl also as /usr/bin/perl. This is useful if you prefer not to modify /usr/bin for some reason or another but harmful because many scripts assume to find Perl in /usr/bin/perl.

SOCKS support

You can use "Configure –Dusesocks" which causes Perl to probe for the SOCKS proxy protocol library (v5, not v4). For more information on SOCKS, see:

```
http://www.socks.nec.com/
```

`-A` flag

You can "post–edit" the Configure variables using the Configure `-A` switch. The editing happens immediately after the platform specific hints files have been processed but before the actual configuration process starts. Run `Configure -h` to find out the full `-A` syntax.

Enhanced Installation Directories

The installation structure has been enriched to improve the support for maintaining multiple versions of perl, to provide locations for vendor–supplied modules, scripts, and manpages, and to ease maintenance of

locally−added modules, scripts, and manpages. See the section on Installation Directories in the INSTALL file for complete details. For most users building and installing from source, the defaults should be fine.

If you previously used `Configure -Dsitelib` or `-Dsitearch` to set special values for library directories, you might wish to consider using the new `-Dsiteprefix` setting instead. Also, if you wish to re−use a config.sh file from an earlier version of perl, you should be sure to check that Configure makes sensible choices for the new directories. See INSTALL for complete details.

Platform specific changes

Supported platforms

- The Mach CThreads (NEXTSTEP, OPENSTEP) are now supported by the Thread extension.
- GNU/Hurd is now supported.
- Rhapsody/Darwin is now supported.
- EPOC is now supported (on Psion 5).
- The cygwin port (formerly cygwin32) has been greatly improved.

DOS

- Perl now works with djgpp 2.02 (and 2.03 alpha).
- Environment variable names are not converted to uppercase any more.
- Incorrect exit codes from backticks have been fixed.
- This port continues to use its own builtin globbing (not File::Glob).

OS390 (OpenEdition MVS)

Support for this EBCDIC platform has not been renewed in this release. There are difficulties in reconciling Perl's standardization on UTF−8 as its internal representation for characters with the EBCDIC character set, because the two are incompatible.

It is unclear whether future versions will renew support for this platform, but the possibility exists.

VMS

Numerous revisions and extensions to configuration, build, testing, and installation process to accommodate core changes and VMS−specific options.

Expand %ENV−handling code to allow runtime mapping to logical names, CLI symbols, and CRTL environ array.

Extension of subprocess invocation code to accept filespecs as command "verbs".

Add to Perl command line processing the ability to use default file types and to recognize Unix−style `2>&1`.

Expansion of File::Spec::VMS routines, and integration into ExtUtils::MM_VMS.

Extension of ExtUtils::MM_VMS to handle complex extensions more flexibly.

Barewords at start of Unix−syntax paths may be treated as text rather than only as logical names.

Optional secure translation of several logical names used internally by Perl.

Miscellaneous bugfixing and porting of new core code to VMS.

Thanks are gladly extended to the many people who have contributed VMS patches, testing, and ideas.

Win32

Perl can now emulate `fork()` internally, using multiple interpreters running in different concurrent threads. This support must be enabled at build time. See *perlfork* for detailed information.

When given a pathname that consists only of a drivename, such as `A:`, `opendir()` and `stat()` now use the current working directory for the drive rather than the drive root.

The builtin XSUB functions in the Win32:: namespace are documented. See *Win32*.

`$^X` now contains the full path name of the running executable.

A `Win32::GetLongPathName()` function is provided to complement `Win32::GetFullPathName()` and `Win32::GetShortPathName()`. See *Win32*.

`POSIX::uname()` is supported.

system(1,...) now returns true process IDs rather than process handles. `kill()` accepts any real process id, rather than strictly return values from system(1,...).

For better compatibility with Unix, `kill(0, $pid)` can now be used to test whether a process exists.

The `Shell` module is supported.

Better support for building Perl under command.com in Windows 95 has been added.

Scripts are read in binary mode by default to allow ByteLoader (and the filter mechanism in general) to work properly. For compatibility, the DATA filehandle will be set to text mode if a carriage return is detected at the end of the line containing the __END__ or __DATA__ token; if not, the DATA filehandle will be left open in binary mode. Earlier versions always opened the DATA filehandle in text mode.

The `glob()` operator is implemented via the `File::Glob` extension, which supports glob syntax of the C shell. This increases the flexibility of the `glob()` operator, but there may be compatibility issues for programs that relied on the older globbing syntax. If you want to preserve compatibility with the older syntax, you might want to run perl with `-MFile::DosGlob`. For details and compatibility information, see *File::Glob*.

Significant bug fixes

<HANDLE on empty files

With `$/` set to `undef`, "slurping" an empty file returns a string of zero length (instead of `undef`, as it used to) the first time the HANDLE is read after `$/` is set to `undef`. Further reads yield `undef`.

This means that the following will append "foo" to an empty file (it used to do nothing):

```
perl -0777 -pi -e 's/^/foo/' empty_file
```

The behaviour of:

```
perl -pi -e 's/^/foo/' empty_file
```

is unchanged (it continues to leave the file empty).

`eval '...'` improvements

Line numbers (as reflected by `caller()` and most diagnostics) within `eval '...'` were often incorrect where here documents were involved. This has been corrected.

Lexical lookups for variables appearing in `eval '...'` within functions that were themselves called within an `eval '...'` were searching the wrong place for lexicals. The lexical search now correctly ends at the subroutine's block boundary.

The use of `return` within `eval {...}` caused `$@` not to be reset correctly when no exception occurred within the eval. This has been fixed.

Parsing of here documents used to be flawed when they appeared as the replacement expression in `eval 's/.../.../e'`. This has been fixed.

All compilation errors are true errors

Some "errors" encountered at compile time were by necessity generated as warnings followed by eventual termination of the program. This enabled more such errors to be reported in a single run, rather than causing

a hard stop at the first error that was encountered.

The mechanism for reporting such errors has been reimplemented to queue compile–time errors and report them at the end of the compilation as true errors rather than as warnings. This fixes cases where error messages leaked through in the form of warnings when code was compiled at run time using `eval STRING`, and also allows such errors to be reliably trapped using `eval "..."`.

Implicitly closed filehandles are safer

Sometimes implicitly closed filehandles (as when they are localized, and Perl automatically closes them on exiting the scope) could inadvertently set `$?` or `$!`. This has been corrected.

Behavior of list slices is more consistent

When taking a slice of a literal list (as opposed to a slice of an array or hash), Perl used to return an empty list if the result happened to be composed of all undef values.

The new behavior is to produce an empty list if (and only if) the original list was empty. Consider the following example:

```
@a = (1,undef,undef,2)[2,1,2];
```

The old behavior would have resulted in @a having no elements. The new behavior ensures it has three undefined elements.

Note in particular that the behavior of slices of the following cases remains unchanged:

```
@a = ()[1,2];
@a = (getpwent)[7,0];
@a = (anything_returning_empty_list())[2,1,2];
@a = @b[2,1,2];
@a = @c{'a','b','c'};
```

See *perldata*.

`(\$)` prototype and `$foo{a}`

A scalar reference prototype now correctly allows a hash or array element in that slot.

`goto &sub` and AUTOLOAD

The `goto &sub` construct works correctly when `&sub` happens to be autoloaded.

`-bareword` allowed under `use integer`

The autoquoting of barewords preceded by – did not work in prior versions when the `integer` pragma was enabled. This has been fixed.

Failures in `DESTROY()`

When code in a destructor threw an exception, it went unnoticed in earlier versions of Perl, unless someone happened to be looking in `$@` just after the point the destructor happened to run. Such failures are now visible as warnings when warnings are enabled.

Locale bugs fixed

`printf()` and `sprintf()` previously reset the numeric locale back to the default "C" locale. This has been fixed.

Numbers formatted according to the local numeric locale (such as using a decimal comma instead of a decimal dot) caused "isn't numeric" warnings, even while the operations accessing those numbers produced correct results. These warnings have been discontinued.

Memory leaks

The `eval 'return sub {...}'` construct could sometimes leak memory. This has been fixed.

Operations that aren't filehandle constructors used to leak memory when used on invalid filehandles. This has been fixed.

Constructs that modified `@_` could fail to deallocate values in `@_` and thus leak memory. This has been corrected.

Spurious subroutine stubs after failed subroutine calls

Perl could sometimes create empty subroutine stubs when a subroutine was not found in the package. Such cases stopped later method lookups from progressing into base packages. This has been corrected.

Taint failures under `-U`

When running in unsafe mode, taint violations could sometimes cause silent failures. This has been fixed.

END blocks and the `-c` switch

Prior versions used to run BEGIN **and** END blocks when Perl was run in compile–only mode. Since this is typically not the expected behavior, END blocks are not executed anymore when the `-c` switch is used, or if compilation fails.

See for how to run things when the compile phase ends.

Potential to leak DATA filehandles

Using the `__DATA__` token creates an implicit filehandle to the file that contains the token. It is the program's responsibility to close it when it is done reading from it.

This caveat is now better explained in the documentation. See *perldata*.

New or Changed Diagnostics

"%s" variable %s masks earlier declaration in same %s

(W misc) A "my" or "our" variable has been redeclared in the current scope or statement, effectively eliminating all access to the previous instance. This is almost always a typographical error. Note that the earlier variable will still exist until the end of the scope or until all closure referents to it are destroyed.

"my sub" not yet implemented

(F) Lexically scoped subroutines are not yet implemented. Don't try that yet.

"our" variable %s redeclared

(W misc) You seem to have already declared the same global once before in the current lexical scope.

'!' allowed only after types %s

(F) The '!' is allowed in `pack()` and `unpack()` only after certain types. See *pack*.

/ cannot take a count

(F) You had an unpack template indicating a counted–length string, but you have also specified an explicit size for the string. See *pack*.

/ must be followed by a, A or Z

(F) You had an unpack template indicating a counted–length string, which must be followed by one of the letters a, A or Z to indicate what sort of string is to be unpacked. See *pack*.

/ must be followed by a*, A* or Z*

(F) You had a pack template indicating a counted–length string, Currently the only things that can have their length counted are a*, A* or Z*. See *pack*.

/ must follow a numeric type

(F) You had an unpack template that contained a '#', but this did not follow some numeric unpack specification. See *pack*.

/%s/: Unrecognized escape \\%c passed through

(W regexp) You used a backslash–character combination which is not recognized by Perl. This combination appears in an interpolated variable or a `'`–delimited regular expression. The character was understood literally.

/%s/: Unrecognized escape \\%c in character class passed through

(W regexp) You used a backslash–character combination which is not recognized by Perl inside character classes. The character was understood literally.

/%s/ should probably be written as "%s"

(W syntax) You have used a pattern where Perl expected to find a string, as in the first argument to `join`. Perl will treat the true or false result of matching the pattern against `$_` as the string, which is probably not what you had in mind.

`%s()` called too early to check prototype

(W prototype) You've called a function that has a prototype before the parser saw a definition or declaration for it, and Perl could not check that the call conforms to the prototype. You need to either add an early prototype declaration for the subroutine in question, or move the subroutine definition ahead of the call to get proper prototype checking. Alternatively, if you are certain that you're calling the function correctly, you may put an ampersand before the name to avoid the warning. See *perlsub*.

%s argument is not a HASH or ARRAY element

(F) The argument to `exists()` must be a hash or array element, such as:

```
$foo{$bar}
$ref->{"susie"}[12]
```

%s argument is not a HASH or ARRAY element or slice

(F) The argument to `delete()` must be either a hash or array element, such as:

```
$foo{$bar}
$ref->{"susie"}[12]
```

or a hash or array slice, such as:

```
@foo[$bar, $baz, $xyzzy]
@{$ref->[12]}{"susie", "queue"}
```

%s argument is not a subroutine name

(F) The argument to `exists()` for `exists &sub` must be a subroutine name, and not a subroutine call. `exists &sub()` will generate this error.

%s package attribute may clash with future reserved word: %s

(W reserved) A lowercase attribute name was used that had a package–specific handler. That name might have a meaning to Perl itself some day, even though it doesn't yet. Perhaps you should use a mixed–case attribute name, instead. See *attributes*.

(in cleanup) %s

(W misc) This prefix usually indicates that a `DESTROY()` method raised the indicated exception. Since destructors are usually called by the system at arbitrary points during execution, and often a vast number of times, the warning is issued only once for any number of failures that would otherwise result in the same message being repeated.

Failure of user callbacks dispatched using the `G_KEEPERR` flag could also result in this warning. See *G_KEEPERR*.

< should be quotes

(F) You wrote `< require <file` when you should have written `require 'file'`.

Attempt to join self

(F) You tried to join a thread from within itself, which is an impossible task. You may be joining the wrong thread, or you may need to move the `join()` to some other thread.

Bad evalled substitution pattern

(F) You've used the /e switch to evaluate the replacement for a substitution, but perl found a syntax error in the code to evaluate, most likely an unexpected right brace '}'.

Bad `realloc()` ignored

(S) An internal routine called `realloc()` on something that had never been `malloc()`ed in the first place. Mandatory, but can be disabled by setting environment variable `PERL_BADFREE` to 1.

Bareword found in conditional

(W bareword) The compiler found a bareword where it expected a conditional, which often indicates that an || or && was parsed as part of the last argument of the previous construct, for example:

```
open FOO || die;
```

It may also indicate a misspelled constant that has been interpreted as a bareword:

```
use constant TYPO => 1;
if (TYOP) { print "foo" }
```

The `strict` pragma is useful in avoiding such errors.

Binary number 0b11111111111111111111111111111111 non–portable

(W portable) The binary number you specified is larger than 2**32–1 (4294967295) and therefore non–portable between systems. See *perlport* for more on portability concerns.

Bit vector size 32 non–portable

(W portable) Using bit vector sizes larger than 32 is non–portable.

Buffer overflow in prime_env_iter: %s

(W internal) A warning peculiar to VMS. While Perl was preparing to iterate over %ENV, it encountered a logical name or symbol definition which was too long, so it was truncated to the string shown.

Can't check filesystem of script "%s"

(P) For some reason you can't check the filesystem of the script for nosuid.

Can't declare class for non–scalar %s in "%s"

(S) Currently, only scalar variables can declared with a specific class qualifier in a "my" or "our" declaration. The semantics may be extended for other types of variables in future.

Can't declare %s in "%s"

(F) Only scalar, array, and hash variables may be declared as "my" or "our" variables. They must have ordinary identifiers as names.

Can't ignore signal CHLD, forcing to default

(W signal) Perl has detected that it is being run with the SIGCHLD signal (sometimes known as SIGCLD) disabled. Since disabling this signal will interfere with proper determination of exit status of child processes, Perl has reset the signal to its default value. This situation typically indicates that the parent program under which Perl may be running (e.g., cron) is being very careless.

Can't modify non–lvalue subroutine call

(F) Subroutines meant to be used in lvalue context should be declared as such, see *Lvalue subroutines in perlsub*.

Can't read CRTL environ

(S) A warning peculiar to VMS. Perl tried to read an element of %ENV from the CRTL's internal environment array and discovered the array was missing. You need to figure out where your CRTL misplaced its environ or define ***PERL_ENV_TABLES*** (see *perlvms*) so that environ is not searched.

Can't remove %s: %s, skipping file

(S) You requested an inplace edit without creating a backup file. Perl was unable to remove the original file to replace it with the modified file. The file was left unmodified.

Can't return %s from lvalue subroutine

(F) Perl detected an attempt to return illegal lvalues (such as temporary or readonly values) from a subroutine used as an lvalue. This is not allowed.

Can't weaken a nonreference

(F) You attempted to weaken something that was not a reference. Only references can be weakened.

Character class [:%s:] unknown

(F) The class in the character class [: :] syntax is unknown. See *perlre*.

Character class syntax [%s] belongs inside character classes

(W unsafe) The character class constructs [: :], [= =], and [. .] go *inside* character classes, the [] are part of the construct, for example: /[012[:alpha:]345]/. Note that [= =] and [. .] are not currently implemented; they are simply placeholders for future extensions.

Constant is not %s reference

(F) A constant value (perhaps declared using the `use constant` pragma) is being dereferenced, but it amounts to the wrong type of reference. The message indicates the type of reference that was expected. This usually indicates a syntax error in dereferencing the constant value. See *Constant Functions in perlsub* and *constant*.

constant(%s): %s

(F) The parser found inconsistencies either while attempting to define an overloaded constant, or when trying to find the character name specified in the `\N{...}` escape. Perhaps you forgot to load the corresponding `overload` or `charnames` pragma? See *charnames* and *overload*.

CORE::%s is not a keyword

(F) The CORE:: namespace is reserved for Perl keywords.

defined(@array) is deprecated

(D) `defined()` is not usually useful on arrays because it checks for an undefined *scalar* value. If you want to see if the array is empty, just use `if (@array) { # not empty }` for example.

defined(%hash) is deprecated

(D) `defined()` is not usually useful on hashes because it checks for an undefined *scalar* value. If you want to see if the hash is empty, just use `if (%hash) { # not empty }` for example.

Did not produce a valid header

See Server error.

(Did you mean "local" instead of "our"?)

(W misc) Remember that "our" does not localize the declared global variable. You have declared it again in the same lexical scope, which seems superfluous.

Document contains no data

See Server error.

entering effective %s failed

(F) While under the `use filetest` pragma, switching the real and effective uids or gids failed.

false [] range "%s" in regexp

(W regexp) A character class range must start and end at a literal character, not another character class like `\d` or `[:alpha:]`. The "-" in your false range is interpreted as a literal "-". Consider quoting the "-", "\-". See *perlre*.

Filehandle %s opened only for output

(W io) You tried to read from a filehandle opened only for writing. If you intended it to be a read/write filehandle, you needed to open it with "+<" or "+" or "+" instead of with "<" or nothing. If you intended only to read from the file, use "<". See *open*.

`flock()` on closed filehandle %s

(W closed) The filehandle you're attempting to `flock()` got itself closed some time before now. Check your logic flow. `flock()` operates on filehandles. Are you attempting to call `flock()` on a dirhandle by the same name?

Global symbol "%s" requires explicit package name

(F) You've said "use strict vars", which indicates that all variables must either be lexically scoped (using "my"), declared beforehand using "our", or explicitly qualified to say which package the global variable is in (using "::").

Hexadecimal number 0xffffffff non−portable

(W portable) The hexadecimal number you specified is larger than 2**32−1 (4294967295) and therefore non−portable between systems. See *perlport* for more on portability concerns.

Ill−formed CRTL environ value "%s"

(W internal) A warning peculiar to VMS. Perl tried to read the CRTL's internal environ array, and encountered an element without the = delimiter used to separate keys from values. The element is ignored.

Ill−formed message in prime_env_iter: |%s|

(W internal) A warning peculiar to VMS. Perl tried to read a logical name or CLI symbol definition when preparing to iterate over %ENV, and didn't see the expected delimiter between key and value, so the line was ignored.

Illegal binary digit %s

(F) You used a digit other than 0 or 1 in a binary number.

Illegal binary digit %s ignored

(W digit) You may have tried to use a digit other than 0 or 1 in a binary number. Interpretation of the binary number stopped before the offending digit.

Illegal number of bits in vec

(F) The number of bits in `vec()` (the third argument) must be a power of two from 1 to 32 (or 64, if your platform supports that).

Integer overflow in %s number

(W overflow) The hexadecimal, octal or binary number you have specified either as a literal or as an argument to `hex()` or `oct()` is too big for your architecture, and has been converted to a floating point number. On a 32−bit architecture the largest hexadecimal, octal or binary number representable without overflow is 0xFFFFFFFF, 037777777777, or 0b11111111111111111111111111111111 respectively. Note that Perl transparently promotes all numbers to a floating point representation internally—subject to loss of precision errors in subsequent operations.

Invalid %s attribute: %s

The indicated attribute for a subroutine or variable was not recognized by Perl or by a user−supplied handler. See *attributes*.

Invalid %s attributes: %s

The indicated attributes for a subroutine or variable were not recognized by Perl or by a user−supplied handler. See *attributes*.

invalid [] range "%s" in regexp

The offending range is now explicitly displayed.

Invalid separator character %s in attribute list

(F) Something other than a colon or whitespace was seen between the elements of an attribute list. If the previous attribute had a parenthesised parameter list, perhaps that list was terminated too soon. See *attributes*.

Invalid separator character %s in subroutine attribute list

(F) Something other than a colon or whitespace was seen between the elements of a subroutine attribute list. If the previous attribute had a parenthesised parameter list, perhaps that list was terminated too soon.

leaving effective %s failed

(F) While under the `use filetest` pragma, switching the real and effective uids or gids failed.

Lvalue subs returning %s not implemented yet

(F) Due to limitations in the current implementation, array and hash values cannot be returned in subroutines used in lvalue context. See *Lvalue subroutines in perlsub*.

Method %s not permitted

See Server error.

Missing %sbrace%s on \N{}

(F) Wrong syntax of character name literal `\N{charname}` within double−quotish context.

Missing command in piped open

(W pipe) You used the `open(FH, "| command")` or `open(FH, "command |")` construction, but the command was missing or blank.

Missing name in "my sub"

(F) The reserved syntax for lexically scoped subroutines requires that they have a name with which they can be found.

No %s specified for −%c

(F) The indicated command line switch needs a mandatory argument, but you haven't specified one.

No package name allowed for variable %s in "our"

(F) Fully qualified variable names are not allowed in "our" declarations, because that doesn't make much sense under existing semantics. Such syntax is reserved for future extensions.

No space allowed after −%c

(F) The argument to the indicated command line switch must follow immediately after the switch, without intervening spaces.

no UTC offset information; assuming local time is UTC

(S) A warning peculiar to VMS. Perl was unable to find the local timezone offset, so it's assuming that local system time is equivalent to UTC. If it's not, define the logical name ***SYS$TIMEZONE_DIFFERENTIAL*** to translate to the number of seconds which need to be added to UTC to get local time.

Octal number 037777777777 non−portable

(W portable) The octal number you specified is larger than 2**32−1 (4294967295) and therefore non−portable between systems. See *perlport* for more on portability concerns.

See also *perlport* for writing portable code.

panic: del_backref

(P) Failed an internal consistency check while trying to reset a weak reference.

panic: kid popen errno read

(F) forked child returned an incomprehensible message about its errno.

panic: magic_killbackrefs

(P) Failed an internal consistency check while trying to reset all weak references to an object.

Parentheses missing around "%s" list

(W parenthesis) You said something like

```
my $foo, $bar = @_;
```

when you meant

```
my ($foo, $bar) = @_;
```

Remember that "my", "our", and "local" bind tighter than comma.

Possible unintended interpolation of %s in string

(W ambiguous) It used to be that Perl would try to guess whether you wanted an array interpolated or a literal @. It no longer does this; arrays are now *always* interpolated into strings. This means that if you try something like:

```
print "fred@example.com";
```

and the array `@example` doesn't exist, Perl is going to print `fred.com`, which is probably not what you wanted. To get a literal `@` sign in a string, put a backslash before it, just as you would to get a literal `$` sign.

Possible Y2K bug: %s

(W y2k) You are concatenating the number 19 with another number, which could be a potential Year 2000 problem.

pragma "attrs" is deprecated, use "sub NAME : ATTRS" instead

(W deprecated) You have written something like this:

```
sub doit
{
    use attrs qw(locked);
}
```

You should use the new declaration syntax instead.

```
sub doit : locked
{
    ...
```

The `use attrs` pragma is now obsolete, and is only provided for backward–compatibility. See *Subroutine Attributes in perlsub*.

Premature end of script headers

See Server error.

Repeat count in pack overflows

(F) You can't specify a repeat count so large that it overflows your signed integers. See *pack*.

Repeat count in unpack overflows

(F) You can't specify a repeat count so large that it overflows your signed integers. See *unpack*.

`realloc()` of freed memory ignored

(S) An internal routine called `realloc()` on something that had already been freed.

Reference is already weak

(W misc) You have attempted to weaken a reference that is already weak. Doing so has no effect.

setpgrp can't take arguments

(F) Your system has the `setpgrp()` from BSD 4.2, which takes no arguments, unlike POSIX `setpgid()`, which takes a process ID and process group ID.

Strange *+?{} on zero-length expression

(W regexp) You applied a regular expression quantifier in a place where it makes no sense, such as on a zero-width assertion. Try putting the quantifier inside the assertion instead. For example, the way to match "abc" provided that it is followed by three repetitions of "xyz" is `/abc(?=(?:xyz){3})/`, not `/abc(?=xyz){3}/`.

switching effective %s is not implemented

(F) While under the `use filetest` pragma, we cannot switch the real and effective uids or gids.

This Perl can't reset CRTL environ elements (%s)
This Perl can't set CRTL environ elements (%s=%s)

(W internal) Warnings peculiar to VMS. You tried to change or delete an element of the CRTL's internal environ array, but your copy of Perl wasn't built with a CRTL that contained the `setenv()` function. You'll need to rebuild Perl with a CRTL that does, or redefine ***PERL_ENV_TABLES*** (see *perlvms*) so that the environ array isn't the target of the change to %ENV which produced the warning.

Too late to run %s block

(W void) A CHECK or INIT block is being defined during run time proper, when the opportunity to run them has already passed. Perhaps you are loading a file with `require` or `do` when you should be using `use` instead. Or perhaps you should put the `require` or `do` inside a BEGIN block.

Unknown `open()` mode '%s'

(F) The second argument of 3-argument `open()` is not among the list of valid modes: `< > >> +< +> +>> -| |-`.

Unknown process %x sent message to prime_env_iter: %s

(P) An error peculiar to VMS. Perl was reading values for %ENV before iterating over it, and someone else stuck a message in the stream of data Perl expected. Someone's very confused, or perhaps trying to subvert Perl's population of %ENV for nefarious purposes.

Unrecognized escape \\%c passed through

(W misc) You used a backslash-character combination which is not recognized by Perl. The character was understood literally.

Unterminated attribute parameter in attribute list

(F) The lexer saw an opening (left) parenthesis character while parsing an attribute list, but the matching closing (right) parenthesis character was not found. You may need to add (or remove) a backslash character to get your parentheses to balance. See *attributes*.

Unterminated attribute list

(F) The lexer found something other than a simple identifier at the start of an attribute, and it wasn't a semicolon or the start of a block. Perhaps you terminated the parameter list of the previous attribute too soon. See *attributes*.

Unterminated attribute parameter in subroutine attribute list

(F) The lexer saw an opening (left) parenthesis character while parsing a subroutine attribute list, but the matching closing (right) parenthesis character was not found. You may need to add (or remove) a backslash character to get your parentheses to balance.

Unterminated subroutine attribute list

(F) The lexer found something other than a simple identifier at the start of a subroutine attribute, and it wasn't a semicolon or the start of a block. Perhaps you terminated the parameter list of the previous attribute too soon.

Value of CLI symbol "%s" too long

(W misc) A warning peculiar to VMS. Perl tried to read the value of an %ENV element from a CLI symbol table, and found a resultant string longer than 1024 characters. The return value has been truncated to 1024 characters.

Version number must be a constant number

(P) The attempt to translate a `use Module n.n LIST` statement into its equivalent `BEGIN` block found an internal inconsistency with the version number.

New tests

lib/attrs

Compatibility tests for `sub : attrs` vs the older `use attrs`.

lib/env

Tests for new environment scalar capability (e.g., `use Env qw($BAR);`).

lib/env−array

Tests for new environment array capability (e.g., `use Env qw(@PATH);`).

lib/io_const

IO constants (SEEK_*, _IO*).

lib/io_dir

Directory−related IO methods (new, read, close, rewind, tied delete).

lib/io_multihomed

INET sockets with multi−homed hosts.

lib/io_poll

IO `poll()`.

lib/io_unix

UNIX sockets.

op/attrs

Regression tests for `my ($x,@y,%z) : attrs` and <sub : attrs.

op/filetest

File test operators.

op/lex_assign

Verify operations that access pad objects (lexicals and temporaries).

op/exists_sub

Verify `exists &sub` operations.

Incompatible Changes

Perl Source Incompatibilities

Beware that any new warnings that have been added or old ones that have been enhanced are **not** considered incompatible changes.

Since all new warnings must be explicitly requested via the `-w` switch or the `warnings` pragma, it is ultimately the programmer's responsibility to ensure that warnings are enabled judiciously.

CHECK is a new keyword

All subroutine definitions named CHECK are now special. See `/"Support for CHECK blocks"` for more information.

Treatment of list slices of undef has changed

There is a potential incompatibility in the behavior of list slices that are comprised entirely of undefined values. See .

Format of `$English::PERL_VERSION` is different

The English module now sets `$PERL_VERSION` to `$^V` (a string value) rather than `$]` (a numeric value). This is a potential incompatibility. Send us a report via perlbug if you are affected by this.

See for the reasons for this change.

Literals of the form `1.2.3` parse differently

Previously, numeric literals with more than one dot in them were interpreted as a floating point number concatenated with one or more numbers. Such "numbers" are now parsed as strings composed of the specified ordinals.

For example, `print 97.98.99` used to output `97.9899` in earlier versions, but now prints `abc`.

See .

Possibly changed pseudo-random number generator

Perl programs that depend on reproducing a specific set of pseudo-random numbers may now produce different output due to improvements made to the `rand()` builtin. You can use `sh Configure -Drandfunc=rand` to obtain the old behavior.

See .

Hashing function for hash keys has changed

Even though Perl hashes are not order preserving, the apparently random order encountered when iterating on the contents of a hash is actually determined by the hashing algorithm used. Improvements in the algorithm may yield a random order that is **different** from that of previous versions, especially when iterating on hashes.

See for additional information.

`undef` fails on read only values

Using the `undef` operator on a readonly value (such as `$1`) has the same effect as assigning `undef` to the readonly value—it throws an exception.

Close-on-exec bit may be set on pipe and socket handles

Pipe and socket handles are also now subject to the close-on-exec behavior determined by the special variable `$^F`.

See .

Writing `"$$1"` to mean `"${$}1"` is unsupported

Perl 5.004 deprecated the interpretation of `$$1` and similar within interpolated strings to mean `$$ . "1"`, but still allowed it.

In Perl 5.6.0 and later, `"$$1"` always means `"${$1}"`.

`delete()`, `values()` and `\(%h)` operate on aliases to values, not copies

`delete()`, `each()`, `values()` and hashes in a list context return the actual values in the hash, instead of copies (as they used to in earlier versions). Typical idioms for using these constructs copy the returned values, but this can make a significant difference when creating references to the returned values. Keys in the hash are still returned as copies when iterating on a hash.

See also */"delete(), each(), values() and hash iteration are faster"*.

vec(EXPR,OFFSET,BITS) enforces powers–of–two BITS

`vec()` generates a run–time error if the BITS argument is not a valid power–of–two integer.

Text of some diagnostic output has changed

Most references to internal Perl operations in diagnostics have been changed to be more descriptive. This may be an issue for programs that may incorrectly rely on the exact text of diagnostics for proper functioning.

`%@` has been removed

The undocumented special variable `%@` that used to accumulate "background" errors (such as those that happen in `DESTROY()`) has been removed, because it could potentially result in memory leaks.

Parenthesized `not()` behaves like a list operator

The `not` operator now falls under the "if it looks like a function, it behaves like a function" rule.

As a result, the parenthesized form can be used with `grep` and `map`. The following construct used to be a syntax error before, but it works as expected now:

```
grep not($_), @things;
```

On the other hand, using `not` with a literal list slice may not work. The following previously allowed construct:

```
print not (1,2,3)[0];
```

needs to be written with additional parentheses now:

```
print not((1,2,3)[0]);
```

The behavior remains unaffected when `not` is not followed by parentheses.

Semantics of bareword prototype `(*)` have changed

The semantics of the bareword prototype `*` have changed. Perl 5.005 always coerced simple scalar arguments to a typeglob, which wasn't useful in situations where the subroutine must distinguish between a simple scalar and a typeglob. The new behavior is to not coerce bareword arguments to a typeglob. The value will always be visible as either a simple scalar or as a reference to a typeglob.

See .

Semantics of bit operators may have changed on 64–bit platforms

If your platform is either natively 64–bit or if Perl has been configured to used 64–bit integers, i.e., `$Config{ivsize}` is 8, there may be a potential incompatibility in the behavior of bitwise numeric operators (`& | ^ ~ << `). These operators used to strictly operate on the lower 32 bits of integers in previous versions, but now operate over the entire native integral width. In particular, note that unary `~` will produce different results on platforms that have different `$Config{ivsize}`. For portability, be sure to mask off the excess bits in the result of unary ~, e.g., `~$x & 0xffffffff`.

See .

More builtins taint their results

As described in , there may be more sources of taint in a Perl program.

To avoid these new tainting behaviors, you can build Perl with the Configure option `-Accflags=-DINCOMPLETE_TAINTS`. Beware that the ensuing perl binary may be insecure.

C Source Incompatibilities

`PERL_POLLUTE`

Release 5.005 grandfathered old global symbol names by providing preprocessor macros for extension source compatibility. As of release 5.6.0, these preprocessor definitions are not available by default. You need to explicitly compile perl with `-DPERL_POLLUTE` to get these definitions. For extensions still using the old symbols, this option can be specified via MakeMaker:

```
perl Makefile.PL POLLUTE=1
```

`PERL_IMPLICIT_CONTEXT`

This new build option provides a set of macros for all API functions such that an implicit interpreter/thread context argument is passed to every API function. As a result of this, something like `sv_setsv(foo,bar)` amounts to a macro invocation that actually translates to something like `Perl_sv_setsv(my_perl,foo,bar)`. While this is generally expected to not have any significant source compatibility issues, the difference between a macro and a real function call will need to be considered.

This means that there **is** a source compatibility issue as a result of this if your extensions attempt to use pointers to any of the Perl API functions.

Note that the above issue is not relevant to the default build of Perl, whose interfaces continue to match those of prior versions (but subject to the other options described here).

See *The Perl API in perlguts* for detailed information on the ramifications of building Perl with this option.

```
NOTE: PERL_IMPLICIT_CONTEXT is automatically enabled whenever Perl is built
with one of -Dusethreads, -Dusemultiplicity, or both.  It is not
intended to be enabled by users at this time.
```

`PERL_POLLUTE_MALLOC`

Enabling Perl's malloc in release 5.005 and earlier caused the namespace of the system's malloc family of functions to be usurped by the Perl versions, since by default they used the same names. Besides causing problems on platforms that do not allow these functions to be cleanly replaced, this also meant that the system versions could not be called in programs that used Perl's malloc. Previous versions of Perl have allowed this behaviour to be suppressed with the HIDEMYMALLOC and EMBEDMYMALLOC preprocessor definitions.

As of release 5.6.0, Perl's malloc family of functions have default names distinct from the system versions. You need to explicitly compile perl with `-DPERL_POLLUTE_MALLOC` to get the older behaviour. HIDEMYMALLOC and EMBEDMYMALLOC have no effect, since the behaviour they enabled is now the default.

Note that these functions do **not** constitute Perl's memory allocation API. See *Memory Allocation in perlguts* for further information about that.

Compatible C Source API Changes

`PATCHLEVEL` is now `PERL_VERSION`

The cpp macros `PERL_REVISION`, `PERL_VERSION`, and `PERL_SUBVERSION` are now available by default from perl.h, and reflect the base revision, patchlevel, and subversion respectively. `PERL_REVISION` had no prior equivalent, while `PERL_VERSION` and `PERL_SUBVERSION` were previously available as `PATCHLEVEL` and `SUBVERSION`.

The new names cause less pollution of the **cpp** namespace and reflect what the numbers have come to stand for in common practice. For compatibility, the old names are still supported when ***patchlevel.h*** is explicitly included (as required before), so there is no source incompatibility from the change.

Binary Incompatibilities

In general, the default build of this release is expected to be binary compatible for extensions built with the 5.005 release or its maintenance versions. However, specific platforms may have broken binary compatibility due to changes in the defaults used in hints files. Therefore, please be sure to always check the platform−specific README files for any notes to the contrary.

The usethreads or usemultiplicity builds are **not** binary compatible with the corresponding builds in 5.005.

On platforms that require an explicit list of exports (AIX, OS/2 and Windows, among others), purely internal symbols such as parser functions and the run time opcodes are not exported by default. Perl 5.005 used to export all functions irrespective of whether they were considered part of the public API or not.

For the full list of public API functions, see *perlapi*.

Known Problems

Thread test failures

The subtests 19 and 20 of lib/thr5005.t test are known to fail due to fundamental problems in the 5.005 threading implementation. These are not new failures—Perl 5.005_0x has the same bugs, but didn't have these tests.

EBCDIC platforms not supported

In earlier releases of Perl, EBCDIC environments like OS390 (also known as Open Edition MVS) and VM−ESA were supported. Due to changes required by the UTF−8 (Unicode) support, the EBCDIC platforms are not supported in Perl 5.6.0.

In 64−bit HP−UX the lib/io_multihomed test may hang

The lib/io_multihomed test may hang in HP−UX if Perl has been configured to be 64−bit. Because other 64−bit platforms do not hang in this test, HP−UX is suspect. All other tests pass in 64−bit HP−UX. The test attempts to create and connect to "multihomed" sockets (sockets which have multiple IP addresses).

NEXTSTEP 3.3 POSIX test failure

In NEXTSTEP 3.3p2 the implementation of the strftime(3) in the operating system libraries is buggy: the %j format numbers the days of a month starting from zero, which, while being logical to programmers, will cause the subtests 19 to 27 of the lib/posix test may fail.

Tru64 (aka Digital UNIX, aka DEC OSF/1) lib/sdbm test failure with gcc

If compiled with gcc 2.95 the lib/sdbm test will fail (dump core). The cure is to use the vendor cc, it comes with the operating system and produces good code.

UNICOS/mk CC failures during Configure run

In UNICOS/mk the following errors may appear during the Configure run:

```
Guessing which symbols your C compiler and preprocessor define...
CC-20 cc: ERROR File = try.c, Line = 3
...
  bad switch yylook 79bad switch yylook 79bad switch yylook 79bad switch yylo
...
4 errors detected in the compilation of "try.c".
```

The culprit is the broken awk of UNICOS/mk. The effect is fortunately rather mild: Perl itself is not adversely affected by the error, only the h2ph utility coming with Perl, and that is rather rarely needed these days.

Arrow operator and arrays

When the left argument to the arrow operator `< −` is an array, or the `scalar` operator operating on an array, the result of the operation must be considered erroneous. For example:

```
@x->[2]
```

```
scalar(@x)->[2]
```

These expressions will get run–time errors in some future release of Perl.

Experimental features

As discussed above, many features are still experimental. Interfaces and implementation of these features are subject to change, and in extreme cases, even subject to removal in some future release of Perl. These features include the following:

Threads
Unicode
64–bit support
Lvalue subroutines
Weak references
The pseudo–hash data type
The Compiler suite
Internal implementation of file globbing
The DB module
The regular expression constructs `(?{ code })` and `(??{ code })`

Obsolete Diagnostics

Character class syntax [: :] is reserved for future extensions

(W) Within regular expression character classes ([]) the syntax beginning with "[:" and ending with ":]" is reserved for future extensions. If you need to represent those character sequences inside a regular expression character class, just quote the square brackets with the backslash: "\[:" and ":\]".

Ill–formed logical name |%s| in prime_env_iter

(W) A warning peculiar to VMS. A logical name was encountered when preparing to iterate over %ENV which violates the syntactic rules governing logical names. Because it cannot be translated normally, it is skipped, and will not appear in %ENV. This may be a benign occurrence, as some software packages might directly modify logical name tables and introduce nonstandard names, or it may indicate that a logical name table has been corrupted.

In string, @%s now must be written as \@%s

The description of this error used to say:

```
(Someday it will simply assume that an unbackslashed @
 interpolates an array.)
```

That day has come, and this fatal error has been removed. It has been replaced by a non–fatal warning instead. See *Arrays now always interpolate into double–quoted strings* for details.

Probable precedence problem on %s

(W) The compiler found a bareword where it expected a conditional, which often indicates that an || or && was parsed as part of the last argument of the previous construct, for example:

```
open FOO || die;
```

regexp too big

(F) The current implementation of regular expressions uses shorts as address offsets within a string. Unfortunately this means that if the regular expression compiles to longer than 32767, it'll blow up. Usually when you want a regular expression this big, there is a better way to do it with multiple statements. See *perlre*.

Use of "$$<digit" to mean "${$}<digit" is deprecated

(D) Perl versions before 5.004 misinterpreted any type marker followed by "$" and a digit. For example, "$$0" was incorrectly taken to mean "${$}0" instead of "${$0}". This bug is (mostly) fixed in Perl 5.004.

However, the developers of Perl 5.004 could not fix this bug completely, because at least two widely−used modules depend on the old meaning of "$$0" in a string. So Perl 5.004 still interprets "$$<digit" in the old (broken) way inside strings; but it generates this message as a warning. And in Perl 5.005, this special treatment will cease.

Reporting Bugs

If you find what you think is a bug, you might check the articles recently posted to the comp.lang.perl.misc newsgroup. There may also be information at http://www.perl.com/perl/, the Perl Home Page.

If you believe you have an unreported bug, please run the **perlbug** program included with your release. Be sure to trim your bug down to a tiny but sufficient test case. Your bug report, along with the output of `perl -V`, will be sent off to perlbug@perl.org to be analysed by the Perl porting team.

SEE ALSO

The ***Changes*** file for exhaustive details on what changed.

The ***INSTALL*** file for how to build Perl.

The ***README*** file for general stuff.

The ***Artistic*** and ***Copying*** files for copyright information.

HISTORY

Written by Gurusamy Sarathy ***<gsar@activestate.com***, with many contributions from The Perl Porters.

Send omissions or corrections to ***<perlbug@perl.org***.

NAME

perlapi – autogenerated documentation for the perl public API

DESCRIPTION

This file contains the documentation of the perl public API generated by embed.pl, specifically a listing of functions, macros, flags, and variables that may be used by extension writers. The interfaces of any functions that are not listed here are subject to change without notice. For this reason, blindly using functions listed in proto.h is to be avoided when writing extensions.

Note that all Perl API global variables must be referenced with the `PL_` prefix. Some macros are provided for compatibility with the older, unadorned names, but this support may be disabled in a future release.

The listing is alphabetical, case insensitive.

AvFILL Same as `av_len()`. Deprecated, use `av_len()` instead.

```
int      AvFILL(AV* av)
```

=for hackers Found in file av.h

av_clear Clears an array, making it empty. Does not free the memory used by the array itself.

```
void     av_clear(AV* ar)
```

=for hackers Found in file av.c

av_delete

Deletes the element indexed by `key` from the array. Returns the deleted element. `flags` is currently ignored.

```
SV*      av_delete(AV* ar, I32 key, I32 flags)
```

=for hackers Found in file av.c

av_exists Returns true if the element indexed by `key` has been initialized.

This relies on the fact that uninitialized array elements are set to `&PL_sv_undef`.

```
bool     av_exists(AV* ar, I32 key)
```

=for hackers Found in file av.c

av_extend

Pre–extend an array. The `key` is the index to which the array should be extended.

```
void     av_extend(AV* ar, I32 key)
```

=for hackers Found in file av.c

av_fetch Returns the SV at the specified index in the array. The `key` is the index. If `lval` is set then the fetch will be part of a store. Check that the return value is non–null before dereferencing it to a `SV*`.

See *Understanding the Magic of Tied Hashes and Arrays in perlguts* for more information on how to use this function on tied arrays.

```
SV**     av_fetch(AV* ar, I32 key, I32 lval)
```

=for hackers Found in file av.c

av_fill Ensure than an array has a given number of elements, equivalent to Perl's `$#array = $fill;`.

```
void     av_fill(AV* ar, I32 fill)
```

=for hackers Found in file av.c

av_len Returns the highest index in the array. Returns −1 if the array is empty.

```
I32     av_len(AV* ar)
```

=for hackers Found in file av.c

av_make Creates a new AV and populates it with a list of SVs. The SVs are copied into the array, so they may be freed after the call to av_make. The new AV will have a reference count of 1.

```
AV*     av_make(I32 size, SV** svp)
```

=for hackers Found in file av.c

av_pop Pops an SV off the end of the array. Returns `&PL_sv_undef` if the array is empty.

```
SV*     av_pop(AV* ar)
```

=for hackers Found in file av.c

av_push Pushes an SV onto the end of the array. The array will grow automatically to accommodate the addition.

```
void    av_push(AV* ar, SV* val)
```

=for hackers Found in file av.c

av_shift Shifts an SV off the beginning of the array.

```
SV*     av_shift(AV* ar)
```

=for hackers Found in file av.c

av_store Stores an SV in an array. The array index is specified as `key`. The return value will be NULL if the operation failed or if the value did not need to be actually stored within the array (as in the case of tied arrays). Otherwise it can be dereferenced to get the original `SV*`. Note that the caller is responsible for suitably incrementing the reference count of `val` before the call, and decrementing it if the function returned NULL.

See *Understanding the Magic of Tied Hashes and Arrays in perlguts* for more information on how to use this function on tied arrays.

```
SV**    av_store(AV* ar, I32 key, SV* val)
```

=for hackers Found in file av.c

av_undef Undefines the array. Frees the memory used by the array itself.

```
void    av_undef(AV* ar)
```

=for hackers Found in file av.c

av_unshift

Unshift the given number of `undef` values onto the beginning of the array. The array will grow automatically to accommodate the addition. You must then use `av_store` to assign values to these new elements.

```
void    av_unshift(AV* ar, I32 num)
```

=for hackers Found in file av.c

bytes_to_utf8

Converts a string `s` of length `len` from ASCII into UTF8 encoding. Returns a pointer to the newly−created string, and sets `len` to reflect the new length.

```
U8 *    bytes_to_utf8(U8 *s, STRLEN *len)
```

=for hackers Found in file utf8.c

call_argv

Performs a callback to the specified Perl sub. See *perlcall*.

NOTE: the perl_ form of this function is deprecated.

```
I32     call_argv(const char* sub_name, I32 flags, char** argv)
```

=for hackers Found in file perl.c

call_method

Performs a callback to the specified Perl method. The blessed object must be on the stack. See *perlcall*.

NOTE: the perl_ form of this function is deprecated.

```
I32     call_method(const char* methname, I32 flags)
```

=for hackers Found in file perl.c

call_pv Performs a callback to the specified Perl sub. See *perlcall*.

NOTE: the perl_ form of this function is deprecated.

```
I32     call_pv(const char* sub_name, I32 flags)
```

=for hackers Found in file perl.c

call_sv Performs a callback to the Perl sub whose name is in the SV. See *perlcall*.

NOTE: the perl_ form of this function is deprecated.

```
I32     call_sv(SV* sv, I32 flags)
```

=for hackers Found in file perl.c

CLASS Variable which is setup by `xsubpp` to indicate the class name for a C++ XS constructor. This is always a `char*`. See `THIS`.

```
char*   CLASS
```

=for hackers Found in file XSUB.h

Copy The XSUB-writer's interface to the C `memcpy` function. The `src` is the source, `dest` is the destination, `nitems` is the number of items, and `type` is the type. May fail on overlapping copies. See also `Move`.

```
void    Copy(void* src, void* dest, int nitems, type)
```

=for hackers Found in file handy.h

croak This is the XSUB-writer's interface to Perl's `die` function. Normally use this function the same way you use the C `printf` function. See `warn`.

If you want to throw an exception object, assign the object to `$@` and then pass `Nullch` to `croak()`:

```
errsv = get_sv("@", TRUE);
sv_setsv(errsv, exception_object);
croak(Nullch);
```

```
void    croak(const char* pat, ...)
```

=for hackers Found in file util.c

CvSTASH

Returns the stash of the CV.

```
HV*     CvSTASH(CV* cv)
```

=for hackers Found in file cv.h

cv_const_sv

If `cv` is a constant sub eligible for inlining. returns the constant value returned by the sub. Otherwise, returns NULL.

Constant subs can be created with `newCONSTSUB` or as described in *Constant Functions in perlsub*.

```
SV*     cv_const_sv(CV* cv)
```

=for hackers Found in file op.c

dMARK Declare a stack marker variable, `mark`, for the XSUB. See `MARK` and `dORIGMARK`.

```
dMARK;
```

=for hackers Found in file pp.h

dORIGMARK

Saves the original stack mark for the XSUB. See `ORIGMARK`.

```
dORIGMARK;
```

=for hackers Found in file pp.h

dSP Declares a local copy of perl's stack pointer for the XSUB, available via the `SP` macro. See `SP`.

```
dSP;
```

=for hackers Found in file pp.h

dXSARGS

Sets up stack and mark pointers for an XSUB, calling dSP and dMARK. This is usually handled automatically by `xsubpp`. Declares the `items` variable to indicate the number of items on the stack.

```
dXSARGS;
```

=for hackers Found in file XSUB.h

dXSI32 Sets up the `ix` variable for an XSUB which has aliases. This is usually handled automatically by `xsubpp`.

```
dXSI32;
```

=for hackers Found in file XSUB.h

ENTER Opening bracket on a callback. See `LEAVE` and *perlcall*.

```
ENTER;
```

=for hackers Found in file scope.h

eval_pv Tells Perl to `eval` the given string and return an SV* result.

NOTE: the perl_ form of this function is deprecated.

```
SV*     eval_pv(const char* p, I32 croak_on_error)
```

=for hackers Found in file perl.c

eval_sv Tells Perl to `eval` the string in the SV.

NOTE: the perl_ form of this function is deprecated.

```
I32     eval_sv(SV* sv, I32 flags)
```

=for hackers Found in file perl.c

EXTEND Used to extend the argument stack for an XSUB's return values. Once used, guarantees that there is room for at least `nitems` to be pushed onto the stack.

```
void    EXTEND(SP, int nitems)
```

=for hackers Found in file pp.h

fbm_compile

Analyses the string in order to make fast searches on it using `fbm_instr()` — the Boyer–Moore algorithm.

```
void    fbm_compile(SV* sv, U32 flags)
```

=for hackers Found in file util.c

fbm_instr Returns the location of the SV in the string delimited by `str` and `strend`. It returns `Nullch` if the string can't be found. The `sv` does not have to be fbm_compiled, but the search will not be as fast then.

```
char*   fbm_instr(unsigned char* big, unsigned char* bigend, SV* litt
```

=for hackers Found in file util.c

FREETMPS

Closing bracket for temporaries on a callback. See `SAVETMPS` and *perlcall*.

```
FREETMPS;
```

=for hackers Found in file scope.h

get_av Returns the AV of the specified Perl array. If `create` is set and the Perl variable does not exist then it will be created. If `create` is not set and the variable does not exist then NULL is returned.

NOTE: the perl_ form of this function is deprecated.

```
AV*     get_av(const char* name, I32 create)
```

=for hackers Found in file perl.c

get_cv Returns the CV of the specified Perl subroutine. If `create` is set and the Perl subroutine does not exist then it will be declared (which has the same effect as saying `sub name;`). If `create` is not set and the subroutine does not exist then NULL is returned.

NOTE: the perl_ form of this function is deprecated.

```
CV*     get_cv(const char* name, I32 create)
```

=for hackers Found in file perl.c

get_hv Returns the HV of the specified Perl hash. If `create` is set and the Perl variable does not exist then it will be created. If `create` is not set and the variable does not exist then NULL is returned.

NOTE: the perl_ form of this function is deprecated.

```
HV*     get_hv(const char* name, I32 create)
```

=for hackers Found in file perl.c

get_sv Returns the SV of the specified Perl scalar. If `create` is set and the Perl variable does not exist then it will be created. If `create` is not set and the variable does not exist then NULL is returned.

NOTE: the perl_ form of this function is deprecated.

```
SV*     get_sv(const char* name, I32 create)
```

=for hackers Found in file perl.c

GIMME A backward−compatible version of GIMME_V which can only return G_SCALAR or G_ARRAY; in a void context, it returns G_SCALAR. Deprecated. Use GIMME_V instead.

```
U32     GIMME
```

=for hackers Found in file op.h

GIMME_V

The XSUB−writer's equivalent to Perl's wantarray. Returns G_VOID, G_SCALAR or G_ARRAY for void, scalar or list context, respectively.

```
U32     GIMME_V
```

=for hackers Found in file op.h

GvSV Return the SV from the GV.

```
SV*     GvSV(GV* gv)
```

=for hackers Found in file gv.h

gv_fetchmeth

Returns the glob with the given name and a defined subroutine or NULL. The glob lives in the given stash, or in the stashes accessible via @ISA and @UNIVERSAL.

The argument level should be either 0 or −1. If level==0, as a side−effect creates a glob with the given name in the given stash which in the case of success contains an alias for the subroutine, and sets up caching info for this glob. Similarly for all the searched stashes.

This function grants "SUPER" token as a postfix of the stash name. The GV returned from gv_fetchmeth may be a method cache entry, which is not visible to Perl code. So when calling call_sv, you should not use the GV directly; instead, you should use the method's CV, which can be obtained from the GV with the GvCV macro.

```
GV*     gv_fetchmeth(HV* stash, const char* name, STRLEN len, I32 lev
```

=for hackers Found in file gv.c

gv_fetchmethod

See *gv_fetchmethod_autoload*.

```
GV*     gv_fetchmethod(HV* stash, const char* name)
```

=for hackers Found in file gv.c

gv_fetchmethod_autoload

Returns the glob which contains the subroutine to call to invoke the method on the stash. In fact in the presence of autoloading this may be the glob for "AUTOLOAD". In this case the corresponding variable $AUTOLOAD is already setup.

The third parameter of gv_fetchmethod_autoload determines whether AUTOLOAD lookup is performed if the given method is not present: non−zero means yes, look for AUTOLOAD; zero means no, don't look for AUTOLOAD. Calling gv_fetchmethod is equivalent to calling gv_fetchmethod_autoload with a non−zero autoload parameter.

These functions grant "SUPER" token as a prefix of the method name. Note that if you want to keep the returned glob for a long time, you need to check for it being "AUTOLOAD", since at the later time the call may load a different subroutine due to $AUTOLOAD changing its value. Use the glob created via a side effect to do this.

These functions have the same side–effects and as `gv_fetchmeth` with `level==0`. `name` should be writable if contains `':'` or `'  ''`. The warning against passing the GV returned by `gv_fetchmeth` to `call_sv` apply equally to these functions.

```
GV*     gv_fetchmethod_autoload(HV* stash, const char* name, I32 auto
```

=for hackers Found in file gv.c

gv_stashpv

Returns a pointer to the stash for a specified package. `name` should be a valid UTF–8 string. If `create` is set then the package will be created if it does not already exist. If `create` is not set and the package does not exist then NULL is returned.

```
HV*     gv_stashpv(const char* name, I32 create)
```

=for hackers Found in file gv.c

gv_stashsv

Returns a pointer to the stash for a specified package, which must be a valid UTF–8 string. See `gv_stashpv`.

```
HV*     gv_stashsv(SV* sv, I32 create)
```

=for hackers Found in file gv.c

G_ARRAY

Used to indicate list context. See `GIMME_V`, `GIMME` and *perlcall*.

=for hackers Found in file cop.h

G_DISCARD

Indicates that arguments returned from a callback should be discarded. See *perlcall*.

=for hackers Found in file cop.h

G_EVAL

Used to force a Perl `eval` wrapper around a callback. See *perlcall*.

=for hackers Found in file cop.h

G_NOARGS

Indicates that no arguments are being sent to a callback. See *perlcall*.

=for hackers Found in file cop.h

G_SCALAR

Used to indicate scalar context. See `GIMME_V`, `GIMME`, and *perlcall*.

=for hackers Found in file cop.h

G_VOID

Used to indicate void context. See `GIMME_V` and *perlcall*.

=for hackers Found in file cop.h

HEf_SVKEY

This flag, used in the length slot of hash entries and magic structures, specifies the structure contains a `SV*` pointer where a `char*` pointer is to be expected. (For information only—not to be used).

=for hackers Found in file hv.h

HeHASH

Returns the computed hash stored in the hash entry.

```
U32     HeHASH(HE* he)
```

=for hackers Found in file hv.h

HeKEY Returns the actual pointer stored in the key slot of the hash entry. The pointer may be either `char*` or `SV*`, depending on the value of `HeKLEN()`. Can be assigned to. The `HePV()` or `HeSVKEY()` macros are usually preferable for finding the value of a key.

```
void*   HeKEY(HE* he)
```

=for hackers Found in file hv.h

HeKLEN If this is negative, and amounts to `HEf_SVKEY`, it indicates the entry holds an `SV*` key. Otherwise, holds the actual length of the key. Can be assigned to. The `HePV()` macro is usually preferable for finding key lengths.

```
STRLEN  HeKLEN(HE* he)
```

=for hackers Found in file hv.h

HePV Returns the key slot of the hash entry as a `char*` value, doing any necessary dereferencing of possibly `SV*` keys. The length of the string is placed in `len` (this is a macro, so do *not* use `&len)`. If you do not care about what the length of the key is, you may use the global variable `PL_na`, though this is rather less efficient than using a local variable. Remember though, that hash keys in perl are free to contain embedded nulls, so using `strlen()` or similar is not a good way to find the length of hash keys. This is very similar to the `SvPV()` macro described elsewhere in this document.

```
char*   HePV(HE* he, STRLEN len)
```

=for hackers Found in file hv.h

HeSVKEY

Returns the key as an `SV*`, or `Nullsv` if the hash entry does not contain an `SV*` key.

```
SV*     HeSVKEY(HE* he)
```

=for hackers Found in file hv.h

HeSVKEY_force

Returns the key as an `SV*`. Will create and return a temporary mortal `SV*` if the hash entry contains only a `char*` key.

```
SV*     HeSVKEY_force(HE* he)
```

=for hackers Found in file hv.h

HeSVKEY_set

Sets the key to a given `SV*`, taking care to set the appropriate flags to indicate the presence of an `SV*` key, and returns the same `SV*`.

```
SV*     HeSVKEY_set(HE* he, SV* sv)
```

=for hackers Found in file hv.h

HeVAL Returns the value slot (type `SV*`) stored in the hash entry.

```
SV*     HeVAL(HE* he)
```

=for hackers Found in file hv.h

HvNAME Returns the package name of a stash. See `SvSTASH`, `CvSTASH`.

```
char*   HvNAME(HV* stash)
```

=for hackers Found in file hv.h

hv_clear Clears a hash, making it empty.

```
void    hv_clear(HV* tb)
```

=for hackers Found in file hv.c

hv_delete

Deletes a key/value pair in the hash. The value SV is removed from the hash and returned to the caller. The `klen` is the length of the key. The `flags` value will normally be zero; if set to G_DISCARD then NULL will be returned.

```
SV*     hv_delete(HV* tb, const char* key, U32 klen, I32 flags)
```

=for hackers Found in file hv.c

hv_delete_ent

Deletes a key/value pair in the hash. The value SV is removed from the hash and returned to the caller. The `flags` value will normally be zero; if set to G_DISCARD then NULL will be returned. `hash` can be a valid precomputed hash value, or 0 to ask for it to be computed.

```
SV*     hv_delete_ent(HV* tb, SV* key, I32 flags, U32 hash)
```

=for hackers Found in file hv.c

hv_exists Returns a boolean indicating whether the specified hash key exists. The `klen` is the length of the key.

```
bool    hv_exists(HV* tb, const char* key, U32 klen)
```

=for hackers Found in file hv.c

hv_exists_ent

Returns a boolean indicating whether the specified hash key exists. `hash` can be a valid precomputed hash value, or 0 to ask for it to be computed.

```
bool    hv_exists_ent(HV* tb, SV* key, U32 hash)
```

=for hackers Found in file hv.c

hv_fetch Returns the SV which corresponds to the specified key in the hash. The `klen` is the length of the key. If `lval` is set then the fetch will be part of a store. Check that the return value is non–null before dereferencing it to a `SV*`.

See *Understanding the Magic of Tied Hashes and Arrays in perlguts* for more information on how to use this function on tied hashes.

```
SV**    hv_fetch(HV* tb, const char* key, U32 klen, I32 lval)
```

=for hackers Found in file hv.c

hv_fetch_ent

Returns the hash entry which corresponds to the specified key in the hash. `hash` must be a valid precomputed hash number for the given `key`, or 0 if you want the function to compute it. IF `lval` is set then the fetch will be part of a store. Make sure the return value is non–null before accessing it. The return value when `tb` is a tied hash is a pointer to a static location, so be sure to make a copy of the structure if you need to store it somewhere.

See *Understanding the Magic of Tied Hashes and Arrays in perlguts* for more information on how to use this function on tied hashes.

```
HE*     hv_fetch_ent(HV* tb, SV* key, I32 lval, U32 hash)
```

=for hackers Found in file hv.c

hv_iterinit

Prepares a starting point to traverse a hash table. Returns the number of keys in the hash (i.e. the same as `HvKEYS(tb)`). The return value is currently only meaningful for hashes without tie magic.

NOTE: Before version 5.004_65, `hv_iterinit` used to return the number of hash buckets that happen to be in use. If you still need that esoteric value, you can get it through the macro `HvFILL(tb)`.

```
I32     hv_iterinit(HV* tb)
```

=for hackers Found in file hv.c

hv_iterkey

Returns the key from the current position of the hash iterator. See `hv_iterinit`.

```
char*   hv_iterkey(HE* entry, I32* retlen)
```

=for hackers Found in file hv.c

hv_iterkeysv

Returns the key as an `SV*` from the current position of the hash iterator. The return value will always be a mortal copy of the key. Also see `hv_iterinit`.

```
SV*     hv_iterkeysv(HE* entry)
```

=for hackers Found in file hv.c

hv_iternext

Returns entries from a hash iterator. See `hv_iterinit`.

```
HE*     hv_iternext(HV* tb)
```

=for hackers Found in file hv.c

hv_iternextsv

Performs an `hv_iternext`, `hv_iterkey`, and `hv_iterval` in one operation.

```
SV*     hv_iternextsv(HV* hv, char** key, I32* retlen)
```

=for hackers Found in file hv.c

hv_iterval Returns the value from the current position of the hash iterator. See `hv_iterkey`.

```
SV*     hv_iterval(HV* tb, HE* entry)
```

=for hackers Found in file hv.c

hv_magic Adds magic to a hash. See `sv_magic`.

```
void    hv_magic(HV* hv, GV* gv, int how)
```

=for hackers Found in file hv.c

hv_store Stores an SV in a hash. The hash key is specified as `key` and `klen` is the length of the key. The `hash` parameter is the precomputed hash value; if it is zero then Perl will compute it. The return value will be NULL if the operation failed or if the value did not need to be actually stored within the hash (as in the case of tied hashes). Otherwise it can be dereferenced to get the original `SV*`. Note that the caller is responsible for suitably incrementing the reference count of `val` before the call, and decrementing it if the function returned NULL.

See *Understanding the Magic of Tied Hashes and Arrays in perlguts* for more information on how to use this function on tied hashes.

```
SV**    hv_store(HV* tb, const char* key, U32 klen, SV* val, U32 hash
```

=for hackers Found in file hv.c

hv_store_ent

Stores `val` in a hash. The hash key is specified as `key`. The `hash` parameter is the precomputed hash value; if it is zero then Perl will compute it. The return value is the new hash entry so created. It will be NULL if the operation failed or if the value did not need to be actually stored within the hash (as in the case of tied hashes). Otherwise the contents of the return value can be accessed using the `He???` macros described here. Note that the caller is responsible for suitably incrementing the reference count of `val` before the call, and decrementing it if the function returned NULL.

See *Understanding the Magic of Tied Hashes and Arrays in perlguts* for more information on how to use this function on tied hashes.

```
HE*     hv_store_ent(HV* tb, SV* key, SV* val, U32 hash)
```

=for hackers Found in file hv.c

hv_undef Undefines the hash.

```
void    hv_undef(HV* tb)
```

=for hackers Found in file hv.c

isALNUM Returns a boolean indicating whether the C `char` is an ASCII alphanumeric character (including underscore) or digit.

```
bool    isALNUM(char ch)
```

=for hackers Found in file handy.h

isALPHA Returns a boolean indicating whether the C `char` is an ASCII alphabetic character.

```
bool    isALPHA(char ch)
```

=for hackers Found in file handy.h

isDIGIT Returns a boolean indicating whether the C `char` is an ASCII digit.

```
bool    isDIGIT(char ch)
```

=for hackers Found in file handy.h

isLOWER

Returns a boolean indicating whether the C `char` is a lowercase character.

```
bool    isLOWER(char ch)
```

=for hackers Found in file handy.h

isSPACE Returns a boolean indicating whether the C `char` is whitespace.

```
bool    isSPACE(char ch)
```

=for hackers Found in file handy.h

isUPPER Returns a boolean indicating whether the C `char` is an uppercase character.

```
bool    isUPPER(char ch)
```

=for hackers Found in file handy.h

items Variable which is setup by `xsubpp` to indicate the number of items on the stack. See *Variable−length Parameter Lists in perlxs*.

```
I32     items
```

=for hackers Found in file XSUB.h

ix Variable which is setup by `xsubpp` to indicate which of an XSUB's aliases was used to invoke it. See *The ALIAS: Keyword in perlxs*.

```
I32     ix
```

=for hackers Found in file XSUB.h

LEAVE Closing bracket on a callback. See `ENTER` and *perlcall*.

```
LEAVE;
```

=for hackers Found in file scope.h

looks_like_number

Test if an the content of an SV looks like a number (or is a number).

```
I32     looks_like_number(SV* sv)
```

=for hackers Found in file sv.c

MARK Stack marker variable for the XSUB. See `dMARK`.

=for hackers Found in file pp.h

mg_clear Clear something magical that the SV represents. See `sv_magic`.

```
int     mg_clear(SV* sv)
```

=for hackers Found in file mg.c

mg_copy Copies the magic from one SV to another. See `sv_magic`.

```
int     mg_copy(SV* sv, SV* nsv, const char* key, I32 klen)
```

=for hackers Found in file mg.c

mg_find Finds the magic pointer for type matching the SV. See `sv_magic`.

```
MAGIC*  mg_find(SV* sv, int type)
```

=for hackers Found in file mg.c

mg_free Free any magic storage used by the SV. See `sv_magic`.

```
int     mg_free(SV* sv)
```

=for hackers Found in file mg.c

mg_get Do magic after a value is retrieved from the SV. See `sv_magic`.

```
int     mg_get(SV* sv)
```

=for hackers Found in file mg.c

mg_length

Report on the SV's length. See `sv_magic`.

```
U32     mg_length(SV* sv)
```

=for hackers Found in file mg.c

mg_magical

Turns on the magical status of an SV. See `sv_magic`.

```
void    mg_magical(SV* sv)
```

=for hackers Found in file mg.c

mg_set Do magic after a value is assigned to the SV. See `sv_magic`.

```
int     mg_set(SV* sv)
```

=for hackers Found in file mg.c

Move The XSUB−writer's interface to the C `memmove` function. The `src` is the source, `dest` is the destination, `nitems` is the number of items, and `type` is the type. Can do overlapping moves. See also `Copy`.

```
void    Move(void* src, void* dest, int nitems, type)
```

=for hackers Found in file handy.h

New The XSUB−writer's interface to the C `malloc` function.

```
void    New(int id, void* ptr, int nitems, type)
```

=for hackers Found in file handy.h

newAV Creates a new AV. The reference count is set to 1.

```
AV*     newAV()
```

=for hackers Found in file av.c

Newc The XSUB−writer's interface to the C `malloc` function, with cast.

```
void    Newc(int id, void* ptr, int nitems, type, cast)
```

=for hackers Found in file handy.h

newCONSTSUB

Creates a constant sub equivalent to Perl `sub FOO () { 123 }` which is eligible for inlining at compile−time.

```
CV*     newCONSTSUB(HV* stash, char* name, SV* sv)
```

=for hackers Found in file op.c

newHV Creates a new HV. The reference count is set to 1.

```
HV*     newHV()
```

=for hackers Found in file hv.c

newRV_inc

Creates an RV wrapper for an SV. The reference count for the original SV is incremented.

```
SV*     newRV_inc(SV* sv)
```

=for hackers Found in file sv.h

newRV_noinc

Creates an RV wrapper for an SV. The reference count for the original SV is **not** incremented.

```
SV*     newRV_noinc(SV *sv)
```

=for hackers Found in file sv.c

NEWSV Creates a new SV. A non−zero `len` parameter indicates the number of bytes of preallocated string space the SV should have. An extra byte for a tailing NUL is also reserved. (SvPOK is not set for the SV even if string space is allocated.) The reference count for the new SV is set to 1. `id` is an integer id between 0 and 1299 (used to identify leaks).

```
SV*     NEWSV(int id, STRLEN len)
```

=for hackers Found in file handy.h

newSViv Creates a new SV and copies an integer into it. The reference count for the SV is set to 1.

```
SV*     newSViv(IV i)
```

=for hackers Found in file sv.c

newSVnv Creates a new SV and copies a floating point value into it. The reference count for the SV is set to 1.

```
SV*     newSVnv(NV n)
```

=for hackers Found in file sv.c

newSVpv Creates a new SV and copies a string into it. The reference count for the SV is set to 1. If `len` is zero, Perl will compute the length using `strlen()`. For efficiency, consider using `newSVpvn` instead.

```
SV*     newSVpv(const char* s, STRLEN len)
```

=for hackers Found in file sv.c

newSVpvf

Creates a new SV an initialize it with the string formatted like `sprintf`.

```
SV*     newSVpvf(const char* pat, ...)
```

=for hackers Found in file sv.c

newSVpvn

Creates a new SV and copies a string into it. The reference count for the SV is set to 1. Note that if `len` is zero, Perl will create a zero length string. You are responsible for ensuring that the source string is at least `len` bytes long.

```
SV*     newSVpvn(const char* s, STRLEN len)
```

=for hackers Found in file sv.c

newSVpvn_share

Creates a new SV and populates it with a string from the string table. Turns on READONLY and FAKE. The idea here is that as string table is used for shared hash keys these strings will have SvPVX == HeKEY and hash lookup will avoid string compare.

```
SV*     newSVpvn_share(const char* s, STRLEN len, U32 hash)
```

=for hackers Found in file sv.c

newSVrv Creates a new SV for the RV, `rv`, to point to. If `rv` is not an RV then it will be upgraded to one. If `classname` is non–null then the new SV will be blessed in the specified package. The new SV is returned and its reference count is 1.

```
SV*     newSVrv(SV* rv, const char* classname)
```

=for hackers Found in file sv.c

newSVsv Creates a new SV which is an exact duplicate of the original SV.

```
SV*     newSVsv(SV* old)
```

=for hackers Found in file sv.c

newSVuv Creates a new SV and copies an unsigned integer into it. The reference count for the SV is set to 1.

```
SV*     newSVuv(UV u)
```

=for hackers Found in file sv.c

newXS Used by `xsubpp` to hook up XSUBs as Perl subs.

=for hackers Found in file op.c

newXSproto

Used by `xsubpp` to hook up XSUBs as Perl subs. Adds Perl prototypes to the subs.

=for hackers Found in file XSUB.h

Newz The XSUB-writer's interface to the C `malloc` function. The allocated memory is zeroed with `memzero`.

```
void    Newz(int id, void* ptr, int nitems, type)
```

=for hackers Found in file handy.h

Nullav Null AV pointer.

=for hackers Found in file av.h

Nullch Null character pointer.

=for hackers Found in file handy.h

Nullcv Null CV pointer.

=for hackers Found in file cv.h

Nullhv Null HV pointer.

=for hackers Found in file hv.h

Nullsv Null SV pointer.

=for hackers Found in file handy.h

ORIGMARK

The original stack mark for the XSUB. See `dORIGMARK`.

=for hackers Found in file pp.h

perl_alloc Allocates a new Perl interpreter. See *perlembed*.

```
PerlInterpreter*        perl_alloc()
```

=for hackers Found in file perl.c

perl_construct

Initializes a new Perl interpreter. See *perlembed*.

```
void    perl_construct(PerlInterpreter* interp)
```

=for hackers Found in file perl.c

perl_destruct

Shuts down a Perl interpreter. See *perlembed*.

```
void    perl_destruct(PerlInterpreter* interp)
```

=for hackers Found in file perl.c

perl_free Releases a Perl interpreter. See *perlembed*.

```
void    perl_free(PerlInterpreter* interp)
```

=for hackers Found in file perl.c

perl_parse

Tells a Perl interpreter to parse a Perl script. See *perlembed*.

```
int     perl_parse(PerlInterpreter* interp, XSINIT_t xsinit, int argc
```

=for hackers Found in file perl.c

perl_run Tells a Perl interpreter to run. See *perlembed*.

```
int     perl_run(PerlInterpreter* interp)
```

=for hackers Found in file perl.c

PL_DBsingle

When Perl is run in debugging mode, with the **-d** switch, this SV is a boolean which indicates whether subs are being single-stepped. Single-stepping is automatically turned on after every step. This is the C variable which corresponds to Perl's `$DB::single` variable. See `PL_DBsub`.

```
SV *    PL_DBsingle
```

=for hackers Found in file intrpvar.h

PL_DBsub

When Perl is run in debugging mode, with the **-d** switch, this GV contains the SV which holds the name of the sub being debugged. This is the C variable which corresponds to Perl's `$DB::sub` variable. See `PL_DBsingle`.

```
GV *    PL_DBsub
```

=for hackers Found in file intrpvar.h

PL_DBtrace

Trace variable used when Perl is run in debugging mode, with the **-d** switch. This is the C variable which corresponds to Perl's `$DB::trace` variable. See `PL_DBsingle`.

```
SV *    PL_DBtrace
```

=for hackers Found in file intrpvar.h

PL_dowarn

The C variable which corresponds to Perl's `$^W` warning variable.

```
bool    PL_dowarn
```

=for hackers Found in file intrpvar.h

PL_modglobal

`PL_modglobal` is a general purpose, interpreter global HV for use by extensions that need to keep information on a per-interpreter basis. In a pinch, it can also be used as a symbol table for extensions to share data among each other. It is a good idea to use keys prefixed by the package name of the extension that owns the data.

```
HV*     PL_modglobal
```

=for hackers Found in file intrpvar.h

PL_na A convenience variable which is typically used with `SvPV` when one doesn't care about the length of the string. It is usually more efficient to either declare a local variable and use that instead or to use the `SvPV_nolen` macro.

```
STRLEN  PL_na
```

=for hackers Found in file thrdvar.h

PL_sv_no

This is the `false` SV. See `PL_sv_yes`. Always refer to this as `&PL_sv_no`.

```
SV      PL_sv_no
```

=for hackers Found in file intrpvar.h

PL_sv_undef

This is the `undef` SV. Always refer to this as `&PL_sv_undef`.

```
SV      PL_sv_undef
```

=for hackers Found in file intrpvar.h

PL_sv_yes

This is the `true` SV. See `PL_sv_no`. Always refer to this as `&PL_sv_yes`.

```
SV      PL_sv_yes
```

=for hackers Found in file intrpvar.h

POPi Pops an integer off the stack.

```
IV      POPi
```

=for hackers Found in file pp.h

POPl Pops a long off the stack.

```
long    POPl
```

=for hackers Found in file pp.h

POPn Pops a double off the stack.

```
NV      POPn
```

=for hackers Found in file pp.h

POPp Pops a string off the stack.

```
char*   POPp
```

=for hackers Found in file pp.h

POPs Pops an SV off the stack.

```
SV*     POPs
```

=for hackers Found in file pp.h

PUSHi Push an integer onto the stack. The stack must have room for this element. Handles 'set' magic. See `XPUSHi`.

```
void    PUSHi(IV iv)
```

=for hackers Found in file pp.h

PUSHMARK

Opening bracket for arguments on a callback. See `PUTBACK` and *perlcall*.

```
PUSHMARK;
```

=for hackers Found in file pp.h

PUSHn Push a double onto the stack. The stack must have room for this element. Handles 'set' magic. See `XPUSHn`.

```
void    PUSHn(NV nv)
```

=for hackers Found in file pp.h

PUSHp Push a string onto the stack. The stack must have room for this element. The `len` indicates the length of the string. Handles 'set' magic. See `XPUSHp`.

```
void    PUSHp(char* str, STRLEN len)
```

=for hackers Found in file pp.h

PUSHs Push an SV onto the stack. The stack must have room for this element. Does not handle 'set' magic. See `XPUSHs`.

```
void    PUSHs(SV* sv)
```

=for hackers Found in file pp.h

PUSHu Push an unsigned integer onto the stack. The stack must have room for this element. See `XPUSHu`.

```
void    PUSHu(UV uv)
```

=for hackers Found in file pp.h

PUTBACK

Closing bracket for XSUB arguments. This is usually handled by `xsubpp`. See `PUSHMARK` and *perlcall* for other uses.

```
PUTBACK;
```

=for hackers Found in file pp.h

Renew The XSUB–writer's interface to the C `realloc` function.

```
void    Renew(void* ptr, int nitems, type)
```

=for hackers Found in file handy.h

Renewc The XSUB–writer's interface to the C `realloc` function, with cast.

```
void    Renewc(void* ptr, int nitems, type, cast)
```

=for hackers Found in file handy.h

require_pv

Tells Perl to `require` a module.

NOTE: the perl_ form of this function is deprecated.

```
void    require_pv(const char* pv)
```

=for hackers Found in file perl.c

RETVAL Variable which is setup by `xsubpp` to hold the return value for an XSUB. This is always the proper type for the XSUB. See *The RETVAL Variable in perlxs*.

```
(whatever)      RETVAL
```

=for hackers Found in file XSUB.h

Safefree The XSUB–writer's interface to the C `free` function.

```
void    Safefree(void* ptr)
```

=for hackers Found in file handy.h

savepv Copy a string to a safe spot. This does not use an SV.

```
char*   savepv(const char* sv)
```

=for hackers Found in file util.c

savepvn Copy a string to a safe spot. The `len` indicates number of bytes to copy. This does not use an SV.

```
char*   savepvn(const char* sv, I32 len)
```

=for hackers Found in file util.c

SAVETMPS

Opening bracket for temporaries on a callback. See `FREETMPS` and *perlcall*.

```
SAVETMPS;
```

=for hackers Found in file scope.h

SP Stack pointer. This is usually handled by `xsubpp`. See `dSP` and `SPAGAIN`.

=for hackers Found in file pp.h

SPAGAIN

Refetch the stack pointer. Used after a callback. See *perlcall*.

```
SPAGAIN;
```

=for hackers Found in file pp.h

ST Used to access elements on the XSUB's stack.

```
SV*     ST(int ix)
```

=for hackers Found in file XSUB.h

strEQ Test two strings to see if they are equal. Returns true or false.

```
bool    strEQ(char* s1, char* s2)
```

=for hackers Found in file handy.h

strGE Test two strings to see if the first, `s1`, is greater than or equal to the second, `s2`. Returns true or false.

```
bool    strGE(char* s1, char* s2)
```

=for hackers Found in file handy.h

strGT Test two strings to see if the first, `s1`, is greater than the second, `s2`. Returns true or false.

```
bool    strGT(char* s1, char* s2)
```

=for hackers Found in file handy.h

strLE Test two strings to see if the first, `s1`, is less than or equal to the second, `s2`. Returns true or false.

```
bool    strLE(char* s1, char* s2)
```

=for hackers Found in file handy.h

strLT Test two strings to see if the first, `s1`, is less than the second, `s2`. Returns true or false.

```
bool    strLT(char* s1, char* s2)
```

=for hackers Found in file handy.h

strNE Test two strings to see if they are different. Returns true or false.

```
bool    strNE(char* s1, char* s2)
```

=for hackers Found in file handy.h

strnEQ Test two strings to see if they are equal. The `len` parameter indicates the number of bytes to compare. Returns true or false. (A wrapper for `strncmp`).

```
bool    strnEQ(char* s1, char* s2, STRLEN len)
```

=for hackers Found in file handy.h

strnNE Test two strings to see if they are different. The `len` parameter indicates the number of bytes to compare. Returns true or false. (A wrapper for `strncmp`).

```
bool    strnNE(char* s1, char* s2, STRLEN len)
```

=for hackers Found in file handy.h

StructCopy

This is an architecture–independent macro to copy one structure to another.

```
void    StructCopy(type src, type dest, type)
```

=for hackers Found in file handy.h

SvCUR Returns the length of the string which is in the SV. See `SvLEN`.

```
STRLEN  SvCUR(SV* sv)
```

=for hackers Found in file sv.h

SvCUR_set

Set the length of the string which is in the SV. See `SvCUR`.

```
void    SvCUR_set(SV* sv, STRLEN len)
```

=for hackers Found in file sv.h

SvEND Returns a pointer to the last character in the string which is in the SV. See `SvCUR`. Access the character as *(SvEND(sv)).

```
char*   SvEND(SV* sv)
```

=for hackers Found in file sv.h

SvGETMAGIC

Invokes `mg_get` on an SV if it has 'get' magic. This macro evaluates its argument more than once.

```
void    SvGETMAGIC(SV* sv)
```

=for hackers Found in file sv.h

SvGROW

Expands the character buffer in the SV so that it has room for the indicated number of bytes (remember to reserve space for an extra trailing NUL character). Calls `sv_grow` to perform the expansion if necessary. Returns a pointer to the character buffer.

```
void    SvGROW(SV* sv, STRLEN len)
```

=for hackers Found in file sv.h

SvIOK Returns a boolean indicating whether the SV contains an integer.

```
bool    SvIOK(SV* sv)
```

=for hackers Found in file sv.h

SvIOKp Returns a boolean indicating whether the SV contains an integer. Checks the **private** setting. Use `SvIOK`.

```
bool    SvIOKp(SV* sv)
```

=for hackers Found in file sv.h

SvIOK_notUV

Returns a boolean indicating whether the SV contains an signed integer.

```
void    SvIOK_notUV(SV* sv)
```

=for hackers Found in file sv.h

SvIOK_off

Unsets the IV status of an SV.

```
void    SvIOK_off(SV* sv)
```

=for hackers Found in file sv.h

SvIOK_on

Tells an SV that it is an integer.

```
void    SvIOK_on(SV* sv)
```

=for hackers Found in file sv.h

SvIOK_only

Tells an SV that it is an integer and disables all other OK bits.

```
void    SvIOK_only(SV* sv)
```

=for hackers Found in file sv.h

SvIOK_only_UV

Tells and SV that it is an unsigned integer and disables all other OK bits.

```
void    SvIOK_only_UV(SV* sv)
```

=for hackers Found in file sv.h

SvIOK_UV

Returns a boolean indicating whether the SV contains an unsigned integer.

```
void    SvIOK_UV(SV* sv)
```

=for hackers Found in file sv.h

SvIV Coerces the given SV to an integer and returns it.

```
IV      SvIV(SV* sv)
```

=for hackers Found in file sv.h

SvIVX Returns the integer which is stored in the SV, assuming SvIOK is true.

```
IV      SvIVX(SV* sv)
```

=for hackers Found in file sv.h

SvLEN Returns the size of the string buffer in the SV, not including any part attributable to `SvOOK`. See `SvCUR`.

```
STRLEN  SvLEN(SV* sv)
```

=for hackers Found in file sv.h

SvNIOK Returns a boolean indicating whether the SV contains a number, integer or double.

```
bool    SvNIOK(SV* sv)
```

=for hackers Found in file sv.h

SvNIOKp Returns a boolean indicating whether the SV contains a number, integer or double. Checks the **private** setting. Use `SvNIOK`.

```
bool    SvNIOKp(SV* sv)
```

=for hackers Found in file sv.h

SvNIOK_off

Unsets the NV/IV status of an SV.

```
void    SvNIOK_off(SV* sv)
```

=for hackers Found in file sv.h

SvNOK Returns a boolean indicating whether the SV contains a double.

```
bool    SvNOK(SV* sv)
```

=for hackers Found in file sv.h

SvNOKp Returns a boolean indicating whether the SV contains a double. Checks the **private** setting. Use `SvNOK`.

```
bool    SvNOKp(SV* sv)
```

=for hackers Found in file sv.h

SvNOK_off

Unsets the NV status of an SV.

```
void    SvNOK_off(SV* sv)
```

=for hackers Found in file sv.h

SvNOK_on

Tells an SV that it is a double.

```
void    SvNOK_on(SV* sv)
```

=for hackers Found in file sv.h

SvNOK_only

Tells an SV that it is a double and disables all other OK bits.

```
void    SvNOK_only(SV* sv)
```

=for hackers Found in file sv.h

SvNV Coerce the given SV to a double and return it.

```
NV      SvNV(SV* sv)
```

=for hackers Found in file sv.h

SvNVX Returns the double which is stored in the SV, assuming SvNOK is true.

```
NV      SvNVX(SV* sv)
```

=for hackers Found in file sv.h

SvOK Returns a boolean indicating whether the value is an SV.

```
bool    SvOK(SV* sv)
```

=for hackers Found in file sv.h

SvOOK Returns a boolean indicating whether the SvIVX is a valid offset value for the SvPVX. This hack is used internally to speed up removal of characters from the beginning of a SvPV. When SvOOK is true, then the start of the allocated string buffer is really (SvPVX − SvIVX).

```
bool    SvOOK(SV* sv)
```

=for hackers Found in file sv.h

SvPOK Returns a boolean indicating whether the SV contains a character string.

```
bool    SvPOK(SV* sv)
```

=for hackers Found in file sv.h

SvPOKp Returns a boolean indicating whether the SV contains a character string. Checks the **private** setting. Use `SvPOK`.

```
bool    SvPOKp(SV* sv)
```

=for hackers Found in file sv.h

SvPOK_off

Unsets the PV status of an SV.

```
void    SvPOK_off(SV* sv)
```

=for hackers Found in file sv.h

SvPOK_on

Tells an SV that it is a string.

```
void    SvPOK_on(SV* sv)
```

=for hackers Found in file sv.h

SvPOK_only

Tells an SV that it is a string and disables all other OK bits.

```
void    SvPOK_only(SV* sv)
```

=for hackers Found in file sv.h

SvPOK_only_UTF8

Tells an SV that it is a UTF8 string (do not use frivolously) and disables all other OK bits.

```
void    SvPOK_only_UTF8(SV* sv)
```

=for hackers Found in file sv.h

SvPV Returns a pointer to the string in the SV, or a stringified form of the SV if the SV does not contain a string. Handles 'get' magic.

```
char*   SvPV(SV* sv, STRLEN len)
```

=for hackers Found in file sv.h

SvPVX Returns a pointer to the string in the SV. The SV must contain a string.

```
char*   SvPVX(SV* sv)
```

=for hackers Found in file sv.h

SvPV_force

Like <SvPV but will force the SV into becoming a string (SvPOK). You want force if you are going to update the SvPVX directly.

```
char*   SvPV_force(SV* sv, STRLEN len)
```

=for hackers Found in file sv.h

SvPV_nolen

Returns a pointer to the string in the SV, or a stringified form of the SV if the SV does not contain a string. Handles 'get' magic.

```
char*   SvPV_nolen(SV* sv)
```

=for hackers Found in file sv.h

SvREFCNT

Returns the value of the object's reference count.

```
U32     SvREFCNT(SV* sv)
```

=for hackers Found in file sv.h

SvREFCNT_dec

Decrements the reference count of the given SV.

```
void    SvREFCNT_dec(SV* sv)
```

=for hackers Found in file sv.h

SvREFCNT_inc

Increments the reference count of the given SV.

```
SV*     SvREFCNT_inc(SV* sv)
```

=for hackers Found in file sv.h

SvROK Tests if the SV is an RV.

```
bool    SvROK(SV* sv)
```

=for hackers Found in file sv.h

SvROK_off

Unsets the RV status of an SV.

```
void    SvROK_off(SV* sv)
```

=for hackers Found in file sv.h

SvROK_on

Tells an SV that it is an RV.

```
void    SvROK_on(SV* sv)
```

=for hackers Found in file sv.h

SvRV Dereferences an RV to return the SV.

```
SV*     SvRV(SV* sv)
```

=for hackers Found in file sv.h

SvSETMAGIC

Invokes `mg_set` on an SV if it has 'set' magic. This macro evaluates its argument more than once.

```
void    SvSETMAGIC(SV* sv)
```

=for hackers Found in file sv.h

SvSetSV Calls `sv_setsv` if dsv is not the same as ssv. May evaluate arguments more than once.

```
void    SvSetSV(SV* dsb, SV* ssv)
```

=for hackers Found in file sv.h

SvSetSV_nosteal

Calls a non–destructive version of `sv_setsv` if dsv is not the same as ssv. May evaluate arguments more than once.

```
void    SvSetSV_nosteal(SV* dsv, SV* ssv)
```

=for hackers Found in file sv.h

SvSTASH

Returns the stash of the SV.

```
HV*     SvSTASH(SV* sv)
```

=for hackers Found in file sv.h

SvTAINT Taints an SV if tainting is enabled

```
void    SvTAINT(SV* sv)
```

=for hackers Found in file sv.h

SvTAINTED

Checks to see if an SV is tainted. Returns TRUE if it is, FALSE if not.

```
bool    SvTAINTED(SV* sv)
```

=for hackers Found in file sv.h

SvTAINTED_off

Untaints an SV. Be *very* careful with this routine, as it short–circuits some of Perl's fundamental security features. XS module authors should not use this function unless they fully understand all the implications of unconditionally untainting the value. Untainting should be done in the standard perl fashion, via a carefully crafted regexp, rather than directly untainting variables.

```
void    SvTAINTED_off(SV* sv)
```

=for hackers Found in file sv.h

SvTAINTED_on

Marks an SV as tainted.

```
void    SvTAINTED_on(SV* sv)
```

=for hackers Found in file sv.h

SvTRUE Returns a boolean indicating whether Perl would evaluate the SV as true or false, defined or undefined. Does not handle 'get' magic.

```
bool    SvTRUE(SV* sv)
```

=for hackers Found in file sv.h

SvTYPE Returns the type of the SV. See `svtype`.

```
svtype  SvTYPE(SV* sv)
```

=for hackers Found in file sv.h

svtype An enum of flags for Perl types. These are found in the file **sv.h** in the `svtype` enum. Test these flags with the `SvTYPE` macro.

=for hackers Found in file sv.h

SVt_IV Integer type flag for scalars. See `svtype`.

=for hackers Found in file sv.h

SVt_NV Double type flag for scalars. See `svtype`.

=for hackers Found in file sv.h

SVt_PV Pointer type flag for scalars. See `svtype`.

=for hackers Found in file sv.h

SVt_PVAV

Type flag for arrays. See `svtype`.

=for hackers Found in file sv.h

SVt_PVCV

Type flag for code refs. See `svtype`.

=for hackers Found in file sv.h

SVt_PVHV

Type flag for hashes. See `svtype`.

=for hackers Found in file sv.h

SVt_PVMG

Type flag for blessed scalars. See `svtype`.

=for hackers Found in file sv.h

SvUPGRADE

Used to upgrade an SV to a more complex form. Uses `sv_upgrade` to perform the upgrade if necessary. See `svtype`.

```
void    SvUPGRADE(SV* sv, svtype type)
```

=for hackers Found in file sv.h

SvUTF8 Returns a boolean indicating whether the SV contains UTF-8 encoded data.

```
void    SvUTF8(SV* sv)
```

=for hackers Found in file sv.h

SvUTF8_off

Unsets the UTF8 status of an SV.

```
void    SvUTF8_off(SV *sv)
```

=for hackers Found in file sv.h

SvUTF8_on

Tells an SV that it is a string and encoded in UTF8. Do not use frivolously.

```
void    SvUTF8_on(SV *sv)
```

=for hackers Found in file sv.h

SvUV Coerces the given SV to an unsigned integer and returns it.

```
UV       SvUV(SV* sv)
```

=for hackers Found in file sv.h

SvUVX Returns the unsigned integer which is stored in the SV, assuming SvIOK is true.

```
UV       SvUVX(SV* sv)
```

=for hackers Found in file sv.h

sv_2mortal

Marks an SV as mortal. The SV will be destroyed when the current context ends.

```
SV*      sv_2mortal(SV* sv)
```

=for hackers Found in file sv.c

sv_bless Blesses an SV into a specified package. The SV must be an RV. The package must be designated by its stash (see `gv_stashpv()`). The reference count of the SV is unaffected.

```
SV*      sv_bless(SV* sv, HV* stash)
```

=for hackers Found in file sv.c

sv_catpv Concatenates the string onto the end of the string which is in the SV. Handles 'get' magic, but not 'set' magic. See `sv_catpv_mg`.

```
void     sv_catpv(SV* sv, const char* ptr)
```

=for hackers Found in file sv.c

sv_catpvf Processes its arguments like `sprintf` and appends the formatted output to an SV. Handles 'get' magic, but not 'set' magic. `SvSETMAGIC()` must typically be called after calling this function to handle 'set' magic.

```
void     sv_catpvf(SV* sv, const char* pat, ...)
```

=for hackers Found in file sv.c

sv_catpvf_mg

Like `sv_catpvf`, but also handles 'set' magic.

```
void     sv_catpvf_mg(SV *sv, const char* pat, ...)
```

=for hackers Found in file sv.c

sv_catpvn

Concatenates the string onto the end of the string which is in the SV. The `len` indicates number of bytes to copy. Handles 'get' magic, but not 'set' magic. See `sv_catpvn_mg`.

```
void     sv_catpvn(SV* sv, const char* ptr, STRLEN len)
```

=for hackers Found in file sv.c

sv_catpvn_mg

Like `sv_catpvn`, but also handles 'set' magic.

```
void     sv_catpvn_mg(SV *sv, const char *ptr, STRLEN len)
```

=for hackers Found in file sv.c

sv_catpv_mg

Like `sv_catpv`, but also handles 'set' magic.

```
void     sv_catpv_mg(SV *sv, const char *ptr)
```

=for hackers Found in file sv.c

sv_catsv Concatenates the string from SV `ssv` onto the end of the string in SV `dsv`. Handles 'get' magic, but not 'set' magic. See `sv_catsv_mg`.

```
void    sv_catsv(SV* dsv, SV* ssv)
```

=for hackers Found in file sv.c

sv_catsv_mg

Like `sv_catsv`, but also handles 'set' magic.

```
void    sv_catsv_mg(SV *dstr, SV *sstr)
```

=for hackers Found in file sv.c

sv_chop Efficient removal of characters from the beginning of the string buffer. SvPOK(sv) must be true and the `ptr` must be a pointer to somewhere inside the string buffer. The `ptr` becomes the first character of the adjusted string.

```
void    sv_chop(SV* sv, char* ptr)
```

=for hackers Found in file sv.c

sv_clear Clear an SV, making it empty. Does not free the memory used by the SV itself.

```
void    sv_clear(SV* sv)
```

=for hackers Found in file sv.c

sv_cmp Compares the strings in two SVs. Returns −1, 0, or 1 indicating whether the string in `sv1` is less than, equal to, or greater than the string in `sv2`.

```
I32     sv_cmp(SV* sv1, SV* sv2)
```

=for hackers Found in file sv.c

sv_cmp_locale

Compares the strings in two SVs in a locale−aware manner. See */sv_cmp_locale*

```
I32     sv_cmp_locale(SV* sv1, SV* sv2)
```

=for hackers Found in file sv.c

sv_dec Auto−decrement of the value in the SV.

```
void    sv_dec(SV* sv)
```

=for hackers Found in file sv.c

sv_derived_from

Returns a boolean indicating whether the SV is derived from the specified class. This is the function that implements `UNIVERSAL::isa`. It works for class names as well as for objects.

```
bool    sv_derived_from(SV* sv, const char* name)
```

=for hackers Found in file universal.c

sv_eq Returns a boolean indicating whether the strings in the two SVs are identical.

```
I32     sv_eq(SV* sv1, SV* sv2)
```

=for hackers Found in file sv.c

sv_free Free the memory used by an SV.

```
void    sv_free(SV* sv)
```

=for hackers Found in file sv.c

sv_gets Get a line from the filehandle and store it into the SV, optionally appending to the currently−stored string.

```
char*   sv_gets(SV* sv, PerlIO* fp, I32 append)
```

=for hackers Found in file sv.c

sv_grow Expands the character buffer in the SV. This will use `sv_unref` and will upgrade the SV to `SVt_PV`. Returns a pointer to the character buffer. Use `SvGROW`.

```
char*   sv_grow(SV* sv, STRLEN newlen)
```

=for hackers Found in file sv.c

sv_inc Auto−increment of the value in the SV.

```
void    sv_inc(SV* sv)
```

=for hackers Found in file sv.c

sv_insert Inserts a string at the specified offset/length within the SV. Similar to the Perl `substr()` function.

```
void    sv_insert(SV* bigsv, STRLEN offset, STRLEN len, char* little,
```

=for hackers Found in file sv.c

sv_isa Returns a boolean indicating whether the SV is blessed into the specified class. This does not check for subtypes; use `sv_derived_from` to verify an inheritance relationship.

```
int     sv_isa(SV* sv, const char* name)
```

=for hackers Found in file sv.c

sv_isobject

Returns a boolean indicating whether the SV is an RV pointing to a blessed object. If the SV is not an RV, or if the object is not blessed, then this will return false.

```
int     sv_isobject(SV* sv)
```

=for hackers Found in file sv.c

sv_len Returns the length of the string in the SV. See also `SvCUR`.

```
STRLEN  sv_len(SV* sv)
```

=for hackers Found in file sv.c

sv_len_utf8

Returns the number of characters in the string in an SV, counting wide UTF8 bytes as a single character.

```
STRLEN  sv_len_utf8(SV* sv)
```

=for hackers Found in file sv.c

sv_magic Adds magic to an SV.

```
void    sv_magic(SV* sv, SV* obj, int how, const char* name, I32 naml
```

=for hackers Found in file sv.c

sv_mortalcopy

Creates a new SV which is a copy of the original SV. The new SV is marked as mortal.

```
SV*     sv_mortalcopy(SV* oldsv)
```

=for hackers Found in file sv.c

sv_newmortal

Creates a new SV which is mortal. The reference count of the SV is set to 1.

```
SV*     sv_newmortal()
```

=for hackers Found in file sv.c

sv_pvn_force

Get a sensible string out of the SV somehow.

```
char*   sv_pvn_force(SV* sv, STRLEN* lp)
```

=for hackers Found in file sv.c

sv_pvutf8n_force

Get a sensible UTF8-encoded string out of the SV somehow. See */sv_pvn_force*.

```
char*   sv_pvutf8n_force(SV* sv, STRLEN* lp)
```

=for hackers Found in file sv.c

sv_reftype

Returns a string describing what the SV is a reference to.

```
char*   sv_reftype(SV* sv, int ob)
```

=for hackers Found in file sv.c

sv_replace

Make the first argument a copy of the second, then delete the original.

```
void    sv_replace(SV* sv, SV* nsv)
```

=for hackers Found in file sv.c

sv_rvweaken

Weaken a reference.

```
SV*     sv_rvweaken(SV *sv)
```

=for hackers Found in file sv.c

sv_setiv Copies an integer into the given SV. Does not handle 'set' magic. See `sv_setiv_mg`.

```
void    sv_setiv(SV* sv, IV num)
```

=for hackers Found in file sv.c

sv_setiv_mg

Like `sv_setiv`, but also handles 'set' magic.

```
void    sv_setiv_mg(SV *sv, IV i)
```

=for hackers Found in file sv.c

sv_setnv Copies a double into the given SV. Does not handle 'set' magic. See `sv_setnv_mg`.

```
void    sv_setnv(SV* sv, NV num)
```

=for hackers Found in file sv.c

sv_setnv_mg

Like `sv_setnv`, but also handles 'set' magic.

```
void    sv_setnv_mg(SV *sv, NV num)
```

=for hackers Found in file sv.c

sv_setpv Copies a string into an SV. The string must be null–terminated. Does not handle 'set' magic. See `sv_setpv_mg`.

```
void    sv_setpv(SV* sv, const char* ptr)
```

=for hackers Found in file sv.c

sv_setpvf Processes its arguments like `sprintf` and sets an SV to the formatted output. Does not handle 'set' magic. See `sv_setpvf_mg`.

```
void    sv_setpvf(SV* sv, const char* pat, ...)
```

=for hackers Found in file sv.c

sv_setpvf_mg

Like `sv_setpvf`, but also handles 'set' magic.

```
void    sv_setpvf_mg(SV *sv, const char* pat, ...)
```

=for hackers Found in file sv.c

sv_setpviv

Copies an integer into the given SV, also updating its string value. Does not handle 'set' magic. See `sv_setpviv_mg`.

```
void    sv_setpviv(SV* sv, IV num)
```

=for hackers Found in file sv.c

sv_setpviv_mg

Like `sv_setpviv`, but also handles 'set' magic.

```
void    sv_setpviv_mg(SV *sv, IV iv)
```

=for hackers Found in file sv.c

sv_setpvn

Copies a string into an SV. The `len` parameter indicates the number of bytes to be copied. Does not handle 'set' magic. See `sv_setpvn_mg`.

```
void    sv_setpvn(SV* sv, const char* ptr, STRLEN len)
```

=for hackers Found in file sv.c

sv_setpvn_mg

Like `sv_setpvn`, but also handles 'set' magic.

```
void    sv_setpvn_mg(SV *sv, const char *ptr, STRLEN len)
```

=for hackers Found in file sv.c

sv_setpv_mg

Like `sv_setpv`, but also handles 'set' magic.

```
void    sv_setpv_mg(SV *sv, const char *ptr)
```

=for hackers Found in file sv.c

sv_setref_iv

Copies an integer into a new SV, optionally blessing the SV. The `rv` argument will be upgraded to an RV. That RV will be modified to point to the new SV. The `classname` argument indicates the package for the blessing. Set `classname` to `Nullch` to avoid the blessing. The new SV will be returned and will have a reference count of 1.

```
SV*     sv_setref_iv(SV* rv, const char* classname, IV iv)
```

=for hackers Found in file sv.c

sv_setref_nv

Copies a double into a new SV, optionally blessing the SV. The rv argument will be upgraded to an RV. That RV will be modified to point to the new SV. The classname argument indicates the package for the blessing. Set classname to Nullch to avoid the blessing. The new SV will be returned and will have a reference count of 1.

```
SV*     sv_setref_nv(SV* rv, const char* classname, NV nv)
```

=for hackers Found in file sv.c

sv_setref_pv

Copies a pointer into a new SV, optionally blessing the SV. The rv argument will be upgraded to an RV. That RV will be modified to point to the new SV. If the pv argument is NULL then PL_sv_undef will be placed into the SV. The classname argument indicates the package for the blessing. Set classname to Nullch to avoid the blessing. The new SV will be returned and will have a reference count of 1.

Do not use with other Perl types such as HV, AV, SV, CV, because those objects will become corrupted by the pointer copy process.

Note that sv_setref_pvn copies the string while this copies the pointer.

```
SV*     sv_setref_pv(SV* rv, const char* classname, void* pv)
```

=for hackers Found in file sv.c

sv_setref_pvn

Copies a string into a new SV, optionally blessing the SV. The length of the string must be specified with n. The rv argument will be upgraded to an RV. That RV will be modified to point to the new SV. The classname argument indicates the package for the blessing. Set classname to Nullch to avoid the blessing. The new SV will be returned and will have a reference count of 1.

Note that sv_setref_pv copies the pointer while this copies the string.

```
SV*     sv_setref_pvn(SV* rv, const char* classname, char* pv, STRLEN
```

=for hackers Found in file sv.c

sv_setsv Copies the contents of the source SV ssv into the destination SV dsv. The source SV may be destroyed if it is mortal. Does not handle 'set' magic. See the macro forms SvSetSV, SvSetSV_nosteal and sv_setsv_mg.

```
void    sv_setsv(SV* dsv, SV* ssv)
```

=for hackers Found in file sv.c

sv_setsv_mg

Like sv_setsv, but also handles 'set' magic.

```
void    sv_setsv_mg(SV *dstr, SV *sstr)
```

=for hackers Found in file sv.c

sv_setuv Copies an unsigned integer into the given SV. Does not handle 'set' magic. See sv_setuv_mg.

```
void    sv_setuv(SV* sv, UV num)
```

=for hackers Found in file sv.c

sv_setuv_mg

Like sv_setuv, but also handles 'set' magic.

```
void    sv_setuv_mg(SV *sv, UV u)
```

=for hackers Found in file sv.c

sv_true Returns true if the SV has a true value by Perl's rules.

```
I32     sv_true(SV *sv)
```

=for hackers Found in file sv.c

sv_unmagic

Removes magic from an SV.

```
int     sv_unmagic(SV* sv, int type)
```

=for hackers Found in file sv.c

sv_unref Unsets the RV status of the SV, and decrements the reference count of whatever was being referenced by the RV. This can almost be thought of as a reversal of newSVrv. See SvROK_off.

```
void    sv_unref(SV* sv)
```

=for hackers Found in file sv.c

sv_upgrade

Upgrade an SV to a more complex form. Use SvUPGRADE. See svtype.

```
bool    sv_upgrade(SV* sv, U32 mt)
```

=for hackers Found in file sv.c

sv_usepvn

Tells an SV to use ptr to find its string value. Normally the string is stored inside the SV but sv_usepvn allows the SV to use an outside string. The ptr should point to memory that was allocated by malloc. The string length, len, must be supplied. This function will realloc the memory pointed to by ptr, so that pointer should not be freed or used by the programmer after giving it to sv_usepvn. Does not handle 'set' magic. See sv_usepvn_mg.

```
void    sv_usepvn(SV* sv, char* ptr, STRLEN len)
```

=for hackers Found in file sv.c

sv_usepvn_mg

Like sv_usepvn, but also handles 'set' magic.

```
void    sv_usepvn_mg(SV *sv, char *ptr, STRLEN len)
```

=for hackers Found in file sv.c

sv_utf8_downgrade

Attempt to convert the PV of an SV from UTF8−encoded to byte encoding. This may not be possible if the PV contains non−byte encoding characters; if this is the case, either returns false or, if fail_ok is not true, croaks.

NOTE: this function is experimental and may change or be removed without notice.

```
bool    sv_utf8_downgrade(SV *sv, bool fail_ok)
```

=for hackers Found in file sv.c

sv_utf8_encode

Convert the PV of an SV to UTF8−encoded, but then turn off the SvUTF8 flag so that it looks like bytes again. Nothing calls this.

NOTE: this function is experimental and may change or be removed without notice.

```
void    sv_utf8_encode(SV *sv)
```

=for hackers Found in file sv.c

sv_utf8_upgrade

Convert the PV of an SV to its UTF8−encoded form.

```
void    sv_utf8_upgrade(SV *sv)
```

=for hackers Found in file sv.c

sv_vcatpvfn

Processes its arguments like vsprintf and appends the formatted output to an SV. Uses an array of SVs if the C style variable argument list is missing (NULL). When running with taint checks enabled, indicates via maybe_tainted if results are untrustworthy (often due to the use of locales).

```
void    sv_vcatpvfn(SV* sv, const char* pat, STRLEN patlen, va_list*
```

=for hackers Found in file sv.c

sv_vsetpvfn

Works like vcatpvfn but copies the text into the SV instead of appending it.

```
void    sv_vsetpvfn(SV* sv, const char* pat, STRLEN patlen, va_list*
```

=for hackers Found in file sv.c

THIS Variable which is setup by xsubpp to designate the object in a C++ XSUB. This is always the proper type for the C++ object. See CLASS and *Using XS With C++ in perlxs*.

```
(whatever)      THIS
```

=for hackers Found in file XSUB.h

toLOWER

Converts the specified character to lowercase.

```
char    toLOWER(char ch)
```

=for hackers Found in file handy.h

toUPPER Converts the specified character to uppercase.

```
char    toUPPER(char ch)
```

=for hackers Found in file handy.h

U8 *s Returns true if first len bytes of the given string form valid a UTF8 string, false otherwise.

```
is_utf8_string  U8 *s(STRLEN len)
```

=for hackers Found in file utf8.c

utf8_to_bytes

Converts a string s of length len from UTF8 into byte encoding. Unlike bytes_to_utf8, this over−writes the original string, and updates len to contain the new length. Returns zero on failure, setting len to −1.

```
U8 *    utf8_to_bytes(U8 *s, STRLEN *len)
```

=for hackers Found in file utf8.c

utf8_to_uv

Returns the character value of the first character in the string `s` which is assumed to be in UTF8 encoding and no longer than `curlen`; `retlen` will be set to the length, in bytes, of that character, and the pointer `s` will be advanced to the end of the character.

If `s` does not point to a well−formed UTF8 character, the behaviour is dependent on the value of `flags`: if it contains UTF8_CHECK_ONLY, it is assumed that the caller will raise a warning, and this function will set `retlen` to `−1` and return. The `flags` can also contain various flags to allow deviations from the strict UTF−8 encoding.

```
U8* s   utf8_to_uv(STRLEN curlen, I32 *retlen, U32 flags)
```

=for hackers Found in file utf8.c

utf8_to_uv_simple

Returns the character value of the first character in the string `s` which is assumed to be in UTF8 encoding; `retlen` will be set to the length, in bytes, of that character, and the pointer `s` will be advanced to the end of the character.

If `s` does not point to a well−formed UTF8 character, zero is returned and retlen is set, if possible, to −1.

```
U8* s   utf8_to_uv_simple(STRLEN *retlen)
```

=for hackers Found in file utf8.c

warn This is the XSUB−writer's interface to Perl's `warn` function. Use this function the same way you use the C `printf` function. See `croak`.

```
void    warn(const char* pat, ...)
```

=for hackers Found in file util.c

XPUSHi Push an integer onto the stack, extending the stack if necessary. Handles 'set' magic. See `PUSHi`.

```
void    XPUSHi(IV iv)
```

=for hackers Found in file pp.h

XPUSHn Push a double onto the stack, extending the stack if necessary. Handles 'set' magic. See `PUSHn`.

```
void    XPUSHn(NV nv)
```

=for hackers Found in file pp.h

XPUSHp Push a string onto the stack, extending the stack if necessary. The `len` indicates the length of the string. Handles 'set' magic. See `PUSHp`.

```
void    XPUSHp(char* str, STRLEN len)
```

=for hackers Found in file pp.h

XPUSHs Push an SV onto the stack, extending the stack if necessary. Does not handle 'set' magic. See `PUSHs`.

```
void    XPUSHs(SV* sv)
```

=for hackers Found in file pp.h

XPUSHu Push an unsigned integer onto the stack, extending the stack if necessary. See PUSHu.

```
void    XPUSHu(UV uv)
```

=for hackers Found in file pp.h

XS Macro to declare an XSUB and its C parameter list. This is handled by xsubpp.

=for hackers Found in file XSUB.h

XSRETURN

Return from XSUB, indicating number of items on the stack. This is usually handled by xsubpp.

```
void    XSRETURN(int nitems)
```

=for hackers Found in file XSUB.h

XSRETURN_EMPTY

Return an empty list from an XSUB immediately.

```
XSRETURN_EMPTY;
```

=for hackers Found in file XSUB.h

XSRETURN_IV

Return an integer from an XSUB immediately. Uses XST_mIV.

```
void    XSRETURN_IV(IV iv)
```

=for hackers Found in file XSUB.h

XSRETURN_NO

Return &PL_sv_no from an XSUB immediately. Uses XST_mNO.

```
XSRETURN_NO;
```

=for hackers Found in file XSUB.h

XSRETURN_NV

Return an double from an XSUB immediately. Uses XST_mNV.

```
void    XSRETURN_NV(NV nv)
```

=for hackers Found in file XSUB.h

XSRETURN_PV

Return a copy of a string from an XSUB immediately. Uses XST_mPV.

```
void    XSRETURN_PV(char* str)
```

=for hackers Found in file XSUB.h

XSRETURN_UNDEF

Return &PL_sv_undef from an XSUB immediately. Uses XST_mUNDEF.

```
XSRETURN_UNDEF;
```

=for hackers Found in file XSUB.h

XSRETURN_YES

Return &PL_sv_yes from an XSUB immediately. Uses XST_mYES.

```
XSRETURN_YES;
```

=for hackers Found in file XSUB.h

XST_mIV

Place an integer into the specified position `pos` on the stack. The value is stored in a new mortal SV.

```
void    XST_mIV(int pos, IV iv)
```

=for hackers Found in file XSUB.h

XST_mNO

Place `&PL_sv_no` into the specified position `pos` on the stack.

```
void    XST_mNO(int pos)
```

=for hackers Found in file XSUB.h

XST_mNV

Place a double into the specified position `pos` on the stack. The value is stored in a new mortal SV.

```
void    XST_mNV(int pos, NV nv)
```

=for hackers Found in file XSUB.h

XST_mPV

Place a copy of a string into the specified position `pos` on the stack. The value is stored in a new mortal SV.

```
void    XST_mPV(int pos, char* str)
```

=for hackers Found in file XSUB.h

XST_mUNDEF

Place `&PL_sv_undef` into the specified position `pos` on the stack.

```
void    XST_mUNDEF(int pos)
```

=for hackers Found in file XSUB.h

XST_mYES

Place `&PL_sv_yes` into the specified position `pos` on the stack.

```
void    XST_mYES(int pos)
```

=for hackers Found in file XSUB.h

XS_VERSION

The version identifier for an XS module. This is usually handled automatically by `ExtUtils::MakeMaker`. See `XS_VERSION_BOOTCHECK`.

=for hackers Found in file XSUB.h

XS_VERSION_BOOTCHECK

Macro to verify that a PM module's `$VERSION` variable matches the XS module's `XS_VERSION` variable. This is usually handled automatically by `xsubpp`. See *The VERSIONCHECK: Keyword in perlxs*.

```
XS_VERSION_BOOTCHECK;
```

=for hackers Found in file XSUB.h

Zero The XSUB-writer's interface to the C `memzero` function. The `dest` is the destination, `nitems` is the number of items, and `type` is the type.

```
void    Zero(void* dest, int nitems, type)
```

=for hackers Found in file handy.h

AUTHORS

Until May 1997, this document was maintained by Jeff Okamoto <okamoto@corp.hp.com. It is now maintained as part of Perl itself.

With lots of help and suggestions from Dean Roehrich, Malcolm Beattie, Andreas Koenig, Paul Hudson, Ilya Zakharevich, Paul Marquess, Neil Bowers, Matthew Green, Tim Bunce, Spider Boardman, Ulrich Pfeifer, Stephen McCamant, and Gurusamy Sarathy.

API Listing originally by Dean Roehrich <roehrich@cray.com.

Updated to be autogenerated from comments in the source by Benjamin Stuhl.

SEE ALSO

perlguts(1), perlxs(1), perlxstut(1), perlintern(1)

NAME

perlapio – perl's IO abstraction interface.

SYNOPSIS

```
PerlIO *PerlIO_stdin(void);
PerlIO *PerlIO_stdout(void);
PerlIO *PerlIO_stderr(void);

PerlIO *PerlIO_open(const char *,const char *);
int     PerlIO_close(PerlIO *);

int     PerlIO_stdoutf(const char *,...)
int     PerlIO_puts(PerlIO *,const char *);
int     PerlIO_putc(PerlIO *,int);
int     PerlIO_write(PerlIO *,const void *,size_t);
int     PerlIO_printf(PerlIO *, const char *,...);
int     PerlIO_vprintf(PerlIO *, const char *, va_list);
int     PerlIO_flush(PerlIO *);

int     PerlIO_eof(PerlIO *);
int     PerlIO_error(PerlIO *);
void    PerlIO_clearerr(PerlIO *);

int     PerlIO_getc(PerlIO *);
int     PerlIO_ungetc(PerlIO *,int);
int     PerlIO_read(PerlIO *,void *,size_t);

int     PerlIO_fileno(PerlIO *);
PerlIO *PerlIO_fdopen(int, const char *);
PerlIO *PerlIO_importFILE(FILE *, int flags);
FILE   *PerlIO_exportFILE(PerlIO *, int flags);
FILE   *PerlIO_findFILE(PerlIO *);
void    PerlIO_releaseFILE(PerlIO *,FILE *);

void    PerlIO_setlinebuf(PerlIO *);

long    PerlIO_tell(PerlIO *);
int     PerlIO_seek(PerlIO *,off_t,int);
int     PerlIO_getpos(PerlIO *,Fpos_t *)
int     PerlIO_setpos(PerlIO *,Fpos_t *)
void    PerlIO_rewind(PerlIO *);

int     PerlIO_has_base(PerlIO *);
int     PerlIO_has_cntptr(PerlIO *);
int     PerlIO_fast_gets(PerlIO *);
int     PerlIO_canset_cnt(PerlIO *);

char   *PerlIO_get_ptr(PerlIO *);
int     PerlIO_get_cnt(PerlIO *);
void    PerlIO_set_cnt(PerlIO *,int);
void    PerlIO_set_ptrcnt(PerlIO *,char *,int);
char   *PerlIO_get_base(PerlIO *);
int     PerlIO_get_bufsiz(PerlIO *);
```

DESCRIPTION

Perl's source code should use the above functions instead of those defined in ANSI C's *stdio.h*. The perl headers will `#define` them to the I/O mechanism selected at Configure time.

The functions are modeled on those in *stdio.h*, but parameter order has been "tidied up a little".

PerlIO *

This takes the place of FILE *. Like FILE * it should be treated as opaque (it is probably safe to assume it is a pointer to something).

`PerlIO_stdin()`, **`PerlIO_stdout()`**, **`PerlIO_stderr()`**

Use these rather than `stdin`, `stdout`, `stderr`. They are written to look like "function calls" rather than variables because this makes it easier to *make them* function calls if platform cannot export data to loaded modules, or if (say) different "threads" might have different values.

PerlIO_open(path, mode), **PerlIO_fdopen(fd,mode)**

These correspond to `fopen()`/`fdopen()` arguments are the same.

PerlIO_printf(f,fmt,...), **PerlIO_vprintf(f,fmt,a)**

These are `fprintf()`/`vfprintf()` equivalents.

PerlIO_stdoutf(fmt,...)

This is `printf()` equivalent. printf is #defined to this function, so it is (currently) legal to use `printf(fmt,...)` in perl sources.

PerlIO_read(f,buf,count), **PerlIO_write(f,buf,count)**

These correspond to `fread()` and `fwrite()`. Note that arguments are different, there is only one "count" and order has "file" first.

PerlIO_close(f)
PerlIO_puts(f,s), **PerlIO_putc(f,c)**

These correspond to `fputs()` and `fputc()`. Note that arguments have been revised to have "file" first.

PerlIO_ungetc(f,c)

This corresponds to `ungetc()`. Note that arguments have been revised to have "file" first.

PerlIO_getc(f)

This corresponds to `getc()`.

PerlIO_eof(f)

This corresponds to `feof()`.

PerlIO_error(f)

This corresponds to `ferror()`.

PerlIO_fileno(f)

This corresponds to `fileno()`, note that on some platforms, the meaning of "fileno" may not match Unix.

PerlIO_clearerr(f)

This corresponds to `clearerr()`, i.e., clears ‘eof’ and ‘error’ flags for the "stream".

PerlIO_flush(f)

This corresponds to `fflush()`.

PerlIO_tell(f)

This corresponds to `ftell()`.

PerlIO_seek(f,o,w)

This corresponds to `fseek()`.

PerlIO_getpos(f,p), **PerlIO_setpos(f,p)**

These correspond to `fgetpos()` and `fsetpos()`. If platform does not have the stdio calls then they are implemented in terms of `PerlIO_tell()` and `PerlIO_seek()`.

PerlIO_rewind(f)

This corresponds to `rewind()`. Note may be redefined in terms of `PerlIO_seek()` at some point.

`PerlIO_tmpfile()`

This corresponds to `tmpfile()`, i.e., returns an anonymous PerlIO which will automatically be deleted when closed.

Co−existence with stdio

There is outline support for co−existence of PerlIO with stdio. Obviously if PerlIO is implemented in terms of stdio there is no problem. However if perlio is implemented on top of (say) sfio then mechanisms must exist to create a FILE * which can be passed to library code which is going to use stdio calls.

PerlIO_importFILE(f,flags)

Used to get a PerlIO * from a FILE *. May need additional arguments, interface under review.

PerlIO_exportFILE(f,flags)

Given an PerlIO * return a 'native' FILE * suitable for passing to code expecting to be compiled and linked with ANSI C *stdio.h*.

The fact that such a FILE * has been 'exported' is recorded, and may affect future PerlIO operations on the original PerlIO *.

PerlIO_findFILE(f)

Returns previously 'exported' FILE * (if any). Place holder until interface is fully defined.

PerlIO_releaseFILE(p,f)

Calling PerlIO_releaseFILE informs PerlIO that all use of FILE * is complete. It is removed from list of 'exported' FILE *s, and associated PerlIO * should revert to original behaviour.

PerlIO_setlinebuf(f)

This corresponds to `setlinebuf()`. Use is deprecated pending further discussion. (Perl core uses it *only* when "dumping"; it has nothing to do with `$|` auto−flush.)

In addition to user API above there is an "implementation" interface which allows perl to get at internals of PerlIO. The following calls correspond to the various FILE_xxx macros determined by Configure. This section is really of interest to only those concerned with detailed perl−core behaviour or implementing a PerlIO mapping.

PerlIO_has_cntptr(f)

Implementation can return pointer to current position in the "buffer" and a count of bytes available in the buffer.

PerlIO_get_ptr(f)

Return pointer to next readable byte in buffer.

PerlIO_get_cnt(f)

Return count of readable bytes in the buffer.

PerlIO_canset_cnt(f)

Implementation can adjust its idea of number of bytes in the buffer.

PerlIO_fast_gets(f)

Implementation has all the interfaces required to allow perl's fast code to handle <FILE mechanism.

```
PerlIO_fast_gets(f) = PerlIO_has_cntptr(f) && \
                      PerlIO_canset_cnt(f) && \
                      'Can set pointer into buffer'
```

PerlIO_set_ptrcnt(f,p,c)

Set pointer into buffer, and a count of bytes still in the buffer. Should be used only to set pointer to within range implied by previous calls to `PerlIO_get_ptr` and `PerlIO_get_cnt`.

PerlIO_set_cnt(f,c)

Obscure − set count of bytes in the buffer. Deprecated. Currently used in only doio.c to force count < −1 to −1. Perhaps should be PerlIO_set_empty or similar. This call may actually do nothing if "count" is deduced from pointer and a "limit".

PerlIO_has_base(f)

Implementation has a buffer, and can return pointer to whole buffer and its size. Used by perl for **−T / −B** tests. Other uses would be very obscure...

PerlIO_get_base(f)

Return *start* of buffer.

PerlIO_get_bufsiz(f)

Return *total size* of buffer.

NAME

perlbook – Perl book information

DESCRIPTION

The Camel Book, officially known as *Programming Perl, Second Edition*, by Larry Wall et al, is the definitive reference work covering nearly all of Perl. You can order it and other Perl books from O'Reilly & Associates, 1–800–998–9938. Local/overseas is +1 707 829 0515. If you can locate an O'Reilly order form, you can also fax to +1 707 829 0104. If you're web–connected, you can even mosey on over to http://www.oreilly.com/ for an online order form.

Other Perl books from various publishers and authors can be found listed in *perlfaq2*.

NAME

perlboot – Beginner's Object–Oriented Tutorial

DESCRIPTION

If you're not familiar with objects from other languages, some of the other Perl object documentation may be a little daunting, such as *perlobj*, a basic reference in using objects, and *perltoot*, which introduces readers to the peculiarities of Perl's object system in a tutorial way.

So, let's take a different approach, presuming no prior object experience. It helps if you know about subroutines (*perlsub*), references (*perlref* et. seq.), and packages (*perlmod*), so become familiar with those first if you haven't already.

If we could talk to the animals...

Let's let the animals talk for a moment:

```
sub Cow::speak {
  print "a Cow goes moooo!\n";
}
sub Horse::speak {
  print "a Horse goes neigh!\n";
}
sub Sheep::speak {
  print "a Sheep goes baaaah!\n"
}

Cow::speak;
Horse::speak;
Sheep::speak;
```

This results in:

```
a Cow goes moooo!
a Horse goes neigh!
a Sheep goes baaaah!
```

Nothing spectacular here. Simple subroutines, albeit from separate packages, and called using the full package name. So let's create an entire pasture:

```
# Cow::speak, Horse::speak, Sheep::speak as before
@pasture = qw(Cow Cow Horse Sheep Sheep);
foreach $animal (@pasture) {
  &{$animal."::speak"};
}
```

This results in:

```
a Cow goes moooo!
a Cow goes moooo!
a Horse goes neigh!
a Sheep goes baaaah!
a Sheep goes baaaah!
```

Wow. That symbolic coderef de–referencing there is pretty nasty. We're counting on `no strict subs` mode, certainly not recommended for larger programs. And why was that necessary? Because the name of the package seems to be inseparable from the name of the subroutine we want to invoke within that package.

Or is it?

Introducing the method invocation arrow

For now, let's say that `< Class->method` invokes subroutine `method` in package `Class`. (Here, "Class" is used in its "category" meaning, not its "scholastic" meaning.) That's not completely accurate, but we'll do this one step at a time. Now let's use it like so:

```
# Cow::speak, Horse::speak, Sheep::speak as before
Cow->speak;
Horse->speak;
Sheep->speak;
```

And once again, this results in:

```
a Cow goes moooo!
a Horse goes neigh!
a Sheep goes baaaah!
```

That's not fun yet. Same number of characters, all constant, no variables. But yet, the parts are separable now. Watch:

```
$a = "Cow";
$a->speak; # invokes Cow->speak
```

Ahh! Now that the package name has been parted from the subroutine name, we can use a variable package name. And this time, we've got something that works even when `use strict refs` is enabled.

Invoking a barnyard

Let's take that new arrow invocation and put it back in the barnyard example:

```
sub Cow::speak {
  print "a Cow goes moooo!\n";
}
sub Horse::speak {
  print "a Horse goes neigh!\n";
}
sub Sheep::speak {
  print "a Sheep goes baaaah!\n"
}

@pasture = qw(Cow Cow Horse Sheep Sheep);
foreach $animal (@pasture) {
  $animal->speak;
}
```

There! Now we have the animals all talking, and safely at that, without the use of symbolic coderefs.

But look at all that common code. Each of the `speak` routines has a similar structure: a `print` operator and a string that contains common text, except for two of the words. It'd be nice if we could factor out the commonality, in case we decide later to change it all to `says` instead of `goes`.

And we actually have a way of doing that without much fuss, but we have to hear a bit more about what the method invocation arrow is actually doing for us.

The extra parameter of method invocation

The invocation of:

```
Class->method(@args)
```

attempts to invoke subroutine `Class::method` as:

```
Class::method("Class", @args);
```

(If the subroutine can't be found, "inheritance" kicks in, but we'll get to that later.) This means that we get the class name as the first parameter (the only parameter, if no arguments are given). So we can rewrite the `Sheep` speaking subroutine as:

```
sub Sheep::speak {
  my $class = shift;
  print "a $class goes baaaah!\n";
}
```

And the other two animals come out similarly:

```
sub Cow::speak {
  my $class = shift;
  print "a $class goes moooo!\n";
}
sub Horse::speak {
  my $class = shift;
  print "a $class goes neigh!\n";
}
```

In each case, `$class` will get the value appropriate for that subroutine. But once again, we have a lot of similar structure. Can we factor that out even further? Yes, by calling another method in the same class.

Calling a second method to simplify things

Let's call out from `speak` to a helper method called `sound`. This method provides the constant text for the sound itself.

```
{ package Cow;
  sub sound { "moooo" }
  sub speak {
    my $class = shift;
    print "a $class goes ", $class->sound, "!\n"
  }
}
```

Now, when we call `< Cow-speak >`, we get a `$class` of `Cow` in `speak`. This in turn selects the `< Cow-sound >` method, which returns `moooo`. But how different would this be for the `Horse`?

```
{ package Horse;
  sub sound { "neigh" }
  sub speak {
    my $class = shift;
    print "a $class goes ", $class->sound, "!\n"
  }
}
```

Only the name of the package and the specific sound change. So can we somehow share the definition for `speak` between the Cow and the Horse? Yes, with inheritance!

Inheriting the windpipes

We'll define a common subroutine package called `Animal`, with the definition for `speak`:

```
{ package Animal;
  sub speak {
    my $class = shift;
    print "a $class goes ", $class->sound, "!\n"
  }
}
```

Then, for each animal, we say it "inherits" from `Animal`, along with the animal-specific sound:

```
{ package Cow;
  @ISA = qw(Animal);
  sub sound { "moooo" }
}
```

Note the added `@ISA` array. We'll get to that in a minute.

But what happens when we invoke `< Cow-speak` now?

First, Perl constructs the argument list. In this case, it's just `Cow`. Then Perl looks for `Cow::speak`. But that's not there, so Perl checks for the inheritance array `@Cow::ISA`. It's there, and contains the single name `Animal`.

Perl next checks for `speak` inside `Animal` instead, as in `Animal::speak`. And that's found, so Perl invokes that subroutine with the already frozen argument list.

Inside the `Animal::speak` subroutine, `$class` becomes `Cow` (the first argument). So when we get to the step of invoking `< $class-sound` , it'll be looking for `< Cow-sound` , which gets it on the first try without looking at `@ISA`. Success!

A few notes about @ISA

This magical `@ISA` variable (pronounced "is a" not "ice-uh"), has declared that `Cow` "is a" `Animal`. Note that it's an array, not a simple single value, because on rare occasions, it makes sense to have more than one parent class searched for the missing methods.

If `Animal` also had an `@ISA`, then we'd check there too. The search is recursive, depth-first, left-to-right in each `@ISA`. Typically, each `@ISA` has only one element (multiple elements means multiple inheritance and multiple headaches), so we get a nice tree of inheritance.

When we turn on `use strict`, we'll get complaints on `@ISA`, since it's not a variable containing an explicit package name, nor is it a lexical ("my") variable. We can't make it a lexical variable though (it has to belong to the package to be found by the inheritance mechanism), so there's a couple of straightforward ways to handle that.

The easiest is to just spell the package name out:

```
@Cow::ISA = qw(Animal);
```

Or allow it as an implicitly named package variable:

```
package Cow;
use vars qw(@ISA);
@ISA = qw(Animal);
```

If you're bringing in the class from outside, via an object-oriented module, you change:

```
package Cow;
use Animal;
use vars qw(@ISA);
@ISA = qw(Animal);
```

into just:

```
package Cow;
use base qw(Animal);
```

And that's pretty darn compact.

Overriding the methods

Let's add a mouse, which can barely be heard:

```
# Animal package from before
{ package Mouse;
  @ISA = qw(Animal);
```

```
  sub sound { "squeak" }
  sub speak {
    my $class = shift;
    print "a $class goes ", $class->sound, "!\n";
    print "[but you can barely hear it!]\n";
  }
}

Mouse->speak;
```

which results in:

```
a Mouse goes squeak!
[but you can barely hear it!]
```

Here, `Mouse` has its own speaking routine, so `Mouse->speak` doesn't immediately invoke `Animal->speak`. This is known as "overriding". In fact, we didn't even need to say that a `Mouse` was an `Animal` at all, since all of the methods needed for `speak` are completely defined with `Mouse`.

But we've now duplicated some of the code from `Animal->speak`, and this can once again be a maintenance headache. So, can we avoid that? Can we say somehow that a `Mouse` does everything any other `Animal` does, but add in the extra comment? Sure!

First, we can invoke the `Animal::speak` method directly:

```
# Animal package from before
{ package Mouse;
  @ISA = qw(Animal);
  sub sound { "squeak" }
  sub speak {
    my $class = shift;
    Animal::speak($class);
    print "[but you can barely hear it!]\n";
  }
}
```

Note that we have to include the `$class` parameter (almost surely the value of `"Mouse"`) as the first parameter to `Animal::speak`, since we've stopped using the method arrow. Why did we stop? Well, if we invoke `Animal->speak` there, the first parameter to the method will be `"Animal"` not `"Mouse"`, and when time comes for it to call for the `sound`, it won't have the right class to come back to this package.

Invoking `Animal::speak` directly is a mess, however. What if `Animal::speak` didn't exist before, and was being inherited from a class mentioned in `@Animal::ISA`? Because we are no longer using the method arrow, we get one and only one chance to hit the right subroutine.

Also note that the `Animal` classname is now hardwired into the subroutine selection. This is a mess if someone maintains the code, changing `@ISA` for <Mouse and didn't notice `Animal` there in `speak`. So, this is probably not the right way to go.

Starting the search from a different place

A better solution is to tell Perl to search from a higher place in the inheritance chain:

```
# same Animal as before
{ package Mouse;
  # same @ISA, &sound as before
  sub speak {
    my $class = shift;
    $class->Animal::speak;
    print "[but you can barely hear it!]\n";
  }
```

```
}
```

Ahh. This works. Using this syntax, we start with `Animal` to find `speak`, and use all of `Animal`'s inheritance chain if not found immediately. And yet the first parameter will be `$class`, so the found `speak` method will get `Mouse` as its first entry, and eventually work its way back to `Mouse::sound` for the details.

But this isn't the best solution. We still have to keep the `@ISA` and the initial search package coordinated. Worse, if `Mouse` had multiple entries in `@ISA`, we wouldn't necessarily know which one had actually defined `speak`. So, is there an even better way?

The SUPER way of doing things

By changing the `Animal` class to the `SUPER` class in that invocation, we get a search of all of our super classes (classes listed in `@ISA`) automatically:

```
# same Animal as before
{ package Mouse;
  # same @ISA, &sound as before
  sub speak {
    my $class = shift;
    $class->SUPER::speak;
    print "[but you can barely hear it!]\n";
  }
}
```

So, `SUPER::speak` means look in the current package's `@ISA` for `speak`, invoking the first one found.

Where we're at so far...

So far, we've seen the method arrow syntax:

```
Class->method(@args);
```

or the equivalent:

```
$a = "Class";
$a->method(@args);
```

which constructs an argument list of:

```
("Class", @args)
```

and attempts to invoke

```
Class::method("Class", @Args);
```

However, if `Class::method` is not found, then `@Class::ISA` is examined (recursively) to locate a package that does indeed contain `method`, and that subroutine is invoked instead.

Using this simple syntax, we have class methods, (multiple) inheritance, overriding, and extending. Using just what we've seen so far, we've been able to factor out common code, and provide a nice way to reuse implementations with variations. This is at the core of what objects provide, but objects also provide instance data, which we haven't even begun to cover.

A horse is a horse, of course of course — or is it?

Let's start with the code for the `Animal` class and the `Horse` class:

```
{ package Animal;
  sub speak {
    my $class = shift;
    print "a $class goes ", $class->sound, "!\n"
  }
}
```

```
{ package Horse;
  @ISA = qw(Animal);
  sub sound { "neigh" }
}
```

This lets us invoke `Horse->speak` to ripple upward to `Animal::speak`, calling back to `Horse::sound` to get the specific sound, and the output of:

```
a Horse goes neigh!
```

But all of our Horse objects would have to be absolutely identical. If I add a subroutine, all horses automatically share it. That's great for making horses the same, but how do we capture the distinctions about an individual horse? For example, suppose I want to give my first horse a name. There's got to be a way to keep its name separate from the other horses.

We can do that by drawing a new distinction, called an "instance". An "instance" is generally created by a class. In Perl, any reference can be an instance, so let's start with the simplest reference that can hold a horse's name: a scalar reference.

```
my $name = "Mr. Ed";
my $talking = \$name;
```

So now `$talking` is a reference to what will be the instance-specific data (the name). The final step in turning this into a real instance is with a special operator called `bless`:

```
bless $talking, Horse;
```

This operator stores information about the package named `Horse` into the thing pointed at by the reference. At this point, we say `$talking` is an instance of `Horse`. That is, it's a specific horse. The reference is otherwise unchanged, and can still be used with traditional dereferencing operators.

Invoking an instance method

The method arrow can be used on instances, as well as names of packages (classes). So, let's get the sound that `$talking` makes:

```
my $noise = $talking->sound;
```

To invoke `sound`, Perl first notes that `$talking` is a blessed reference (and thus an instance). It then constructs an argument list, in this case from just `($talking)`. (Later we'll see that arguments will take their place following the instance variable, just like with classes.)

Now for the fun part: Perl takes the class in which the instance was blessed, in this case `Horse`, and uses that to locate the subroutine to invoke the method. In this case, `Horse::sound` is found directly (without using inheritance), yielding the final subroutine invocation:

```
Horse::sound($talking)
```

Note that the first parameter here is still the instance, not the name of the class as before. We'll get `neigh` as the return value, and that'll end up as the `$noise` variable above.

If Horse::sound had not been found, we'd be wandering up the `@Horse::ISA` list to try to find the method in one of the superclasses, just as for a class method. The only difference between a class method and an instance method is whether the first parameter is an instance (a blessed reference) or a class name (a string).

Accessing the instance data

Because we get the instance as the first parameter, we can now access the instance-specific data. In this case, let's add a way to get at the name:

```
{ package Horse;
  @ISA = qw(Animal);
  sub sound { "neigh" }
  sub name {
    my $self = shift;
```

```
    $$self;
  }
}
```

Now we call for the name:

```
print $talking->name, " says ", $talking->sound, "\n";
```

Inside `Horse::name`, the `@_` array contains just `$talking`, which the `shift` stores into `$self`. (It's traditional to shift the first parameter off into a variable named `$self` for instance methods, so stay with that unless you have strong reasons otherwise.) Then, `$self` gets de-referenced as a scalar ref, yielding `Mr. Ed`, and we're done with that. The result is:

```
Mr. Ed says neigh.
```

How to build a horse

Of course, if we constructed all of our horses by hand, we'd most likely make mistakes from time to time. We're also violating one of the properties of object-oriented programming, in that the "inside guts" of a Horse are visible. That's good if you're a veterinarian, but not if you just like to own horses. So, let's let the Horse class build a new horse:

```
{ package Horse;
  @ISA = qw(Animal);
  sub sound { "neigh" }
  sub name {
    my $self = shift;
    $$self;
  }
  sub named {
    my $class = shift;
    my $name = shift;
    bless \$name, $class;
  }
}
```

Now with the new `named` method, we can build a horse:

```
my $talking = Horse->named("Mr. Ed");
```

Notice we're back to a class method, so the two arguments to `Horse::named` are `Horse` and `Mr. Ed`. The `bless` operator not only blesses `$name`, it also returns the reference to `$name`, so that's fine as a return value. And that's how to build a horse.

We've called the constructor `named` here, so that it quickly denotes the constructor's argument as the name for this particular `Horse`. You can use different constructors with different names for different ways of "giving birth" to the object (like maybe recording its pedigree or date of birth). However, you'll find that most people coming to Perl from more limited languages use a single constructor named `new`, with various ways of interpreting the arguments to `new`. Either style is fine, as long as you document your particular way of giving birth to an object. (And you *were* going to do that, right?)

Inheriting the constructor

But was there anything specific to `Horse` in that method? No. Therefore, it's also the same recipe for building anything else that inherited from `Animal`, so let's put it there:

```
{ package Animal;
  sub speak {
    my $class = shift;
    print "a $class goes ", $class->sound, "!\n"
  }
  sub name {
```

```
    my $self = shift;
    $$self;
  }
  sub named {
    my $class = shift;
    my $name = shift;
    bless \$name, $class;
  }
}
{ package Horse;
  @ISA = qw(Animal);
  sub sound { "neigh" }
}
```

Ahh, but what happens if we invoke speak on an instance?

```
my $talking = Horse->named("Mr. Ed");
$talking->speak;
```

We get a debugging value:

```
a Horse=SCALAR(0xaca42ac) goes neigh!
```

Why? Because the Animal::speak routine is expecting a classname as its first parameter, not an instance. When the instance is passed in, we'll end up using a blessed scalar reference as a string, and that shows up as we saw it just now.

Making a method work with either classes or instances

All we need is for a method to detect if it is being called on a class or called on an instance. The most straightforward way is with the ref operator. This returns a string (the classname) when used on a blessed reference, and undef when used on a string (like a classname). Let's modify the name method first to notice the change:

```
sub name {
  my $either = shift;
  ref $either
    ? $$either # it's an instance, return name
    : "an unnamed $either"; # it's a class, return generic
}
```

Here, the ?: operator comes in handy to select either the dereference or a derived string. Now we can use this with either an instance or a class. Note that I've changed the first parameter holder to $either to show that this is intended:

```
my $talking = Horse->named("Mr. Ed");
print Horse->name, "\n"; # prints "an unnamed Horse\n"
print $talking->name, "\n"; # prints "Mr Ed.\n"
```

and now we'll fix speak to use this:

```
sub speak {
  my $either = shift;
  print $either->name, " goes ", $either->sound, "\n";
}
```

And since sound already worked with either a class or an instance, we're done!

Adding parameters to a method

Let's train our animals to eat:

```
{ package Animal;
```

```
    sub named {
      my $class = shift;
      my $name = shift;
      bless \$name, $class;
    }
    sub name {
      my $either = shift;
      ref $either
        ? $$either # it's an instance, return name
        : "an unnamed $either"; # it's a class, return generic
    }
    sub speak {
      my $either = shift;
      print $either->name, " goes ", $either->sound, "\n";
    }
    sub eat {
      my $either = shift;
      my $food = shift;
      print $either->name, " eats $food.\n";
    }
  }
  { package Horse;
    @ISA = qw(Animal);
    sub sound { "neigh" }
  }
  { package Sheep;
    @ISA = qw(Animal);
    sub sound { "baaaah" }
  }
```

And now try it out:

```
my $talking = Horse->named("Mr. Ed");
$talking->eat("hay");
Sheep->eat("grass");
```

which prints:

```
Mr. Ed eats hay.
an unnamed Sheep eats grass.
```

An instance method with parameters gets invoked with the instance, and then the list of parameters. So that first invocation is like:

```
Animal::eat($talking, "hay");
```

More interesting instances

What if an instance needs more data? Most interesting instances are made of many items, each of which can in turn be a reference or even another object. The easiest way to store these is often in a hash. The keys of the hash serve as the names of parts of the object (often called "instance variables" or "member variables"), and the corresponding values are, well, the values.

But how do we turn the horse into a hash? Recall that an object was any blessed reference. We can just as easily make it a blessed hash reference as a blessed scalar reference, as long as everything that looks at the reference is changed accordingly.

Let‘s make a sheep that has a name and a color:

```
my $bad = bless { Name => "Evil", Color => "black" }, Sheep;
```

so `< $bad->{Name} >` has `Evil`, and `< $bad->{Color} >` has `black`. But we want to make `< $bad->name >` access the name, and that's now messed up because it's expecting a scalar reference. Not to worry, because that's pretty easy to fix up:

```
## in Animal
sub name {
  my $either = shift;
  ref $either ?
    $either->{Name} :
    "an unnamed $either";
}
```

And of course `named` still builds a scalar sheep, so let's fix that as well:

```
## in Animal
sub named {
  my $class = shift;
  my $name = shift;
  my $self = { Name => $name, Color => $class->default_color };
  bless $self, $class;
}
```

What's this `default_color`? Well, if `named` has only the name, we still need to set a color, so we'll have a class-specific initial color. For a sheep, we might define it as white:

```
## in Sheep
sub default_color { "white" }
```

And then to keep from having to define one for each additional class, we'll define a "backstop" method that serves as the "default default", directly in `Animal`:

```
## in Animal
sub default_color { "brown" }
```

Now, because `name` and `named` were the only methods that referenced the "structure" of the object, the rest of the methods can remain the same, so `speak` still works as before.

A horse of a different color

But having all our horses be brown would be boring. So let's add a method or two to get and set the color.

```
## in Animal
sub color {
  $_[0]->{Color}
}
sub set_color {
  $_[0]->{Color} = $_[1];
}
```

Note the alternate way of accessing the arguments: `$_[0]` is used in-place, rather than with a `shift`. (This saves us a bit of time for something that may be invoked frequently.) And now we can fix that color for Mr. Ed:

```
my $talking = Horse->named("Mr. Ed");
$talking->set_color("black-and-white");
print $talking->name, " is colored ", $talking->color, "\n";
```

which results in:

```
Mr. Ed is colored black-and-white
```

Summary

So, now we have class methods, constructors, instance methods, instance data, and even accessors. But that's still just the beginning of what Perl has to offer. We haven't even begun to talk about accessors that double as getters and setters, destructors, indirect object notation, subclasses that add instance data, per−class data, overloading, "isa" and "can" tests, `UNIVERSAL` class, and so on. That's for the rest of the Perl documentation to cover. Hopefully, this gets you started, though.

SEE ALSO

For more information, see *perlobj* (for all the gritty details about Perl objects, now that you've seen the basics), *perltoot* (the tutorial for those who already know objects), *perlbot* (for some more tricks), and books such as Damian Conway's excellent *Object Oriented Perl*.

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NAME

perlbot – Bag‘o Object Tricks (the BOT)

DESCRIPTION

The following collection of tricks and hints is intended to whet curious appetites about such things as the use of instance variables and the mechanics of object and class relationships. The reader is encouraged to consult relevant textbooks for discussion of Object Oriented definitions and methodology. This is not intended as a tutorial for object–oriented programming or as a comprehensive guide to Perl‘s object oriented features, nor should it be construed as a style guide.

The Perl motto still holds: There‘s more than one way to do it.

OO SCALING TIPS

1 Do not attempt to verify the type of `$self`. That‘ll break if the class is inherited, when the type of `$self` is valid but its package isn‘t what you expect. See rule 5.

2 If an object–oriented (OO) or indirect–object (IO) syntax was used, then the object is probably the correct type and there‘s no need to become paranoid about it. Perl isn‘t a paranoid language anyway. If people subvert the OO or IO syntax then they probably know what they‘re doing and you should let them do it. See rule 1.

3 Use the two–argument form of `bless()`. Let a subclass use your constructor. See *INHERITING A CONSTRUCTOR*.

4 The subclass is allowed to know things about its immediate superclass, the superclass is allowed to know nothing about a subclass.

5 Don‘t be trigger happy with inheritance. A "using", "containing", or "delegation" relationship (some sort of aggregation, at least) is often more appropriate. See *OBJECT RELATIONSHIPS*, *USING RELATIONSHIP WITH SDBM*, and *"DELEGATION"*.

6 The object is the namespace. Make package globals accessible via the object. This will remove the guess work about the symbol‘s home package. See *CLASS CONTEXT AND THE OBJECT*.

7 IO syntax is certainly less noisy, but it is also prone to ambiguities that can cause difficult–to–find bugs. Allow people to use the sure–thing OO syntax, even if you don‘t like it.

8 Do not use function–call syntax on a method. You‘re going to be bitten someday. Someone might move that method into a superclass and your code will be broken. On top of that you‘re feeding the paranoia in rule 2.

9 Don‘t assume you know the home package of a method. You‘re making it difficult for someone to override that method. See *THINKING OF CODE REUSE*.

INSTANCE VARIABLES

An anonymous array or anonymous hash can be used to hold instance variables. Named parameters are also demonstrated.

```
package Foo;

sub new {
        my $type = shift;
        my %params = @_;
        my $self = {};
        $self->{'High'} = $params{'High'};
        $self->{'Low'}  = $params{'Low'};
        bless $self, $type;
}

package Bar;
```

```
sub new {
        my $type = shift;
        my %params = @_;
        my $self = [];
        $self->[0] = $params{'Left'};
        $self->[1] = $params{'Right'};
        bless $self, $type;
}

package main;

$a = Foo->new( 'High' => 42, 'Low' => 11 );
print "High=$a->{'High'}\n";
print "Low=$a->{'Low'}\n";

$b = Bar->new( 'Left' => 78, 'Right' => 40 );
print "Left=$b->[0]\n";
print "Right=$b->[1]\n";
```

SCALAR INSTANCE VARIABLES

An anonymous scalar can be used when only one instance variable is needed.

```
package Foo;

sub new {
        my $type = shift;
        my $self;
        $self = shift;
        bless \$self, $type;
}

package main;

$a = Foo->new( 42 );
print "a=$$a\n";
```

INSTANCE VARIABLE INHERITANCE

This example demonstrates how one might inherit instance variables from a superclass for inclusion in the new class. This requires calling the superclass's constructor and adding one's own instance variables to the new object.

```
package Bar;

sub new {
        my $type = shift;
        my $self = {};
        $self->{'buz'} = 42;
        bless $self, $type;
}

package Foo;
@ISA = qw( Bar );

sub new {
        my $type = shift;
        my $self = Bar->new;
        $self->{'biz'} = 11;
        bless $self, $type;
}

package main;
```

```
$a = Foo->new;
print "buz = ", $a->{'buz'}, "\n";
print "biz = ", $a->{'biz'}, "\n";
```

OBJECT RELATIONSHIPS

The following demonstrates how one might implement "containing" and "using" relationships between objects.

```
package Bar;

sub new {
        my $type = shift;
        my $self = {};
        $self->{'buz'} = 42;
        bless $self, $type;
}

package Foo;

sub new {
        my $type = shift;
        my $self = {};
        $self->{'Bar'} = Bar->new;
        $self->{'biz'} = 11;
        bless $self, $type;
}

package main;

$a = Foo->new;
print "buz = ", $a->{'Bar'}->{'buz'}, "\n";
print "biz = ", $a->{'biz'}, "\n";
```

OVERRIDING SUPERCLASS METHODS

The following example demonstrates how to override a superclass method and then call the overridden method. The **SUPER** pseudo−class allows the programmer to call an overridden superclass method without actually knowing where that method is defined.

```
package Buz;
sub goo { print "here's the goo\n" }

package Bar; @ISA = qw( Buz );
sub google { print "google here\n" }

package Baz;
sub mumble { print "mumbling\n" }

package Foo;
@ISA = qw( Bar Baz );

sub new {
        my $type = shift;
        bless [], $type;
}
sub grr { print "grumble\n" }
sub goo {
        my $self = shift;
        $self->SUPER::goo();
}
sub mumble {
        my $self = shift;
```

```
        $self->SUPER::mumble();
}
sub google {
        my $self = shift;
        $self->SUPER::google();
}

package main;

$foo = Foo->new;
$foo->mumble;
$foo->grr;
$foo->goo;
$foo->google;
```

USING RELATIONSHIP WITH SDBM

This example demonstrates an interface for the SDBM class. This creates a "using" relationship between the SDBM class and the new class Mydbm.

```
package Mydbm;

require SDBM_File;
require Tie::Hash;
@ISA = qw( Tie::Hash );

sub TIEHASH {
    my $type = shift;
    my $ref  = SDBM_File->new(@_);
    bless {'dbm' => $ref}, $type;
}
sub FETCH {
    my $self = shift;
    my $ref  = $self->{'dbm'};
    $ref->FETCH(@_);
}
sub STORE {
    my $self = shift;
    if (defined $_[0]){
        my $ref = $self->{'dbm'};
        $ref->STORE(@_);
    } else {
        die "Cannot STORE an undefined key in Mydbm\n";
    }
}

package main;
use Fcntl qw( O_RDWR O_CREAT );

tie %foo, "Mydbm", "Sdbm", O_RDWR|O_CREAT, 0640;
$foo{'bar'} = 123;
print "foo-bar = $foo{'bar'}\n";

tie %bar, "Mydbm", "Sdbm2", O_RDWR|O_CREAT, 0640;
$bar{'Cathy'} = 456;
print "bar-Cathy = $bar{'Cathy'}\n";
```

THINKING OF CODE REUSE

One strength of Object−Oriented languages is the ease with which old code can use new code. The following examples will demonstrate first how one can hinder code reuse and then how one can promote code reuse.

This first example illustrates a class which uses a fully−qualified method call to access the "private" method `BAZ()`. The second example will show that it is impossible to override the `BAZ()` method.

```
package FOO;

sub new {
        my $type = shift;
        bless {}, $type;
}
sub bar {
        my $self = shift;
        $self->FOO::private::BAZ;
}

package FOO::private;

sub BAZ {
        print "in BAZ\n";
}

package main;

$a = FOO->new;
$a->bar;
```

Now we try to override the `BAZ()` method. We would like `FOO::bar()` to call `GOOP::BAZ()`, but this cannot happen because `FOO::bar()` explicitly calls `FOO::private::BAZ()`.

```
package FOO;

sub new {
        my $type = shift;
        bless {}, $type;
}
sub bar {
        my $self = shift;
        $self->FOO::private::BAZ;
}

package FOO::private;

sub BAZ {
        print "in BAZ\n";
}

package GOOP;
@ISA = qw( FOO );
sub new {
        my $type = shift;
        bless {}, $type;
}

sub BAZ {
        print "in GOOP::BAZ\n";
}
```

```
package main;

$a = GOOP->new;
$a->bar;
```

To create reusable code we must modify class FOO, flattening class FOO::private. The next example shows a reusable class FOO which allows the method `GOOP::BAZ()` to be used in place of `FOO::BAZ()`.

```
package FOO;

sub new {
        my $type = shift;
        bless {}, $type;
}
sub bar {
        my $self = shift;
        $self->BAZ;
}

sub BAZ {
        print "in BAZ\n";
}

package GOOP;
@ISA = qw( FOO );

sub new {
        my $type = shift;
        bless {}, $type;
}
sub BAZ {
        print "in GOOP::BAZ\n";
}

package main;

$a = GOOP->new;
$a->bar;
```

CLASS CONTEXT AND THE OBJECT

Use the object to solve package and class context problems. Everything a method needs should be available via the object or should be passed as a parameter to the method.

A class will sometimes have static or global data to be used by the methods. A subclass may want to override that data and replace it with new data. When this happens the superclass may not know how to find the new copy of the data.

This problem can be solved by using the object to define the context of the method. Let the method look in the object for a reference to the data. The alternative is to force the method to go hunting for the data ("Is it in my class, or in a subclass? Which subclass?"), and this can be inconvenient and will lead to hackery. It is better just to let the object tell the method where that data is located.

```
package Bar;

%fizzle = ( 'Password' => 'XYZZY' );

sub new {
        my $type = shift;
        my $self = {};
        $self->{'fizzle'} = \%fizzle;
        bless $self, $type;
}
```

```
sub enter {
        my $self = shift;

        # Don't try to guess if we should use %Bar::fizzle
        # or %Foo::fizzle.  The object already knows which
        # we should use, so just ask it.
        #
        my $fizzle = $self->{'fizzle'};

        print "The word is ", $fizzle->{'Password'}, "\n";
}

package Foo;
@ISA = qw( Bar );

%fizzle = ( 'Password' => 'Rumple' );

sub new {
        my $type = shift;
        my $self = Bar->new;
        $self->{'fizzle'} = \%fizzle;
        bless $self, $type;
}

package main;

$a = Bar->new;
$b = Foo->new;
$a->enter;
$b->enter;
```

INHERITING A CONSTRUCTOR

An inheritable constructor should use the second form of `bless()` which allows blessing directly into a specified class. Notice in this example that the object will be a BAR not a FOO, even though the constructor is in class FOO.

```
package FOO;

sub new {
        my $type = shift;
        my $self = {};
        bless $self, $type;
}

sub baz {
        print "in FOO::baz()\n";
}

package BAR;
@ISA = qw(FOO);

sub baz {
        print "in BAR::baz()\n";
}

package main;

$a = BAR->new;
$a->baz;
```

DELEGATION

Some classes, such as SDBM_File, cannot be effectively subclassed because they create foreign objects. Such a class can be extended with some sort of aggregation technique such as the "using" relationship mentioned earlier or by delegation.

The following example demonstrates delegation using an `AUTOLOAD()` function to perform message−forwarding. This will allow the Mydbm object to behave exactly like an SDBM_File object. The Mydbm class could now extend the behavior by adding custom `FETCH()` and `STORE()` methods, if this is desired.

```
package Mydbm;

require SDBM_File;
require Tie::Hash;
@ISA = qw(Tie::Hash);

sub TIEHASH {
        my $type = shift;
        my $ref = SDBM_File->new(@_);
        bless {'delegate' => $ref};
}

sub AUTOLOAD {
        my $self = shift;

        # The Perl interpreter places the name of the
        # message in a variable called $AUTOLOAD.

        # DESTROY messages should never be propagated.
        return if $AUTOLOAD =~ /::DESTROY$/;

        # Remove the package name.
        $AUTOLOAD =~ s/^Mydbm::://;

        # Pass the message to the delegate.
        $self->{'delegate'}->$AUTOLOAD(@_);
}

package main;
use Fcntl qw( O_RDWR O_CREAT );

tie %foo, "Mydbm", "adbm", O_RDWR|O_CREAT, 0640;
$foo{'bar'} = 123;
print "foo-bar = $foo{'bar'}\n";
```

NAME

perlcall – Perl calling conventions from C

DESCRIPTION

The purpose of this document is to show you how to call Perl subroutines directly from C, i.e., how to write *callbacks*.

Apart from discussing the C interface provided by Perl for writing callbacks the document uses a series of examples to show how the interface actually works in practice. In addition some techniques for coding callbacks are covered.

Examples where callbacks are necessary include

- An Error Handler

  You have created an XSUB interface to an application's C API.

  A fairly common feature in applications is to allow you to define a C function that will be called whenever something nasty occurs. What we would like is to be able to specify a Perl subroutine that will be called instead.

- An Event Driven Program

  The classic example of where callbacks are used is when writing an event driven program like for an X windows application. In this case you register functions to be called whenever specific events occur, e.g., a mouse button is pressed, the cursor moves into a window or a menu item is selected.

Although the techniques described here are applicable when embedding Perl in a C program, this is not the primary goal of this document. There are other details that must be considered and are specific to embedding Perl. For details on embedding Perl in C refer to *perlembed*.

Before you launch yourself head first into the rest of this document, it would be a good idea to have read the following two documents – *perlxs* and *perlguts*.

THE CALL_ FUNCTIONS

Although this stuff is easier to explain using examples, you first need be aware of a few important definitions.

Perl has a number of C functions that allow you to call Perl subroutines. They are

```
I32 call_sv(SV* sv, I32 flags) ;
I32 call_pv(char *subname, I32 flags) ;
I32 call_method(char *methname, I32 flags) ;
I32 call_argv(char *subname, I32 flags, register char **argv) ;
```

The key function is *call_sv*. All the other functions are fairly simple wrappers which make it easier to call Perl subroutines in special cases. At the end of the day they will all call *call_sv* to invoke the Perl subroutine.

All the *call_** functions have a `flags` parameter which is used to pass a bit mask of options to Perl. This bit mask operates identically for each of the functions. The settings available in the bit mask are discussed in *FLAG VALUES*.

Each of the functions will now be discussed in turn.

call_sv

call_sv takes two parameters, the first, `sv`, is an SV*. This allows you to specify the Perl subroutine to be called either as a C string (which has first been converted to an SV) or a reference to a subroutine. The section, *Using call_sv*, shows how you can make use of *call_sv*.

call_pv

The function, *call_pv*, is similar to *call_sv* except it expects its first parameter to be a C char* which identifies the Perl subroutine you want to call, e.g., `call_pv("fred", 0)`. If the subroutine you

want to call is in another package, just include the package name in the string, e.g., `"pkg::fred"`.

call_method

The function *call_method* is used to call a method from a Perl class. The parameter `methname` corresponds to the name of the method to be called. Note that the class that the method belongs to is passed on the Perl stack rather than in the parameter list. This class can be either the name of the class (for a static method) or a reference to an object (for a virtual method). See *perlobj* for more information on static and virtual methods and *Using call_method* for an example of using *call_method*.

call_argv

call_argv calls the Perl subroutine specified by the C string stored in the `subname` parameter. It also takes the usual `flags` parameter. The final parameter, `argv`, consists of a NULL terminated list of C strings to be passed as parameters to the Perl subroutine. See *Using call_argv*.

All the functions return an integer. This is a count of the number of items returned by the Perl subroutine. The actual items returned by the subroutine are stored on the Perl stack.

As a general rule you should *always* check the return value from these functions. Even if you are expecting only a particular number of values to be returned from the Perl subroutine, there is nothing to stop someone from doing something unexpected—don't say you haven't been warned.

FLAG VALUES

The `flags` parameter in all the *call_** functions is a bit mask which can consist of any combination of the symbols defined below, OR'ed together.

G_VOID

Calls the Perl subroutine in a void context.

This flag has 2 effects:

1. It indicates to the subroutine being called that it is executing in a void context (if it executes *wantarray* the result will be the undefined value).

2. It ensures that nothing is actually returned from the subroutine.

The value returned by the *call_** function indicates how many items have been returned by the Perl subroutine – in this case it will be 0.

G_SCALAR

Calls the Perl subroutine in a scalar context. This is the default context flag setting for all the *call_** functions.

This flag has 2 effects:

1. It indicates to the subroutine being called that it is executing in a scalar context (if it executes *wantarray* the result will be false).

2. It ensures that only a scalar is actually returned from the subroutine. The subroutine can, of course, ignore the *wantarray* and return a list anyway. If so, then only the last element of the list will be returned.

The value returned by the *call_** function indicates how many items have been returned by the Perl subroutine – in this case it will be either 0 or 1.

If 0, then you have specified the G_DISCARD flag.

If 1, then the item actually returned by the Perl subroutine will be stored on the Perl stack – the section *Returning a Scalar* shows how to access this value on the stack. Remember that regardless of how many items the Perl subroutine returns, only the last one will be accessible from the stack – think of the case where only one value is returned as being a list with only one element. Any other items that were returned will not exist by the time control returns from the *call_** function. The section *Returning a list in a scalar context*

shows an example of this behavior.

G_ARRAY

Calls the Perl subroutine in a list context.

As with G_SCALAR, this flag has 2 effects:

1. It indicates to the subroutine being called that it is executing in a list context (if it executes *wantarray* the result will be true).
2. It ensures that all items returned from the subroutine will be accessible when control returns from the *call_** function.

The value returned by the *call_** function indicates how many items have been returned by the Perl subroutine.

If 0, then you have specified the G_DISCARD flag.

If not 0, then it will be a count of the number of items returned by the subroutine. These items will be stored on the Perl stack. The section *Returning a list of values* gives an example of using the G_ARRAY flag and the mechanics of accessing the returned items from the Perl stack.

G_DISCARD

By default, the *call_** functions place the items returned from by the Perl subroutine on the stack. If you are not interested in these items, then setting this flag will make Perl get rid of them automatically for you. Note that it is still possible to indicate a context to the Perl subroutine by using either G_SCALAR or G_ARRAY.

If you do not set this flag then it is *very* important that you make sure that any temporaries (i.e., parameters passed to the Perl subroutine and values returned from the subroutine) are disposed of yourself. The section *Returning a Scalar* gives details of how to dispose of these temporaries explicitly and the section *Using Perl to dispose of temporaries* discusses the specific circumstances where you can ignore the problem and let Perl deal with it for you.

G_NOARGS

Whenever a Perl subroutine is called using one of the *call_** functions, it is assumed by default that parameters are to be passed to the subroutine. If you are not passing any parameters to the Perl subroutine, you can save a bit of time by setting this flag. It has the effect of not creating the `@_` array for the Perl subroutine.

Although the functionality provided by this flag may seem straightforward, it should be used only if there is a good reason to do so. The reason for being cautious is that even if you have specified the G_NOARGS flag, it is still possible for the Perl subroutine that has been called to think that you have passed it parameters.

In fact, what can happen is that the Perl subroutine you have called can access the `@_` array from a previous Perl subroutine. This will occur when the code that is executing the *call_** function has itself been called from another Perl subroutine. The code below illustrates this

```
sub fred
  { print "@_\n"  }

sub joe
  { &fred }

&joe(1,2,3) ;
```

This will print

```
1 2 3
```

What has happened is that `fred` accesses the `@_` array which belongs to `joe`.

G_EVAL

It is possible for the Perl subroutine you are calling to terminate abnormally, e.g., by calling *die* explicitly or by not actually existing. By default, when either of these events occurs, the process will terminate immediately. If you want to trap this type of event, specify the G_EVAL flag. It will put an *eval { }* around the subroutine call.

Whenever control returns from the *call_** function you need to check the `$@` variable as you would in a normal Perl script.

The value returned from the *call_** function is dependent on what other flags have been specified and whether an error has occurred. Here are all the different cases that can occur:

- If the *call_** function returns normally, then the value returned is as specified in the previous sections.
- If G_DISCARD is specified, the return value will always be 0.
- If G_ARRAY is specified *and* an error has occurred, the return value will always be 0.
- If G_SCALAR is specified *and* an error has occurred, the return value will be 1 and the value on the top of the stack will be *undef*. This means that if you have already detected the error by checking `$@` and you want the program to continue, you must remember to pop the *undef* from the stack.

See *Using G_EVAL* for details on using G_EVAL.

G_KEEPERR

You may have noticed that using the G_EVAL flag described above will **always** clear the `$@` variable and set it to a string describing the error iff there was an error in the called code. This unqualified resetting of `$@` can be problematic in the reliable identification of errors using the `eval {}` mechanism, because the possibility exists that perl will call other code (end of block processing code, for example) between the time the error causes `$@` to be set within `eval {}`, and the subsequent statement which checks for the value of `$@` gets executed in the user's script.

This scenario will mostly be applicable to code that is meant to be called from within destructors, asynchronous callbacks, signal handlers, `__DIE__` or `__WARN__` hooks, and `tie` functions. In such situations, you will not want to clear `$@` at all, but simply to append any new errors to any existing value of `$@`.

The G_KEEPERR flag is meant to be used in conjunction with G_EVAL in *call_** functions that are used to implement such code. This flag has no effect when G_EVAL is not used.

When G_KEEPERR is used, any errors in the called code will be prefixed with the string "\t(in cleanup)", and appended to the current value of `$@`.

The G_KEEPERR flag was introduced in Perl version 5.002.

See *Using G_KEEPERR* for an example of a situation that warrants the use of this flag.

Determining the Context

As mentioned above, you can determine the context of the currently executing subroutine in Perl with *wantarray*. The equivalent test can be made in C by using the `GIMME_V` macro, which returns `G_ARRAY` if you have been called in a list context, `G_SCALAR` if in a scalar context, or `G_VOID` if in a void context (i.e. the return value will not be used). An older version of this macro is called `GIMME`; in a void context it returns `G_SCALAR` instead of `G_VOID`. An example of using the `GIMME_V` macro is shown in section *Using GIMME_V*.

KNOWN PROBLEMS

This section outlines all known problems that exist in the *call_** functions.

1. If you are intending to make use of both the G_EVAL and G_SCALAR flags in your code, use a version of Perl greater than 5.000. There is a bug in version 5.000 of Perl which means that the combination of these two flags will not work as described in the section *FLAG VALUES*.

   Specifically, if the two flags are used when calling a subroutine and that subroutine does not call *die*, the value returned by *call_** will be wrong.

2. In Perl 5.000 and 5.001 there is a problem with using *call_** if the Perl sub you are calling attempts to trap a *die*.

   The symptom of this problem is that the called Perl sub will continue to completion, but whenever it attempts to pass control back to the XSUB, the program will immediately terminate.

   For example, say you want to call this Perl sub

```
sub fred
{
    eval { die "Fatal Error" ; }
    print "Trapped error: $@\n"
        if $@ ;
}
```

   via this XSUB

```
void
Call_fred()
    CODE:
    PUSHMARK(SP) ;
    call_pv("fred", G_DISCARD|G_NOARGS) ;
    fprintf(stderr, "back in Call_fred\n") ;
```

   When `Call_fred` is executed it will print

```
Trapped error: Fatal Error
```

   As control never returns to `Call_fred`, the `"back in Call_fred"` string will not get printed.

   To work around this problem, you can either upgrade to Perl 5.002 or higher, or use the G_EVAL flag with *call_** as shown below

```
void
Call_fred()
    CODE:
    PUSHMARK(SP) ;
    call_pv("fred", G_EVAL|G_DISCARD|G_NOARGS) ;
    fprintf(stderr, "back in Call_fred\n") ;
```

EXAMPLES

Enough of the definition talk, let's have a few examples.

Perl provides many macros to assist in accessing the Perl stack. Wherever possible, these macros should always be used when interfacing to Perl internals. We hope this should make the code less vulnerable to any changes made to Perl in the future.

Another point worth noting is that in the first series of examples I have made use of only the *call_pv* function. This has been done to keep the code simpler and ease you into the topic. Wherever possible, if the choice is between using *call_pv* and *call_sv*, you should always try to use *call_sv*. See *Using call_sv* for details.

No Parameters, Nothing returned

This first trivial example will call a Perl subroutine, *PrintUID*, to print out the UID of the process.

```
sub PrintUID
{
    print "UID is $<\n" ;
}
```

and here is a C function to call it

```
static void
call_PrintUID()
{
    dSP ;

    PUSHMARK(SP) ;
    call_pv("PrintUID", G_DISCARD|G_NOARGS) ;
}
```

Simple, eh.

A few points to note about this example.

1. Ignore `dSP` and `PUSHMARK(SP)` for now. They will be discussed in the next example.
2. We aren't passing any parameters to *PrintUID* so G_NOARGS can be specified.
3. We aren't interested in anything returned from *PrintUID*, so G_DISCARD is specified. Even if *PrintUID* was changed to return some value(s), having specified G_DISCARD will mean that they will be wiped by the time control returns from *call_pv*.
4. As *call_pv* is being used, the Perl subroutine is specified as a C string. In this case the subroutine name has been 'hard−wired' into the code.
5. Because we specified G_DISCARD, it is not necessary to check the value returned from *call_pv*. It will always be 0.

Passing Parameters

Now let's make a slightly more complex example. This time we want to call a Perl subroutine, `LeftString`, which will take 2 parameters—a string (`$s`) and an integer (`$n`). The subroutine will simply print the first `$n` characters of the string.

So the Perl subroutine would look like this

```
sub LeftString
{
    my($s, $n) = @_ ;
    print substr($s, 0, $n), "\n" ;
}
```

The C function required to call *LeftString* would look like this.

```
static void
call_LeftString(a, b)
char * a ;
int b ;
{
    dSP ;

    ENTER ;
    SAVETMPS ;
```

```
    PUSHMARK(SP) ;
    XPUSHs(sv_2mortal(newSVpv(a, 0)));
    XPUSHs(sv_2mortal(newSViv(b)));
    PUTBACK ;

    call_pv("LeftString", G_DISCARD);

    FREETMPS ;
    LEAVE ;
}
```

Here are a few notes on the C function *call_LeftString*.

1. Parameters are passed to the Perl subroutine using the Perl stack. This is the purpose of the code beginning with the line `dSP` and ending with the line `PUTBACK`. The `dSP` declares a local copy of the stack pointer. This local copy should **always** be accessed as `SP`.

2. If you are going to put something onto the Perl stack, you need to know where to put it. This is the purpose of the macro `dSP`—it declares and initializes a *local* copy of the Perl stack pointer.

   All the other macros which will be used in this example require you to have used this macro.

   The exception to this rule is if you are calling a Perl subroutine directly from an XSUB function. In this case it is not necessary to use the `dSP` macro explicitly—it will be declared for you automatically.

3. Any parameters to be pushed onto the stack should be bracketed by the `PUSHMARK` and `PUTBACK` macros. The purpose of these two macros, in this context, is to count the number of parameters you are pushing automatically. Then whenever Perl is creating the `@_` array for the subroutine, it knows how big to make it.

   The `PUSHMARK` macro tells Perl to make a mental note of the current stack pointer. Even if you aren't passing any parameters (like the example shown in the section *No Parameters, Nothing returned*) you must still call the `PUSHMARK` macro before you can call any of the *call_** functions—Perl still needs to know that there are no parameters.

   The `PUTBACK` macro sets the global copy of the stack pointer to be the same as our local copy. If we didn't do this *call_pv* wouldn't know where the two parameters we pushed were—remember that up to now all the stack pointer manipulation we have done is with our local copy, *not* the global copy.

4. The only flag specified this time is G_DISCARD. Because we are passing 2 parameters to the Perl subroutine this time, we have not specified G_NOARGS.

5. Next, we come to XPUSHs. This is where the parameters actually get pushed onto the stack. In this case we are pushing a string and an integer.

   See *XSUBs and the Argument Stack in perlguts* for details on how the XPUSH macros work.

6. Because we created temporary values (by means of `sv_2mortal()` calls) we will have to tidy up the Perl stack and dispose of mortal SVs.

   This is the purpose of

   ```
   ENTER ;
   SAVETMPS ;
   ```

   at the start of the function, and

   ```
   FREETMPS ;
   LEAVE ;
   ```

   at the end. The `ENTER`/`SAVETMPS` pair creates a boundary for any temporaries we create. This means that the temporaries we get rid of will be limited to those which were created after these calls.

The FREETMPS/LEAVE pair will get rid of any values returned by the Perl subroutine (see next example), plus it will also dump the mortal SVs we have created. Having ENTER/SAVETMPS at the beginning of the code makes sure that no other mortals are destroyed.

Think of these macros as working a bit like using { and } in Perl to limit the scope of local variables.

See the section *Using Perl to dispose of temporaries* for details of an alternative to using these macros.

7. Finally, *LeftString* can now be called via the *call_pv* function.

Returning a Scalar

Now for an example of dealing with the items returned from a Perl subroutine.

Here is a Perl subroutine, *Adder*, that takes 2 integer parameters and simply returns their sum.

```
sub Adder
{
    my($a, $b) = @_ ;
    $a + $b ;
}
```

Because we are now concerned with the return value from *Adder*, the C function required to call it is now a bit more complex.

```
static void
call_Adder(a, b)
int a ;
int b ;
{
    dSP ;
    int count ;

    ENTER ;
    SAVETMPS;

    PUSHMARK(SP) ;
    XPUSHs(sv_2mortal(newSViv(a)));
    XPUSHs(sv_2mortal(newSViv(b)));
    PUTBACK ;

    count = call_pv("Adder", G_SCALAR);

    SPAGAIN ;

    if (count != 1)
        croak("Big trouble\n") ;

    printf ("The sum of %d and %d is %d\n", a, b, POPi) ;

    PUTBACK ;
    FREETMPS ;
    LEAVE ;
}
```

Points to note this time are

1. The only flag specified this time was G_SCALAR. That means the @_ array will be created and that the value returned by *Adder* will still exist after the call to *call_pv*.

2. The purpose of the macro SPAGAIN is to refresh the local copy of the stack pointer. This is necessary because it is possible that the memory allocated to the Perl stack has been reallocated whilst in the *call_pv* call.

   If you are making use of the Perl stack pointer in your code you must always refresh the local copy using SPAGAIN whenever you make use of the *call_** functions or any other Perl internal function.

3. Although only a single value was expected to be returned from *Adder*, it is still good practice to check the return code from *call_pv* anyway.

   Expecting a single value is not quite the same as knowing that there will be one. If someone modified *Adder* to return a list and we didn't check for that possibility and take appropriate action the Perl stack would end up in an inconsistent state. That is something you *really* don't want to happen ever.

4. The POPi macro is used here to pop the return value from the stack. In this case we wanted an integer, so POPi was used.

   Here is the complete list of POP macros available, along with the types they return.

   ```
   POPs        SV
   POPp        pointer
   POPn        double
   POPi        integer
   POPl        long
   ```

5. The final PUTBACK is used to leave the Perl stack in a consistent state before exiting the function. This is necessary because when we popped the return value from the stack with POPi it updated only our local copy of the stack pointer. Remember, PUTBACK sets the global stack pointer to be the same as our local copy.

Returning a list of values

Now, let's extend the previous example to return both the sum of the parameters and the difference.

Here is the Perl subroutine

```
sub AddSubtract
{
   my($a, $b) = @_ ;
   ($a+$b, $a-$b) ;
}
```

and this is the C function

```
static void
call_AddSubtract(a, b)
int a ;
int b ;
{
    dSP ;
    int count ;

    ENTER ;
    SAVETMPS;

    PUSHMARK(SP) ;
    XPUSHs(sv_2mortal(newSViv(a)));
    XPUSHs(sv_2mortal(newSViv(b)));
    PUTBACK ;

    count = call_pv("AddSubtract", G_ARRAY);
```

```
    SPAGAIN ;

    if (count != 2)
        croak("Big trouble\n") ;

    printf ("%d - %d = %d\n", a, b, POPi) ;
    printf ("%d + %d = %d\n", a, b, POPi) ;

    PUTBACK ;
    FREETMPS ;
    LEAVE ;
}
```

If *call_AddSubtract* is called like this

```
call_AddSubtract(7, 4) ;
```

then here is the output

```
7 - 4 = 3
7 + 4 = 11
```

Notes

1. We wanted list context, so G_ARRAY was used.
2. Not surprisingly `POPi` is used twice this time because we were retrieving 2 values from the stack. The important thing to note is that when using the `POP*` macros they come off the stack in *reverse* order.

Returning a list in a scalar context

Say the Perl subroutine in the previous section was called in a scalar context, like this

```
static void
call_AddSubScalar(a, b)
int a ;
int b ;
{
    dSP ;
    int count ;
    int i ;

    ENTER ;
    SAVETMPS;

    PUSHMARK(SP) ;
    XPUSHs(sv_2mortal(newSViv(a)));
    XPUSHs(sv_2mortal(newSViv(b)));
    PUTBACK ;

    count = call_pv("AddSubtract", G_SCALAR);

    SPAGAIN ;

    printf ("Items Returned = %d\n", count) ;

    for (i = 1 ; i <= count ; ++i)
        printf ("Value %d = %d\n", i, POPi) ;

    PUTBACK ;
    FREETMPS ;
    LEAVE ;
}
```

The other modification made is that *call_AddSubScalar* will print the number of items returned from the Perl subroutine and their value (for simplicity it assumes that they are integer). So if *call_AddSubScalar* is called

```
call_AddSubScalar(7, 4) ;
```

then the output will be

```
Items Returned = 1
Value 1 = 3
```

In this case the main point to note is that only the last item in the list is returned from the subroutine, *AddSubtract* actually made it back to *call_AddSubScalar*.

Returning Data from Perl via the parameter list

It is also possible to return values directly via the parameter list – whether it is actually desirable to do it is another matter entirely.

The Perl subroutine, *Inc*, below takes 2 parameters and increments each directly.

```
sub Inc
{
    ++ $_[0] ;
    ++ $_[1] ;
}
```

and here is a C function to call it.

```
static void
call_Inc(a, b)
int a ;
int b ;
{
    dSP ;
    int count ;
    SV * sva ;
    SV * svb ;

    ENTER ;
    SAVETMPS;

    sva = sv_2mortal(newSViv(a)) ;
    svb = sv_2mortal(newSViv(b)) ;

    PUSHMARK(SP) ;
    XPUSHs(sva);
    XPUSHs(svb);
    PUTBACK ;

    count = call_pv("Inc", G_DISCARD);

    if (count != 0)
        croak ("call_Inc: expected 0 values from 'Inc', got %d\n",
               count) ;

    printf ("%d + 1 = %d\n", a, SvIV(sva)) ;
    printf ("%d + 1 = %d\n", b, SvIV(svb)) ;

    FREETMPS ;
    LEAVE ;
}
```

To be able to access the two parameters that were pushed onto the stack after they return from *call_pv* it is necessary to make a note of their addresses—thus the two variables `sva` and `svb`.

The reason this is necessary is that the area of the Perl stack which held them will very likely have been overwritten by something else by the time control returns from *call_pv*.

Using G_EVAL

Now an example using G_EVAL. Below is a Perl subroutine which computes the difference of its 2 parameters. If this would result in a negative result, the subroutine calls *die*.

```
sub Subtract
{
    my ($a, $b) = @_ ;

    die "death can be fatal\n" if $a < $b ;

    $a - $b ;
}
```

and some C to call it

```
static void
call_Subtract(a, b)
int a ;
int b ;
{
    dSP ;
    int count ;

    ENTER ;
    SAVETMPS;

    PUSHMARK(SP) ;
    XPUSHs(sv_2mortal(newSViv(a)));
    XPUSHs(sv_2mortal(newSViv(b)));
    PUTBACK ;

    count = call_pv("Subtract", G_EVAL|G_SCALAR);

    SPAGAIN ;

    /* Check the eval first */
    if (SvTRUE(ERRSV))
    {
        STRLEN n_a;
        printf ("Uh oh - %s\n", SvPV(ERRSV, n_a)) ;
        POPs ;
    }
    else
    {
        if (count != 1)
           croak("call_Subtract: wanted 1 value from 'Subtract', got %d\n",
                     count) ;

        printf ("%d - %d = %d\n", a, b, POPi) ;
    }

    PUTBACK ;
    FREETMPS ;
    LEAVE ;
}
```

If *call_Subtract* is called thus

```
call_Subtract(4, 5)
```

the following will be printed

```
Uh oh - death can be fatal
```

Notes

1. We want to be able to catch the *die* so we have used the G_EVAL flag. Not specifying this flag would mean that the program would terminate immediately at the *die* statement in the subroutine *Subtract*.

2. The code

```
if (SvTRUE(ERRSV))
{
    STRLEN n_a;
    printf ("Uh oh - %s\n", SvPV(ERRSV, n_a)) ;
    POPs ;
}
```

   is the direct equivalent of this bit of Perl

```
print "Uh oh - $@\n" if $@ ;
```

   `PL_errgv` is a perl global of type `GV *` that points to the symbol table entry containing the error. `ERRSV` therefore refers to the C equivalent of `$@`.

3. Note that the stack is popped using `POPs` in the block where `SvTRUE(ERRSV)` is true. This is necessary because whenever a *call_** function invoked with G_EVAL|G_SCALAR returns an error, the top of the stack holds the value *undef*. Because we want the program to continue after detecting this error, it is essential that the stack is tidied up by removing the *undef*.

Using G_KEEPERR

Consider this rather facetious example, where we have used an XS version of the call_Subtract example above inside a destructor:

```
package Foo;
sub new { bless {}, $_[0] }
sub Subtract {
    my($a,$b) = @_;
    die "death can be fatal" if $a < $b ;
    $a - $b;
}
sub DESTROY { call_Subtract(5, 4); }
sub foo { die "foo dies"; }

package main;
eval { Foo->new->foo };
print "Saw: $@" if $@;             # should be, but isn't
```

This example will fail to recognize that an error occurred inside the `eval {}`. Here's why: the call_Subtract code got executed while perl was cleaning up temporaries when exiting the eval block, and because call_Subtract is implemented with *call_pv* using the G_EVAL flag, it promptly reset `$@`. This results in the failure of the outermost test for `$@`, and thereby the failure of the error trap.

Appending the G_KEEPERR flag, so that the *call_pv* call in call_Subtract reads:

```
count = call_pv("Subtract", G_EVAL|G_SCALAR|G_KEEPERR);
```

will preserve the error and restore reliable error handling.

Using call_sv

In all the previous examples I have 'hard−wired' the name of the Perl subroutine to be called from C. Most of the time though, it is more convenient to be able to specify the name of the Perl subroutine from within the Perl script.

Consider the Perl code below

```
sub fred
{
    print "Hello there\n" ;
}

CallSubPV("fred") ;
```

Here is a snippet of XSUB which defines *CallSubPV*.

```
void
CallSubPV(name)
    char *  name
    CODE:
    PUSHMARK(SP) ;
    call_pv(name, G_DISCARD|G_NOARGS) ;
```

That is fine as far as it goes. The thing is, the Perl subroutine can be specified as only a string. For Perl 4 this was adequate, but Perl 5 allows references to subroutines and anonymous subroutines. This is where *call_sv* is useful.

The code below for *CallSubSV* is identical to *CallSubPV* except that the `name` parameter is now defined as an SV* and we use *call_sv* instead of *call_pv*.

```
void
CallSubSV(name)
    SV *    name
    CODE:
    PUSHMARK(SP) ;
    call_sv(name, G_DISCARD|G_NOARGS) ;
```

Because we are using an SV to call *fred* the following can all be used

```
CallSubSV("fred") ;
CallSubSV(\&fred) ;
$ref = \&fred ;
CallSubSV($ref) ;
CallSubSV( sub { print "Hello there\n" } ) ;
```

As you can see, *call_sv* gives you much greater flexibility in how you can specify the Perl subroutine.

You should note that if it is necessary to store the SV (`name` in the example above) which corresponds to the Perl subroutine so that it can be used later in the program, it not enough just to store a copy of the pointer to the SV. Say the code above had been like this

```
static SV * rememberSub ;

void
SaveSub1(name)
    SV *    name
    CODE:
    rememberSub = name ;

void
CallSavedSub1()
```

```
    CODE:
    PUSHMARK(SP) ;
    call_sv(rememberSub, G_DISCARD|G_NOARGS) ;
```

The reason this is wrong is that by the time you come to use the pointer `rememberSub` in `CallSavedSub1`, it may or may not still refer to the Perl subroutine that was recorded in `SaveSub1`. This is particularly true for these cases

```
SaveSub1(\&fred) ;
CallSavedSub1() ;

SaveSub1( sub { print "Hello there\n" } ) ;
CallSavedSub1() ;
```

By the time each of the `SaveSub1` statements above have been executed, the SV*s which corresponded to the parameters will no longer exist. Expect an error message from Perl of the form

```
Can't use an undefined value as a subroutine reference at ...
```

for each of the `CallSavedSub1` lines.

Similarly, with this code

```
$ref = \&fred ;
SaveSub1($ref) ;
$ref = 47 ;
CallSavedSub1() ;
```

you can expect one of these messages (which you actually get is dependent on the version of Perl you are using)

```
Not a CODE reference at ...
Undefined subroutine &main::47 called ...
```

The variable `$ref` may have referred to the subroutine `fred` whenever the call to `SaveSub1` was made but by the time `CallSavedSub1` gets called it now holds the number `47`. Because we saved only a pointer to the original SV in `SaveSub1`, any changes to `$ref` will be tracked by the pointer `rememberSub`. This means that whenever `CallSavedSub1` gets called, it will attempt to execute the code which is referenced by the SV* `rememberSub`. In this case though, it now refers to the integer `47`, so expect Perl to complain loudly.

A similar but more subtle problem is illustrated with this code

```
$ref = \&fred ;
SaveSub1($ref) ;
$ref = \&joe ;
CallSavedSub1() ;
```

This time whenever `CallSavedSub1` get called it will execute the Perl subroutine `joe` (assuming it exists) rather than `fred` as was originally requested in the call to `SaveSub1`.

To get around these problems it is necessary to take a full copy of the SV. The code below shows `SaveSub2` modified to do that

```
static SV * keepSub = (SV*)NULL ;

void
SaveSub2(name)
    SV *    name
    CODE:
    /* Take a copy of the callback */
    if (keepSub == (SV*)NULL)
        /* First time, so create a new SV */
```

```
        keepSub = newSVsv(name) ;
    else
        /* Been here before, so overwrite */
        SvSetSV(keepSub, name) ;

void
CallSavedSub2()
    CODE:
    PUSHMARK(SP) ;
    call_sv(keepSub, G_DISCARD|G_NOARGS) ;
```

To avoid creating a new SV every time `SaveSub2` is called, the function first checks to see if it has been called before. If not, then space for a new SV is allocated and the reference to the Perl subroutine, `name` is copied to the variable `keepSub` in one operation using `newSVsv`. Thereafter, whenever `SaveSub2` is called the existing SV, `keepSub`, is overwritten with the new value using `SvSetSV`.

Using call_argv

Here is a Perl subroutine which prints whatever parameters are passed to it.

```
sub PrintList
{
    my(@list) = @_ ;

    foreach (@list) { print "$_\n" }
}
```

and here is an example of *call_argv* which will call *PrintList*.

```
static char * words[] = {"alpha", "beta", "gamma", "delta", NULL} ;

static void
call_PrintList()
{
    dSP ;

    call_argv("PrintList", G_DISCARD, words) ;
}
```

Note that it is not necessary to call `PUSHMARK` in this instance. This is because *call_argv* will do it for you.

Using call_method

Consider the following Perl code

```
{
    package Mine ;

    sub new
    {
        my($type) = shift ;
        bless [@_]
    }

    sub Display
    {
        my ($self, $index) = @_ ;
        print "$index: $$self[$index]\n" ;
    }

    sub PrintID
    {
        my($class) = @_ ;
        print "This is Class $class version 1.0\n" ;
```

```
        }
    }
```

It implements just a very simple class to manage an array. Apart from the constructor, `new`, it declares methods, one static and one virtual. The static method, `PrintID`, prints out simply the class name and a version number. The virtual method, `Display`, prints out a single element of the array. Here is an all Perl example of using it.

```
$a = new Mine ('red', 'green', 'blue') ;
$a->Display(1) ;
PrintID Mine;
```

will print

```
1: green
This is Class Mine version 1.0
```

Calling a Perl method from C is fairly straightforward. The following things are required

- a reference to the object for a virtual method or the name of the class for a static method.
- the name of the method.
- any other parameters specific to the method.

Here is a simple XSUB which illustrates the mechanics of calling both the `PrintID` and `Display` methods from C.

```
void
call_Method(ref, method, index)
    SV *    ref
    char *  method
    int             index
    CODE:
    PUSHMARK(SP);
    XPUSHs(ref);
    XPUSHs(sv_2mortal(newSViv(index))) ;
    PUTBACK;

    call_method(method, G_DISCARD) ;

void
call_PrintID(class, method)
    char *  class
    char *  method
    CODE:
    PUSHMARK(SP);
    XPUSHs(sv_2mortal(newSVpv(class, 0))) ;
    PUTBACK;

    call_method(method, G_DISCARD) ;
```

So the methods `PrintID` and `Display` can be invoked like this

```
$a = new Mine ('red', 'green', 'blue') ;
call_Method($a, 'Display', 1) ;
call_PrintID('Mine', 'PrintID') ;
```

The only thing to note is that in both the static and virtual methods, the method name is not passed via the stack—it is used as the first parameter to *call_method*.

Using GIMME_V

Here is a trivial XSUB which prints the context in which it is currently executing.

```
void
PrintContext()
    CODE:
    I32 gimme = GIMME_V;
    if (gimme == G_VOID)
        printf ("Context is Void\n") ;
    else if (gimme == G_SCALAR)
        printf ("Context is Scalar\n") ;
    else
        printf ("Context is Array\n") ;
```

and here is some Perl to test it

```
PrintContext ;
$a = PrintContext ;
@a = PrintContext ;
```

The output from that will be

```
Context is Void
Context is Scalar
Context is Array
```

Using Perl to dispose of temporaries

In the examples given to date, any temporaries created in the callback (i.e., parameters passed on the stack to the *call_** function or values returned via the stack) have been freed by one of these methods

- specifying the G_DISCARD flag with *call_**.
- explicitly disposed of using the `ENTER`/`SAVETMPS` – `FREETMPS`/`LEAVE` pairing.

There is another method which can be used, namely letting Perl do it for you automatically whenever it regains control after the callback has terminated. This is done by simply not using the

```
ENTER ;
SAVETMPS ;
...
FREETMPS ;
LEAVE ;
```

sequence in the callback (and not, of course, specifying the G_DISCARD flag).

If you are going to use this method you have to be aware of a possible memory leak which can arise under very specific circumstances. To explain these circumstances you need to know a bit about the flow of control between Perl and the callback routine.

The examples given at the start of the document (an error handler and an event driven program) are typical of the two main sorts of flow control that you are likely to encounter with callbacks. There is a very important distinction between them, so pay attention.

In the first example, an error handler, the flow of control could be as follows. You have created an interface to an external library. Control can reach the external library like this

```
perl --> XSUB --> external library
```

Whilst control is in the library, an error condition occurs. You have previously set up a Perl callback to handle this situation, so it will get executed. Once the callback has finished, control will drop back to Perl again. Here is what the flow of control will be like in that situation

```
perl --> XSUB --> external library
                  ...
                  error occurs
                  ...
                  external library --> call_* --> perl
                                                  |
perl <-- XSUB <-- external library <-- call_* <----+
```

After processing of the error using *call_** is completed, control reverts back to Perl more or less immediately.

In the diagram, the further right you go the more deeply nested the scope is. It is only when control is back with perl on the extreme left of the diagram that you will have dropped back to the enclosing scope and any temporaries you have left hanging around will be freed.

In the second example, an event driven program, the flow of control will be more like this

```
perl --> XSUB --> event handler
                  ...
                  event handler --> call_* --> perl
                                               |
                  event handler <-- call_* <---+
                  ...
                  event handler --> call_* --> perl
                                               |
                  event handler <-- call_* <---+
                  ...
                  event handler --> call_* --> perl
                                               |
                  event handler <-- call_* <---+
```

In this case the flow of control can consist of only the repeated sequence

```
event handler --> call_* --> perl
```

for practically the complete duration of the program. This means that control may *never* drop back to the surrounding scope in Perl at the extreme left.

So what is the big problem? Well, if you are expecting Perl to tidy up those temporaries for you, you might be in for a long wait. For Perl to dispose of your temporaries, control must drop back to the enclosing scope at some stage. In the event driven scenario that may never happen. This means that as time goes on, your program will create more and more temporaries, none of which will ever be freed. As each of these temporaries consumes some memory your program will eventually consume all the available memory in your system—kapow!

So here is the bottom line—if you are sure that control will revert back to the enclosing Perl scope fairly quickly after the end of your callback, then it isn't absolutely necessary to dispose explicitly of any temporaries you may have created. Mind you, if you are at all uncertain about what to do, it doesn't do any harm to tidy up anyway.

Strategies for storing Callback Context Information

Potentially one of the trickiest problems to overcome when designing a callback interface can be figuring out how to store the mapping between the C callback function and the Perl equivalent.

To help understand why this can be a real problem first consider how a callback is set up in an all C environment. Typically a C API will provide a function to register a callback. This will expect a pointer to a function as one of its parameters. Below is a call to a hypothetical function `register_fatal` which registers the C function to get called when a fatal error occurs.

```
register_fatal(cb1) ;
```

The single parameter cb1 is a pointer to a function, so you must have defined cb1 in your code, say something like this

```
static void
cb1()
{
    printf ("Fatal Error\n") ;
    exit(1) ;
}
```

Now change that to call a Perl subroutine instead

```
static SV * callback = (SV*)NULL;

static void
cb1()
{
    dSP ;

    PUSHMARK(SP) ;

    /* Call the Perl sub to process the callback */
    call_sv(callback, G_DISCARD) ;
}

void
register_fatal(fn)
    SV *    fn
    CODE:
    /* Remember the Perl sub */
    if (callback == (SV*)NULL)
        callback = newSVsv(fn) ;
    else
        SvSetSV(callback, fn) ;

    /* register the callback with the external library */
    register_fatal(cb1) ;
```

where the Perl equivalent of register_fatal and the callback it registers, pcb1, might look like this

```
# Register the sub pcb1
register_fatal(\&pcb1) ;

sub pcb1
{
    die "I'm dying...\n" ;
}
```

The mapping between the C callback and the Perl equivalent is stored in the global variable callback.

This will be adequate if you ever need to have only one callback registered at any time. An example could be an error handler like the code sketched out above. Remember though, repeated calls to register_fatal will replace the previously registered callback function with the new one.

Say for example you want to interface to a library which allows asynchronous file i/o. In this case you may be able to register a callback whenever a read operation has completed. To be of any use we want to be able to call separate Perl subroutines for each file that is opened. As it stands, the error handler example above would not be adequate as it allows only a single callback to be defined at any time. What we require is a means of storing the mapping between the opened file and the Perl subroutine we want to be called for that file.

Say the i/o library has a function `asynch_read` which associates a C function `ProcessRead` with a file handle `fh`—this assumes that it has also provided some routine to open the file and so obtain the file handle.

```
asynch_read(fh, ProcessRead)
```

This may expect the C *ProcessRead* function of this form

```
void
ProcessRead(fh, buffer)
int fh ;
char *      buffer ;
{
     ...
}
```

To provide a Perl interface to this library we need to be able to map between the `fh` parameter and the Perl subroutine we want called. A hash is a convenient mechanism for storing this mapping. The code below shows a possible implementation

```
static HV * Mapping = (HV*)NULL ;

void
asynch_read(fh, callback)
    int     fh
    SV *    callback
    CODE:
    /* If the hash doesn't already exist, create it */
    if (Mapping == (HV*)NULL)
        Mapping = newHV() ;

    /* Save the fh -> callback mapping */
    hv_store(Mapping, (char*)&fh, sizeof(fh), newSVsv(callback), 0) ;

    /* Register with the C Library */
    asynch_read(fh, asynch_read_if) ;
```

and `asynch_read_if` could look like this

```
static void
asynch_read_if(fh, buffer)
int fh ;
char *      buffer ;
{
    dSP ;
    SV ** sv ;

    /* Get the callback associated with fh */
    sv =  hv_fetch(Mapping, (char*)&fh , sizeof(fh), FALSE) ;
    if (sv == (SV**)NULL)
        croak("Internal error...\n") ;

    PUSHMARK(SP) ;
    XPUSHs(sv_2mortal(newSViv(fh))) ;
    XPUSHs(sv_2mortal(newSVpv(buffer, 0))) ;
    PUTBACK ;

    /* Call the Perl sub */
    call_sv(*sv, G_DISCARD) ;
}
```

For completeness, here is `asynch_close`. This shows how to remove the entry from the hash `Mapping`.

```
void
asynch_close(fh)
    int
    CODE:
    /* Remove the entry from the hash */
    (void) hv_delete(Mapping, (char*)&fh, sizeof(fh), G_DISCARD) ;

    /* Now call the real asynch_close */
    asynch_close(fh) ;
```

So the Perl interface would look like this

```
sub callback1
{
    my($handle, $buffer) = @_ ;
}

# Register the Perl callback
asynch_read($fh, \&callback1) ;

asynch_close($fh) ;
```

The mapping between the C callback and Perl is stored in the global hash `Mapping` this time. Using a hash has the distinct advantage that it allows an unlimited number of callbacks to be registered.

What if the interface provided by the C callback doesn't contain a parameter which allows the file handle to Perl subroutine mapping? Say in the asynchronous i/o package, the callback function gets passed only the `buffer` parameter like this

```
void
ProcessRead(buffer)
char *      buffer ;
{
    ...
}
```

Without the file handle there is no straightforward way to map from the C callback to the Perl subroutine.

In this case a possible way around this problem is to predefine a series of C functions to act as the interface to Perl, thus

```
#define MAX_CB              3
#define NULL_HANDLE -1
typedef void (*FnMap)() ;

struct MapStruct {
    FnMap    Function ;
    SV *     PerlSub ;
    int      Handle ;
  } ;

static void  fn1() ;
static void  fn2() ;
static void  fn3() ;

static struct MapStruct Map [MAX_CB] =
    {
        { fn1, NULL, NULL_HANDLE },
        { fn2, NULL, NULL_HANDLE },
        { fn3, NULL, NULL_HANDLE }
    } ;
```

```
static void
Pcb(index, buffer)
int index ;
char * buffer ;
{
    dSP ;

    PUSHMARK(SP) ;
    XPUSHs(sv_2mortal(newSVpv(buffer, 0))) ;
    PUTBACK ;

    /* Call the Perl sub */
    call_sv(Map[index].PerlSub, G_DISCARD) ;
}

static void
fn1(buffer)
char * buffer ;
{
    Pcb(0, buffer) ;
}

static void
fn2(buffer)
char * buffer ;
{
    Pcb(1, buffer) ;
}

static void
fn3(buffer)
char * buffer ;
{
    Pcb(2, buffer) ;
}

void
array_asynch_read(fh, callback)
    int             fh
    SV *    callback
    CODE:
    int index ;
    int null_index = MAX_CB ;

    /* Find the same handle or an empty entry */
    for (index = 0 ; index < MAX_CB ; ++index)
    {
        if (Map[index].Handle == fh)
            break ;

        if (Map[index].Handle == NULL_HANDLE)
            null_index = index ;
    }

    if (index == MAX_CB && null_index == MAX_CB)
        croak ("Too many callback functions registered\n") ;

    if (index == MAX_CB)
        index = null_index ;
```

```
    /* Save the file handle */
    Map[index].Handle = fh ;

    /* Remember the Perl sub */
    if (Map[index].PerlSub == (SV*)NULL)
        Map[index].PerlSub = newSVsv(callback) ;
    else
        SvSetSV(Map[index].PerlSub, callback) ;

    asynch_read(fh, Map[index].Function) ;

void
array_asynch_close(fh)
    int     fh
    CODE:
    int index ;

    /* Find the file handle */
    for (index = 0; index < MAX_CB ; ++ index)
        if (Map[index].Handle == fh)
            break ;

    if (index == MAX_CB)
        croak ("could not close fh %d\n", fh) ;

    Map[index].Handle = NULL_HANDLE ;
    SvREFCNT_dec(Map[index].PerlSub) ;
    Map[index].PerlSub = (SV*)NULL ;

    asynch_close(fh) ;
```

In this case the functions `fn1`, `fn2`, and `fn3` are used to remember the Perl subroutine to be called. Each of the functions holds a separate hard–wired index which is used in the function `Pcb` to access the `Map` array and actually call the Perl subroutine.

There are some obvious disadvantages with this technique.

Firstly, the code is considerably more complex than with the previous example.

Secondly, there is a hard–wired limit (in this case 3) to the number of callbacks that can exist simultaneously. The only way to increase the limit is by modifying the code to add more functions and then recompiling. None the less, as long as the number of functions is chosen with some care, it is still a workable solution and in some cases is the only one available.

To summarize, here are a number of possible methods for you to consider for storing the mapping between C and the Perl callback

1. Ignore the problem – Allow only 1 callback

   For a lot of situations, like interfacing to an error handler, this may be a perfectly adequate solution.

2. Create a sequence of callbacks – hard wired limit

   If it is impossible to tell from the parameters passed back from the C callback what the context is, then you may need to create a sequence of C callback interface functions, and store pointers to each in an array.

3. Use a parameter to map to the Perl callback

   A hash is an ideal mechanism to store the mapping between C and Perl.

Alternate Stack Manipulation

Although I have made use of only the `POP*` macros to access values returned from Perl subroutines, it is also possible to bypass these macros and read the stack using the `ST` macro (See *perlxs* for a full description of the `ST` macro).

Most of the time the POP* macros should be adequate, the main problem with them is that they force you to process the returned values in sequence. This may not be the most suitable way to process the values in some cases. What we want is to be able to access the stack in a random order. The ST macro as used when coding an XSUB is ideal for this purpose.

The code below is the example given in the section *Returning a list of values* recoded to use ST instead of POP*.

```
static void
call_AddSubtract2(a, b)
int a ;
int b ;
{
    dSP ;
    I32 ax ;
    int count ;

    ENTER ;
    SAVETMPS;

    PUSHMARK(SP) ;
    XPUSHs(sv_2mortal(newSViv(a)));
    XPUSHs(sv_2mortal(newSViv(b)));
    PUTBACK ;

    count = call_pv("AddSubtract", G_ARRAY);

    SPAGAIN ;
    SP -= count ;
    ax = (SP - PL_stack_base) + 1 ;

    if (count != 2)
        croak("Big trouble\n") ;

    printf ("%d + %d = %d\n", a, b, SvIV(ST(0))) ;
    printf ("%d - %d = %d\n", a, b, SvIV(ST(1))) ;

    PUTBACK ;
    FREETMPS ;
    LEAVE ;
}
```

Notes

1. Notice that it was necessary to define the variable ax. This is because the ST macro expects it to exist. If we were in an XSUB it would not be necessary to define ax as it is already defined for you.

2. The code

   ```
   SPAGAIN ;
   SP -= count ;
   ax = (SP - PL_stack_base) + 1 ;
   ```

   sets the stack up so that we can use the ST macro.

3. Unlike the original coding of this example, the returned values are not accessed in reverse order. So ST(0) refers to the first value returned by the Perl subroutine and ST(count-1) refers to the last.

Creating and calling an anonymous subroutine in C

As we've already shown, call_sv can be used to invoke an anonymous subroutine. However, our example showed a Perl script invoking an XSUB to perform this operation. Let's see how it can be done inside our C code:

```
...
SV *cvrv = eval_pv("sub { print 'You will not find me cluttering any namespace!' }",
...
call_sv(cvrv, G_VOID|G_NOARGS);
```

`eval_pv` is used to compile the anonymous subroutine, which will be the return value as well (read more about `eval_pv` in *eval_pv*). Once this code reference is in hand, it can be mixed in with all the previous examples we've shown.

SEE ALSO

perlxs, *perlguts*, *perlembed*

AUTHOR

Paul Marquess

Special thanks to the following people who assisted in the creation of the document.

Jeff Okamoto, Tim Bunce, Nick Gianniotis, Steve Kelem, Gurusamy Sarathy and Larry Wall.

DATE

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NAME

perlcompile − Introduction to the Perl Compiler−Translator

DESCRIPTION

Perl has always had a compiler: your source is compiled into an internal form (a parse tree) which is then optimized before being run. Since version 5.005, Perl has shipped with a module capable of inspecting the optimized parse tree (`B`), and this has been used to write many useful utilities, including a module that lets you turn your Perl into C source code that can be compiled into an native executable.

The `B` module provides access to the parse tree, and other modules ("back ends") do things with the tree. Some write it out as bytecode, C source code, or a semi−human−readable text. Another traverses the parse tree to build a cross−reference of which subroutines, formats, and variables are used where. Another checks your code for dubious constructs. Yet another back end dumps the parse tree back out as Perl source, acting as a source code beautifier or deobfuscator.

Because its original purpose was to be a way to produce C code corresponding to a Perl program, and in turn a native executable, the `B` module and its associated back ends are known as "the compiler", even though they don't really compile anything. Different parts of the compiler are more accurately a "translator", or an "inspector", but people want Perl to have a "compiler option" not an "inspector gadget". What can you do?

This document covers the use of the Perl compiler: which modules it comprises, how to use the most important of the back end modules, what problems there are, and how to work around them.

Layout

The compiler back ends are in the `B::` hierarchy, and the front−end (the module that you, the user of the compiler, will sometimes interact with) is the O module. Some back ends (e.g., `B::C`) have programs (e.g., *perlcc*) to hide the modules' complexity.

Here are the important back ends to know about, with their status expressed as a number from 0 (outline for later implementation) to 10 (if there's a bug in it, we're very surprised):

B::Bytecode

Stores the parse tree in a machine−independent format, suitable for later reloading through the ByteLoader module. Status: 5 (some things work, some things don't, some things are untested).

B::C

Creates a C source file containing code to rebuild the parse tree and resume the interpreter. Status: 6 (many things work adequately, including programs using Tk).

B::CC

Creates a C source file corresponding to the run time code path in the parse tree. This is the closest to a Perl−to−C translator there is, but the code it generates is almost incomprehensible because it translates the parse tree into a giant switch structure that manipulates Perl structures. Eventual goal is to reduce (given sufficient type information in the Perl program) some of the Perl data structure manipulations into manipulations of C−level ints, floats, etc. Status: 5 (some things work, including uncomplicated Tk examples).

B::Lint

Complains if it finds dubious constructs in your source code. Status: 6 (it works adequately, but only has a very limited number of areas that it checks).

B::Deparse

Recreates the Perl source, making an attempt to format it coherently. Status: 8 (it works nicely, but a few obscure things are missing).

B::Xref

Reports on the declaration and use of subroutines and variables. Status: 8 (it works nicely, but still has a few lingering bugs).

Using The Back Ends

The following sections describe how to use the various compiler back ends. They're presented roughly in order of maturity, so that the most stable and proven back ends are described first, and the most experimental and incomplete back ends are described last.

The O module automatically enabled the **−c** flag to Perl, which prevents Perl from executing your code once it has been compiled. This is why all the back ends print:

```
myperlprogram syntax OK
```

before producing any other output.

The Cross Referencing Back End

The cross referencing back end (B::Xref) produces a report on your program, breaking down declarations and uses of subroutines and variables (and formats) by file and subroutine. For instance, here's part of the report from the *pod2man* program that comes with Perl:

```
Subroutine clear_noremap
  Package (lexical)
    $ready_to_print   i1069, 1079
  Package main
    $&                1086
    $.                1086
    $0                1086
    $1                1087
    $2                1085, 1085
    $3                1085, 1085
    $ARGV             1086
    %HTML_Escapes     1085, 1085
```

This shows the variables used in the subroutine `clear_noremap`. The variable `$ready_to_print` is a `my()` (lexical) variable, **i**ntroduced (first declared with `my()`) on line 1069, and used on line 1079. The variable `$&` from the main package is used on 1086, and so on.

A line number may be prefixed by a single letter:

i Lexical variable introduced (declared with `my()`) for the first time.

`&` Subroutine or method call.

s Subroutine defined.

r Format defined.

The most useful option the cross referencer has is to save the report to a separate file. For instance, to save the report on *myperlprogram* to the file *report*:

```
$ perl -MO=Xref,-oreport myperlprogram
```

The Decompiling Back End

The Deparse back end turns your Perl source back into Perl source. It can reformat along the way, making it useful as a de−obfuscator. The most basic way to use it is:

```
$ perl -MO=Deparse myperlprogram
```

You'll notice immediately that Perl has no idea of how to paragraph your code. You'll have to separate chunks of code from each other with newlines by hand. However, watch what it will do with one−liners:

```
$ perl -MO=Deparse -e '$op=shift||die "usage: $0
code [...]";chomp(@ARGV=<>)unless@ARGV; for(@ARGV){$was=$_;eval$op;
die$@ if$@; rename$was,$_ unless$was eq $_}'
-e syntax OK
```

```
$op = shift @ARGV || die("usage: $0 code [...]");
chomp(@ARGV = <ARGV>) unless @ARGV;
foreach $_ (@ARGV) {
    $was = $_;
    eval $op;
    die $@ if $@;
    rename $was, $_ unless $was eq $_;
}
```

The decompiler has several options for the code it generates. For instance, you can set the size of each indent from 4 (as above) to 2 with:

```
$ perl -MO=Deparse,-si2 myperlprogram
```

The **-p** option adds parentheses where normally they are omitted:

```
$ perl -MO=Deparse -e 'print "Hello, world\n"'
-e syntax OK
print "Hello, world\n";
$ perl -MO=Deparse,-p -e 'print "Hello, world\n"'
-e syntax OK
print("Hello, world\n");
```

See *B::Deparse* for more information on the formatting options.

The Lint Back End

The lint back end (B::Lint) inspects programs for poor style. One programmer's bad style is another programmer's useful tool, so options let you select what is complained about.

To run the style checker across your source code:

```
$ perl -MO=Lint myperlprogram
```

To disable context checks and undefined subroutines:

```
$ perl -MO=Lint,-context,-undefined-subs myperlprogram
```

See *B::Lint* for information on the options.

The Simple C Back End

This module saves the internal compiled state of your Perl program to a C source file, which can be turned into a native executable for that particular platform using a C compiler. The resulting program links against the Perl interpreter library, so it will not save you disk space (unless you build Perl with a shared library) or program size. It may, however, save you startup time.

The `perlcc` tool generates such executables by default.

```
perlcc myperlprogram.pl
```

The Bytecode Back End

This back end is only useful if you also have a way to load and execute the bytecode that it produces. The ByteLoader module provides this functionality.

To turn a Perl program into executable byte code, you can use `perlcc` with the `-b` switch:

```
perlcc -b myperlprogram.pl
```

The byte code is machine independent, so once you have a compiled module or program, it is as portable as Perl source (assuming that the user of the module or program has a modern–enough Perl interpreter to decode the byte code).

See **B::Bytecode** for information on options to control the optimization and nature of the code generated by the Bytecode module.

The Optimized C Back End

The optimized C back end will turn your Perl program's run time code–path into an equivalent (but optimized) C program that manipulates the Perl data structures directly. The program will still link against the Perl interpreter library, to allow for `eval()`, `s///e`, `require`, etc.

The `perlcc` tool generates such executables when using the –opt switch. To compile a Perl program (ending in `.pl` or `.p`):

```
perlcc -opt myperlprogram.pl
```

To produce a shared library from a Perl module (ending in `.pm`):

```
perlcc -opt Myperlmodule.pm
```

For more information, see *perlcc* and *B::CC*.

B This module is the introspective ("reflective" in Java terms) module, which allows a Perl program to inspect its innards. The back end modules all use this module to gain access to the compiled parse tree. You, the user of a back end module, will not need to interact with B.

O This module is the front–end to the compiler's back ends. Normally called something like this:

```
$ perl -MO=Deparse myperlprogram
```

This is like saying `use O 'Deparse'` in your Perl program.

B::Asmdata

This module is used by the B::Assembler module, which is in turn used by the B::Bytecode module, which stores a parse–tree as bytecode for later loading. It's not a back end itself, but rather a component of a back end.

B::Assembler

This module turns a parse–tree into data suitable for storing and later decoding back into a parse–tree. It's not a back end itself, but rather a component of a back end. It's used by the *assemble* program that produces bytecode.

B::Bblock

This module is used by the B::CC back end. It walks "basic blocks". A basic block is a series of operations which is known to execute from start to finish, with no possibility of branching or halting.

B::Bytecode

This module is a back end that generates bytecode from a program's parse tree. This bytecode is written to a file, from where it can later be reconstructed back into a parse tree. The goal is to do the expensive program compilation once, save the interpreter's state into a file, and then restore the state from the file when the program is to be executed. See for details about usage.

B::C

This module writes out C code corresponding to the parse tree and other interpreter internal structures. You compile the corresponding C file, and get an executable file that will restore the internal structures and the Perl interpreter will begin running the program. See for details about usage.

B::CC

This module writes out C code corresponding to your program's operations. Unlike the B::C module, which merely stores the interpreter and its state in a C program, the B::CC module makes a C program that does not involve the interpreter. As a consequence, programs translated into C by B::CC can execute faster than normal interpreted programs. See for details about usage.

B::Debug

This module dumps the Perl parse tree in verbose detail to STDOUT. It's useful for people who are writing their own back end, or who are learning about the Perl internals. It's not useful to the average

programmer.

B::Deparse

This module produces Perl source code from the compiled parse tree. It is useful in debugging and deconstructing other people's code, also as a pretty−printer for your own source. See for details about usage.

B::Disassembler

This module turns bytecode back into a parse tree. It's not a back end itself, but rather a component of a back end. It's used by the *disassemble* program that comes with the bytecode.

B::Lint

This module inspects the compiled form of your source code for things which, while some people frown on them, aren't necessarily bad enough to justify a warning. For instance, use of an array in scalar context without explicitly saying `scalar(@array)` is something that Lint can identify. See for details about usage.

B::Showlex

This module prints out the `my()` variables used in a function or a file. To get a list of the `my()` variables used in the subroutine `mysub()` defined in the file myperlprogram:

```
$ perl -MO=Showlex,mysub myperlprogram
```

To get a list of the `my()` variables used in the file myperlprogram:

```
$ perl -MO=Showlex myperlprogram
```

[BROKEN]

B::Stackobj

This module is used by the B::CC module. It's not a back end itself, but rather a component of a back end.

B::Stash

This module is used by the *perlcc* program, which compiles a module into an executable. B::Stash prints the symbol tables in use by a program, and is used to prevent B::CC from producing C code for the B::* and O modules. It's not a back end itself, but rather a component of a back end.

B::Terse

This module prints the contents of the parse tree, but without as much information as B::Debug. For comparison, `print "Hello, world."` produced 96 lines of output from B::Debug, but only 6 from B::Terse.

This module is useful for people who are writing their own back end, or who are learning about the Perl internals. It's not useful to the average programmer.

B::Xref

This module prints a report on where the variables, subroutines, and formats are defined and used within a program and the modules it loads. See for details about usage.

KNOWN PROBLEMS

The simple C backend currently only saves typeglobs with alphanumeric names.

The optimized C backend outputs code for more modules than it should (e.g., DirHandle). It also has little hope of properly handling `goto LABEL` outside the running subroutine (`goto &sub` is okay). `goto LABEL` currently does not work at all in this backend. It also creates a huge initialization function that gives C compilers headaches. Splitting the initialization function gives better results. Other problems include: unsigned math does not work correctly; some opcodes are handled incorrectly by default opcode handling mechanism.

BEGIN{} blocks are executed while compiling your code. Any external state that is initialized in BEGIN{}, such as opening files, initiating database connections etc., do not behave properly. To work around this, Perl has an INIT{} block that corresponds to code being executed before your program begins running but after your program has finished being compiled. Execution order: BEGIN{}, (possible save of state through compiler back−end), INIT{}, program runs, END{}.

AUTHOR

This document was originally written by Nathan Torkington, and is now maintained by the perl5−porters mailing list *perl5−porters@perl.org*.

NAME

perldata – Perl data types

DESCRIPTION

Variable names

Perl has three built–in data types: scalars, arrays of scalars, and associative arrays of scalars, known as "hashes". Normal arrays are ordered lists of scalars indexed by number, starting with 0 and with negative subscripts counting from the end. Hashes are unordered collections of scalar values indexed by their associated string key.

Values are usually referred to by name, or through a named reference. The first character of the name tells you to what sort of data structure it refers. The rest of the name tells you the particular value to which it refers. Usually this name is a single *identifier*, that is, a string beginning with a letter or underscore, and containing letters, underscores, and digits. In some cases, it may be a chain of identifiers, separated by `::` (or by the slightly archaic `'`); all but the last are interpreted as names of packages, to locate the namespace in which to look up the final identifier (see *Packages* for details). It's possible to substitute for a simple identifier, an expression that produces a reference to the value at runtime. This is described in more detail below and in *perlref*.

Perl also has its own built–in variables whose names don't follow these rules. They have strange names so they don't accidentally collide with one of your normal variables. Strings that match parenthesized parts of a regular expression are saved under names containing only digits after the `$` (see *perlop* and *perlre*). In addition, several special variables that provide windows into the inner working of Perl have names containing punctuation characters and control characters. These are documented in *perlvar*.

Scalar values are always named with `$`, even when referring to a scalar that is part of an array or a hash. The `$` symbol works semantically like the English word "the" in that it indicates a single value is expected.

```
$days               # the simple scalar value "days"
$days[28]           # the 29th element of array @days
$days{'Feb'}        # the 'Feb' value from hash %days
$#days              # the last index of array @days
```

Entire arrays (and slices of arrays and hashes) are denoted by `@`, which works much like the word "these" or "those" does in English, in that it indicates multiple values are expected.

```
@days               # ($days[0], $days[1],... $days[n])
@days[3,4,5]        # same as ($days[3],$days[4],$days[5])
@days{'a','c'}      # same as ($days{'a'},$days{'c'})
```

Entire hashes are denoted by `%`:

```
%days               # (key1, val1, key2, val2 ...)
```

In addition, subroutines are named with an initial `&`, though this is optional when unambiguous, just as the word "do" is often redundant in English. Symbol table entries can be named with an initial `*`, but you don't really care about that yet (if ever :–).

Every variable type has its own namespace, as do several non–variable identifiers. This means that you can, without fear of conflict, use the same name for a scalar variable, an array, or a hash—or, for that matter, for a filehandle, a directory handle, a subroutine name, a format name, or a label. This means that `$foo` and @foo are two different variables. It also means that `$foo[1]` is a part of @foo, not a part of `$foo`. This may seem a bit weird, but that's okay, because it is weird.

Because variable references always start with `$`, `@`, or `%`, the "reserved" words aren't in fact reserved with respect to variable names. They *are* reserved with respect to labels and filehandles, however, which don't have an initial special character. You can't have a filehandle named "log", for instance. Hint: you could say `open(LOG,'logfile')` rather than `open(log,'logfile')`. Using uppercase filehandles

also improves readability and protects you from conflict with future reserved words. Case *is* significant—"FOO", "Foo", and "foo" are all different names. Names that start with a letter or underscore may also contain digits and underscores.

It is possible to replace such an alphanumeric name with an expression that returns a reference to the appropriate type. For a description of this, see *perlref*.

Names that start with a digit may contain only more digits. Names that do not start with a letter, underscore, or digit are limited to one character, e.g., `$%` or `$$`. (Most of these one character names have a predefined significance to Perl. For instance, `$$` is the current process id.)

Context

The interpretation of operations and values in Perl sometimes depends on the requirements of the context around the operation or value. There are two major contexts: list and scalar. Certain operations return list values in contexts wanting a list, and scalar values otherwise. If this is true of an operation it will be mentioned in the documentation for that operation. In other words, Perl overloads certain operations based on whether the expected return value is singular or plural. Some words in English work this way, like "fish" and "sheep".

In a reciprocal fashion, an operation provides either a scalar or a list context to each of its arguments. For example, if you say

```
int( <STDIN> )
```

the integer operation provides scalar context for the <> operator, which responds by reading one line from STDIN and passing it back to the integer operation, which will then find the integer value of that line and return that. If, on the other hand, you say

```
sort( <STDIN> )
```

then the sort operation provides list context for <>, which will proceed to read every line available up to the end of file, and pass that list of lines back to the sort routine, which will then sort those lines and return them as a list to whatever the context of the sort was.

Assignment is a little bit special in that it uses its left argument to determine the context for the right argument. Assignment to a scalar evaluates the right-hand side in scalar context, while assignment to an array or hash evaluates the righthand side in list context. Assignment to a list (or slice, which is just a list anyway) also evaluates the righthand side in list context.

When you use the `use warnings` pragma or Perl's **-w** command-line option, you may see warnings about useless uses of constants or functions in "void context". Void context just means the value has been discarded, such as a statement containing only `"fred";` or `getpwuid(0);`. It still counts as scalar context for functions that care whether or not they're being called in list context.

User-defined subroutines may choose to care whether they are being called in a void, scalar, or list context. Most subroutines do not need to bother, though. That's because both scalars and lists are automatically interpolated into lists. See *wantarray* for how you would dynamically discern your function's calling context.

Scalar values

All data in Perl is a scalar, an array of scalars, or a hash of scalars. A scalar may contain one single value in any of three different flavors: a number, a string, or a reference. In general, conversion from one form to another is transparent. Although a scalar may not directly hold multiple values, it may contain a reference to an array or hash which in turn contains multiple values.

Scalars aren't necessarily one thing or another. There's no place to declare a scalar variable to be of type "string", type "number", type "reference", or anything else. Because of the automatic conversion of scalars, operations that return scalars don't need to care (and in fact, cannot care) whether their caller is looking for a string, a number, or a reference. Perl is a contextually polymorphic language whose scalars can be strings, numbers, or references (which includes objects). Although strings and numbers are considered pretty much the same thing for nearly all purposes, references are strongly-typed, uncastable pointers with builtin

reference–counting and destructor invocation.

A scalar value is interpreted as TRUE in the Boolean sense if it is not the null string or the number 0 (or its string equivalent, "0"). The Boolean context is just a special kind of scalar context where no conversion to a string or a number is ever performed.

There are actually two varieties of null strings (sometimes referred to as "empty" strings), a defined one and an undefined one. The defined version is just a string of length zero, such as `""`. The undefined version is the value that indicates that there is no real value for something, such as when there was an error, or at end of file, or when you refer to an uninitialized variable or element of an array or hash. Although in early versions of Perl, an undefined scalar could become defined when first used in a place expecting a defined value, this no longer happens except for rare cases of autovivification as explained in *perlref*. You can use the `defined()` operator to determine whether a scalar value is defined (this has no meaning on arrays or hashes), and the `undef()` operator to produce an undefined value.

To find out whether a given string is a valid non–zero number, it's sometimes enough to test it against both numeric 0 and also lexical "0" (although this will cause **–w** noises). That's because strings that aren't numbers count as 0, just as they do in **awk**:

```
if ($str == 0 && $str ne "0")  {
    warn "That doesn't look like a number";
}
```

That method may be best because otherwise you won't treat IEEE notations like `NaN` or `Infinity` properly. At other times, you might prefer to determine whether string data can be used numerically by calling the `POSIX::strtod()` function or by inspecting your string with a regular expression (as documented in *perlre*).

```
warn "has nondigits"        if     /\D/;
warn "not a natural number" unless /^\d+$/;             # rejects -3
warn "not an integer"       unless /^-?\d+$/;           # rejects +3
warn "not an integer"       unless /^[+-]?\d+$/;
warn "not a decimal number" unless /^-?\d+\.?\d*$/;     # rejects .2
warn "not a decimal number" unless /^-?(?:\d+(?:\.\d*)?|\.\d+)$/;
warn "not a C float"
    unless /^([+-]?)(?=\d|\.\d)\d*(\.\d*)?([Ee]([+-]?\d+))?$/;
```

The length of an array is a scalar value. You may find the length of array @days by evaluating `$#days`, as in **csh**. Technically speaking, this isn't the length of the array; it's the subscript of the last element, since there is ordinarily a 0th element. Assigning to `$#days` actually changes the length of the array. Shortening an array this way destroys intervening values. Lengthening an array that was previously shortened does not recover values that were in those elements. (It used to do so in Perl 4, but we had to break this to make sure destructors were called when expected.)

You can also gain some miniscule measure of efficiency by pre–extending an array that is going to get big. You can also extend an array by assigning to an element that is off the end of the array. You can truncate an array down to nothing by assigning the null list `()` to it. The following are equivalent:

```
@whatever = ();
$#whatever = -1;
```

If you evaluate an array in scalar context, it returns the length of the array. (Note that this is not true of lists, which return the last value, like the C comma operator, nor of built–in functions, which return whatever they feel like returning.) The following is always true:

```
scalar(@whatever) == $#whatever - $[ + 1;
```

Version 5 of Perl changed the semantics of `$[`: files that don't set the value of `$[` no longer need to worry about whether another file changed its value. (In other words, use of `$[` is deprecated.) So in general you can assume that

```
scalar(@whatever) == $#whatever + 1;
```

Some programmers choose to use an explicit conversion so as to leave nothing to doubt:

```
$element_count = scalar(@whatever);
```

If you evaluate a hash in scalar context, it returns false if the hash is empty. If there are any key/value pairs, it returns true; more precisely, the value returned is a string consisting of the number of used buckets and the number of allocated buckets, separated by a slash. This is pretty much useful only to find out whether Perl's internal hashing algorithm is performing poorly on your data set. For example, you stick 10,000 things in a hash, but evaluating %HASH in scalar context reveals `"1/16"`, which means only one out of sixteen buckets has been touched, and presumably contains all 10,000 of your items. This isn't supposed to happen.

You can preallocate space for a hash by assigning to the `keys()` function. This rounds up the allocated buckets to the next power of two:

```
keys(%users) = 1000;                # allocate 1024 buckets
```

Scalar value constructors

Numeric literals are specified in any of the following floating point or integer formats:

```
12345
12345.67
.23E-10             # a very small number
4_294_967_296       # underline for legibility
0xff                # hex
0377                # octal
0b011011            # binary
```

String literals are usually delimited by either single or double quotes. They work much like quotes in the standard Unix shells: double-quoted string literals are subject to backslash and variable substitution; single-quoted strings are not (except for `\'` and `\\`). The usual C-style backslash rules apply for making characters such as newline, tab, etc., as well as some more exotic forms. See *Quote and Quote-like Operators in perlop* for a list.

Hexadecimal, octal, or binary, representations in string literals (e.g. '0xff') are not automatically converted to their integer representation. The `hex()` and `oct()` functions make these conversions for you. See *hex* and *oct* for more details.

You can also embed newlines directly in your strings, i.e., they can end on a different line than they begin. This is nice, but if you forget your trailing quote, the error will not be reported until Perl finds another line containing the quote character, which may be much further on in the script. Variable substitution inside strings is limited to scalar variables, arrays, and array or hash slices. (In other words, names beginning with `$` or `@`, followed by an optional bracketed expression as a subscript.) The following code segment prints out "The price is `$100.`"

```
$Price = '$100';    # not interpreted
print "The price is $Price.\n";     # interpreted
```

As in some shells, you can enclose the variable name in braces to disambiguate it from following alphanumerics (and underscores). You must also do this when interpolating a variable into a string to separate the variable name from a following double-colon or an apostrophe, since these would be otherwise treated as a package separator:

```
$who = "Larry";
print PASSWD "${who}::0:0:Superuser:/:/bin/perl\n";
print "We use ${who}speak when ${who}'s here.\n";
```

Without the braces, Perl would have looked for a `$whospeak`, a `$who::0`, and a `$who's` variable. The last two would be the `$0` and the `$s` variables in the (presumably) non-existent package `who`.

In fact, an identifier within such curlies is forced to be a string, as is any simple identifier within a hash subscript. Neither need quoting. Our earlier example, `$days{'Feb'}` can be written as `$days{Feb}` and the quotes will be assumed automatically. But anything more complicated in the subscript will be interpreted as an expression.

A literal of the form `v1.20.300.4000` is parsed as a string composed of characters with the specified ordinals. This provides an alternative, more readable way to construct strings, rather than use the somewhat less readable interpolation form `"\x{1}\x{14}\x{12c}\x{fa0}"`. This is useful for representing Unicode strings, and for comparing version "numbers" using the string comparison operators, `cmp`, `gt`, `lt` etc. If there are two or more dots in the literal, the leading `v` may be omitted.

```
print v9786;              # prints UTF-8 encoded SMILEY, "\x{263a}"
print v102.111.111;       # prints "foo"
print 102.111.111;        # same
```

Such literals are accepted by both `require` and `use` for doing a version check. The `$^V` special variable also contains the running Perl interpreter's version in this form. See *$^V*.

The special literals __FILE__, __LINE__, and __PACKAGE__ represent the current filename, line number, and package name at that point in your program. They may be used only as separate tokens; they will not be interpolated into strings. If there is no current package (due to an empty `package;` directive), __PACKAGE__ is the undefined value.

The two control characters ^D and ^Z, and the tokens __END__ and __DATA__ may be used to indicate the logical end of the script before the actual end of file. Any following text is ignored.

Text after __DATA__ but may be read via the filehandle `PACKNAME::DATA`, where `PACKNAME` is the package that was current when the __DATA__ token was encountered. The filehandle is left open pointing to the contents after __DATA__. It is the program's responsibility to `close DATA` when it is done reading from it. For compatibility with older scripts written before __DATA__ was introduced, __END__ behaves like __DATA__ in the toplevel script (but not in files loaded with `require` or `do`) and leaves the remaining contents of the file accessible via `main::DATA`.

See *SelfLoader* for more description of __DATA__, and an example of its use. Note that you cannot read from the DATA filehandle in a BEGIN block: the BEGIN block is executed as soon as it is seen (during compilation), at which point the corresponding __DATA__ (or __END__) token has not yet been seen.

A word that has no other interpretation in the grammar will be treated as if it were a quoted string. These are known as "barewords". As with filehandles and labels, a bareword that consists entirely of lowercase letters risks conflict with future reserved words, and if you use the `use warnings` pragma or the **-w** switch, Perl will warn you about any such words. Some people may wish to outlaw barewords entirely. If you say

```
use strict 'subs';
```

then any bareword that would NOT be interpreted as a subroutine call produces a compile-time error instead. The restriction lasts to the end of the enclosing block. An inner block may countermand this by saying `no strict 'subs'`.

Arrays and slices are interpolated into double-quoted strings by joining the elements with the delimiter specified in the `$"` variable (`$LIST_SEPARATOR` in English), space by default. The following are equivalent:

```
$temp = join($", @ARGV);
system "echo $temp";

system "echo @ARGV";
```

Within search patterns (which also undergo double-quotish substitution) there is an unfortunate ambiguity: Is `/$foo[bar]/` to be interpreted as `/${foo}[bar]/` (where `[bar]` is a character class for the regular expression) or as `/${foo[bar]}/` (where `[bar]` is the subscript to array @foo)? If @foo doesn't otherwise exist, then it's obviously a character class. If @foo exists, Perl takes a good guess about `[bar]`,

and is almost always right. If it does guess wrong, or if you're just plain paranoid, you can force the correct interpretation with curly braces as above.

A line-oriented form of quoting is based on the shell "here-document" syntax. Following a `<<` you specify a string to terminate the quoted material, and all lines following the current line down to the terminating string are the value of the item. The terminating string may be either an identifier (a word), or some quoted text. If quoted, the type of quotes you use determines the treatment of the text, just as in regular quoting. An unquoted identifier works like double quotes. There must be no space between the `<<` and the identifier. (If you put a space it will be treated as a null identifier, which is valid, and matches the first empty line.) The terminating string must appear by itself (unquoted and with no surrounding whitespace) on the terminating line.

```
    print <<EOF;
The price is $Price.
EOF

    print <<"EOF";  # same as above
The price is $Price.
EOF

    print <<`EOC`;  # execute commands
echo hi there
echo lo there
EOC

    print <<"foo", <<"bar"; # you can stack them
I said foo.
foo
I said bar.
bar

    myfunc(<<"THIS", 23, <<'THAT');
Here's a line
or two.
THIS
and here's another.
THAT
```

Just don't forget that you have to put a semicolon on the end to finish the statement, as Perl doesn't know you're not going to try to do this:

```
    print <<ABC
179231
ABC
    + 20;
```

If you want your here-docs to be indented with the rest of the code, you'll need to remove leading whitespace from each line manually:

```
($quote = <<'FINIS') =~ s/^\s+//gm;
    The Road goes ever on and on,
    down from the door where it began.
FINIS
```

If you use a here-doc within a delimited construct, such as in `s///eg`, the quoted material must come on the lines following the final delimiter. So instead of

```
s/this/<<E . 'that'
the other
E
```

```
 . 'more '/eg;
```

you have to write

```
s/this/<<E . 'that'
 . 'more '/eg;
the other
E
```

List value constructors

List values are denoted by separating individual values by commas (and enclosing the list in parentheses where precedence requires it):

```
(LIST)
```

In a context not requiring a list value, the value of what appears to be a list literal is simply the value of the final element, as with the C comma operator. For example,

```
@foo = ('cc', '-E', $bar);
```

assigns the entire list value to array @foo, but

```
$foo = ('cc', '-E', $bar);
```

assigns the value of variable `$bar` to the scalar variable `$foo`. Note that the value of an actual array in scalar context is the length of the array; the following assigns the value 3 to `$foo`:

```
@foo = ('cc', '-E', $bar);
$foo = @foo;                 # $foo gets 3
```

You may have an optional comma before the closing parenthesis of a list literal, so that you can say:

```
@foo = (
    1,
    2,
    3,
);
```

To use a here–document to assign an array, one line per element, you might use an approach like this:

```
@sauces = <<End_Lines =~ m/(\S.*\S)/g;
    normal tomato
    spicy tomato
    green chile
    pesto
    white wine
End_Lines
```

LISTs do automatic interpolation of sublists. That is, when a LIST is evaluated, each element of the list is evaluated in list context, and the resulting list value is interpolated into LIST just as if each individual element were a member of LIST. Thus arrays and hashes lose their identity in a LIST—the list

```
(@foo,@bar,&SomeSub,%glarch)
```

contains all the elements of @foo followed by all the elements of @bar, followed by all the elements returned by the subroutine named SomeSub called in list context, followed by the key/value pairs of %glarch. To make a list reference that does *NOT* interpolate, see *perlref*.

The null list is represented by `()`. Interpolating it in a list has no effect. Thus `((),(),())` is equivalent to `()`. Similarly, interpolating an array with no elements is the same as if no array had been interpolated at that point.

This interpolation combines with the facts that the opening and closing parentheses are optional (except necessary for precedence) and lists may end with an optional comma to mean that multiple commas within

lists are legal syntax. The list `1,,3` is a concatenation of two lists, `1,` and `3`, the first of which ends with that optional comma. `1,,3` is `(1,),(3)` is `1,3` (And similarly for `1,,,3` is `(1,),(,),3` is `1,3` and so on.) Not that we'd advise you to use this obfuscation.

A list value may also be subscripted like a normal array. You must put the list in parentheses to avoid ambiguity. For example:

```
# Stat returns list value.
$time = (stat($file))[8];

# SYNTAX ERROR HERE.
$time = stat($file)[8];  # OOPS, FORGOT PARENTHESES

# Find a hex digit.
$hexdigit = ('a','b','c','d','e','f')[$digit-10];

# A "reverse comma operator".
return (pop(@foo),pop(@foo))[0];
```

Lists may be assigned to only when each element of the list is itself legal to assign to:

```
($a, $b, $c) = (1, 2, 3);

($map{'red'}, $map{'blue'}, $map{'green'}) = (0x00f, 0x0f0, 0xf00);
```

An exception to this is that you may assign to `undef` in a list. This is useful for throwing away some of the return values of a function:

```
($dev, $ino, undef, undef, $uid, $gid) = stat($file);
```

List assignment in scalar context returns the number of elements produced by the expression on the right side of the assignment:

```
$x = (($foo,$bar) = (3,2,1));       # set $x to 3, not 2
$x = (($foo,$bar) = f());           # set $x to f()'s return count
```

This is handy when you want to do a list assignment in a Boolean context, because most list functions return a null list when finished, which when assigned produces a 0, which is interpreted as FALSE.

The final element may be an array or a hash:

```
($a, $b, @rest) = split;
my($a, $b, %rest) = @_;
```

You can actually put an array or hash anywhere in the list, but the first one in the list will soak up all the values, and anything after it will become undefined. This may be useful in a `my()` or `local()`.

A hash can be initialized using a literal list holding pairs of items to be interpreted as a key and a value:

```
# same as map assignment above
%map = ('red',0x00f,'blue',0x0f0,'green',0xf00);
```

While literal lists and named arrays are often interchangeable, that's not the case for hashes. Just because you can subscript a list value like a normal array does not mean that you can subscript a list value as a hash. Likewise, hashes included as parts of other lists (including parameters lists and return lists from functions) always flatten out into key/value pairs. That's why it's good to use references sometimes.

It is often more readable to use the `< =` operator between key/value pairs. The `< =` operator is mostly just a more visually distinctive synonym for a comma, but it also arranges for its left–hand operand to be interpreted as a string—if it's a bareword that would be a legal identifier. This makes it nice for initializing hashes:

```
%map = (
             red   => 0x00f,
             blue  => 0x0f0,
```

```
                green => 0xf00,
);
```

or for initializing hash references to be used as records:

```
$rec = {
            witch => 'Mable the Merciless',
            cat   => 'Fluffy the Ferocious',
            date  => '10/31/1776',
};
```

or for using call-by-named-parameter to complicated functions:

```
$field = $query->radio_group(
           name      => 'group_name',
           values    => ['eenie','meenie','minie'],
           default   => 'meenie',
           linebreak => 'true',
           labels    => \%labels
);
```

Note that just because a hash is initialized in that order doesn't mean that it comes out in that order. See *sort* for examples of how to arrange for an output ordering.

Slices

A common way to access an array or a hash is one scalar element at a time. You can also subscript a list to get a single element from it.

```
$whoami = $ENV{"USER"};             # one element from the hash
$parent = $ISA[0];                  # one element from the array
$dir    = (getpwnam("daemon"))[7];  # likewise, but with list
```

A slice accesses several elements of a list, an array, or a hash simultaneously using a list of subscripts. It's more convenient than writing out the individual elements as a list of separate scalar values.

```
($him, $her)   = @folks[0,-1];              # array slice
@them          = @folks[0 .. 3];            # array slice
($who, $home)  = @ENV{"USER", "HOME"};      # hash slice
($uid, $dir)   = (getpwnam("daemon"))[2,7]; # list slice
```

Since you can assign to a list of variables, you can also assign to an array or hash slice.

```
@days[3..5]    = qw/Wed Thu Fri/;
@colors{'red','blue','green'}
               = (0xff0000, 0x0000ff, 0x00ff00);
@folks[0, -1]  = @folks[-1, 0];
```

The previous assignments are exactly equivalent to

```
($days[3], $days[4], $days[5]) = qw/Wed Thu Fri/;
($colors{'red'}, $colors{'blue'}, $colors{'green'})
               = (0xff0000, 0x0000ff, 0x00ff00);
($folks[0], $folks[-1]) = ($folks[0], $folks[-1]);
```

Since changing a slice changes the original array or hash that it's slicing, a `foreach` construct will alter some—or even all—of the values of the array or hash.

```
foreach (@array[ 4 .. 10 ]) { s/peter/paul/ }

foreach (@hash{keys %hash}) {
    s/^\s+//;           # trim leading whitespace
    s/\s+$//;           # trim trailing whitespace
```

```
    s/(\w+)/\u\L$1/g;   # "titlecase" words
}
```

A slice of an empty list is still an empty list. Thus:

```
@a = ()[1,0];           # @a has no elements
@b = (@a)[0,1];         # @b has no elements
@c = (0,1)[2,3];        # @c has no elements
```

But:

```
@a = (1)[1,0];          # @a has two elements
@b = (1,undef)[1,0,2];  # @b has three elements
```

This makes it easy to write loops that terminate when a null list is returned:

```
while ( ($home, $user) = (getpwent)[7,0]) {
    printf "%-8s %s\n", $user, $home;
}
```

As noted earlier in this document, the scalar sense of list assignment is the number of elements on the right–hand side of the assignment. The null list contains no elements, so when the password file is exhausted, the result is 0, not 2.

If you‘re confused about why you use an ‘@’ there on a hash slice instead of a ‘%‘, think of it like this. The type of bracket (square or curly) governs whether it‘s an array or a hash being looked at. On the other hand, the leading symbol (‘$’ or ‘@’) on the array or hash indicates whether you are getting back a singular value (a scalar) or a plural one (a list).

Typeglobs and Filehandles

Perl uses an internal type called a *typeglob* to hold an entire symbol table entry. The type prefix of a typeglob is a `*`, because it represents all types. This used to be the preferred way to pass arrays and hashes by reference into a function, but now that we have real references, this is seldom needed.

The main use of typeglobs in modern Perl is create symbol table aliases. This assignment:

```
*this = *that;
```

makes `$this` an alias for `$that`, @this an alias for @that, %this an alias for %that, `&this` an alias for `&that`, etc. Much safer is to use a reference. This:

```
local *Here::blue = \$There::green;
```

temporarily makes `$Here::blue` an alias for `$There::green`, but doesn‘t make @Here::blue an alias for @There::green, or %Here::blue an alias for %There::green, etc. See *Symbol Tables in perlmod* for more examples of this. Strange though this may seem, this is the basis for the whole module import/export system.

Another use for typeglobs is to pass filehandles into a function or to create new filehandles. If you need to use a typeglob to save away a filehandle, do it this way:

```
$fh = *STDOUT;
```

or perhaps as a real reference, like this:

```
$fh = \*STDOUT;
```

See *perlsub* for examples of using these as indirect filehandles in functions.

Typeglobs are also a way to create a local filehandle using the `local()` operator. These last until their block is exited, but may be passed back. For example:

```
sub newopen {
    my $path = shift;
    local  *FH;  # not my!
```

```
    open   (FH, $path)  or  return undef;
    return *FH;
}
$fh = newopen('/etc/passwd');
```

Now that we have the `*foo{THING}` notation, typeglobs aren't used as much for filehandle manipulations, although they're still needed to pass brand new file and directory handles into or out of functions. That's because `*HANDLE{IO}` only works if HANDLE has already been used as a handle. In other words, `*FH` must be used to create new symbol table entries; `*foo{THING}` cannot. When in doubt, use `*FH`.

All functions that are capable of creating filehandles (`open()`, `opendir()`, `pipe()`, `socketpair()`, `sysopen()`, `socket()`, and `accept()`) automatically create an anonymous filehandle if the handle passed to them is an uninitialized scalar variable. This allows the constructs such as `open(my $fh, ...)` and `open(local $fh,...)` to be used to create filehandles that will conveniently be closed automatically when the scope ends, provided there are no other references to them. This largely eliminates the need for typeglobs when opening filehandles that must be passed around, as in the following example:

```
sub myopen {
    open my $fh, "@_"
         or die "Can't open '@_': $!";
    return $fh;
}

{
    my $f = myopen("</etc/motd");
    print <$f>;
    # $f implicitly closed here
}
```

Another way to create anonymous filehandles is with the Symbol module or with the IO::Handle module and its ilk. These modules have the advantage of not hiding different types of the same name during the `local()`. See the bottom of *open()* for an example.

SEE ALSO

See *perlvar* for a description of Perl's built–in variables and a discussion of legal variable names. See *perlref*, *perlsub*, and *Symbol Tables in perlmod* for more discussion on typeglobs and the `*foo{THING}` syntax.

NAME

perldbmfilter – Perl DBM Filters

SYNOPSIS

```
$db = tie %hash, 'DBM', ...

$old_filter = $db->filter_store_key  ( sub { ... } ) ;
$old_filter = $db->filter_store_value( sub { ... } ) ;
$old_filter = $db->filter_fetch_key  ( sub { ... } ) ;
$old_filter = $db->filter_fetch_value( sub { ... } ) ;
```

DESCRIPTION

The four `filter_*` methods shown above are available in all the DBM modules that ship with Perl, namely DB_File, GDBM_File, NDBM_File, ODBM_File and SDBM_File.

Each of the methods work identically, and are used to install (or uninstall) a single DBM Filter. The only difference between them is the place that the filter is installed.

To summarise:

filter_store_key

If a filter has been installed with this method, it will be invoked every time you write a key to a DBM database.

filter_store_value

If a filter has been installed with this method, it will be invoked every time you write a value to a DBM database.

filter_fetch_key

If a filter has been installed with this method, it will be invoked every time you read a key from a DBM database.

filter_fetch_value

If a filter has been installed with this method, it will be invoked every time you read a value from a DBM database.

You can use any combination of the methods from none to all four.

All filter methods return the existing filter, if present, or `undef` in not.

To delete a filter pass `undef` to it.

The Filter

When each filter is called by Perl, a local copy of `$_` will contain the key or value to be filtered. Filtering is achieved by modifying the contents of `$_`. The return code from the filter is ignored.

An Example — the NULL termination problem.

DBM Filters are useful for a class of problems where you *always* want to make the same transformation to all keys, all values or both.

For example, consider the following scenario. You have a DBM database that you need to share with a third–party C application. The C application assumes that *all* keys and values are NULL terminated. Unfortunately when Perl writes to DBM databases it doesn't use NULL termination, so your Perl application will have to manage NULL termination itself. When you write to the database you will have to use something like this:

```
$hash{"$key\0"} = "$value\0" ;
```

Similarly the NULL needs to be taken into account when you are considering the length of existing keys/values.

It would be much better if you could ignore the NULL terminations issue in the main application code and have a mechanism that automatically added the terminating NULL to all keys and values whenever you write to the database and have them removed when you read from the database. As I'm sure you have already guessed, this is a problem that DBM Filters can fix very easily.

```
use strict ;
use warnings ;
use SDBM_File ;
use Fcntl ;

my %hash ;
my $filename = "/tmp/filt" ;
unlink $filename ;

my $db = tie(%hash, 'SDBM_File', $filename, O_RDWR|O_CREAT, 0640)
  or die "Cannot open $filename: $!\n" ;

# Install DBM Filters
$db->filter_fetch_key  ( sub { s/\0$//    } ) ;
$db->filter_store_key  ( sub { $_ .= "\0" } ) ;
$db->filter_fetch_value(
    sub { no warnings 'uninitialized' ;s/\0$// } ) ;
$db->filter_store_value( sub { $_ .= "\0" } ) ;

$hash{"abc"} = "def" ;
my $a = $hash{"ABC"} ;
# ...
undef $db ;
untie %hash ;
```

The code above uses SDBM_File, but it will work with any of the DBM modules.

Hopefully the contents of each of the filters should be self–explanatory. Both "fetch" filters remove the terminating NULL, and both "store" filters add a terminating NULL.

Another Example — Key is a C int.

Here is another real–life example. By default, whenever Perl writes to a DBM database it always writes the key and value as strings. So when you use this:

```
$hash{12345} = "something" ;
```

the key 12345 will get stored in the DBM database as the 5 byte string "12345". If you actually want the key to be stored in the DBM database as a C int, you will have to use `pack` when writing, and `unpack` when reading.

Here is a DBM Filter that does it:

```
use strict ;
use warnings ;
use DB_File ;
my %hash ;
my $filename = "/tmp/filt" ;
unlink $filename ;

my $db = tie %hash, 'DB_File', $filename, O_CREAT|O_RDWR, 0666, $DB_HASH
  or die "Cannot open $filename: $!\n" ;

$db->filter_fetch_key  ( sub { $_ = unpack("i", $_) } ) ;
$db->filter_store_key  ( sub { $_ = pack ("i", $_) } ) ;
$hash{123} = "def" ;
# ...
```

```
undef $db ;
untie %hash ;
```

The code above uses DB_File, but again it will work with any of the DBM modules.

This time only two filters have been used — we only need to manipulate the contents of the key, so it wasn't necessary to install any value filters.

SEE ALSO

DB_File, *GDBM_File*, *NDBM_File*, *ODBM_File* and *SDBM_File*.

AUTHOR

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NAME

perldebguts – Guts of Perl debugging

DESCRIPTION

This is not the perldebug(1) manpage, which tells you how to use the debugger. This manpage describes low–level details ranging between difficult and impossible for anyone who isn't incredibly intimate with Perl's guts to understand. Caveat lector.

Debugger Internals

Perl has special debugging hooks at compile–time and run–time used to create debugging environments. These hooks are not to be confused with the *perl –Dxxx* command described in *perlrun*, which is usable only if a special Perl is built per the instructions in the ***INSTALL*** podpage in the Perl source tree.

For example, whenever you call Perl's built–in `caller` function from the package DB, the arguments that the corresponding stack frame was called with are copied to the @DB::args array. The general mechanisms is enabled by calling Perl with the **–d** switch, the following additional features are enabled (cf. *$^P):*

- Perl inserts the contents of `$ENV{PERL5DB}` (or `BEGIN {require 'perl5db.pl'}` if not present) before the first line of your program.
- Each array `@{"_<$filename"}` holds the lines of `$filename` for a file compiled by Perl. The same for `eval`ed strings that contain subroutines, or which are currently being executed. The `$filename` for `eval`ed strings looks like `(eval 34)`. Code assertions in regexes look like `(re_eval 19)`.

  Values in this array are magical in numeric context: they compare equal to zero only if the line is not breakable.
- Each hash `%{"_<$filename"}` contains breakpoints and actions keyed by line number. Individual entries (as opposed to the whole hash) are settable. Perl only cares about Boolean true here, although the values used by ***perl5db.pl*** have the form `"$break_condition\0$action"`.

  The same holds for evaluated strings that contain subroutines, or which are currently being executed. The `$filename` for `eval`ed strings looks like `(eval 34)` or `(re_eval 19)`.
- Each scalar `${"_<$filename"}` contains `"_<$filename"`. This is also the case for evaluated strings that contain subroutines, or which are currently being executed. The `$filename` for `eval`ed strings looks like `(eval 34)` or `(re_eval 19)`.
- After each `require`d file is compiled, but before it is executed, `DB::postponed(*{"_<$filename"})` is called if the subroutine `DB::postponed` exists. Here, the `$filename` is the expanded name of the `require`d file, as found in the values of %INC.
- After each subroutine `subname` is compiled, the existence of `$DB::postponed{subname}` is checked. If this key exists, `DB::postponed(subname)` is called if the `DB::postponed` subroutine also exists.
- A hash `%DB::sub` is maintained, whose keys are subroutine names and whose values have the form `filename:startline-endline`. `filename` has the form `(eval 34)` for subroutines defined inside `eval`s, or `(re_eval 19)` for those within regex code assertions.
- When the execution of your program reaches a point that can hold a breakpoint, the `DB::DB()` subroutine is called any of the variables `$DB::trace`, `$DB::single`, or `$DB::signal` is true. These variables are not `local`izable. This feature is disabled when executing inside `DB::DB()`, including functions called from it unless `< $^D & (1<<30)` is true.
- When execution of the program reaches a subroutine call, a call to `&DB::sub(`*`args`*`)` is made instead, with `$DB::sub` holding the name of the called subroutine. This doesn't happen if the subroutine was compiled in the `DB` package.)

Note that if `&DB::sub` needs external data for it to work, no subroutine call is possible until this is done. For the standard debugger, the `$DB::deep` variable (how many levels of recursion deep into the debugger you can go before a mandatory break) gives an example of such a dependency.

Writing Your Own Debugger

The minimal working debugger consists of one line

```
sub DB::DB {}
```

which is quite handy as contents of `PERL5DB` environment variable:

```
$ PERL5DB="sub DB::DB {}" perl -d your-script
```

Another brief debugger, slightly more useful, could be created with only the line:

```
sub DB::DB {print ++$i; scalar <STDIN>}
```

This debugger would print the sequential number of encountered statement, and would wait for you to hit a newline before continuing.

The following debugger is quite functional:

```
{
  package DB;
  sub DB  {}
  sub sub {print ++$i, " $sub\n"; &$sub}
}
```

It prints the sequential number of subroutine call and the name of the called subroutine. Note that `&DB::sub` should be compiled into the package `DB`.

At the start, the debugger reads your rc file (***./.perldb*** or ***~/.perldb*** under Unix), which can set important options. This file may define a subroutine `&afterinit` to be executed after the debugger is initialized.

After the rc file is read, the debugger reads the PERLDB_OPTS environment variable and parses this as the remainder of a `O ...` line as one might enter at the debugger prompt.

The debugger also maintains magical internal variables, such as `@DB::dbline`, `%DB::dbline`, which are aliases for `@{"::_<current_file"}` `%{"::_<current_file"}`. Here `current_file` is the currently selected file, either explicitly chosen with the debugger's `f` command, or implicitly by flow of execution.

Some functions are provided to simplify customization. See *Options in perldebug* for description of options parsed by `DB::parse_options(string)`. The function `DB::dump_trace(skip[, count])` skips the specified number of frames and returns a list containing information about the calling frames (all of them, if `count` is missing). Each entry is reference to a hash with keys `context` (either `.`, `$`, or `@`), `sub` (subroutine name, or info about `eval`), `args` (`undef` or a reference to an array), `file`, and `line`.

The function `DB::print_trace(FH, skip[, count[, short]])` prints formatted info about caller frames. The last two functions may be convenient as arguments to `< < , < <<` commands.

Note that any variables and functions that are not documented in this manpages (or in *perldebug*) are considered for internal use only, and as such are subject to change without notice.

Frame Listing Output Examples

The `frame` option can be used to control the output of frame information. For example, contrast this expression trace:

```
$ perl -de 42
Stack dump during die enabled outside of evals.

Loading DB routines from perl5db.pl patch level 0.94
Emacs support available.
```

```
Enter h or `h h' for help.

main::(-e:1):   0
  DB<1> sub foo { 14 }

  DB<2> sub bar { 3 }

  DB<3> t print foo() * bar()
main::((eval 172):3):   print foo() + bar();
main::foo((eval 168):2):
main::bar((eval 170):2):
42
```

with this one, once the Option `frame=2` has been set:

```
  DB<4> O f=2
               frame = '2'
  DB<5> t print foo() * bar()
3:      foo() * bar()
entering main::foo
 2:     sub foo { 14 };
exited main::foo
entering main::bar
 2:     sub bar { 3 };
exited main::bar
42
```

By way of demonstration, we present below a laborious listing resulting from setting your `PERLDB_OPTS` environment variable to the value `f=n N`, and running *perl −d −V* from the command line. Examples use various values of `n` are shown to give you a feel for the difference between settings. Long those it may be, this is not a complete listing, but only excerpts.

1

```
      entering main::BEGIN
       entering Config::BEGIN
        Package lib/Exporter.pm.
        Package lib/Carp.pm.
       Package lib/Config.pm.
       entering Config::TIEHASH
       entering Exporter::import
        entering Exporter::export
      entering Config::myconfig
       entering Config::FETCH
       entering Config::FETCH
       entering Config::FETCH
       entering Config::FETCH
```

2

```
      entering main::BEGIN
       entering Config::BEGIN
        Package lib/Exporter.pm.
        Package lib/Carp.pm.
       exited Config::BEGIN
       Package lib/Config.pm.
       entering Config::TIEHASH
       exited Config::TIEHASH
       entering Exporter::import
        entering Exporter::export
```

```
  exited Exporter::export
 exited Exporter::import
exited main::BEGIN
entering Config::myconfig
 entering Config::FETCH
 exited Config::FETCH
 entering Config::FETCH
 exited Config::FETCH
 entering Config::FETCH
```

4

```
in  $=main::BEGIN() from /dev/null:0
 in  $=Config::BEGIN() from lib/Config.pm:2
  Package lib/Exporter.pm.
  Package lib/Carp.pm.
 Package lib/Config.pm.
 in  $=Config::TIEHASH('Config') from lib/Config.pm:644
 in  $=Exporter::import('Config', 'myconfig', 'config_vars') from /dev/null:0
  in  $=Exporter::export('Config', 'main', 'myconfig', 'config_vars') from li
in  @=Config::myconfig() from /dev/null:0
 in  $=Config::FETCH(ref(Config), 'package') from lib/Config.pm:574
 in  $=Config::FETCH(ref(Config), 'baserev') from lib/Config.pm:574
 in  $=Config::FETCH(ref(Config), 'PERL_VERSION') from lib/Config.pm:574
 in  $=Config::FETCH(ref(Config), 'PERL_SUBVERSION') from lib/Config.pm:574
 in  $=Config::FETCH(ref(Config), 'osname') from lib/Config.pm:574
 in  $=Config::FETCH(ref(Config), 'osvers') from lib/Config.pm:574
```

6

```
in  $=main::BEGIN() from /dev/null:0
 in  $=Config::BEGIN() from lib/Config.pm:2
  Package lib/Exporter.pm.
  Package lib/Carp.pm.
 out $=Config::BEGIN() from lib/Config.pm:0
 Package lib/Config.pm.
 in  $=Config::TIEHASH('Config') from lib/Config.pm:644
 out $=Config::TIEHASH('Config') from lib/Config.pm:644
 in  $=Exporter::import('Config', 'myconfig', 'config_vars') from /dev/null:0
  in  $=Exporter::export('Config', 'main', 'myconfig', 'config_vars') from lib/
  out $=Exporter::export('Config', 'main', 'myconfig', 'config_vars') from lib/
 out $=Exporter::import('Config', 'myconfig', 'config_vars') from /dev/null:0
out $=main::BEGIN() from /dev/null:0
in  @=Config::myconfig() from /dev/null:0
 in  $=Config::FETCH(ref(Config), 'package') from lib/Config.pm:574
 out $=Config::FETCH(ref(Config), 'package') from lib/Config.pm:574
 in  $=Config::FETCH(ref(Config), 'baserev') from lib/Config.pm:574
 out $=Config::FETCH(ref(Config), 'baserev') from lib/Config.pm:574
 in  $=Config::FETCH(ref(Config), 'PERL_VERSION') from lib/Config.pm:574
 out $=Config::FETCH(ref(Config), 'PERL_VERSION') from lib/Config.pm:574
 in  $=Config::FETCH(ref(Config), 'PERL_SUBVERSION') from lib/Config.pm:574
```

14

```
in  $=main::BEGIN() from /dev/null:0
 in  $=Config::BEGIN() from lib/Config.pm:2
  Package lib/Exporter.pm.
  Package lib/Carp.pm.
```

```
 out $=Config::BEGIN() from lib/Config.pm:0
 Package lib/Config.pm.
 in  $=Config::TIEHASH('Config') from lib/Config.pm:644
 out $=Config::TIEHASH('Config') from lib/Config.pm:644
 in  $=Exporter::import('Config', 'myconfig', 'config_vars') from /dev/null:0
  in  $=Exporter::export('Config', 'main', 'myconfig', 'config_vars') from lib/
  out $=Exporter::export('Config', 'main', 'myconfig', 'config_vars') from lib/
 out $=Exporter::import('Config', 'myconfig', 'config_vars') from /dev/null:0
out $=main::BEGIN() from /dev/null:0
in  @=Config::myconfig() from /dev/null:0
 in  $=Config::FETCH('Config=HASH(0x1aa444)', 'package') from lib/Config.pm:574
 out $=Config::FETCH('Config=HASH(0x1aa444)', 'package') from lib/Config.pm:574
 in  $=Config::FETCH('Config=HASH(0x1aa444)', 'baserev') from lib/Config.pm:574
 out $=Config::FETCH('Config=HASH(0x1aa444)', 'baserev') from lib/Config.pm:574
```

30

```
in  $=CODE(0x15eca4)() from /dev/null:0
 in  $=CODE(0x182528)() from lib/Config.pm:2
  Package lib/Exporter.pm.
 out $=CODE(0x182528)() from lib/Config.pm:0
 scalar context return from CODE(0x182528): undef
 Package lib/Config.pm.
 in  $=Config::TIEHASH('Config') from lib/Config.pm:628
 out $=Config::TIEHASH('Config') from lib/Config.pm:628
 scalar context return from Config::TIEHASH:   empty hash
 in  $=Exporter::import('Config', 'myconfig', 'config_vars') from /dev/null:0
  in  $=Exporter::export('Config', 'main', 'myconfig', 'config_vars') from lib/
  out $=Exporter::export('Config', 'main', 'myconfig', 'config_vars') from lib/
  scalar context return from Exporter::export: ''
 out $=Exporter::import('Config', 'myconfig', 'config_vars') from /dev/null:0
 scalar context return from Exporter::import: ''
```

In all cases shown above, the line indentation shows the call tree. If bit 2 of `frame` is set, a line is printed on exit from a subroutine as well. If bit 4 is set, the arguments are printed along with the caller info. If bit 8 is set, the arguments are printed even if they are tied or references. If bit 16 is set, the return value is printed, too.

When a package is compiled, a line like this

```
Package lib/Carp.pm.
```

is printed with proper indentation.

Debugging regular expressions

There are two ways to enable debugging output for regular expressions.

If your perl is compiled with `-DDEBUGGING`, you may use the **-Dr** flag on the command line.

Otherwise, one can `use re 'debug'`, which has effects at compile time and run time. It is not lexically scoped.

Compile-time output

The debugging output at compile time looks like this:

```
compiling RE '[bc]d(ef*g)+h[ij]k$'
size 43 first at 1
   1: ANYOF(11)
  11: EXACT <d>(13)
  13: CURLYX {1,32767}(27)
```

```
   15:   OPEN1(17)
   17:     EXACT <e>(19)
   19:     STAR(22)
   20:       EXACT <f>(0)
   22:     EXACT <g>(24)
   24:   CLOSE1(26)
   26:   WHILEM(0)
   27: NOTHING(28)
   28: EXACT <h>(30)
   30: ANYOF(40)
   40: EXACT <k>(42)
   42: EOL(43)
   43: END(0)
anchored 'de' at 1 floating 'gh' at 3..2147483647 (checking floating)
                                    stclass 'ANYOF' minlen 7
```

The first line shows the pre–compiled form of the regex. The second shows the size of the compiled form (in arbitrary units, usually 4–byte words) and the label *id* of the first node that does a match.

The last line (split into two lines above) contains optimizer information. In the example shown, the optimizer found that the match should contain a substring `de` at offset 1, plus substring `gh` at some offset between 3 and infinity. Moreover, when checking for these substrings (to abandon impossible matches quickly), Perl will check for the substring `gh` before checking for the substring `de`. The optimizer may also use the knowledge that the match starts (at the `first` *id*) with a character class, and the match cannot be shorter than 7 chars.

The fields of interest which may appear in the last line are

`anchored` *STRING* `at` *POS*
`floating` *STRING* `at` *POS1..POS2*

See above.

`matching floating/anchored`

Which substring to check first.

`minlen`

The minimal length of the match.

`stclass` *TYPE*

Type of first matching node.

`noscan`

Don't scan for the found substrings.

`isall`

Means that the optimizer info is all that the regular expression contains, and thus one does not need to enter the regex engine at all.

`GPOS`

Set if the pattern contains `\G`.

`plus`

Set if the pattern starts with a repeated char (as in `x+y`).

`implicit`

Set if the pattern starts with `.*`.

with eval

Set if the pattern contain eval–groups, such as `(?{ code })` and `(??{ code })`.

`anchored(TYPE)`

If the pattern may match only at a handful of places, (with `TYPE` being `BOL`, `MBOL`, or `GPOS`. See the table below.

If a substring is known to match at end–of–line only, it may be followed by `$`, as in `floating 'k'$`.

The optimizer–specific info is used to avoid entering (a slow) regex engine on strings that will not definitely match. If `isall` flag is set, a call to the regex engine may be avoided even when the optimizer found an appropriate place for the match.

The rest of the output contains the list of *nodes* of the compiled form of the regex. Each line has format

id: *TYPE OPTIONAL–INFO* (*next–id*)

Types of nodes

Here are the possible types, with short descriptions:

```
# TYPE arg-description [num-args] [longjump-len] DESCRIPTION

# Exit points
END         no      End of program.
SUCCEED     no      Return from a subroutine, basically.

# Anchors:
BOL         no      Match "" at beginning of line.
MBOL        no      Same, assuming multiline.
SBOL        no      Same, assuming singleline.
EOS         no      Match "" at end of string.
EOL         no      Match "" at end of line.
MEOL        no      Same, assuming multiline.
SEOL        no      Same, assuming singleline.
BOUND       no      Match "" at any word boundary
BOUNDL      no      Match "" at any word boundary
NBOUND      no      Match "" at any word non-boundary
NBOUNDL     no      Match "" at any word non-boundary
GPOS        no      Matches where last m//g left off.

# [Special] alternatives
ANY         no      Match any one character (except newline).
SANY        no      Match any one character.
ANYOF       sv      Match character in (or not in) this class.
ALNUM       no      Match any alphanumeric character
ALNUML      no      Match any alphanumeric char in locale
NALNUM      no      Match any non-alphanumeric character
NALNUML     no      Match any non-alphanumeric char in locale
SPACE       no      Match any whitespace character
SPACEL      no      Match any whitespace char in locale
NSPACE      no      Match any non-whitespace character
NSPACEL     no      Match any non-whitespace char in locale
DIGIT       no      Match any numeric character
NDIGIT      no      Match any non-numeric character

# BRANCH    The set of branches constituting a single choice are hooked
#           together with their "next" pointers, since precedence prevents
#           anything being concatenated to any individual branch.  The
#           "next" pointer of the last BRANCH in a choice points to the
```

```
#           thing following the whole choice.  This is also where the
#           final "next" pointer of each individual branch points; each
#           branch starts with the operand node of a BRANCH node.
#
BRANCH      node    Match this alternative, or the next...

# BACK      Normal "next" pointers all implicitly point forward; BACK
#           exists to make loop structures possible.
# not used
BACK        no      Match "", "next" ptr points backward.

# Literals
EXACT       sv      Match this string (preceded by length).
EXACTF      sv      Match this string, folded (prec. by length).
EXACTFL     sv      Match this string, folded in locale (w/len).

# Do nothing
NOTHING     no      Match empty string.
# A variant of above which delimits a group, thus stops optimizations
TAIL        no      Match empty string. Can jump here from outside.

# STAR,PLUS '?', and complex '*' and '+', are implemented as circular
#           BRANCH structures using BACK.  Simple cases (one character
#           per match) are implemented with STAR and PLUS for speed
#           and to minimize recursive plunges.
#
STAR        node    Match this (simple) thing 0 or more times.
PLUS        node    Match this (simple) thing 1 or more times.

CURLY       sv 2    Match this simple thing {n,m} times.
CURLYN      no 2    Match next-after-this simple thing
#                   {n,m} times, set parens.
CURLYM      no 2    Match this medium-complex thing {n,m} times.
CURLYX      sv 2    Match this complex thing {n,m} times.

# This terminator creates a loop structure for CURLYX
WHILEM      no      Do curly processing and see if rest matches.

# OPEN,CLOSE,GROUPP ...are numbered at compile time.
OPEN        num 1   Mark this point in input as start of #n.
CLOSE       num 1   Analogous to OPEN.

REF         num 1   Match some already matched string
REFF        num 1   Match already matched string, folded
REFFL       num 1   Match already matched string, folded in loc.

# grouping assertions
IFMATCH     off 1 2 Succeeds if the following matches.
UNLESSM     off 1 2 Fails if the following matches.
SUSPEND     off 1 1 "Independent" sub-regex.
IFTHEN      off 1 1 Switch, should be preceded by switcher .
GROUPP      num 1   Whether the group matched.

# Support for long regex
LONGJMP     off 1 1 Jump far away.
BRANCHJ     off 1 1 BRANCH with long offset.

# The heavy worker
EVAL        evl 1   Execute some Perl code.
```

```
# Modifiers
MINMOD      no      Next operator is not greedy.
LOGICAL     no      Next opcode should set the flag only.

# This is not used yet
RENUM       off 1 1 Group with independently numbered parens.

# This is not really a node, but an optimized away piece of a "long" node.
# To simplify debugging output, we mark it as if it were a node
OPTIMIZED   off     Placeholder for dump.
```

Run-time output

First of all, when doing a match, one may get no run-time output even if debugging is enabled. This means that the regex engine was never entered and that all of the job was therefore done by the optimizer.

If the regex engine was entered, the output may look like this:

```
Matching '[bc]d(ef*g)+h[ij]k$' against 'abcdefg__gh__'
  Setting an EVAL scope, savestack=3
   2 <ab> <cdefg__gh_>    |  1: ANYOF
   3 <abc> <defg__gh_>    | 11: EXACT <d>
   4 <abcd> <efg__gh_>    | 13: CURLYX {1,32767}
   4 <abcd> <efg__gh_>    | 26:   WHILEM
                          |   0 out of 1..32767  cc=effff31c
   4 <abcd> <efg__gh_>    | 15:     OPEN1
   4 <abcd> <efg__gh_>    | 17:     EXACT <e>
   5 <abcde> <fg__gh_>    | 19:     STAR
                          |  EXACT <f> can match 1 times out of 32767...
  Setting an EVAL scope, savestack=3
   6 <bcdef> <g__gh__>    | 22:       EXACT <g>
   7 <bcdefg> <__gh__>    | 24:       CLOSE1
   7 <bcdefg> <__gh__>    | 26:       WHILEM
                          |     1 out of 1..32767  cc=effff31c
  Setting an EVAL scope, savestack=12
   7 <bcdefg> <__gh__>    | 15:         OPEN1
   7 <bcdefg> <__gh__>    | 17:         EXACT <e>
     restoring \1 to 4(4)..7
                          |     failed, try continuation...
   7 <bcdefg> <__gh__>    | 27:         NOTHING
   7 <bcdefg> <__gh__>    | 28:         EXACT <h>
                          |     failed...
                          |   failed...
```

The most significant information in the output is about the particular *node* of the compiled regex that is currently being tested against the target string. The format of these lines is

STRING-OFFSET <PRE-STRING <POST-STRING |ID: TYPE

The *TYPE* info is indented with respect to the backtracking level. Other incidental information appears interspersed within.

Debugging Perl memory usage

Perl is a profligate wastrel when it comes to memory use. There is a saying that to estimate memory usage of Perl, assume a reasonable algorithm for memory allocation, multiply that estimate by 10, and while you still may miss the mark, at least you won't be quite so astonished. This is not absolutely true, but may provide a good grasp of what happens.

Assume that an integer cannot take less than 20 bytes of memory, a float cannot take less than 24 bytes, a string cannot take less than 32 bytes (all these examples assume 32-bit architectures, the result are quite a bit

worse on 64–bit architectures). If a variable is accessed in two of three different ways (which require an integer, a float, or a string), the memory footprint may increase yet another 20 bytes. A sloppy malloc(3) implementation can inflate these numbers dramatically.

On the opposite end of the scale, a declaration like

```
sub foo;
```

may take up to 500 bytes of memory, depending on which release of Perl you're running.

Anecdotal estimates of source–to–compiled code bloat suggest an eightfold increase. This means that the compiled form of reasonable (normally commented, properly indented etc.) code will take about eight times more space in memory than the code took on disk.

There are two Perl–specific ways to analyze memory usage: `$ENV{PERL_DEBUG_MSTATS}` and **–DL** command–line switch. The first is available only if Perl is compiled with Perl's `malloc()`; the second only if Perl was built with `-DDEBUGGING`. See the instructions for how to do this in the ***INSTALL*** podpage at the top level of the Perl source tree.

Using `$ENV{PERL_DEBUG_MSTATS}`

If your perl is using Perl's `malloc()` and was compiled with the necessary switches (this is the default), then it will print memory usage statistics after compiling your code when < `$ENV{PERL_DEBUG_MSTATS}` 1 , and before termination of the program when < `$ENV{PERL_DEBUG_MSTATS}` = 1 . The report format is similar to the following example:

```
$ PERL_DEBUG_MSTATS=2 perl -e "require Carp"
Memory allocation statistics after compilation: (buckets 4(4)..8188(8192)
   14216 free:   130   117    28     7     9   0   2     2   1 0 0
               437    61    36     0     5
   60924 used:   125   137   161    55     7   8   6    16   2 0 1
                74   109   304    84    20
Total sbrk(): 77824/21:119. Odd ends: pad+heads+chain+tail: 0+636+0+2048.
Memory allocation statistics after execution:   (buckets 4(4)..8188(8192)
   30888 free:   245    78    85    13     6   2   1     3   2 0 1
               315   162    39    42    11
  175816 used:   265   176  1112   111    26  22  11    27   2 1 1
               196   178  1066   798    39
Total sbrk(): 215040/47:145. Odd ends: pad+heads+chain+tail: 0+2192+0+6144.
```

It is possible to ask for such a statistic at arbitrary points in your execution using the `mstat()` function out of the standard Devel::Peek module.

Here is some explanation of that format:

`buckets SMALLEST(APPROX)..GREATEST(APPROX)`

> Perl's `malloc()` uses bucketed allocations. Every request is rounded up to the closest bucket size available, and a bucket is taken from the pool of buckets of that size.
>
> The line above describes the limits of buckets currently in use. Each bucket has two sizes: memory footprint and the maximal size of user data that can fit into this bucket. Suppose in the above example that the smallest bucket were size 4. The biggest bucket would have usable size 8188, and the memory footprint would be 8192.
>
> In a Perl built for debugging, some buckets may have negative usable size. This means that these buckets cannot (and will not) be used. For larger buckets, the memory footprint may be one page greater than a power of 2. If so, case the corresponding power of two is printed in the `APPROX` field above.

Free/Used

The 1 or 2 rows of numbers following that correspond to the number of buckets of each size between SMALLEST and GREATEST. In the first row, the sizes (memory footprints) of buckets are powers of two—or possibly one page greater. In the second row, if present, the memory footprints of the buckets are between the memory footprints of two buckets "above".

For example, suppose under the previous example, the memory footprints were

```
free:    8     16    32    64    128  256 512 1024 2048 4096 8192
       4     12    24    48    80
```

With non–DEBUGGING perl, the buckets starting from 128 have a 4–byte overhead, and thus a 8192–long bucket may take up to 8188–byte allocations.

`Total sbrk(): SBRKed/SBRKs:CONTINUOUS`

The first two fields give the total amount of memory perl sbrk(2)ed (ess–broken? :–) and number of sbrk(2)s used. The third number is what perl thinks about continuity of returned chunks. So long as this number is positive, malloc() will assume that it is probable that sbrk(2) will provide continuous memory.

Memory allocated by external libraries is not counted.

`pad: 0`

The amount of sbrk(2)ed memory needed to keep buckets aligned.

`heads: 2192`

Although memory overhead of bigger buckets is kept inside the bucket, for smaller buckets, it is kept in separate areas. This field gives the total size of these areas.

`chain: 0`

malloc() may want to subdivide a bigger bucket into smaller buckets. If only a part of the deceased bucket is left unsubdivided, the rest is kept as an element of a linked list. This field gives the total size of these chunks.

`tail: 6144`

To minimize the number of sbrk(2)s, malloc() asks for more memory. This field gives the size of the yet unused part, which is sbrk(2)ed, but never touched.

Example of using –DL switch

Below we show how to analyse memory usage by

```
do 'lib/auto/POSIX/autosplit.ix';
```

The file in question contains a header and 146 lines similar to

```
sub getcwd;
```

WARNING: The discussion below supposes 32–bit architecture. In newer releases of Perl, memory usage of the constructs discussed here is greatly improved, but the story discussed below is a real–life story. This story is mercilessly terse, and assumes rather more than cursory knowledge of Perl internals. Type space to continue, 'q' to quit. (Actually, you just want to skip to the next section.)

Here is the itemized list of Perl allocations performed during parsing of this file:

```
!!! "after" at test.pl line 3.
   Id  subtot   4   8  12  16  20  24  28  32  36  40  48  56  64  72  80 80+
 0 02   13752   .   .   .   . 294   .   .   .   .   .   .   .   .   .   .   4
 0 54    5545   .   .   8 124  16   .   .   .   1   1   .   .   .   .   .   3
 5 05      32   .   .   .   .   .   .   .   1   .   .   .   .   .   .   .   .
 6 02    7152   .   .   .   .   .   .   .   .   .   . 149   .   .   .   .   .
 7 02    3600   .   .   .   .   . 150   .   .   .   .   .   .   .   .   .   .
```

```
  7 03      64    .  -1    .   1    .    .   2    .    .    .    .    .    .    .    .
  7 04    7056    .    .    .   .    .    .   .    .    .    .    .    .    .    .    7
  7 17   38404    .    .    .   .    .    .   .    1    .    . 442  149    .    .  147    .
  9 03    2078   17  249   32   .    .    .   .    2    .    .    .    .    .    .    .    .
```

To see this list, insert two `warn('!...')` statements around the call:

```
warn('!');
do 'lib/auto/POSIX/autosplit.ix';
warn('!!! "after"');
```

and run it with Perl's **–DL** option. The first `warn()` will print memory allocation info before parsing the file and will memorize the statistics at this point (we ignore what it prints). The second `warn()` prints increments with respect to these memorized data. This is the printout shown above.

Different *Id*s on the left correspond to different subsystems of the perl interpreter. They are just the first argument given to the perl memory allocation API named `New()`. To find what `9 03` means, just **grep** the perl source for `903`. You'll find it in ***util.c***, function `savepvn()`. (I know, you wonder why we told you to **grep** and then gave away the answer. That's because grepping the source is good for the soul.) This function is used to store a copy of an existing chunk of memory. Using a C debugger, one can see that the function was called either directly from `gv_init()` or via `sv_magic()`, and that `gv_init()` is called from `gv_fetchpv()`—which was itself called from `newSUB()`. Please stop to catch your breath now.

NOTE: To reach this point in the debugger and skip the calls to `savepvn()` during the compilation of the main program, you should set a C breakpoint in `Perl_warn()`, continue until this point is reached, and *then* set a C breakpoint in `Perl_savepvn()`. Note that you may need to skip a handful of `Perl_savepvn()` calls that do not correspond to mass production of CVs (there are more `903` allocations than 146 similar lines of ***lib/auto/POSIX/autosplit.ix***). Note also that `Perl_` prefixes are added by macroization code in perl header files to avoid conflicts with external libraries.

Anyway, we see that `903` ids correspond to creation of globs, twice per glob – for glob name, and glob stringification magic.

Here are explanations for other *Id*s above:

`717`

Creates bigger `XPV*` structures. In the case above, it creates 3 `AV`s per subroutine, one for a list of lexical variable names, one for a scratchpad (which contains lexical variables and `targets`), and one for the array of scratchpads needed for recursion.

It also creates a `GV` and a `CV` per subroutine, all called from `start_subparse()`.

`002` Creates a C array corresponding to the `AV` of scratchpads and the scratchpad itself. The first fake entry of this scratchpad is created though the subroutine itself is not defined yet.

It also creates C arrays to keep data for the stash. This is one HV, but it grows; thus, there are 4 big allocations: the big chunks are not freed, but are kept as additional arenas for `SV` allocations.

`054` Creates a `HEK` for the name of the glob for the subroutine. This name is a key in a *stash*.

Big allocations with this *Id* correspond to allocations of new arenas to keep `HE`.

`602` Creates a `GP` for the glob for the subroutine.

`702` Creates the `MAGIC` for the glob for the subroutine.

`704` Creates *arenas* which keep SVs.

–DL details

If Perl is run with **–DL** option, then `warn()`s that start with '!' behave specially. They print a list of *categories* of memory allocations, and statistics of allocations of different sizes for these categories.

If `warn()` string starts with

! ! !

print changed categories only, print the differences in counts of allocations.

! ! print grown categories only; print the absolute values of counts, and totals.

! print nonempty categories, print the absolute values of counts and totals.

Limitations of –DL statistics

If an extension or external library does not use the Perl API to allocate memory, such allocations are not counted.

SEE ALSO

perldebug, *perlguts*, *perlrun re*, and *Devel::Dprof*.

NAME

perldebtut – Perl debugging tutorial

DESCRIPTION

A (very) lightweight introduction in the use of the perl debugger, and a pointer to existing, deeper sources of information on the subject of debugging perl programs.

There's an extraordinary number of people out there who don't appear to know anything about using the perl debugger, though they use the language every day. This is for them.

use strict

First of all, there's a few things you can do to make your life a lot more straightforward when it comes to debugging perl programs, without using the debugger at all. To demonstrate, here's a simple script with a problem:

```
#!/usr/bin/perl

$var1 = 'Hello World'; # always wanted to do that :-)
$var2 = "$varl\n";

print $var2;
exit;
```

While this compiles and runs happily, it probably won't do what's expected, namely it doesn't print "Hello World\n" at all; It will on the other hand do exactly what it was told to do, computers being a bit that way inclined. That is, it will print out a newline character, and you'll get what looks like a blank line. It looks like there's 2 variables when (because of the typo) there's really 3:

```
$var1 = 'Hello World'
$varl = undef
$var2 = "\n"
```

To catch this kind of problem, we can force each variable to be declared before use by pulling in the strict module, by putting 'use strict;' after the first line of the script.

Now when you run it, perl complains about the 3 undeclared variables and we get four error messages because one variable is referenced twice:

```
Global symbol "$var1" requires explicit package name at ./t1 line 4.
Global symbol "$var2" requires explicit package name at ./t1 line 5.
Global symbol "$varl" requires explicit package name at ./t1 line 5.
Global symbol "$var2" requires explicit package name at ./t1 line 7.
Execution of ./hello aborted due to compilation errors.
```

Luvverly! and to fix this we declare all variables explicitly and now our script looks like this:

```
#!/usr/bin/perl
use strict;

my $var1 = 'Hello World';
my $varl = '';
my $var2 = "$varl\n";

print $var2;
exit;
```

We then do (always a good idea) a syntax check before we try to run it again:

```
> perl -c hello
hello syntax OK
```

And now when we run it, we get "\n" still, but at least we know why. Just getting this script to compile has

exposed the '$varl' (with the letter 'l) variable, and simply changing $varl to $var1 solves the problem.

Looking at data and –w and w

Ok, but how about when you want to really see your data, what's in that dynamic variable, just before using it?

```
#!/usr/bin/perl
use strict;

my $key = 'welcome';
my %data = (
        'this' => qw(that),
        'tom' => qw(and jerry),
        'welcome' => q(Hello World),
        'zip' => q(welcome),
);
my @data = keys %data;

print "$data{$key}\n";
exit;
```

Looks OK, after it's been through the syntax check (perl –c scriptname), we run it and all we get is a blank line again! Hmmmm.

One common debugging approach here, would be to liberally sprinkle a few print statements, to add a check just before we print out our data, and another just after:

```
print "All OK\n" if grep($key, keys %data);
print "$data{$key}\n";
print "done: '$data{$key}'\n";
```

And try again:

```
> perl data
All OK

done: ''
```

After much staring at the same piece of code and not seeing the wood for the trees for some time, we get a cup of coffee and try another approach. That is, we bring in the cavalry by giving perl the '**–d**' switch on the command line:

```
> perl -d data
Default die handler restored.

Loading DB routines from perl5db.pl version 1.07
Editor support available.

Enter h or `h h' for help, or `man perldebug' for more help.

main::(./data:4):     my $key = 'welcome';
```

Now, what we've done here is to launch the built–in perl debugger on our script. It's stopped at the first line of executable code and is waiting for input.

Before we go any further, you'll want to know how to quit the debugger: use just the letter '**q**', not the words 'quit' or 'exit':

```
DB<1> q
>
```

That's it, you're back on home turf again.

help

Fire the debugger up again on your script and we'll look at the help menu. There's a couple of ways of calling help: a simple '**h**' will get you a long scrolled list of help, '**|h**' (pipe–h) will pipe the help through your pager ('more' or 'less' probably), and finally, '**h h**' (h–space–h) will give you a helpful mini–screen snapshot:

```
 DB<1> h h
 List/search source lines:               Control script execution:
 l [ln|sub]  List source code            T           Stack trace
 - or .      List previous/current line  s [expr]    Single step [in expr]
 w [line]    List around line            n [expr]    Next, steps over subs
 f filename  View source in file         <CR/Enter>  Repeat last n or s
 /pattern/ ?patt?   Search forw/backw    r           Return from subroutine
 v           Show versions of modules    c [ln|sub]  Continue until position
 Debugger controls:                        L           List
break/watch/actions
 O [...]     Set debugger options        t [expr]    Toggle trace [trace expr]
<[<]|{[{]|[] [cmd] Do pre/post–prompt b [ln|event|sub] [cnd] Set breakpoint
 ! [N|pat]   Redo a previous command     d [ln] or D Delete a/all breakpoints
 H [–num]    Display last num commands   a [ln] cmd  Do cmd before line
 = [a val]   Define/list an alias        W expr      Add a watch expression
 h [db_cmd]  Get help on command         A or W      Delete all actions/watch
 |[|]db_cmd  Send output to pager        ![!] syscmd Run cmd in a subprocess
 q or ^D     Quit                        R           Attempt a restart
 Data Examination:      expr     Execute perl code, also see: s,n,t expr
 x|m expr       Evals expr in list context, dumps the result or lists methods.
 p expr         Print expression (uses script's current package).
 S [[!]pat]     List subroutine names [not] matching pattern
 V [Pk [Vars]] List Variables in Package.  Vars can be ~pattern or !pattern.
 X [Vars]       Same as "V current_package [Vars]".
 For more help, type h cmd_letter, or run man perldebug for all docs.
```

More confusing options than you can shake a big stick at! It's not as bad as it looks and it's very useful to know more about all of it, and fun too!

There's a couple of useful ones to know about straight away. You wouldn't think we're using any libraries at all at the moment, but '**v**' will show which modules are currently loaded, by the debugger as well your script. '**V**' and '**X**' show variables in the program by package scope and can be constrained by pattern. '**m**' shows methods and '**S**' shows all subroutines (by pattern):

```
DB<2>S str
dumpvar::stringify
strict::bits
strict::import
strict::unimport
```

Using 'X' and cousins requires you not to use the type identifiers (`$@%`), just the 'name':

```
DM<3>X ~err
FileHandle(stderr) => fileno(2)
```

Remember we're in our tiny program with a problem, we should have a look at where we are, and what our data looks like. First of all let's have a window on our present position (the first line of code in this case), via the letter '**w**':

```
DB<4> w
1       #!/usr/bin/perl
2:      use strict;
```

```
3
4==>    my $key = 'welcome';
5:      my %data = (
6                 'this' => qw(that),
7                 'tom' => qw(and jerry),
8                 'welcome' => q(Hello World),
9                 'zip' => q(welcome),
10      );
```

At line number 4 is a helpful pointer, that tells you where you are now. To see more code, type 'w' again:

```
DB<4> w
8                 'welcome' => q(Hello World),
9                 'zip' => q(welcome),
10      );
11:     my @data = keys %data;
12:     print "All OK\n" if grep($key, keys %data);
13:     print "$data{$key}\n";
14:     print "done: '$data{$key}'\n";
15:     exit;
```

And if you wanted to list line 5 again, type 'l 5', (note the space):

```
DB<4> l 5
5:      my %data = (
```

In this case, there's not much to see, but of course normally there's pages of stuff to wade through, and 'l' can be very useful. To reset your view to the line we're about to execute, type a lone period '.':

```
DB<5> .
main::(./data_a:4):     my $key = 'welcome';
```

The line shown is the one that is about to be executed **next**, it hasn't happened yet. So while we can print a variable with the letter '**p**', at this point all we'd get is an empty (undefined) value back. What we need to do is to step through the next executable statement with an '**s**':

```
DB<6> s
main::(./data_a:5):     my %data = (
main::(./data_a:6):             'this' => qw(that),
main::(./data_a:7):             'tom' => qw(and jerry),
main::(./data_a:8):             'welcome' => q(Hello World),
main::(./data_a:9):             'zip' => q(welcome),
main::(./data_a:10):    );
```

Now we can have a look at that first (`$key`) variable:

```
DB<7> p $key
welcome
```

line 13 is where the action is, so let's continue down to there via the letter '**c**', which by the way, inserts a 'one-time-only' breakpoint at the given line or sub routine:

```
DB<8> c 13
All OK
main::(./data_a:13):    print "$data{$key}\n";
```

We've gone past our check (where 'All OK' was printed) and have stopped just before the meat of our task. We could try to print out a couple of variables to see what is happening:

```
DB<9> p $data{$key}
```

Not much in there, lets have a look at our hash:

```
DB<10> p %data
Hello Worldziptomandwelcomejerrywelcomethisthat

DB<11> p keys %data
Hello Worldtomwelcomejerrythis
```

Well, this isn't very easy to read, and using the helpful manual (**h h**), the '**x**' command looks promising:

```
DB<12> x %data
0  'Hello World'
1  'zip'
2  'tom'
3  'and'
4  'welcome'
5  undef
6  'jerry'
7  'welcome'
8  'this'
9  'that'
```

That's not much help, a couple of welcomes in there, but no indication of which are keys, and which are values, it's just a listed array dump and, in this case, not particularly helpful. The trick here, is to use a **reference** to the data structure:

```
DB<13> x \%data
0  HASH(0x8194bc4)
   'Hello World' => 'zip'
   'jerry' => 'welcome'
   'this' => 'that'
   'tom' => 'and'
   'welcome' => undef
```

The reference is truly dumped and we can finally see what we're dealing with. Our quoting was perfectly valid but wrong for our purposes, with 'and jerry' being treated as 2 separate words rather than a phrase, thus throwing the evenly paired hash structure out of alignment.

The '**–w**' switch would have told us about this, had we used it at the start, and saved us a lot of trouble:

```
> perl -w data
Odd number of elements in hash assignment at ./data line 5.
```

We fix our quoting: 'tom' = q(and jerry), and run it again, this time we get our expected output:

```
> perl -w data
Hello World
```

While we're here, take a closer look at the '**x**' command, it's really useful and will merrily dump out nested references, complete objects, partial objects – just about whatever you throw at it:

Let's make a quick object and x–plode it, first we'll start the the debugger: it wants some form of input from STDIN, so we give it something non–commital, a zero:

```
> perl -de 0
Default die handler restored.

Loading DB routines from perl5db.pl version 1.07
Editor support available.

Enter h or 'h h' for help, or 'man perldebug' for more help.
```

```
main::(-e:1):   0
```

Now build an on–the–fly object over a couple of lines (note the backslash):

```
DB<1> $obj = bless({'unique_id'=>'123', 'attr'=> \
cont:   {'col' => 'black', 'things' => [qw(this that etc)]}}, 'MY_class')
```

And let's have a look at it:

```
DB<2> x $obj
0  MY_class=HASH(0x828ad98)
        'attr' => HASH(0x828ad68)
'col' => 'black'
'things' => ARRAY(0x828abb8)
        0  'this'
        1  'that'
        2  'etc'
        'unique_id' => 123
DB<3>
```

Useful, huh? You can eval nearly anything in there, and experiment with bits of code or regexes until the cows come home:

```
DB<3> @data = qw(this that the other atheism leather theory scythe)

DB<4> p 'saw -> '.($cnt += map { print "\t:\t$_\n" } grep(/the/, sort @data))
atheism
leather
other
scythe
the
theory
saw -> 6
```

If you want to see the command History, type an '**H**':

```
DB<5> H
4: p 'saw -> '.($cnt += map { print "\t:\t$_\n" } grep(/the/, sort @data))
3: @data = qw(this that the other atheism leather theory scythe)
2: x $obj
1: $obj = bless({'unique_id'=>'123', 'attr'=>
{'col' => 'black', 'things' => [qw(this that etc)]}}, 'MY_class')
DB<5>
```

And if you want to repeat any previous command, use the exclamation: '**!**':

```
DB<5> !4
p 'saw -> '.($cnt += map { print "$_\n" } grep(/the/, sort @data))
atheism
leather
other
scythe
the
theory
saw -> 12
```

For more on references see *perlref* and *perlreftut*

Stepping through code

Here's a simple program which converts between Celsius and Fahrenheit, it too has a problem:

```
#!/usr/bin/perl -w
use strict;

my $arg = $ARGV[0] || '-c20';

if ($arg =~ /^\-(c|f)((\-|\+)*\d+(\.\d+)*)$/) {
        my ($deg, $num) = ($1, $2);
        my ($in, $out) = ($num, $num);
        if ($deg eq 'c') {
                $deg = 'f';
                $out = &c2f($num);
        } else {
                $deg = 'c';
                $out = &f2c($num);
        }
        $out = sprintf('%0.2f', $out);
        $out =~ s/^((\-|\+)*\d+)\.0+$/$1/;
        print "$out $deg\n";
} else {
        print "Usage: $0 -[c|f] num\n";
}
exit;

sub f2c {
        my $f = shift;
        my $c = 5 * $f - 32 / 9;
        return $c;
}

sub c2f {
        my $c = shift;
        my $f = 9 * $c / 5 + 32;
        return $f;
}
```

For some reason, the Fahrenheit to Celsius conversion fails to return the expected output. This is what it does:

```
> temp -c0.72
33.30 f

> temp -f33.3
162.94 c
```

Not very consistent! We'll set a breakpoint in the code manually and run it under the debugger to see what's going on. A breakpoint is a flag, to which the debugger will run without interruption, when it reaches the breakpoint, it will stop execution and offer a prompt for further interaction. In normal use, these debugger commands are completely ignored, and they are safe – if a little messy, to leave in production code.

```
my ($in, $out) = ($num, $num);
$DB::single=2; # insert at line 9!
if ($deg eq 'c')
        ...

> perl -d temp -f33.3
Default die handler restored.
```

```
Loading DB routines from perl5db.pl version 1.07
Editor support available.

Enter h or `h h' for help, or `man perldebug' for more help.

main::(temp:4): my $arg = $ARGV[0] || '-c100';
```

We'll simply continue down to our pre-set breakpoint with a '**c**':

```
DB<1> c
main::(temp:10):                if ($deg eq 'c') {
```

Followed by a window command to see where we are:

```
DB<1> w
7:              my ($deg, $num) = ($1, $2);
8:              my ($in, $out) = ($num, $num);
9:              $DB::single=2;
10==>           if ($deg eq 'c') {
11:                     $deg = 'f';
12:                     $out = &c2f($num);
13              } else {
14:                     $deg = 'c';
15:                     $out = &f2c($num);
16              }
```

And a print to show what values we're currently using:

```
DB<1> p $deg, $num
f33.3
```

We can put another break point on any line beginning with a colon, we'll use line 17 as that's just as we come out of the subroutine, and we'd like to pause there later on:

```
DB<2> b 17
```

There's no feedback from this, but you can see what breakpoints are set by using the list 'L' command:

```
DB<3> L
temp:
        17:             print "$out $deg\n";
        break if (1)
```

Note that to delete a breakpoint you use 'd' or 'D'.

Now we'll continue down into our subroutine, this time rather than by line number, we'll use the subroutine name, followed by the now familiar 'w':

```
DB<3> c f2c
main::f2c(temp:30):             my $f = shift;

DB<4> w
24:     exit;
25
26      sub f2c {
27==>           my $f = shift;
28:             my $c = 5 * $f - 32 / 9;
29:             return $c;
30      }
31
32      sub c2f {
33:             my $c = shift;
```

Note that if there was a subroutine call between us and line 29, and we wanted to **single–step** through it, we could use the '**s**' command, and to step over it we would use '**n**' which would execute the sub, but not descend into it for inspection. In this case though, we simply continue down to line 29:

```
DB<4> c 29
main::f2c(temp:29):             return $c;
```

And have a look at the return value:

```
DB<5> p $c
162.944444444444
```

This is not the right answer at all, but the sum looks correct. I wonder if it's anything to do with operator precedence? We'll try a couple of other possibilities with our sum:

```
DB<6> p (5 * $f - 32 / 9)
162.944444444444

DB<7> p 5 * $f - (32 / 9)
162.944444444444

DB<8> p (5 * $f) - 32 / 9
162.944444444444

DB<9> p 5 * ($f - 32) / 9
0.722222222222221
```

:–) that's more like it! Ok, now we can set our return variable and we'll return out of the sub with an 'r':

```
DB<10> $c = 5 * ($f - 32) / 9

DB<11> r
scalar context return from main::f2c: 0.722222222222221
```

Looks good, let's just continue off the end of the script:

```
DB<12> c
0.72 c
Debugged program terminated.  Use q to quit or R to restart,
use O inhibit_exit to avoid stopping after program termination,
h q, h R or h O to get additional info.
```

A quick fix to the offending line (insert the missing parentheses) in the actual program and we're finished.

Placeholder for a, w, t, T

Actions, watch variables, stack traces etc.: on the TODO list.

```
a

W

t

T
```

REGULAR EXPRESSIONS

Ever wanted to know what a regex looked like? You'll need perl compiled with the DEBUGGING flag for this one:

```
> perl -Dr -e '/^pe(a)*rl$/i'
Compiling REx '^pe(a)*rl$'
size 17 first at 2
rarest char
 at 0
   1: BOL(2)
```

```
   2: EXACTF <pe>(4)
   4: CURLYN[1] {0,32767}(14)
   6:   NOTHING(8)
   8:   EXACTF <a>(0)
  12:   WHILEM(0)
  13: NOTHING(14)
  14: EXACTF <rl>(16)
  16: EOL(17)
  17: END(0)
floating ''$ at 4..2147483647 (checking floating) stclass 'EXACTF <pe>'
```
anchored(BOL) minlen 4

Omitting `$' $& $'` support.

```
EXECUTING...

Freeing REx: '^pe(a)*rl$'
```

Did you really want to know? :–) For more gory details on getting regular expressions to work, have a look at *perlre*, *perlretut*, and to decode the mysterious labels (BOL and CURLYN, etc. above), see *perldebguts*.

OUTPUT TIPS

To get all the output from your error log, and not miss any messages via helpful operating system buffering, insert a line like this, at the start of your script:

```
$|=1;
```

To watch the tail of a dynamically growing logfile, (from the command line):

```
tail -f $error_log
```

Wrapping all die calls in a handler routine can be useful to see how, and from where, they're being called, *perlvar* has more information:

```
BEGIN { $SIG{__DIE__} = sub { require Carp; Carp::confess(@_) } }
```

Various useful techniques for the redirection of STDOUT and STDERR filehandles are explained in *perlopentut* and *perlfaq8*.

CGI

Just a quick hint here for all those CGI programmers who can't figure out how on earth to get past that 'waiting for input' prompt, when running their CGI script from the command–line, try something like this:

```
> perl -d my_cgi.pl -nodebug
```

Of course *CGI* and *perlfaq9* will tell you more.

GUIs

The command line interface is tightly integrated with an **emacs** extension and there's a **vi** interface too.

You don't have to do this all on the command line, though, there are a few GUI options out there. The nice thing about these is you can wave a mouse over a variable and a dump of it's data will appear in an appropriate window, or in a popup balloon, no more tiresome typing of 'x `$varname`' :–)

In particular have a hunt around for the following:

ptkdb perlTK based wrapper for the built–in debugger

ddd data display debugger

PerlDevKit and **PerlBuilder** are NT specific

NB. (more info on these and others would be appreciated).

SUMMARY

We've seen how to encourage good coding practices with **use strict** and **−w**. We can run the perl debugger **perl −d scriptname** to inspect your data from within the perl debugger with the **p** and **x** commands. You can walk through your code, set breakpoints with **b** and step through that code with **s** or **n**, continue with **c** and return from a sub with **r**. Fairly intuitive stuff when you get down to it.

There is of course lots more to find out about, this has just scratched the surface. The best way to learn more is to use perldoc to find out more about the language, to read the on−line help (*perldebug* is probably the next place to go), and of course, experiment.

SEE ALSO

perldebug, *perldebguts*, *perldiag*, *dprofpp*, *perlrun*

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NAME

perldebug – Perl debugging

DESCRIPTION

First of all, have you tried using the **–w** switch?

The Perl Debugger

If you invoke Perl with the **–d** switch, your script runs under the Perl source debugger. This works like an interactive Perl environment, prompting for debugger commands that let you examine source code, set breakpoints, get stack backtraces, change the values of variables, etc. This is so convenient that you often fire up the debugger all by itself just to test out Perl constructs interactively to see what they do. For example:

```
$ perl -d -e 42
```

In Perl, the debugger is not a separate program the way it usually is in the typical compiled environment. Instead, the **–d** flag tells the compiler to insert source information into the parse trees it's about to hand off to the interpreter. That means your code must first compile correctly for the debugger to work on it. Then when the interpreter starts up, it preloads a special Perl library file containing the debugger.

The program will halt *right before* the first run–time executable statement (but see below regarding compile–time statements) and ask you to enter a debugger command. Contrary to popular expectations, whenever the debugger halts and shows you a line of code, it always displays the line it's *about* to execute, rather than the one it has just executed.

Any command not recognized by the debugger is directly executed (`eval`'d) as Perl code in the current package. (The debugger uses the DB package for keeping its own state information.)

For any text entered at the debugger prompt, leading and trailing whitespace is first stripped before further processing. If a debugger command coincides with some function in your own program, merely precede the function with something that doesn't look like a debugger command, such as a leading `;` or perhaps a `+`, or by wrapping it with parentheses or braces.

Debugger Commands

The debugger understands the following commands:

h [command] Prints out a help message.

If you supply another debugger command as an argument to the `h` command, it prints out the description for just that command. The special argument of `h h` produces a more compact help listing, designed to fit together on one screen.

If the output of the `h` command (or any command, for that matter) scrolls past your screen, precede the command with a leading pipe symbol so that it's run through your pager, as in

```
DB> |h
```

You may change the pager which is used via `O pager=...` command.

p expr Same as `print {$DB::OUT} expr` in the current package. In particular, because this is just Perl's own `print` function, this means that nested data structures and objects are not dumped, unlike with the `x` command.

The `DB::OUT` filehandle is opened to ***/dev/tty***, regardless of where STDOUT may be redirected to.

x expr Evaluates its expression in list context and dumps out the result in a pretty–printed fashion. Nested data structures are printed out recursively, unlike the real `print` function in Perl. See *Dumpvalue* if you'd like to do this yourself.

The output format is governed by multiple options described under *"Configurable Options"*.

V [pkg [vars]] Display all (or some) variables in package (defaulting to `main`) using a data pretty−printer (hashes show their keys and values so you see what's what, control characters are made printable, etc.). Make sure you don't put the type specifier (like `$`) there, just the symbol names, like this:

```
V DB filename line
```

Use `~pattern` and `!pattern` for positive and negative regexes.

This is similar to calling the `x` command on each applicable var.

X [vars] Same as `V currentpackage [vars]`.

T Produce a stack backtrace. See below for details on its output.

s [expr] Single step. Executes until the beginning of another statement, descending into subroutine calls. If an expression is supplied that includes function calls, it too will be single−stepped.

n [expr] Next. Executes over subroutine calls, until the beginning of the next statement. If an expression is supplied that includes function calls, those functions will be executed with stops before each statement.

r Continue until the return from the current subroutine. Dump the return value if the `PrintRet` option is set (default).

<CR Repeat last `n` or `s` command.

c [line|sub] Continue, optionally inserting a one−time−only breakpoint at the specified line or subroutine.

l List next window of lines.

l min+incr List `incr+1` lines starting at `min`.

l min−max List lines `min` through `max`. `l -` is synonymous to `-`.

l line List a single line.

l subname List first window of lines from subroutine. *subname* may be a variable that contains a code reference.

− List previous window of lines.

w [line] List window (a few lines) around the current line.

. Return the internal debugger pointer to the line last executed, and print out that line.

f filename Switch to viewing a different file or `eval` statement. If *filename* is not a full pathname found in the values of %INC, it is considered a regex.

`eval`ed strings (when accessible) are considered to be filenames: `f (eval 7)` and `f eval 7\b` access the body of the 7th `eval`ed string (in the order of execution). The bodies of the currently executed `eval` and of `eval`ed strings that define subroutines are saved and thus accessible.

/pattern/ Search forwards for pattern (a Perl regex); final / is optional.

?pattern? Search backwards for pattern; final ? is optional.

L List all breakpoints and actions.

S [[!]regex] List subroutine names [not] matching the regex.

t Toggle trace mode (see also the `AutoTrace` option).

t expr Trace through execution of `expr`. See *Frame Listing Output Examples in perldebguts* for examples.

b [line] [condition]

Set a breakpoint before the given line. If *line* is omitted, set a breakpoint on the line about to be executed. If a condition is specified, it's evaluated each time the statement is reached: a breakpoint is taken only if the condition is true. Breakpoints may only be set on lines that begin an executable statement. Conditions don't use `if`:

```
b 237 $x > 30
b 237 ++$count237 < 11
b 33 /pattern/i
```

b subname [condition]

Set a breakpoint before the first line of the named subroutine. *subname* may be a variable containing a code reference (in this case *condition* is not supported).

b postpone subname [condition]

Set a breakpoint at first line of subroutine after it is compiled.

b load filename

Set a breakpoint before the first executed line of the *filename*, which should be a full pathname found amongst the %INC values.

b compile subname

Sets a breakpoint before the first statement executed after the specified subroutine is compiled.

d [line] Delete a breakpoint from the specified *line*. If *line* is omitted, deletes the breakpoint from the line about to be executed.

D Delete all installed breakpoints.

a [line] command

Set an action to be done before the line is executed. If *line* is omitted, set an action on the line about to be executed. The sequence of steps taken by the debugger is

```
1. check for a breakpoint at this line
2. print the line if necessary (tracing)
3. do any actions associated with that line
4. prompt user if at a breakpoint or in single-step
5. evaluate line
```

For example, this will print out `$foo` every time line 53 is passed:

```
a 53 print "DB FOUND $foo\n"
```

a [line] Delete an action from the specified line. If *line* is omitted, delete the action on the line that is about to be executed.

A Delete all installed actions.

W expr Add a global watch–expression. We hope you know what one of these is, because they're supposed to be obvious. **WARNING**: It is far too easy to destroy your watch expressions by accidentally omitting the *expr*.

W Delete all watch–expressions.

O booloption ...

Set each listed Boolean option to the value `1`.

O anyoption? ...

Print out the value of one or more options.

O option=value ...

Set the value of one or more options. If the value has internal whitespace, it should be quoted. For example, you could set `O pager="less -MQeicsNfr"` to call **less** with those specific options. You may use either single or double quotes, but if you do, you must escape any embedded instances of same sort of quote you began with, as well as any escaping any escapes that immediately precede that quote but which are not meant to escape the quote itself. In other words, you follow single–quoting rules irrespective of the quote; eg: `O option='this isn\'t bad'` or `O option="She said, \"Isn't it?\""`.

For historical reasons, the `=value` is optional, but defaults to 1 only where it is safe to do so—that is, mostly for Boolean options. It is always better to assign a specific value using `=`. The `option` can be abbreviated, but for clarity probably should not be. Several options can be set together. See *"Configurable Options"* for a list of these.

< ? List out all pre–prompt Perl command actions.

< [command] Set an action (Perl command) to happen before every debugger prompt. A multi–line command may be entered by backslashing the newlines. **WARNING** If `command` is missing, all actions are wiped out!

<< command Add an action (Perl command) to happen before every debugger prompt. A multi–line command may be entered by backwhacking the newlines.

? List out post–prompt Perl command actions.

command Set an action (Perl command) to happen after the prompt when you've just given a command to return to executing the script. A multi–line command may be entered by backslashing the newlines (we bet you couldn't've guessed this by now). **WARNING** If `command` is missing, all actions are wiped out!

command Adds an action (Perl command) to happen after the prompt when you've just given a command to return to executing the script. A multi–line command may be entered by backslashing the newlines.

{ ? List out pre–prompt debugger commands.

{ [command] Set an action (debugger command) to happen before every debugger prompt. A multi–line command may be entered in the customary fashion. **WARNING** If `command` is missing, all actions are wiped out!

Because this command is in some senses new, a warning is issued if you appear to have accidentally entered a block instead. If that's what you mean to do, write it as with `;{ ... }` or even `do { ... }`.

{{ command Add an action (debugger command) to happen before every debugger prompt. A multi–line command may be entered, if you can guess how: see above.

! number Redo a previous command (defaults to the previous command).

! –number Redo number'th previous command.

! pattern Redo last command that started with pattern. See `O recallCommand`, too.

!! cmd
: Run cmd in a subprocess (reads from DB::IN, writes to DB::OUT) See `O shellBang`, also. Note that the user's current shell (well, their `$ENV{SHELL}` variable) will be used, which can interfere with proper interpretation of exit status or signal and coredump information.

H –number
: Display last n commands. Only commands longer than one character are listed. If *number* is omitted, list them all.

q or ^D
: Quit. ("quit" doesn't work for this, unless you've made an alias) This is the only supported way to exit the debugger, though typing `exit` twice might work.

  Set the `inhibit_exit` option to 0 if you want to be able to step off the end the script. You may also need to set `$finished` to 0 if you want to step through global destruction.

R
: Restart the debugger by `exec()`ing a new session. We try to maintain your history across this, but internal settings and command–line options may be lost.

  The following setting are currently preserved: history, breakpoints, actions, debugger options, and the Perl command–line options **–w**, **–I**, and **–e**.

|dbcmd
: Run the debugger command, piping DB::OUT into your current pager.

||dbcmd
: Same as `|dbcmd` but DB::OUT is temporarily `select`ed as well.

= [alias value]
: Define a command alias, like

```
= quit q
```

  or list current aliases.

command
: Execute command as a Perl statement. A trailing semicolon will be supplied. If the Perl statement would otherwise be confused for a Perl debugger, use a leading semicolon, too.

m expr
: List which methods may be called on the result of the evaluated expression. The expression may evaluated to a reference to a blessed object, or to a package name.

man [manpage]
: Despite its name, this calls your system's default documentation viewer on the given page, or on the viewer itself if *manpage* is omitted. If that viewer is **man**, the current `Config` information is used to invoke **man** using the proper MANPATH or **–M** *manpath* option. Failed lookups of the form `XXX` that match known manpages of the form *perlXXX* will be retried. This lets you type `man debug` or `man op` from the debugger.

  On systems traditionally bereft of a usable **man** command, the debugger invokes **perldoc**. Occasionally this determination is incorrect due to recalcitrant vendors or rather more felicitously, to enterprising users. If you fall into either category, just manually set the `$DB::doccmd` variable to whatever viewer to view the Perl documentation on your system. This may be set in an rc file, or through direct assignment. We're still waiting for a working example of something along the lines of:

```
$DB::doccmd = 'netscape -remote http://something.here/';
```

Configurable Options

The debugger has numerous options settable using the `O` command, either interactively or from the environment or an rc file.

`recallCommand`, `ShellBang`
: The characters used to recall command or spawn shell. By default, both are set to `!`, which is unfortunate.

pager Program to use for output of pager–piped commands (those beginning with a | character.) By default, `$ENV{PAGER}` will be used. Because the debugger uses your current terminal characteristics for bold and underlining, if the chosen pager does not pass escape sequences through unchanged, the output of some debugger commands will not be readable when sent through the pager.

`tkRunning` Run Tk while prompting (with ReadLine).

`signalLevel`, `warnLevel`, `dieLevel`

Level of verbosity. By default, the debugger leaves your exceptions and warnings alone, because altering them can break correctly running programs. It will attempt to print a message when uncaught INT, BUS, or SEGV signals arrive. (But see the mention of signals in *BUGS* below.)

To disable this default safe mode, set these values to something higher than 0. At a level of 1, you get backtraces upon receiving any kind of warning (this is often annoying) or exception (this is often valuable). Unfortunately, the debugger cannot discern fatal exceptions from non–fatal ones. If `dieLevel` is even 1, then your non–fatal exceptions are also traced and unceremoniously altered if they came from `eval'd` strings or from any kind of `eval` within modules you're attempting to load. If `dieLevel` is 2, the debugger doesn't care where they came from: It usurps your exception handler and prints out a trace, then modifies all exceptions with its own embellishments. This may perhaps be useful for some tracing purposes, but tends to hopelessly destroy any program that takes its exception handling seriously.

`AutoTrace` Trace mode (similar to `t` command, but can be put into `PERLDB_OPTS`).

`LineInfo` File or pipe to print line number info to. If it is a pipe (say, `|visual_perl_db`), then a short message is used. This is the mechanism used to interact with a slave editor or visual debugger, such as the special `vi` or `emacs` hooks, or the `ddd` graphical debugger.

`inhibit_exit`

If 0, allows *stepping off* the end of the script.

`PrintRet` Print return value after `r` command if set (default).

`ornaments` Affects screen appearance of the command line (see *Term::ReadLine*). There is currently no way to disable these, which can render some output illegible on some displays, or with some pagers. This is considered a bug.

`frame` Affects the printing of messages upon entry and exit from subroutines. If `frame & 2` is false, messages are printed on entry only. (Printing on exit might be useful if interspersed with other messages.)

If `frame & 4`, arguments to functions are printed, plus context and caller info. If `frame & 8`, overloaded `stringify` and `tied FETCH` is enabled on the printed arguments. If `frame & 16`, the return value from the subroutine is printed.

The length at which the argument list is truncated is governed by the next option:

`maxTraceLen` Length to truncate the argument list when the `frame` option's bit 4 is set.

The following options affect what happens with `V`, `X`, and `x` commands:

`arrayDepth`, `hashDepth`

Print only first N elements ('' for all).

`compactDump`, `veryCompact`

Change the style of array and hash output. If `compactDump`, short array may be printed on one line.

globPrint Whether to print contents of globs.

DumpDBFiles Dump arrays holding debugged files.

DumpPackages
Dump symbol tables of packages.

DumpReused Dump contents of "reused" addresses.

quote, HighBit, undefPrint
Change the style of string dump. The default value for quote is auto; one can enable double–quotish or single–quotish format by setting it to " or ', respectively. By default, characters with their high bit set are printed verbatim.

UsageOnly Rudimentary per–package memory usage dump. Calculates total size of strings found in variables in the package. This does not include lexicals in a module's file scope, or lost in closures.

During startup, options are initialized from $ENV{PERLDB_OPTS}. You may place the initialization options TTY, noTTY, ReadLine, and NonStop there.

If your rc file contains:

```
parse_options("NonStop=1 LineInfo=db.out AutoTrace");
```

then your script will run without human intervention, putting trace information into the file *db.out*. (If you interrupt it, you'd better reset LineInfo to ***/dev/tty*** if you expect to see anything.)

TTY The TTY to use for debugging I/O.

noTTY If set, the debugger goes into NonStop mode and will not connect to a TTY. If interrupted (or if control goes to the debugger via explicit setting of $DB::signal or $DB::single from the Perl script), it connects to a TTY specified in the TTY option at startup, or to a tty found at runtime using the Term::Rendezvous module of your choice.

This module should implement a method named new that returns an object with two methods: IN and OUT. These should return filehandles to use for debugging input and output correspondingly. The new method should inspect an argument containing the value of $ENV{PERLDB_NOTTY} at startup, or "/tmp/perldbtty$$" otherwise. This file is not inspected for proper ownership, so security hazards are theoretically possible.

ReadLine If false, readline support in the debugger is disabled in order to debug applications that themselves use ReadLine.

NonStop If set, the debugger goes into non–interactive mode until interrupted, or programmatically by setting $DB::signal or $DB::single.

Here's an example of using the $ENV{PERLDB_OPTS} variable:

```
$ PERLDB_OPTS="NonStop frame=2" perl -d myprogram
```

That will run the script **myprogram** without human intervention, printing out the call tree with entry and exit points. Note that NonStop=1 frame=2 is equivalent to N f=2, and that originally, options could be uniquely abbreviated by the first letter (modulo the Dump* options). It is nevertheless recommended that you always spell them out in full for legibility and future compatibility.

Other examples include

```
$ PERLDB_OPTS="NonStop frame=2" perl -d myprogram
```

which runs script non–interactively, printing info on each entry into a subroutine and each executed line into the file named ***listing***. (If you interrupt it, you would better reset LineInfo to something "interactive"!)

Other examples include (using standard shell syntax to show environment variable settings):

```
$ ( PERLDB_OPTS="NonStop frame=1 AutoTrace LineInfo=tperl.out"
    perl -d myprogram )
```

which may be useful for debugging a program that uses `Term::ReadLine` itself. Do not forget to detach your shell from the TTY in the window that corresponds to ***/dev/ttyXX***, say, by issuing a command like

```
$ sleep 1000000
```

See *Debugger Internals in perldebguts* for details.

Debugger input/output

Prompt The debugger prompt is something like

```
DB<8>
```

or even

```
DB<<17>>
```

where that number is the command number, and which you'd use to access with the built-in **csh**-like history mechanism. For example, `!17` would repeat command number 17. The depth of the angle brackets indicates the nesting depth of the debugger. You could get more than one set of brackets, for example, if you'd already at a breakpoint and then printed the result of a function call that itself has a breakpoint, or you step into an expression via `s/n/t expression` command.

Multiline commands

If you want to enter a multi-line command, such as a subroutine definition with several statements or a format, escape the newline that would normally end the debugger command with a backslash. Here's an example:

```
DB<1> for (1..4) {          \
cont:     print "ok\n";    \
cont: }
ok
ok
ok
ok
```

Note that this business of escaping a newline is specific to interactive commands typed into the debugger.

Stack backtrace

Here's an example of what a stack backtrace via `T` command might look like:

```
$ = main::infested called from file 'Ambulation.pm' line 10
@ = Ambulation::legs(1, 2, 3, 4) called from file 'camel_flea' line 7
$ = main::pests('bactrian', 4) called from file 'camel_flea' line 4
```

The left-hand character up there indicates the context in which the function was called, with `$` and `@` meaning scalar or list contexts respectively, and `.` meaning void context (which is actually a sort of scalar context). The display above says that you were in the function `main::infested` when you ran the stack dump, and that it was called in scalar context from line 10 of the file *Ambulation.pm*, but without any arguments at all, meaning it was called as `&infested`. The next stack frame shows that the function `Ambulation::legs` was called in list context from the *camel_flea* file with four arguments. The last stack frame shows that `main::pests` was called in scalar context, also from *camel_flea*, but from line 4.

If you execute the `T` command from inside an active `use` statement, the backtrace will contain both a `require` frame and an `eval`) frame.

Line Listing Format

This shows the sorts of output the `l` command can produce:

```
  DB<<13>> l
101:                @i{@i} = ();
102:b               @isa{@i,$pack} = ()
103                     if(exists $i{$prevpack} || exists $isa{$pack});
104             }
105
106             next
107==>               if(exists $isa{$pack});
108
109:a           if ($extra-- > 0) {
110:                %isa = ($pack,1);
```

Breakable lines are marked with `:`. Lines with breakpoints are marked by `b` and those with actions by `a`. The line that's about to be executed is marked by `< ==` .

Please be aware that code in debugger listings may not look the same as your original source code. Line directives and external source filters can alter the code before Perl sees it, causing code to move from its original positions or take on entirely different forms.

Frame listing

When the `frame` option is set, the debugger would print entered (and optionally exited) subroutines in different styles. See *perldebguts* for incredibly long examples of these.

Debugging compile–time statements

If you have compile–time executable statements (such as code within BEGIN and CHECK blocks or `use` statements), these will *not* be stopped by debugger, although `requires` and INIT blocks will, and compile–time statements can be traced with `AutoTrace` option set in `PERLDB_OPTS`). From your own Perl code, however, you can transfer control back to the debugger using the following statement, which is harmless if the debugger is not running:

```
$DB::single = 1;
```

If you set `$DB::single` to 2, it's equivalent to having just typed the `n` command, whereas a value of 1 means the `s` command. The `$DB::trace` variable should be set to 1 to simulate having typed the `t` command.

Another way to debug compile–time code is to start the debugger, set a breakpoint on the *load* of some module:

```
  DB<7> b load f:/perllib/lib/Carp.pm
Will stop on load of `f:/perllib/lib/Carp.pm'.
```

and then restart the debugger using the `R` command (if possible). One can use `b compile subname` for the same purpose.

Debugger Customization

The debugger probably contains enough configuration hooks that you won't ever have to modify it yourself. You may change the behaviour of debugger from within the debugger using its `O` command, from the command line via the `PERLDB_OPTS` environment variable, and from customization files.

You can do some customization by setting up a ***.perldb*** file, which contains initialization code. For instance, you could make aliases like these (the last one is one people expect to be there):

```
$DB::alias{'len'}  = 's/^len(.*)/p length($1)/';
$DB::alias{'stop'} = 's/^stop (at|in)/b/';
$DB::alias{'ps'}   = 's/^ps\b/p scalar /';
$DB::alias{'quit'} = 's/^quit(\s*)/exit/';
```

You can change options from ***.perldb*** by using calls like this one;

```
parse_options("NonStop=1 LineInfo=db.out AutoTrace=1 frame=2");
```

The code is executed in the package `DB`. Note that ***.perldb*** is processed before processing `PERLDB_OPTS`. If ***.perldb*** defines the subroutine `afterinit`, that function is called after debugger initialization ends. ***.perldb*** may be contained in the current directory, or in the home directory. Because this file is sourced in by Perl and may contain arbitrary commands, for security reasons, it must be owned by the superuser or the current user, and writable by no one but its owner.

If you want to modify the debugger, copy ***perl5db.pl*** from the Perl library to another name and hack it to your heart's content. You'll then want to set your `PERL5DB` environment variable to say something like this:

```
BEGIN { require "myperl5db.pl" }
```

As a last resort, you could also use `PERL5DB` to customize the debugger by directly setting internal variables or calling debugger functions.

Note that any variables and functions that are not documented in this document (or in *perldebguts*) are considered for internal use only, and as such are subject to change without notice.

Readline Support

As shipped, the only command–line history supplied is a simplistic one that checks for leading exclamation points. However, if you install the Term::ReadKey and Term::ReadLine modules from CPAN, you will have full editing capabilities much like GNU *readline*(3) provides. Look for these in the ***modules/by–module/Term*** directory on CPAN. These do not support normal **vi** command–line editing, however.

A rudimentary command–line completion is also available. Unfortunately, the names of lexical variables are not available for completion.

Editor Support for Debugging

If you have the FSF's version of **emacs** installed on your system, it can interact with the Perl debugger to provide an integrated software development environment reminiscent of its interactions with C debuggers.

Perl comes with a start file for making **emacs** act like a syntax–directed editor that understands (some of) Perl's syntax. Look in the *emacs* directory of the Perl source distribution.

A similar setup by Tom Christiansen for interacting with any vendor–shipped **vi** and the X11 window system is also available. This works similarly to the integrated multiwindow support that **emacs** provides, where the debugger drives the editor. At the time of this writing, however, that tool's eventual location in the Perl distribution was uncertain.

Users of **vi** should also look into **vim** and **gvim**, the mousey and windy version, for coloring of Perl keywords.

Note that only perl can truly parse Perl, so all such CASE tools fall somewhat short of the mark, especially if you don't program your Perl as a C programmer might.

The Perl Profiler

If you wish to supply an alternative debugger for Perl to run, just invoke your script with a colon and a package argument given to the **–d** flag. The most popular alternative debuggers for Perl is the Perl profiler. Devel::DProf is now included with the standard Perl distribution. To profile your Perl program in the file ***mycode.pl***, just type:

```
$ perl -d:DProf mycode.pl
```

When the script terminates the profiler will dump the profile information to a file called ***tmon.out***. A tool like **dprofpp**, also supplied with the standard Perl distribution, can be used to interpret the information in that profile.

Debugging regular expressions

`use re 'debug'` enables you to see the gory details of how the Perl regular expression engine works. In order to understand this typically voluminous output, one must not only have some idea about about how regular expression matching works in general, but also know how Perl's regular expressions are internally compiled into an automaton. These matters are explored in some detail in *Debugging regular expressions in perldebguts*.

Debugging memory usage

Perl contains internal support for reporting its own memory usage, but this is a fairly advanced concept that requires some understanding of how memory allocation works. See *Debugging Perl memory usage in perldebguts* for the details.

SEE ALSO

You did try the **−w** switch, didn't you?

perldebguts, *re*, *DB*, *Devel::Dprof*, *dprofpp*, *Dumpvalue*, and *perlrun*.

BUGS

You cannot get stack frame information or in any fashion debug functions that were not compiled by Perl, such as those from C or C++ extensions.

If you alter your `@_` arguments in a subroutine (such as with `shift` or `pop`, the stack backtrace will not show the original values.

The debugger does not currently work in conjunction with the **−W** command−line switch, because it itself is not free of warnings.

If you're in a slow syscall (like `wait`ing, `accept`ing, or `read`ing from your keyboard or a socket) and haven't set up your own `$SIG{INT}` handler, then you won't be able to CTRL−C your way back to the debugger, because the debugger's own `$SIG{INT}` handler doesn't understand that it needs to raise an exception to longjmp(3) out of slow syscalls.

NAME

perldelta – what's new for perl v5.7.0

DESCRIPTION

This document describes differences between the 5.6.0 release and the 5.7.0 release.

Security Vulnerability Closed

A potential security vulnerability in the optional suidperl component of Perl has been identified. suidperl is neither built nor installed by default. As of September the 2nd, 2000, the only known vulnerable platform is Linux, most likely all Linux distributions. CERT and various vendors have been alerted about the vulnerability.

The problem was caused by Perl trying to report a suspected security exploit attempt using an external program, /bin/mail. On Linux platforms the /bin/mail program had an undocumented feature which when combined with suidperl gave access to a root shell, resulting in a serious compromise instead of reporting the exploit attempt. If you don't have /bin/mail, or if you have 'safe setuid scripts', or if suidperl is not installed, you are safe.

The exploit attempt reporting feature has been completely removed from the Perl 5.7.0 release, so that particular vulnerability isn't there anymore. However, further security vulnerabilities are, unfortunately, always possible. The suidperl code is being reviewed and if deemed too risky to continue to be supported, it may be completely removed from future releases. In any case, suidperl should only be used by security experts who know exactly what they are doing and why they are using suidperl instead of some other solution such as sudo (see http://www.courtesan.com/sudo/).

Incompatible Changes

- Arrays now always interpolate into double-quoted strings: constructs like "foo@bar" now always assume `@bar` is an array, whether or not the compiler has seen use of `@bar`.
- The semantics of bless(REF, REF) were unclear and until someone proves it to make some sense, it is forbidden.
- A reference to a reference now stringify as "REF(0x81485ec)" instead of "SCALAR(0x81485ec)" in order to be more consistent with the return value of `ref()`.
- The very dusty examples in the eg/ directory have been removed. Suggestions for new shiny examples welcome but the main issue is that the examples need to be documented, tested and (most importantly) maintained.
- The obsolete chat2 library that should never have been allowed to escape the laboratory has been decommissioned.
- The unimplemented POSIX regex features [[.cc.]] and [[=c=]] are still recognised but now cause fatal errors. The previous behaviour of ignoring them by default and warning if requested was unacceptable since it, in a way, falsely promised that the features could be used.
- The (bogus) escape sequences \8 and \9 now give an optional warning ("Unrecognized escape passed through"). There is no need to \-escape any `\w` character.
- lstat(FILEHANDLE) now gives a warning because the operation makes no sense. In future releases this may become a fatal error.
- The long deprecated uppercase aliases for the string comparison operators (EQ, NE, LT, LE, GE, GT) have now been removed.
- The regular expression captured submatches (`$1, $2, ...`) are now more consistently unset if the match fails, instead of leaving false data lying around in them.

- The tr///C and tr///U features have been removed and will not return; the interface was a mistake. Sorry about that. For similar functionality, see pack('U0', ...) and pack('C0', ...).

Core Enhancements

- Formats now support zero-padded decimal fields.
- `perl -d:Module=arg,arg,arg` now works (previously one couldn't pass in multiple arguments.)
- my __PACKAGE__ now works.
- `no Module;` now works even if there is no "sub unimport" in the Module.
- The numerical comparison operators return `undef` if either operand is a NaN. Previously the behaviour was unspecified.
- `pack('U0a*', ...)` can now be used to force a string to UTF8.
- The printf and sprintf now support parameter reordering using the `%\d+\$` and `*\d+\$` syntaxes.
- prototype(\&) is now available.
- There is now an UNTIE method.

Modules and Pragmata

New Modules

- File::Temp allows one to create temporary files and directories in an easy, portable, and secure way.
- Storable gives persistence to Perl data structures by allowing the storage and retrieval of Perl data to and from files in a fast and compact binary format.

Updated And Improved Modules and Pragmata

- The following independently supported modules have been updated to newer versions from CPAN: CGI, CPAN, DB_File, File::Spec, Getopt::Long, the podlators bundle, Pod::LaTeX, Pod::Parser, Term::ANSIColor, Test.
- Bug fixes and minor enhancements have been applied to B::Deparse, Data::Dumper, IO::Poll, IO::Socket::INET, Math::BigFloat, Math::Complex, Math::Trig, Net::protoent, the re pragma, SelfLoader, Sys::SysLog, Test::Harness, Text::Wrap, UNIVERSAL, and the warnings pragma.
- The `attributes::reftype()` now works on tied arguments.
- AutoLoader can now be disabled with `no AutoLoader;`,
- The English module can now be used without the infamous performance hit by saying

  ```
  use English '-no_performance_hit';
  ```

  (Assuming, of course, that one doesn't need the troublesome variables `$``, `$&`, or `$'`.) Also, introduced `@LAST_MATCH_START` and `@LAST_MATCH_END` English aliases for `@-` and `@+`.
- File::Find now has pre- and post-processing callbacks. It also correctly changes directories when chasing symbolic links. Callbacks (naughtily) exiting with "next;" instead of "return;" now work.
- `File::Glob::glob()` renamed to `File::Glob::bsd_glob()` to avoid prototype mismatch with `CORE::glob()`.
- IPC::Open3 now allows the use of numeric file descriptors.
- use lib now works identically to @INC. Removing directories with 'no lib' now works.

- %INC now localised in a Safe compartment so that use/require work.
- The Shell module now has an OO interface.

Utility Changes

- The Emacs perl mode (emacs/cperl−mode.el) has been updated to version 4.31.
- Perlbug is now much more robust. It also sends the bug report to perl.org, not perl.com.
- The perlcc utility has been rewritten and its user interface (that is, command line) is much more like that of the UNIX C compiler, cc.
- The xsubpp utility for extension writers now understands POD documentation embedded in the *.xs files.

New Documentation

- perl56delta details the changes between the 5.005 release and the 5.6.0 release.
- perldebtut is a Perl debugging tutorial.
- perlebcdic contains considerations for running Perl on EBCDIC platforms. Note that unfortunately EBCDIC platforms that used to supported back in Perl 5.005 are still unsupported by Perl 5.7.0; the plan, however, is to bring them back to the fold.
- perlnewmod tells about writing and submitting a new module.
- perlposix−bc explains using Perl on the POSIX−BC platform (an EBCDIC mainframe platform).
- perlretut is a regular expression tutorial.
- perlrequick is a regular expressions quick−start guide. Yes, much quicker than perlretut.
- perlutil explains the command line utilities packaged with the Perl distribution.

Performance Enhancements

- map() that changes the size of the list should now work faster.
- sort() has been changed to use mergesort internally as opposed to the earlier quicksort. For very small lists this may result in slightly slower sorting times, but in general the speedup should be at least 20%. Additional bonuses are that the worst case behaviour of sort() is now better (in computer science terms it now runs in time O(N log N), as opposed to quicksort's Theta(N**2) worst−case run time behaviour), and that sort() is now stable (meaning that elements with identical keys will stay ordered as they were before the sort).

Installation and Configuration Improvements

Generic Improvements

- INSTALL now explains how you can configure Perl to use 64−bit integers even on non−64−bit platforms.
- Policy.sh policy change: if you are reusing a Policy.sh file (see INSTALL) and you use Configure −Dprefix=/foo/bar and in the old Policy $prefix eq $siteprefix and $prefix eq $vendorprefix, all of them will now be changed to the new prefix, /foo/bar. (Previously only $prefix changed.) If you do not like this new behaviour, specify prefix, siteprefix, and vendorprefix explicitly.
- A new optional location for Perl libraries, otherlibdirs, is available. It can be used for example for vendor add−ons without disturbing Perl's own library directories.
- In many platforms the vendor−supplied 'cc' is too stripped−down to build Perl (basically, 'cc' doesn't do ANSI C). If this seems to be the case and 'cc' does not seem to be the GNU C compiler 'gcc', an automatic attempt is made to find and use 'gcc' instead.

- gcc needs to closely track the operating system release to avoid build problems. If Configure finds that gcc was built for a different operating system release than is running, it now gives a clearly visible warning that there may be trouble ahead.
- If binary compatibility with the 5.005 release is not wanted, Configure no longer suggests including the 5.005 modules in @INC.
- Configure `-S` can now run non-interactively.
- configure.gnu now works with options with whitespace in them.
- installperl now outputs everything to STDERR.
- `$Config{byteorder}` is now computed dynamically (this is more robust with "fat binaries" where an executable image contains binaries for more than one binary platform.)
- Configure no longer included the DBM libraries (dbm, gdbm, db, ndbm) when building the Perl binary. The only exception to this is SunOS 4.x, which needs them.

Selected Bug Fixes

- Several debugger fixes: exit code now reflects the script exit code, condition `"0"` now treated correctly, the `d` command now checks line number, the `$.` no longer gets corrupted, all debugger output now goes correctly to the socket if RemotePort is set.
- `*foo{FORMAT}` now works.
- Lexical warnings now propagating correctly between scopes.
- Line renumbering with eval and `#line` now works.
- Fixed numerous memory leaks, especially in eval "".
- Modulus of unsigned numbers now works (4063328477 % 65535 used to return 27406, instead of 27047).
- Some "not a number" warnings introduced in 5.6.0 eliminated to be more compatible with 5.005. Infinity is now recognised as a number.
- `our()` variables will not cause "will not stay shared" warnings.
- pack "Z" now correctly terminates the string with "\0".
- Fix password routines which in some shadow password platforms (e.g. HP-UX) caused `getpwent()` to return every other entry.
- `printf()` no longer resets the numeric locale to "C".
- `q(a\\b)` now parses correctly as `'a\\b'`.
- Printing quads (64-bit integers) with printf/sprintf now works without the q L ll prefixes (assuming you are on a quad-capable platform).
- Regular expressions on references and overloaded scalars now work.
- `scalar()` now forces scalar context even when used in void context.
- `sort()` arguments are now compiled in the right wantarray context (they were accidentally using the context of the `sort()` itself).
- Changed the POSIX character class `[[:space:]]` to include the (very rare) vertical tab character. Added a new POSIX-ish character class `[[:blank:]]` which stands for horizontal whitespace (currently, the space and the tab).

- $AUTOLOAD, sort(), lock(), and spawning subprocesses in multiple threads simultaneously are now thread−safe.
- Allow read−only string on left hand side of non−modifying tr///.
- Several Unicode fixes (but still not perfect).
  - BOMs (byte order marks) in the beginning of Perl files (scripts, modules) should now be transparently skipped. UTF−16 (UCS−2)encoded Perl files should now be read correctly.
  - The character tables have been updated to Unicode 3.0.1.
  - chr() for values greater than 127 now create utf8 when under use utf8.
  - Comparing with utf8 data does not magically upgrade non−utf8 data into utf8.
  - IsAlnum, IsAlpha, and IsWord now match titlecase.
  - Concatenation with the . operator or via variable interpolation, eq, substr, reverse, quotemeta, the x operator, substitution with s///, single−quoted UTF8, should now work—in theory.
  - The tr/// operator now works *slightly* better but is still rather broken. Note that the tr///CU functionality has been removed (but see pack('U0', ...)).
  - vec() now tries to work with characters <= 255 when possible, but it leaves higher character values in place. In that case, if vec() was used to modify the string, it is no longer considered to be utf8−encoded.
  - Zero entries were missing from the Unicode classes like IsDigit.
- UNIVERSAL::isa no longer caches methods incorrectly. (This broke the Tk extension with 5.6.0.)

Platform Specific Changes and Fixes

- BSDI 4.*

  Perl now works on post−4.0 BSD/OSes.

- All BSDs

  Setting $0 now works (as much as possible; see perlvar for details).

- Cygwin

  Numerous updates; currently synchronised with Cygwin 1.1.4.

- EPOC

  EPOC update after Perl 5.6.0. See README.epoc.

- FreeBSD 3.*

  Perl now works on post−3.0 FreeBSDs.

- HP−UX

  README.hpux updated; Configure −Duse64bitall now almost works.

- IRIX

  Numerous compilation flag and hint enhancements; accidental mixing of 32−bit and 64−bit libraries (a doomed attempt) made much harder.

- Linux

  Long doubles should now work (see INSTALL).

- MacOS Classic

  Compilation of the standard Perl distribution in MacOS Classic should now work if you have the Metrowerks development environment and the missing Mac−specific toolkit bits. Contact the macperl mailing list for details.

- MPE/iX

  MPE/iX update after Perl 5.6.0. See README.mpeix.

- NetBSD/sparc

  Perl now works on NetBSD/sparc.

- OS/2

  Now works with usethreads (see INSTALL).

- Solaris

  64−bitness using the Sun Workshop compiler now works.

- Tru64 (aka Digital UNIX, aka DEC OSF/1)

  The operating system version letter now recorded in `$Config{osvers}`. Allow compiling with gcc (previously explicitly forbidden). Compiling with gcc still not recommended because buggy code results, even with gcc 2.95.2.

- Unicos

  Fixed various alignment problems that lead into core dumps either during build or later; no longer dies on math errors at runtime; now using full quad integers (64 bits), previously was using only 46 bit integers for speed.

- VMS

  `chdir()` now works better despite a CRT bug; now works with MULTIPLICITY (see INSTALL); now works with Perl's malloc.

- Windows

  - `accept()` no longer leaks memory.
  - Better `chdir()` return value for a non−existent directory.
  - New %ENV entries now propagate to subprocesses.
  - `$ENV{LIB}` now used to search for libs under Visual C.
  - A failed (pseudo)fork now returns undef and sets errno to EAGAIN.
  - Allow REG_EXPAND_SZ keys in the registry.
  - Can now `send()` from all threads, not just the first one.
  - Fake signal handling reenabled, bugs and all.
  - Less stack reserved per thread so that more threads can run concurrently. (Still 16M per thread.)
  - `File::Spec−tmpdir()` now prefers C:/temp over /tmp (works better when perl is running as service).
  - Better UNC path handling under ithreads.
  - `wait()` and `waitpid()` now work much better.

- winsock handle leak fixed.

New or Changed Diagnostics

All regular expression compilation error messages are now hopefully easier to understand both because the error message now comes before the failed regex and because the point of failure is now clearly marked.

The various "opened only for", "on closed", "never opened" warnings drop the `main::` prefix for filehandles in the `main` package, for example `STDIN` instead of <main::STDIN.

The "Unrecognized escape" warning has been extended to include `\8`, `\9`, and `\_`. There is no need to escape any of the `\w` characters.

Changed Internals

- perlapi.pod (a companion to perlguts) now attempts to document the internal API.
- You can now build a really minimal perl called microperl. Building microperl does not require even running Configure; `make -f Makefile.micro` should be enough. Beware: microperl makes many assumptions, some of which may be too bold; the resulting executable may crash or otherwise misbehave in wondrous ways. For careful hackers only.
- Added `rsignal()`, `whichsig()`, `do_join()` to the publicised API.
- Made possible to propagate customised exceptions via `croak()`ing.
- Added `is_utf8_char()`, `is_utf8_string()`, `bytes_to_utf8()`, and `utf8_to_bytes()`.
- Now xsubs can have attributes just like subs.

Known Problems

Unicode Support Still Far From Perfect

We‘re working on it. Stay tuned.

EBCDIC Still A Lost Platform

The plan is to bring them back.

Building Extensions Can Fail Because Of Largefiles

Certain extensions like mod_perl and BSD::Resource are known to have issues with ‘largefiles‘, a change brought by Perl 5.6.0 in which file offsets default to 64 bits wide, where supported. Modules may fail to compile at all or compile and work incorrectly. Currently there is no good solution for the problem, but Configure now provides appropriate non−largefile ccflags, ldflags, libswanted, and libs in the %Config hash (e.g., `$Config{ccflags_nolargefiles}`) so the extensions that are having problems can try configuring themselves without the largefileness. This is admittedly not a clean solution, and the solution may not even work at all. One potential failure is whether one can (or, if one can, whether it‘s a good idea) link together at all binaries with different ideas about file offsets, all this is platform−dependent.

ftmp−security tests warn ‘system possibly insecure’

Don‘t panic. Read INSTALL ‘make test’ section instead.

Test lib/posix Subtest 9 Fails In LP64−Configured HP−UX

If perl is configured with −Duse64bitall, the successful result of the subtest 10 of lib/posix may arrive before the successful result of the subtest 9, which confuses the test harness so much that it thinks the subtest 9 failed.

Long Doubles Still Don‘t Work In Solaris

The experimental long double support is still very much so in Solaris. (Other platforms like Linux and Tru64 are beginning to solidify in this area.)

Linux With Sfio Fails op/misc Test 48

No known fix.

Storable tests fail in some platforms

If any Storable tests fail the use of Storable is not advisable.

- Many Storable tests fail on AIX configured with 64 bit integers.

  So far unidentified problems break Storable in AIX if Perl is configured to use 64 bit integers. AIX in 32−bit mode works and other 64−bit platforms work with Storable.

- DOS DJGPP may hang when testing Storable.

- st−06compat fails in UNICOS and UNICOS/mk.

  This means that you cannot read old (pre−Storable−0.7) Storable images made in other platforms.

- st−store.t and st−retrieve may fail with Compaq C 6.2 on OpenVMS Alpha 7.2.

Threads Are Still Experimental

Multithreading is still an experimental feature. Some platforms emit the following message for lib/thr5005

```
#
# This is a KNOWN FAILURE, and one of the reasons why threading
# is still an experimental feature.  It is here to stop people
# from deploying threads in production. ;-)
#
```

and another known thread−related warning is

```
pragma/overload......Unbalanced saves: 3 more saves than restores
panic: magic_mutexfree during global destruction.
ok
lib/selfloader.......Unbalanced saves: 3 more saves than restores
panic: magic_mutexfree during global destruction.
ok
lib/st-dclone........Unbalanced saves: 3 more saves than restores
panic: magic_mutexfree during global destruction.
ok
```

The Compiler Suite Is Still Experimental

The compiler suite is slowly getting better but is nowhere near working order yet. The backend part that has seen perhaps the most progress is the bytecode compiler.

Reporting Bugs

If you find what you think is a bug, you might check the articles recently posted to the comp.lang.perl.misc newsgroup and the perl bug database at http://bugs.perl.org. There may also be information at http://www.perl.com/perl/, the Perl Home Page.

If you believe you have an unreported bug, please run the **perlbug** program included with your release. Be sure to trim your bug down to a tiny but sufficient test case. Your bug report, along with the output of `perl −V`, will be sent off to perlbug@perl.org to be analysed by the Perl porting team.

SEE ALSO

The ***Changes*** file for exhaustive details on what changed.

The ***INSTALL*** file for how to build Perl.

The ***README*** file for general stuff.

The ***Artistic*** and ***Copying*** files for copyright information.

HISTORY

Written by Jarkko Hietaniemi *<jhi@iki.fi*, with many contributions from The Perl Porters and Perl Users submitting feedback and patches.

Send omissions or corrections to *<perlbug@perl.org*.

NAME

perldiag – various Perl diagnostics

DESCRIPTION

These messages are classified as follows (listed in increasing order of desperation):

```
(W) A warning (optional).
(D) A deprecation (optional).
(S) A severe warning (default).
(F) A fatal error (trappable).
(P) An internal error you should never see (trappable).
(X) A very fatal error (nontrappable).
(A) An alien error message (not generated by Perl).
```

The majority of messages from the first three classifications above (W, D & S) can be controlled using the `warnings` pragma.

If a message can be controlled by the `warnings` pragma, its warning category is included with the classification letter in the description below.

Optional warnings are enabled by using the `warnings` pragma or the **–w** and **–W** switches. Warnings may be captured by setting `$SIG{__WARN__}` to a reference to a routine that will be called on each warning instead of printing it. See *perlvar*.

Default warnings are always enabled unless they are explicitly disabled with the `warnings` pragma or the **–X** switch.

Trappable errors may be trapped using the eval operator. See *eval*. In almost all cases, warnings may be selectively disabled or promoted to fatal errors using the `warnings` pragma. See *warnings*.

The messages are in alphabetical order, without regard to upper or lower–case. Some of these messages are generic. Spots that vary are denoted with a %s or other printf–style escape. These escapes are ignored by the alphabetical order, as are all characters other than letters. To look up your message, just ignore anything that is not a letter.

`accept()` on closed socket %s

(W closed) You tried to do an accept on a closed socket. Did you forget to check the return value of your `socket()` call? See *accept*.

Allocation too large: %lx

(X) You can't allocate more than 64K on an MS–DOS machine.

'!' allowed only after types %s

(F) The '!' is allowed in `pack()` and `unpack()` only after certain types. See *pack*.

Ambiguous call resolved as `CORE::%s()`, qualify as such or use `&`

(W ambiguous) A subroutine you have declared has the same name as a Perl keyword, and you have used the name without qualification for calling one or the other. Perl decided to call the builtin because the subroutine is not imported.

To force interpretation as a subroutine call, either put an ampersand before the subroutine name, or qualify the name with its package. Alternatively, you can import the subroutine (or pretend that it's imported with the `use subs` pragma).

To silently interpret it as the Perl operator, use the `CORE::` prefix on the operator (e.g. `CORE::log($x)`) or by declaring the subroutine to be an object method (see *Subroutine Attributes in perlsub* or *attributes*).

Ambiguous range in transliteration operator

(F) You wrote something like `tr/a-z-0//` which doesn't mean anything at all. To include a - character in a transliteration, put it either first or last. (In the past, `tr/a-z-0//` was synonymous with `tr/a-y//`, which was probably not what you would have expected.)

Ambiguous use of %s resolved as %s

(W ambiguous)(S) You said something that may not be interpreted the way you thought. Normally it's pretty easy to disambiguate it by supplying a missing quote, operator, parenthesis pair or declaration.

'|' and '<' may not both be specified on command line

(F) An error peculiar to VMS. Perl does its own command line redirection, and found that STDIN was a pipe, and that you also tried to redirect STDIN using '<'. Only one STDIN stream to a customer, please.

'|' and '' may not both be specified on command line

(F) An error peculiar to VMS. Perl does its own command line redirection, and thinks you tried to redirect stdout both to a file and into a pipe to another command. You need to choose one or the other, though nothing's stopping you from piping into a program or Perl script which 'splits' output into two streams, such as

```
open(OUT,">$ARGV[0]") or die "Can't write to $ARGV[0]: $!";
while (<STDIN>) {
    print;
    print OUT;
}
close OUT;
```

Applying %s to %s will act on scalar(%s)

(W misc) The pattern match (//), substitution (s///), and transliteration (tr///) operators work on scalar values. If you apply one of them to an array or a hash, it will convert the array or hash to a scalar value — the length of an array, or the population info of a hash — and then work on that scalar value. This is probably not what you meant to do. See *grep* and *map* for alternatives.

Args must match #! line

(F) The setuid emulator requires that the arguments Perl was invoked with match the arguments specified on the #! line. Since some systems impose a one–argument limit on the #! line, try combining switches; for example, turn `-w -U` into `-wU`.

Arg too short for msgsnd

(F) `msgsnd()` requires a string at least as long as sizeof(long).

%s argument is not a HASH or ARRAY element

(F) The argument to `exists()` must be a hash or array element, such as:

```
$foo{$bar}
$ref->{"susie"}[12]
```

%s argument is not a HASH or ARRAY element or slice

(F) The argument to `delete()` must be either a hash or array element, such as:

```
$foo{$bar}
$ref->{"susie"}[12]
```

or a hash or array slice, such as:

```
@foo[$bar, $baz, $xyzzy]
@{$ref->[12]}{"susie", "queue"}
```

%s argument is not a subroutine name

(F) The argument to `exists()` for `exists &sub` must be a subroutine name, and not a subroutine call. `exists &sub()` will generate this error.

Argument "%s" isn't numeric%s

(W numeric) The indicated string was fed as an argument to an operator that expected a numeric value instead. If you're fortunate the message will identify which operator was so unfortunate.

Array @%s missing the @ in argument %d of `%s()`

(D deprecated) Really old Perl let you omit the @ on array names in some spots. This is now heavily deprecated.

assertion botched: %s

(P) The malloc package that comes with Perl had an internal failure.

Assertion failed: file "%s"

(P) A general assertion failed. The file in question must be examined.

Assignment to both a list and a scalar

(F) If you assign to a conditional operator, the 2nd and 3rd arguments must either both be scalars or both be lists. Otherwise Perl won't know which context to supply to the right side.

Negative offset to vec in lvalue context

(F) When vec is called in an lvalue context, the second argument must be greater than or equal to zero.

Attempt to bless into a reference

(F) The CLASSNAME argument to the `bless()` operator is expected to be the name of the package to bless the resulting object into. You've supplied instead a reference to something: perhaps you wrote

```
bless $self, $proto;
```

when you intended

```
bless $self, ref($proto) || $proto;
```

If you actually want to bless into the stringified version of the reference supplied, you need to stringify it yourself, for example by:

```
bless $self, "$proto";
```

Attempt to free non-arena SV: 0x%lx

(P internal) All SV objects are supposed to be allocated from arenas that will be garbage collected on exit. An SV was discovered to be outside any of those arenas.

Attempt to free nonexistent shared string

(P internal) Perl maintains a reference counted internal table of strings to optimize the storage and access of hash keys and other strings. This indicates someone tried to decrement the reference count of a string that can no longer be found in the table.

Attempt to free temp prematurely

(W debugging) Mortalized values are supposed to be freed by the `free_tmps()` routine. This indicates that something else is freeing the SV before the `free_tmps()` routine gets a chance, which means that the `free_tmps()` routine will be freeing an unreferenced scalar when it does try to free it.

Attempt to free unreferenced glob pointers

(P internal) The reference counts got screwed up on symbol aliases.

Attempt to free unreferenced scalar

(W internal) Perl went to decrement the reference count of a scalar to see if it would go to 0, and discovered that it had already gone to 0 earlier, and should have been freed, and in fact, probably was freed. This could indicate that `SvREFCNT_dec()` was called too many times, or that `SvREFCNT_inc()` was called too few times, or that the SV was mortalized when it shouldn't have been, or that memory has been corrupted.

Attempt to join self

(F) You tried to join a thread from within itself, which is an impossible task. You may be joining the wrong thread, or you may need to move the `join()` to some other thread.

Attempt to pack pointer to temporary value

(W pack) You tried to pass a temporary value (like the result of a function, or a computed expression) to the "p" `pack()` template. This means the result contains a pointer to a location that could become invalid anytime, even before the end of the current statement. Use literals or global values as arguments to the "p" `pack()` template to avoid this warning.

Attempt to use reference as lvalue in substr

(W substr) You supplied a reference as the first argument to `substr()` used as an lvalue, which is pretty strange. Perhaps you forgot to dereference it first. See *substr*.

Bad arg length for %s, is %d, should be %d

(F) You passed a buffer of the wrong size to one of `msgctl()`, `semctl()` or `shmctl()`. In C parlance, the correct sizes are, respectively, sizeof(struct msqid_ds *), sizeof(struct semid_ds *), and sizeof(struct shmid_ds *).

Bad evalled substitution pattern

(F) You've used the /e switch to evaluate the replacement for a substitution, but perl found a syntax error in the code to evaluate, most likely an unexpected right brace '}'.

Bad filehandle: %s

(F) A symbol was passed to something wanting a filehandle, but the symbol has no filehandle associated with it. Perhaps you didn't do an `open()`, or did it in another package.

Bad `free()` ignored

(S malloc) An internal routine called `free()` on something that had never been `malloc()`ed in the first place. Mandatory, but can be disabled by setting environment variable `PERL_BADFREE` to 0.

This message can be seen quite often with DB_File on systems with "hard" dynamic linking, like `AIX` and `OS/2`. It is a bug of `Berkeley DB` which is left unnoticed if `DB` uses *forgiving* system `malloc()`.

Bad hash

(P) One of the internal hash routines was passed a null HV pointer.

Bad index while coercing array into hash

(F) The index looked up in the hash found as the 0'th element of a pseudo–hash is not legal. Index values must be at 1 or greater. See *perlref*.

Badly placed `()`'s

(A) You've accidentally run your script through **csh** instead of Perl. Check the #! line, or manually feed your script into Perl yourself.

Bad name after %s::

(F) You started to name a symbol by using a package prefix, and then didn't finish the symbol. In particular, you can't interpolate outside of quotes, so

```
$var = 'myvar';
```

```
$sym = mypack::$var;
```

is not the same as

```
$var = 'myvar';
$sym = "mypack::$var";
```

Bad `realloc()` ignored

(S malloc) An internal routine called `realloc()` on something that had never been `malloc()`ed in the first place. Mandatory, but can be disabled by setting environment variable `PERL_BADFREE` to 1.

Bad symbol for array

(P) An internal request asked to add an array entry to something that wasn't a symbol table entry.

Bad symbol for filehandle

(P) An internal request asked to add a filehandle entry to something that wasn't a symbol table entry.

Bad symbol for hash

(P) An internal request asked to add a hash entry to something that wasn't a symbol table entry.

Bareword found in conditional

(W bareword) The compiler found a bareword where it expected a conditional, which often indicates that an || or `&&` was parsed as part of the last argument of the previous construct, for example:

```
open FOO || die;
```

It may also indicate a misspelled constant that has been interpreted as a bareword:

```
use constant TYPO => 1;
if (TYOP) { print "foo" }
```

The `strict` pragma is useful in avoiding such errors.

Bareword "%s" not allowed while "strict subs" in use

(F) With "strict subs" in use, a bareword is only allowed as a subroutine identifier, in curly brackets or to the left of the "=" symbol. Perhaps you need to predeclare a subroutine?

Bareword "%s" refers to nonexistent package

(W bareword) You used a qualified bareword of the form `Foo::`, but the compiler saw no other uses of that namespace before that point. Perhaps you need to predeclare a package?

BEGIN failed—compilation aborted

(F) An untrapped exception was raised while executing a BEGIN subroutine. Compilation stops immediately and the interpreter is exited.

BEGIN not safe after errors—compilation aborted

(F) Perl found a `BEGIN {}` subroutine (or a `use` directive, which implies a `BEGIN {}`) after one or more compilation errors had already occurred. Since the intended environment for the `BEGIN {}` could not be guaranteed (due to the errors), and since subsequent code likely depends on its correct operation, Perl just gave up.

\1 better written as `$1`

(W syntax) Outside of patterns, backreferences live on as variables. The use of backslashes is grandfathered on the right-hand side of a substitution, but stylistically it's better to use the variable form because other Perl programmers will expect it, and it works better if there are more than 9 backreferences.

Binary number 0b11111111111111111111111111111111 non-portable

(W portable) The binary number you specified is larger than 2**32-1 (4294967295) and therefore non-portable between systems. See *perlport* for more on portability concerns.

`bind()` on closed socket %s

(W closed) You tried to do a bind on a closed socket. Did you forget to check the return value of your `socket()` call? See *bind*.

Bit vector size 32 non–portable

(W portable) Using bit vector sizes larger than 32 is non–portable.

Bizarre copy of %s in %s

(P) Perl detected an attempt to copy an internal value that is not copyable.

–P not allowed for setuid/setgid script

(F) The script would have to be opened by the C preprocessor by name, which provides a race condition that breaks security.

Buffer overflow in prime_env_iter: %s

(W internal) A warning peculiar to VMS. While Perl was preparing to iterate over %ENV, it encountered a logical name or symbol definition which was too long, so it was truncated to the string shown.

Callback called exit

(F) A subroutine invoked from an external package via `call_sv()` exited by calling exit.

`%s()` called too early to check prototype

(W prototype) You've called a function that has a prototype before the parser saw a definition or declaration for it, and Perl could not check that the call conforms to the prototype. You need to either add an early prototype declaration for the subroutine in question, or move the subroutine definition ahead of the call to get proper prototype checking. Alternatively, if you are certain that you're calling the function correctly, you may put an ampersand before the name to avoid the warning. See *perlsub*.

/ cannot take a count

(F) You had an unpack template indicating a counted–length string, but you have also specified an explicit size for the string. See *pack*.

Can't bless non–reference value

(F) Only hard references may be blessed. This is how Perl "enforces" encapsulation of objects. See *perlobj*.

Can't call method "%s" in empty package "%s"

(F) You called a method correctly, and it correctly indicated a package functioning as a class, but that package doesn't have ANYTHING defined in it, let alone methods. See *perlobj*.

Can't call method "%s" on an undefined value

(F) You used the syntax of a method call, but the slot filled by the object reference or package name contains an undefined value. Something like this will reproduce the error:

```
$BADREF = undef;
process $BADREF 1,2,3;
$BADREF->process(1,2,3);
```

Can't call method "%s" on unblessed reference

(F) A method call must know in what package it's supposed to run. It ordinarily finds this out from the object reference you supply, but you didn't supply an object reference in this case. A reference isn't an object reference until it has been blessed. See *perlobj*.

Can't call method "%s" without a package or object reference

(F) You used the syntax of a method call, but the slot filled by the object reference or package name contains an expression that returns a defined value which is neither an object reference nor a package name. Something like this will reproduce the error:

```
$BADREF = 42;
process $BADREF 1,2,3;
$BADREF->process(1,2,3);
```

Can't chdir to %s

(F) You called `perl -x/foo/bar`, but `/foo/bar` is not a directory that you can chdir to, possibly because it doesn't exist.

Can't check filesystem of script "%s" for nosuid

(P) For some reason you can't check the filesystem of the script for nosuid.

Can't coerce array into hash

(F) You used an array where a hash was expected, but the array has no information on how to map from keys to array indices. You can do that only with arrays that have a hash reference at index 0.

Can't coerce %s to integer in %s

(F) Certain types of SVs, in particular real symbol table entries (typeglobs), can't be forced to stop being what they are. So you can't say things like:

```
*foo += 1;
```

You CAN say

```
$foo = *foo;
$foo += 1;
```

but then `$foo` no longer contains a glob.

Can't coerce %s to number in %s

(F) Certain types of SVs, in particular real symbol table entries (typeglobs), can't be forced to stop being what they are.

Can't coerce %s to string in %s

(F) Certain types of SVs, in particular real symbol table entries (typeglobs), can't be forced to stop being what they are.

Can't create pipe mailbox

(P) An error peculiar to VMS. The process is suffering from exhausted quotas or other plumbing problems.

Can't declare class for non-scalar %s in "%s"

(S) Currently, only scalar variables can declared with a specific class qualifier in a "my" or "our" declaration. The semantics may be extended for other types of variables in future.

Can't declare %s in "%s"

(F) Only scalar, array, and hash variables may be declared as "my" or "our" variables. They must have ordinary identifiers as names.

Can't do inplace edit: %s is not a regular file

(S inplace) You tried to use the **-i** switch on a special file, such as a file in /dev, or a FIFO. The file was ignored.

Can't do inplace edit on %s: %s

(S inplace) The creation of the new file failed for the indicated reason.

Can't do inplace edit without backup

(F) You're on a system such as MS-DOS that gets confused if you try reading from a deleted (but still opened) file. You have to say `-i.bak`, or some such.

Can't do inplace edit: %s would not be unique

(S inplace) Your filesystem does not support filenames longer than 14 characters and Perl was unable to create a unique filename during inplace editing with the **–i** switch. The file was ignored.

Can't do {n,m} with n > m before << HERE in regex m/%s/

(F) Minima must be less than or equal to maxima. If you really want your regexp to match something 0 times, just put {0}. The << HERE shows in the regular expression about where the problem was discovered. See *perlre*.

Can't do setegid!

(P) The `setegid()` call failed for some reason in the setuid emulator of suidperl.

Can't do seteuid!

(P) The setuid emulator of suidperl failed for some reason.

Can't do setuid

(F) This typically means that ordinary perl tried to exec suidperl to do setuid emulation, but couldn't exec it. It looks for a name of the form sperl5.000 in the same directory that the perl executable resides under the name perl5.000, typically /usr/local/bin on Unix machines. If the file is there, check the execute permissions. If it isn't, ask your sysadmin why he and/or she removed it.

Can't do waitpid with flags

(F) This machine doesn't have either `waitpid()` or `wait4()`, so only `waitpid()` without flags is emulated.

Can't emulate –%s on #! line

(F) The #! line specifies a switch that doesn't make sense at this point. For example, it'd be kind of silly to put a **–x** on the #! line.

Can't exec "%s": %s

(W exec) An `system()`, `exec()`, or piped open call could not execute the named program for the indicated reason. Typical reasons include: the permissions were wrong on the file, the file wasn't found in `$ENV{PATH}`, the executable in question was compiled for another architecture, or the #! line in a script points to an interpreter that can't be run for similar reasons. (Or maybe your system doesn't support #! at all.)

Can't exec %s

(F) Perl was trying to execute the indicated program for you because that's what the #! line said. If that's not what you wanted, you may need to mention "perl" on the #! line somewhere.

Can't execute %s

(F) You used the **–S** switch, but the copies of the script to execute found in the PATH did not have correct permissions.

Can't find an opnumber for "%s"

(F) A string of a form `CORE::word` was given to `prototype()`, but there is no builtin with the name `word`.

Can't find label %s

(F) You said to goto a label that isn't mentioned anywhere that it's possible for us to go to. See *goto*.

Can't find %s on PATH

(F) You used the **–S** switch, but the script to execute could not be found in the PATH.

Can't find %s on PATH, '.' not in PATH

(F) You used the **–S** switch, but the script to execute could not be found in the PATH, or at least not with the correct permissions. The script exists in the current directory, but PATH prohibits running it.

Can't find string terminator %s anywhere before EOF

(F) Perl strings can stretch over multiple lines. This message means that the closing delimiter was omitted. Because bracketed quotes count nesting levels, the following is missing its final parenthesis:

```
print q(The character '(' starts a side comment.);
```

If you're getting this error from a here-document, you may have included unseen whitespace before or after your closing tag. A good programmer's editor will have a way to help you find these characters.

Can't find %s property definition %s

(F) You may have tried to use `\p` which means a Unicode property for example \p{Lu} is all uppercase letters. Escape the `\p`, either `\\p` (just the `\p`) or by `\Q\p` (the rest of the string, until possible `\E`).

Can't fork

(F) A fatal error occurred while trying to fork while opening a pipeline.

Can't get filespec - stale stat buffer?

(S) A warning peculiar to VMS. This arises because of the difference between access checks under VMS and under the Unix model Perl assumes. Under VMS, access checks are done by filename, rather than by bits in the stat buffer, so that ACLs and other protections can be taken into account. Unfortunately, Perl assumes that the stat buffer contains all the necessary information, and passes it, instead of the filespec, to the access checking routine. It will try to retrieve the filespec using the device name and FID present in the stat buffer, but this works only if you haven't made a subsequent call to the CRTL `stat()` routine, because the device name is overwritten with each call. If this warning appears, the name lookup failed, and the access checking routine gave up and returned FALSE, just to be conservative. (Note: The access checking routine knows about the Perl `stat` operator and file tests, so you shouldn't ever see this warning in response to a Perl command; it arises only if some internal code takes stat buffers lightly.)

Can't get pipe mailbox device name

(P) An error peculiar to VMS. After creating a mailbox to act as a pipe, Perl can't retrieve its name for later use.

Can't get SYSGEN parameter value for MAXBUF

(P) An error peculiar to VMS. Perl asked `$GETSYI` how big you want your mailbox buffers to be, and didn't get an answer.

Can't "goto" into the middle of a foreach loop

(F) A "goto" statement was executed to jump into the middle of a foreach loop. You can't get there from here. See *goto*.

Can't "goto" out of a pseudo block

(F) A "goto" statement was executed to jump out of what might look like a block, except that it isn't a proper block. This usually occurs if you tried to jump out of a `sort()` block or subroutine, which is a no-no. See *goto*.

Can't goto subroutine from an eval-string

(F) The "goto subroutine" call can't be used to jump out of an eval "string". (You can use it to jump out of an eval {BLOCK}, but you probably don't want to.)

Can't goto subroutine outside a subroutine

(F) The deeply magical "goto subroutine" call can only replace one subroutine call for another. It can't manufacture one out of whole cloth. In general you should be calling it out of only an AUTOLOAD routine anyway. See *goto*.

Can't ignore signal CHLD, forcing to default

(W signal) Perl has detected that it is being run with the SIGCHLD signal (sometimes known as SIGCLD) disabled. Since disabling this signal will interfere with proper determination of exit status of child processes, Perl has reset the signal to its default value. This situation typically indicates that the parent program under which Perl may be running (e.g. cron) is being very careless.

Can't "last" outside a loop block

(F) A "last" statement was executed to break out of the current block, except that there's this itty bitty problem called there isn't a current block. Note that an "if" or "else" block doesn't count as a "loopish" block, as doesn't a block given to `sort()`, `map()` or `grep()`. You can usually double the curlies to get the same effect though, because the inner curlies will be considered a block that loops once. See *last*.

Can't localize lexical variable %s

(F) You used local on a variable name that was previously declared as a lexical variable using "my". This is not allowed. If you want to localize a package variable of the same name, qualify it with the package name.

Can't localize pseudo-hash element

(F) You said something like `< local $ar-{'key'}` , where `$ar` is a reference to a pseudo-hash. That hasn't been implemented yet, but you can get a similar effect by localizing the corresponding array element directly — `< local $ar-[$ar-[0]{'key'}]` .

Can't localize through a reference

(F) You said something like `local $$ref,` which Perl can't currently handle, because when it goes to restore the old value of whatever `$ref` pointed to after the scope of the `local()` is finished, it can't be sure that `$ref` will still be a reference.

Can't locate %s

(F) You said to `do` (or `require`, or `use`) a file that couldn't be found. Perl looks for the file in all the locations mentioned in @INC, unless the file name included the full path to the file. Perhaps you need to set the PERL5LIB or PERL5OPT environment variable to say where the extra library is, or maybe the script needs to add the library name to @INC. Or maybe you just misspelled the name of the file. See *require* and *lib*.

Can't locate auto/%s.al in @INC

(F) A function (or method) was called in a package which allows autoload, but there is no function to autoload. Most probable causes are a misprint in a function/method name or a failure to `AutoSplit` the file, say, by doing `make install`.

Can't locate object method "%s" via package "%s"

(F) You called a method correctly, and it correctly indicated a package functioning as a class, but that package doesn't define that particular method, nor does any of its base classes. See *perlobj*.

(perhaps you forgot to load "%s"?)

(F) This is an educated guess made in conjunction with the message "Can't locate object method \"%s\" via package \"%s\"". It often means that a method requires a package that has not been loaded.

Can't locate package %s for @%s::ISA

(W syntax) The @ISA array contained the name of another package that doesn't seem to exist.

Can't make list assignment to \%ENV on this system

(F) List assignment to %ENV is not supported on some systems, notably VMS.

Can't modify %s in %s

(F) You aren't allowed to assign to the item indicated, or otherwise try to change it, such as with an auto-increment.

Can't modify nonexistent substring

(P) The internal routine that does assignment to a `substr()` was handed a NULL.

Can't modify non-lvalue subroutine call

(F) Subroutines meant to be used in lvalue context should be declared as such, see *Lvalue subroutines in perlsub*.

Can't msgrcv to read-only var

(F) The target of a msgrcv must be modifiable to be used as a receive buffer.

Can't "next" outside a loop block

(F) A "next" statement was executed to reiterate the current block, but there isn't a current block. Note that an "if" or "else" block doesn't count as a "loopish" block, as doesn't a block given to `sort()`, `map()` or `grep()`. You can usually double the curlies to get the same effect though, because the inner curlies will be considered a block that loops once. See *next*.

Can't open %s: %s

(S inplace) The implicit opening of a file through use of the `< <` filehandle, either implicitly under the `-n` or `-p` command-line switches, or explicitly, failed for the indicated reason. Usually this is because you don't have read permission for a file which you named on the command line.

Can't open bidirectional pipe

(W pipe) You tried to say `open(CMD, "|cmd|")`, which is not supported. You can try any of several modules in the Perl library to do this, such as IPC::Open2. Alternately, direct the pipe's output to a file using "", and then read it in under a different file handle.

Can't open error file %s as stderr

(F) An error peculiar to VMS. Perl does its own command line redirection, and couldn't open the file specified after '2' or '2' on the command line for writing.

Can't open input file %s as stdin

(F) An error peculiar to VMS. Perl does its own command line redirection, and couldn't open the file specified after '<' on the command line for reading.

Can't open output file %s as stdout

(F) An error peculiar to VMS. Perl does its own command line redirection, and couldn't open the file specified after '' or '' on the command line for writing.

Can't open output pipe (name: %s)

(P) An error peculiar to VMS. Perl does its own command line redirection, and couldn't open the pipe into which to send data destined for stdout.

Can't open perl script "%s": %s

(F) The script you specified can't be opened for the indicated reason.

Can't read CRTL environ

(S) A warning peculiar to VMS. Perl tried to read an element of %ENV from the CRTL's internal environment array and discovered the array was missing. You need to figure out where your CRTL misplaced its environ or define ***PERL_ENV_TABLES*** (see *perlvms*) so that environ is not searched.

Can't redefine active sort subroutine %s

(F) Perl optimizes the internal handling of sort subroutines and keeps pointers into them. You tried to redefine one such sort subroutine when it was currently active, which is not allowed. If you really want to do this, you should write `sort { &func } @x` instead of `sort func @x`.

Can't "redo" outside a loop block

(F) A "redo" statement was executed to restart the current block, but there isn't a current block. Note that an "if" or "else" block doesn't count as a "loopish" block, as doesn't a block given to `sort()`,

`map()` or `grep()`. You can usually double the curlies to get the same effect though, because the inner curlies will be considered a block that loops once. See *redo*.

Can't remove %s: %s, skipping file

(S inplace) You requested an inplace edit without creating a backup file. Perl was unable to remove the original file to replace it with the modified file. The file was left unmodified.

Can't rename %s to %s: %s, skipping file

(S inplace) The rename done by the **–i** switch failed for some reason, probably because you don't have write permission to the directory.

Can't reopen input pipe (name: %s) in binary mode

(P) An error peculiar to VMS. Perl thought stdin was a pipe, and tried to reopen it to accept binary data. Alas, it failed.

Can't resolve method '%s' overloading '%s' in package '%s'

(F|P) Error resolving overloading specified by a method name (as opposed to a subroutine reference): no such method callable via the package. If method name is `???`, this is an internal error.

Can't reswap uid and euid

(P) The `setreuid()` call failed for some reason in the setuid emulator of suidperl.

Can't return %s from lvalue subroutine

(F) Perl detected an attempt to return illegal lvalues (such as temporary or readonly values) from a subroutine used as an lvalue. This is not allowed.

Can't return outside a subroutine

(F) The return statement was executed in mainline code, that is, where there was no subroutine call to return out of. See *perlsub*.

Can't stat script "%s"

(P) For some reason you can't `fstat()` the script even though you have it open already. Bizarre.

Can't swap uid and euid

(P) The `setreuid()` call failed for some reason in the setuid emulator of suidperl.

Can't take log of %g

(F) For ordinary real numbers, you can't take the logarithm of a negative number or zero. There's a Math::Complex package that comes standard with Perl, though, if you really want to do that for the negative numbers.

Can't take sqrt of %g

(F) For ordinary real numbers, you can't take the square root of a negative number. There's a Math::Complex package that comes standard with Perl, though, if you really want to do that.

Can't undef active subroutine

(F) You can't undefine a routine that's currently running. You can, however, redefine it while it's running, and you can even undef the redefined subroutine while the old routine is running. Go figure.

Can't unshift

(F) You tried to unshift an "unreal" array that can't be unshifted, such as the main Perl stack.

Can't upgrade that kind of scalar

(P) The internal sv_upgrade routine adds "members" to an SV, making it into a more specialized kind of SV. The top several SV types are so specialized, however, that they cannot be interconverted. This message indicates that such a conversion was attempted.

Can't upgrade to undef

(P) The undefined SV is the bottom of the totem pole, in the scheme of upgradability. Upgrading to undef indicates an error in the code calling sv_upgrade.

Can't use an undefined value as %s reference

(F) A value used as either a hard reference or a symbolic reference must be a defined value. This helps to delurk some insidious errors.

Can't use bareword ("%s") as %s ref while "strict refs" in use

(F) Only hard references are allowed by "strict refs". Symbolic references are disallowed. See *perlref*.

Can't use %%! because Errno.pm is not available

(F) The first time the %! hash is used, perl automatically loads the Errno.pm module. The Errno module is expected to tie the %! hash to provide symbolic names for `$!` errno values.

Can't use %s for loop variable

(F) Only a simple scalar variable may be used as a loop variable on a foreach.

Can't use global %s in "my"

(F) You tried to declare a magical variable as a lexical variable. This is not allowed, because the magic can be tied to only one location (namely the global variable) and it would be incredibly confusing to have variables in your program that looked like magical variables but weren't.

Can't use "my %s" in sort comparison

(F) The global variables `$a` and `$b` are reserved for sort comparisons. You mentioned `$a` or `$b` in the same line as the <= or cmp operator, and the variable had earlier been declared as a lexical variable. Either qualify the sort variable with the package name, or rename the lexical variable.

Can't use %s ref as %s ref

(F) You've mixed up your reference types. You have to dereference a reference of the type needed. You can use the `ref()` function to test the type of the reference, if need be.

Can't use string ("%s") as %s ref while "strict refs" in use

(F) Only hard references are allowed by "strict refs". Symbolic references are disallowed. See *perlref*.

Can't use subscript on %s

(F) The compiler tried to interpret a bracketed expression as a subscript. But to the left of the brackets was an expression that didn't look like an array reference, or anything else subscriptable.

Can't use \%c to mean `$%c` in expression

(W syntax) In an ordinary expression, backslash is a unary operator that creates a reference to its argument. The use of backslash to indicate a backreference to a matched substring is valid only as part of a regular expression pattern. Trying to do this in ordinary Perl code produces a value that prints out looking like SCALAR(0xdecaf). Use the `$1` form instead.

Can't weaken a nonreference

(F) You attempted to weaken something that was not a reference. Only references can be weakened.

Can't x= to read-only value

(F) You tried to repeat a constant value (often the undefined value) with an assignment operator, which implies modifying the value itself. Perhaps you need to copy the value to a temporary, and repeat that.

`chmod()` mode argument is missing initial 0

(W chmod) A novice will sometimes say

```
chmod 777, $filename
```

not realizing that 777 will be interpreted as a decimal number, equivalent to 01411. Octal constants are introduced with a leading 0 in Perl, as in C.

`close()` on unopened filehandle %s

(W unopened) You tried to close a filehandle that was never opened.

%s: Command not found

(A) You've accidentally run your script through **csh** instead of Perl. Check the #! line, or manually feed your script into Perl yourself.

Compilation failed in require

(F) Perl could not compile a file specified in a `require` statement. Perl uses this generic message when none of the errors that it encountered were severe enough to halt compilation immediately.

Complex regular subexpression recursion limit (%d) exceeded

(W regexp) The regular expression engine uses recursion in complex situations where back–tracking is required. Recursion depth is limited to 32766, or perhaps less in architectures where the stack cannot grow arbitrarily. ("Simple" and "medium" situations are handled without recursion and are not subject to a limit.) Try shortening the string under examination; looping in Perl code (e.g. with `while`) rather than in the regular expression engine; or rewriting the regular expression so that it is simpler or backtracks less. (See *perlfaq2* for information on *Mastering Regular Expressions*.)

`connect()` on closed socket %s

(W closed) You tried to do a connect on a closed socket. Did you forget to check the return value of your `socket()` call? See *connect*.

Constant(%s)%s: %s

(F) The parser found inconsistencies either while attempting to define an overloaded constant, or when trying to find the character name specified in the `\N{...}` escape. Perhaps you forgot to load the corresponding `overload` or `charnames` pragma? See *charnames* and *overload*.

Constant is not %s reference

(F) A constant value (perhaps declared using the `use constant` pragma) is being dereferenced, but it amounts to the wrong type of reference. The message indicates the type of reference that was expected. This usually indicates a syntax error in dereferencing the constant value. See *Constant Functions in perlsub* and *constant*.

Constant subroutine %s redefined

(S|W redefine) You redefined a subroutine which had previously been eligible for inlining. See *Constant Functions in perlsub* for commentary and workarounds.

Constant subroutine %s undefined

(W misc) You undefined a subroutine which had previously been eligible for inlining. See *Constant Functions in perlsub* for commentary and workarounds.

Copy method did not return a reference

(F) The method which overloads "=" is buggy. See *Copy Constructor*.

CORE::%s is not a keyword

(F) The CORE:: namespace is reserved for Perl keywords.

corrupted regexp pointers

(P) The regular expression engine got confused by what the regular expression compiler gave it.

corrupted regexp program

(P) The regular expression engine got passed a regexp program without a valid magic number.

Corrupt malloc ptr 0x%lx at 0x%lx

(P) The malloc package that comes with Perl had an internal failure.

-p destination: %s

(F) An error occurred during the implicit output invoked by the -p command-line switch. (This output goes to STDOUT unless you've redirected it with `select()`.)

-T and -B not implemented on filehandles

(F) Perl can't peek at the stdio buffer of filehandles when it doesn't know about your kind of stdio. You'll have to use a filename instead.

Deep recursion on subroutine "%s"

(W recursion) This subroutine has called itself (directly or indirectly) 100 times more than it has returned. This probably indicates an infinite recursion, unless you're writing strange benchmark programs, in which case it indicates something else.

defined(@array) is deprecated

(D deprecated) `defined()` is not usually useful on arrays because it checks for an undefined *scalar* value. If you want to see if the array is empty, just use `if (@array) { # not empty }` for example.

defined(%hash) is deprecated

(D deprecated) `defined()` is not usually useful on hashes because it checks for an undefined *scalar* value. If you want to see if the hash is empty, just use `if (%hash) { # not empty }` for example.

Delimiter for here document is too long

(F) In a here document construct like `<<FOO`, the label `FOO` is too long for Perl to handle. You have to be seriously twisted to write code that triggers this error.

Did not produce a valid header

See Server error.

%s did not return a true value

(F) A required (or used) file must return a true value to indicate that it compiled correctly and ran its initialization code correctly. It's traditional to end such a file with a "1;", though any true value would do. See *require*.

(Did you mean `&%s` instead?)

(W) You probably referred to an imported subroutine `&FOO` as `$FOO` or some such.

(Did you mean "local" instead of "our"?)

(W misc) Remember that "our" does not localize the declared global variable. You have declared it again in the same lexical scope, which seems superfluous.

(Did you mean `$` or `@` instead of %?)

(W) You probably said %hash{$key} when you meant `$hash{$key}` or @hash{@keys}. On the other hand, maybe you just meant %hash and got carried away.

Died

(F) You passed `die()` an empty string (the equivalent of `die ""`) or you called it with no args and both `$@` and `$_` were empty.

Document contains no data

See Server error.

Don't know how to handle magic of type '%s'

(P) The internal handling of magical variables has been cursed.

do_study: out of memory

(P) This should have been caught by `safemalloc()` instead.

(Do you need to predeclare %s?)

(S) This is an educated guess made in conjunction with the message "%s found where operator expected". It often means a subroutine or module name is being referenced that hasn't been declared yet. This may be because of ordering problems in your file, or because of a missing "sub", "package", "require", or "use" statement. If you're referencing something that isn't defined yet, you don't actually have to define the subroutine or package before the current location. You can use an empty "sub foo;" or "package FOO;" to enter a "forward" declaration.

Duplicate `free()` ignored

(S malloc) An internal routine called `free()` on something that had already been freed.

elseif should be elsif

(S) There is no keyword "elseif" in Perl because Larry thinks it's ugly. Your code will be interpreted as an attempt to call a method named "elseif" for the class returned by the following block. This is unlikely to be what you want.

entering effective %s failed

(F) While under the `use filetest` pragma, switching the real and effective uids or gids failed.

Error converting file specification %s

(F) An error peculiar to VMS. Because Perl may have to deal with file specifications in either VMS or Unix syntax, it converts them to a single form when it must operate on them directly. Either you've passed an invalid file specification to Perl, or you've found a case the conversion routines don't handle. Drat.

%s: Eval-group in insecure regular expression

(F) Perl detected tainted data when trying to compile a regular expression that contains the `(?{ ... })` zero-width assertion, which is unsafe. See *(?{ code })*, and *perlsec*.

%s: Eval-group not allowed at run time

(F) Perl tried to compile a regular expression containing the `(?{ ... })` zero-width assertion at run time, as it would when the pattern contains interpolated values. Since that is a security risk, it is not allowed. If you insist, you may still do this by explicitly building the pattern from an interpolated string at run time and using that in an `eval()`. See *(?{ code })*.

%s: Eval-group not allowed, use re 'eval'

(F) A regular expression contained the `(?{ ... })` zero-width assertion, but that construct is only allowed when the `use re 'eval'` pragma is in effect. See *(?{ code })*.

Excessively long < operator

(F) The contents of a < operator may not exceed the maximum size of a Perl identifier. If you're just trying to glob a long list of filenames, try using the `glob()` operator, or put the filenames into a variable and glob that.

Execution of %s aborted due to compilation errors

(F) The final summary message when a Perl compilation fails.

Exiting eval via %s

(W exiting) You are exiting an eval by unconventional means, such as a goto, or a loop control statement.

Exiting format via %s

(W exiting) You are exiting an eval by unconventional means, such as a goto, or a loop control statement.

Exiting pseudo-block via %s

(W exiting) You are exiting a rather special block construct (like a sort block or subroutine) by unconventional means, such as a goto, or a loop control statement. See *sort*.

Exiting subroutine via %s

(W exiting) You are exiting a subroutine by unconventional means, such as a goto, or a loop control statement.

Exiting substitution via %s

(W exiting) You are exiting a substitution by unconventional means, such as a return, a goto, or a loop control statement.

Explicit blessing to '' (assuming package main)

(W misc) You are blessing a reference to a zero length string. This has the effect of blessing the reference into the package main. This is usually not what you want. Consider providing a default target package, e.g. bless(`$ref, $p` || 'MyPackage');

%s: Expression syntax

(A) You've accidentally run your script through **csh** instead of Perl. Check the #! line, or manually feed your script into Perl yourself.

%s failed--call queue aborted

(F) An untrapped exception was raised while executing a CHECK, INIT, or END subroutine. Processing of the remainder of the queue of such routines has been prematurely ended.

false [] range "%s" in regexp

(W regexp) A character class range must start and end at a literal character, not another character class like `\d` or `[:alpha:]`. The "-" in your false range is interpreted as a literal "-". Consider quoting the "-", "\-". See *perlre*.

Fatal VMS error at %s, line %d

(P) An error peculiar to VMS. Something untoward happened in a VMS system service or RTL routine; Perl's exit status should provide more details. The filename in "at %s" and the line number in "line %d" tell you which section of the Perl source code is distressed.

fcntl is not implemented

(F) Your machine apparently doesn't implement `fcntl()`. What is this, a PDP-11 or something?

Filehandle %s opened only for input

(W io) You tried to write on a read-only filehandle. If you intended it to be a read-write filehandle, you needed to open it with "+<" or "+" or "+" instead of with "<" or nothing. If you intended only to write the file, use "" or "". See *open*.

Filehandle %s opened only for output

(W io) You tried to read from a filehandle opened only for writing. If you intended it to be a read/write filehandle, you needed to open it with "+<" or "+" or "+" instead of with "<" or nothing. If you intended only to read from the file, use "<". See *open*.

Final `$` should be \$ or `$name`

(F) You must now decide whether the final `$` in a string was meant to be a literal dollar sign, or was meant to introduce a variable name that happens to be missing. So you have to put either the backslash or the name.

Final @ should be \@ or @name

(F) You must now decide whether the final @ in a string was meant to be a literal "at" sign, or was meant to introduce a variable name that happens to be missing. So you have to put either the backslash or the name.

`flock()` on closed filehandle %s

(W closed) The filehandle you're attempting to `flock()` got itself closed some time before now. Check your logic flow. `flock()` operates on filehandles. Are you attempting to call `flock()` on a dirhandle by the same name?

Quantifier follows nothing before << HERE in regex m/%s/

(F) You started a regular expression with a quantifier. Backslash it if you meant it literally. The << HERE shows in the regular expression about where the problem was discovered. See *perlre*.

Format not terminated

(F) A format must be terminated by a line with a solitary dot. Perl got to the end of your file without finding such a line.

Format %s redefined

(W redefine) You redefined a format. To suppress this warning, say

```
{
    no warnings;
    eval "format NAME =...";
}
```

Found = in conditional, should be ==

(W syntax) You said

```
if ($foo = 123)
```

when you meant

```
if ($foo == 123)
```

(or something like that).

%s found where operator expected

(S) The Perl lexer knows whether to expect a term or an operator. If it sees what it knows to be a term when it was expecting to see an operator, it gives you this warning. Usually it indicates that an operator or delimiter was omitted, such as a semicolon.

gdbm store returned %d, errno %d, key "%s"

(S) A warning from the GDBM_File extension that a store failed.

gethostent not implemented

(F) Your C library apparently doesn't implement `gethostent()`, probably because if it did, it'd feel morally obligated to return every hostname on the Internet.

`get%sname()` on closed socket %s

(W closed) You tried to get a socket or peer socket name on a closed socket. Did you forget to check the return value of your `socket()` call?

getpwnam returned invalid UIC %#o for user "%s"

(S) A warning peculiar to VMS. The call to `sys$getuai` underlying the `getpwnam` operator returned an invalid UIC.

`getsockopt()` on closed socket %s

(W closed) You tried to get a socket option on a closed socket. Did you forget to check the return value of your `socket()` call? See *getsockopt*.

Global symbol "%s" requires explicit package name

(F) You've said "use strict vars", which indicates that all variables must either be lexically scoped (using "my"), declared beforehand using "our", or explicitly qualified to say which package the global variable is in (using "::").

glob failed (%s)

(W glob) Something went wrong with the external program(s) used for `glob` and `< <*.c`. Usually, this means that you supplied a `glob` pattern that caused the external program to fail and exit with a nonzero status. If the message indicates that the abnormal exit resulted in a coredump, this may also mean that your csh (C shell) is broken. If so, you should change all of the csh-related variables in config.sh: If you have tcsh, make the variables refer to it as if it were csh (e.g. `full_csh='/usr/bin/tcsh'`); otherwise, make them all empty (except that `d_csh` should be `'undef'`) so that Perl will think csh is missing. In either case, after editing config.sh, run `./Configure -S` and rebuild Perl.

Glob not terminated

(F) The lexer saw a left angle bracket in a place where it was expecting a term, so it's looking for the corresponding right angle bracket, and not finding it. Chances are you left some needed parentheses out earlier in the line, and you really meant a "less than".

Got an error from DosAllocMem

(P) An error peculiar to OS/2. Most probably you're using an obsolete version of Perl, and this should not happen anyway.

goto must have label

(F) Unlike with "next" or "last", you're not allowed to goto an unspecified destination. See *goto*.

%s had compilation errors

(F) The final summary message when a `perl -c` fails.

Had to create %s unexpectedly

(S internal) A routine asked for a symbol from a symbol table that ought to have existed already, but for some reason it didn't, and had to be created on an emergency basis to prevent a core dump.

Hash %%s missing the % in argument %d of `%s()`

(D deprecated) Really old Perl let you omit the % on hash names in some spots. This is now heavily deprecated.

%s has too many errors

(F) The parser has given up trying to parse the program after 10 errors. Further error messages would likely be uninformative.

Hexadecimal number 0xffffffff non-portable

(W portable) The hexadecimal number you specified is larger than 2**32-1 (4294967295) and therefore non-portable between systems. See *perlport* for more on portability concerns.

Identifier too long

(F) Perl limits identifiers (names for variables, functions, etc.) to about 250 characters for simple names, and somewhat more for compound names (like `$A::B`). You've exceeded Perl's limits. Future versions of Perl are likely to eliminate these arbitrary limitations.

Illegal binary digit %s

(F) You used a digit other than 0 or 1 in a binary number.

Illegal binary digit %s ignored

(W digit) You may have tried to use a digit other than 0 or 1 in a binary number. Interpretation of the binary number stopped before the offending digit.

Illegal character %s (carriage return)

(F) Perl normally treats carriage returns in the program text as it would any other whitespace, which means you should never see this error when Perl was built using standard options. For some reason, your version of Perl appears to have been built without this support. Talk to your Perl administrator.

Illegal division by zero

(F) You tried to divide a number by 0. Either something was wrong in your logic, or you need to put a conditional in to guard against meaningless input.

Illegal hexadecimal digit %s ignored

(W digit) You may have tried to use a character other than 0 – 9 or A – F, a – f in a hexadecimal number. Interpretation of the hexadecimal number stopped before the illegal character.

Illegal modulus zero

(F) You tried to divide a number by 0 to get the remainder. Most numbers don't take to this kindly.

Illegal number of bits in vec

(F) The number of bits in `vec()` (the third argument) must be a power of two from 1 to 32 (or 64, if your platform supports that).

Illegal octal digit %s

(F) You used an 8 or 9 in a octal number.

Illegal octal digit %s ignored

(W digit) You may have tried to use an 8 or 9 in a octal number. Interpretation of the octal number stopped before the 8 or 9.

Illegal switch in PERL5OPT: %s

(X) The PERL5OPT environment variable may only be used to set the following switches: **–[DIMUdmw]**.

Ill–formed CRTL environ value "%s"

(W internal) A warning peculiar to VMS. Perl tried to read the CRTL's internal environ array, and encountered an element without the = delimiter used to separate keys from values. The element is ignored.

Ill–formed message in prime_env_iter: |%s|

(W internal) A warning peculiar to VMS. Perl tried to read a logical name or CLI symbol definition when preparing to iterate over %ENV, and didn't see the expected delimiter between key and value, so the line was ignored.

(in cleanup) %s

(W misc) This prefix usually indicates that a `DESTROY()` method raised the indicated exception. Since destructors are usually called by the system at arbitrary points during execution, and often a vast number of times, the warning is issued only once for any number of failures that would otherwise result in the same message being repeated.

Failure of user callbacks dispatched using the `G_KEEPERR` flag could also result in this warning. See *G_KEEPERR*.

Insecure dependency in %s

(F) You tried to do something that the tainting mechanism didn't like. The tainting mechanism is turned on when you're running setuid or setgid, or when you specify **–T** to turn it on explicitly. The tainting mechanism labels all data that's derived directly or indirectly from the user, who is considered to be unworthy of your trust. If any such data is used in a "dangerous" operation, you get this error. See *perlsec* for more information.

Insecure directory in %s

(F) You can't use `system()`, `exec()`, or a piped open in a setuid or setgid script if `$ENV{PATH}` contains a directory that is writable by the world. See *perlsec*.

Insecure `$ENV{%s}` while running %s

(F) You can't use `system()`, `exec()`, or a piped open in a setuid or setgid script if any of `$ENV{PATH}`, `$ENV{IFS}`, `$ENV{CDPATH}`, `$ENV{ENV}` or `$ENV{BASH_ENV}` are derived from data supplied (or potentially supplied) by the user. The script must set the path to a known value, using trustworthy data. See *perlsec*.

Integer overflow in %s number

(W overflow) The hexadecimal, octal or binary number you have specified either as a literal or as an argument to `hex()` or `oct()` is too big for your architecture, and has been converted to a floating point number. On a 32−bit architecture the largest hexadecimal, octal or binary number representable without overflow is 0xFFFFFFFF, 037777777777, or 0b11111111111111111111111111111111 respectively. Note that Perl transparently promotes all numbers to a floating point representation internally—subject to loss of precision errors in subsequent operations.

Internal disaster before << HERE in regex m/%s/

(P) Something went badly wrong in the regular expression parser. The << HERE shows in the regular expression about where the problem was discovered.

Internal inconsistency in tracking vforks

(S) A warning peculiar to VMS. Perl keeps track of the number of times you've called `fork` and `exec`, to determine whether the current call to `exec` should affect the current script or a subprocess (see *exec LIST in perlvms*). Somehow, this count has become scrambled, so Perl is making a guess and treating this `exec` as a request to terminate the Perl script and execute the specified command.

Internal urp before << HERE in regex m/%s/

(P) Something went badly awry in the regular expression parser. The <<<HERE shows in the regular expression about where the problem was discovered.

%s (...) interpreted as function

(W syntax) You've run afoul of the rule that says that any list operator followed by parentheses turns into a function, with all the list operators arguments found inside the parentheses. See *Terms and List Operators (Leftward)*.

Invalid %s attribute: %s

The indicated attribute for a subroutine or variable was not recognized by Perl or by a user−supplied handler. See *attributes*.

Invalid %s attributes: %s

The indicated attributes for a subroutine or variable were not recognized by Perl or by a user−supplied handler. See *attributes*.

Invalid conversion in %s: "%s"

(W printf) Perl does not understand the given format conversion. See *sprintf*.

invalid [] range "%s" in regexp

(F) The range specified in a character class had a minimum character greater than the maximum character. See *perlre*.

invalid [] range "%s" in transliteration operator

(F) The range specified in the tr/// or y/// operator had a minimum character greater than the maximum character. See *perlop*.

Invalid separator character %s in attribute list

(F) Something other than a colon or whitespace was seen between the elements of an attribute list. If the previous attribute had a parenthesised parameter list, perhaps that list was terminated too soon. See *attributes*.

Invalid type in pack: '%s'

(F) The given character is not a valid pack type. See *pack*. (W pack) The given character is not a valid pack type but used to be silently ignored.

Invalid type in unpack: '%s'

(F) The given character is not a valid unpack type. See *unpack*. (W unpack) The given character is not a valid unpack type but used to be silently ignored.

ioctl is not implemented

(F) Your machine apparently doesn't implement `ioctl()`, which is pretty strange for a machine that supports C.

'%s' is not a code reference

(W) The second (fourth, sixth, ...) argument of overload::constant needs to be a code reference. Either an anonymous subroutine, or a reference to a subroutine.

'%s' is not an overloadable type

(W) You tried to overload a constant type the overload package is unaware of.

junk on end of regexp

(P) The regular expression parser is confused.

Label not found for "last %s"

(F) You named a loop to break out of, but you're not currently in a loop of that name, not even if you count where you were called from. See *last*.

Label not found for "next %s"

(F) You named a loop to continue, but you're not currently in a loop of that name, not even if you count where you were called from. See *last*.

Label not found for "redo %s"

(F) You named a loop to restart, but you're not currently in a loop of that name, not even if you count where you were called from. See *last*.

leaving effective %s failed

(F) While under the `use filetest` pragma, switching the real and effective uids or gids failed.

`listen()` on closed socket %s

(W closed) You tried to do a listen on a closed socket. Did you forget to check the return value of your `socket()` call? See *listen*.

`lstat()` on filehandle %s

(W io) You tried to do a lstat on a filehandle. What did you mean by that? `lstat()` makes sense only on filenames. (Perl did a `fstat()` instead on the filehandle.)

Lvalue subs returning %s not implemented yet

(F) Due to limitations in the current implementation, array and hash values cannot be returned in subroutines used in lvalue context. See *Lvalue subroutines in perlsub*.

Lookbehind longer than %d not implemented before << HERE in reges m/%s/

(F) There is currently a limit on the length of string which lookbehind can handle. This restriction may be eased in a future release. The << HERE shows in the regular expression about where the problem was discovered.

Malformed PERLLIB_PREFIX

(F) An error peculiar to OS/2. PERLLIB_PREFIX should be of the form

```
prefix1;prefix2
```

or

```
prefix1 prefix2
```

with nonempty prefix1 and prefix2. If `prefix1` is indeed a prefix of a builtin library search path, prefix2 is substituted. The error may appear if components are not found, or are too long. See "PERLLIB_PREFIX" in *perlos2*.

Malformed UTF−8 character (%s)

Perl detected something that didn't comply with UTF−8 encoding rules.

Malformed UTF−16 surrogate

Perl thought it was reading UTF−16 encoded character data but while doing it Perl met a malformed Unicode surrogate.

%s matches null string many times

(W regexp) The pattern you've specified would be an infinite loop if the regular expression engine didn't specifically check for that. See *perlre*.

% may only be used in unpack

(F) You can't pack a string by supplying a checksum, because the checksumming process loses information, and you can't go the other way. See *unpack*.

Method for operation %s not found in package %s during blessing

(F) An attempt was made to specify an entry in an overloading table that doesn't resolve to a valid subroutine. See *overload*.

Method %s not permitted

See Server error.

Might be a runaway multi−line %s string starting on line %d

(S) An advisory indicating that the previous error may have been caused by a missing delimiter on a string or pattern, because it eventually ended earlier on the current line.

Misplaced _ in number

(W syntax) An underline in a decimal constant wasn't on a 3−digit boundary.

Missing %sbrace%s on \N{}

(F) Wrong syntax of character name literal `\N{charname}` within double−quotish context.

Missing comma after first argument to %s function

(F) While certain functions allow you to specify a filehandle or an "indirect object" before the argument list, this ain't one of them.

Missing command in piped open

(W pipe) You used the `open(FH, "| command")` or `open(FH, "command |")` construction, but the command was missing or blank.

Missing name in "my sub"

(F) The reserved syntax for lexically scoped subroutines requires that they have a name with which they can be found.

Missing `$` on loop variable

(F) Apparently you've been programming in **csh** too much. Variables are always mentioned with the `$` in Perl, unlike in the shells, where it can vary from one line to the next.

(Missing operator before %s?)

(S) This is an educated guess made in conjunction with the message "%s found where operator expected". Often the missing operator is a comma.

Missing right curly or square bracket

(F) The lexer counted more opening curly or square brackets than closing ones. As a general rule, you'll find it's missing near the place you were last editing.

(Missing semicolon on previous line?)

(S) This is an educated guess made in conjunction with the message "%s found where operator expected". Don't automatically put a semicolon on the previous line just because you saw this message.

Modification of a read–only value attempted

(F) You tried, directly or indirectly, to change the value of a constant. You didn't, of course, try "2 = 1", because the compiler catches that. But an easy way to do the same thing is:

```
sub mod { $_[0] = 1 }
mod(2);
```

Another way is to assign to a `substr()` that's off the end of the string.

Yet another way is to assign to a `foreach` loop *VAR* when *VAR* is aliased to a constant in the look *LIST*:

```
$x = 1;
foreach my $n ($x, 2) {
    $n *= 2; # modifies the $x, but fails on attempt to modify the 2
}
```

Modification of non–creatable array value attempted, %s

(F) You tried to make an array value spring into existence, and the subscript was probably negative, even counting from end of the array backwards.

Modification of non–creatable hash value attempted, %s

(P) You tried to make a hash value spring into existence, and it couldn't be created for some peculiar reason.

Module name must be constant

(F) Only a bare module name is allowed as the first argument to a "use".

Module name required with –%c option

(F) The `–M` or `–m` options say that Perl should load some module, but you omitted the name of the module. Consult *perlrun* for full details about `–M` and `–m`.

msg%s not implemented

(F) You don't have System V message IPC on your system.

Multidimensional syntax %s not supported

(W syntax) Multidimensional arrays aren't written like `$foo[1,2,3]`. They're written like `$foo[1][2][3]`, as in C.

/ must be followed by a*, A* or Z*

(F) You had a pack template indicating a counted–length string, Currently the only things that can have their length counted are a*, A* or Z*. See *pack*.

/ must be followed by a, A or Z

(F) You had an unpack template indicating a counted–length string, which must be followed by one of the letters a, A or Z to indicate what sort of string is to be unpacked. See *pack*.

/ must follow a numeric type

(F) You had an unpack template that contained a '#', but this did not follow some numeric unpack specification. See *pack*.

"my sub" not yet implemented

(F) Lexically scoped subroutines are not yet implemented. Don't try that yet.

"my" variable %s can't be in a package

(F) Lexically scoped variables aren't in a package, so it doesn't make sense to try to declare one with a package qualifier on the front. Use `local()` if you want to localize a package variable.

Name "%s::%s" used only once: possible typo

(W once) Typographical errors often show up as unique variable names. If you had a good reason for having a unique name, then just mention it again somehow to suppress the message. The `our` declaration is provided for this purpose.

Negative length

(F) You tried to do a read/write/send/recv operation with a buffer length that is less than 0. This is difficult to imagine.

Nested quantifiers before << HERE in regex m/%s/

(F) You can't quantify a quantifier without intervening parentheses. So things like ** or +* or ?* are illegal. The << HERE shows in the regular expression about where the problem was discovered.

Note, however, that the minimal matching quantifiers, `*?`, `+?`, and `??` appear to be nested quantifiers, but aren't. See *perlre*.

%s never introduced

(S internal) The symbol in question was declared but somehow went out of scope before it could possibly have been used.

No %s allowed while running setuid

(F) Certain operations are deemed to be too insecure for a setuid or setgid script to even be allowed to attempt. Generally speaking there will be another way to do what you want that is, if not secure, at least securable. See *perlsec*.

No **-e** allowed in setuid scripts

(F) A setuid script can't be specified by the user.

No comma allowed after %s

(F) A list operator that has a filehandle or "indirect object" is not allowed to have a comma between that and the following arguments. Otherwise it'd be just another one of the arguments.

One possible cause for this is that you expected to have imported a constant to your name space with **use** or **import** while no such importing took place, it may for example be that your operating system does not support that particular constant. Hopefully you did use an explicit import list for the constants you expect to see, please see *use* and *import*. While an explicit import list would probably have caught this error earlier it naturally does not remedy the fact that your operating system still does not support that constant. Maybe you have a typo in the constants of the symbol import list of **use** or **import** or in the constant name at the line where this error was triggered?

No command into which to pipe on command line

(F) An error peculiar to VMS. Perl handles its own command line redirection, and found a 'l' at the end of the command line, so it doesn't know where you want to pipe the output from this command.

No DB::DB routine defined

(F) The currently executing code was compiled with the **-d** switch, but for some reason the perl5db.pl file (or some facsimile thereof) didn't define a routine to be called at the beginning of each statement.

Which is odd, because the file should have been required automatically, and should have blown up the require if it didn't parse right.

No dbm on this machine

(P) This is counted as an internal error, because every machine should supply dbm nowadays, because Perl comes with SDBM. See *SDBM_File*.

No DBsub routine

(F) The currently executing code was compiled with the **-d** switch, but for some reason the perl5db.pl file (or some facsimile thereof) didn't define a DB::sub routine to be called at the beginning of each ordinary subroutine call.

No error file after 2 or 2 on command line

(F) An error peculiar to VMS. Perl handles its own command line redirection, and found a '2' or a '2' on the command line, but can't find the name of the file to which to write data destined for stderr.

No input file after < on command line

(F) An error peculiar to VMS. Perl handles its own command line redirection, and found a '<' on the command line, but can't find the name of the file from which to read data for stdin.

No #! line

(F) The setuid emulator requires that scripts have a well-formed #! line even on machines that don't support the #! construct.

"no" not allowed in expression

(F) The "no" keyword is recognized and executed at compile time, and returns no useful value. See *perlmod*.

No output file after on command line

(F) An error peculiar to VMS. Perl handles its own command line redirection, and found a lone '' at the end of the command line, so it doesn't know where you wanted to redirect stdout.

No output file after or on command line

(F) An error peculiar to VMS. Perl handles its own command line redirection, and found a '' or a '' on the command line, but can't find the name of the file to which to write data destined for stdout.

No package name allowed for variable %s in "our"

(F) Fully qualified variable names are not allowed in "our" declarations, because that doesn't make much sense under existing semantics. Such syntax is reserved for future extensions.

No Perl script found in input

(F) You called `perl -x`, but no line was found in the file beginning with #! and containing the word "perl".

No setregid available

(F) Configure didn't find anything resembling the `setregid()` call for your system.

No setreuid available

(F) Configure didn't find anything resembling the `setreuid()` call for your system.

No space allowed after -%c

(F) The argument to the indicated command line switch must follow immediately after the switch, without intervening spaces.

No %s specified for -%c

(F) The indicated command line switch needs a mandatory argument, but you haven't specified one.

No such pipe open

(P) An error peculiar to VMS. The internal routine `my_pclose()` tried to close a pipe which hadn't been opened. This should have been caught earlier as an attempt to close an unopened filehandle.

No such pseudo-hash field "%s"

(F) You tried to access an array as a hash, but the field name used is not defined. The hash at index 0 should map all valid field names to array indices for that to work.

No such pseudo-hash field "%s" in variable %s of type %s

(F) You tried to access a field of a typed variable where the type does not know about the field name. The field names are looked up in the %FIELDS hash in the type package at compile time. The %FIELDS hash is %usually set up with the 'fields' pragma.

No such signal: SIG%s

(W signal) You specified a signal name as a subscript to %SIG that was not recognized. Say `kill -l` in your shell to see the valid signal names on your system.

Not a CODE reference

(F) Perl was trying to evaluate a reference to a code value (that is, a subroutine), but found a reference to something else instead. You can use the `ref()` function to find out what kind of ref it really was. See also *perlref*.

Not a format reference

(F) I'm not sure how you managed to generate a reference to an anonymous format, but this indicates you did, and that it didn't exist.

Not a GLOB reference

(F) Perl was trying to evaluate a reference to a "typeglob" (that is, a symbol table entry that looks like `*foo`), but found a reference to something else instead. You can use the `ref()` function to find out what kind of ref it really was. See *perlref*.

Not a HASH reference

(F) Perl was trying to evaluate a reference to a hash value, but found a reference to something else instead. You can use the `ref()` function to find out what kind of ref it really was. See *perlref*.

Not an ARRAY reference

(F) Perl was trying to evaluate a reference to an array value, but found a reference to something else instead. You can use the `ref()` function to find out what kind of ref it really was. See *perlref*.

Not a perl script

(F) The setuid emulator requires that scripts have a well-formed #! line even on machines that don't support the #! construct. The line must mention perl.

Not a SCALAR reference

(F) Perl was trying to evaluate a reference to a scalar value, but found a reference to something else instead. You can use the `ref()` function to find out what kind of ref it really was. See *perlref*.

Not a subroutine reference

(F) Perl was trying to evaluate a reference to a code value (that is, a subroutine), but found a reference to something else instead. You can use the `ref()` function to find out what kind of ref it really was. See also *perlref*.

Not a subroutine reference in overload table

(F) An attempt was made to specify an entry in an overloading table that doesn't somehow point to a valid subroutine. See *overload*.

Not enough arguments for %s

(F) The function requires more arguments than you specified.

Not enough format arguments

(W syntax) A format specified more picture fields than the next line supplied. See *perlform*.

%s: not found

(A) You've accidentally run your script through the Bourne shell instead of Perl. Check the #! line, or manually feed your script into Perl yourself.

no UTC offset information; assuming local time is UTC

(S) A warning peculiar to VMS. Perl was unable to find the local timezone offset, so it's assuming that local system time is equivalent to UTC. If it's not, define the logical name ***SYS$TIMEZONE_DIFFERENTIAL*** to translate to the number of seconds which need to be added to UTC to get local time.

Null filename used

(F) You can't require the null filename, especially because on many machines that means the current directory! See *require*.

NULL OP IN RUN

(P debugging) Some internal routine called `run()` with a null opcode pointer.

Null picture in formline

(F) The first argument to formline must be a valid format picture specification. It was found to be empty, which probably means you supplied it an uninitialized value. See *perlform*.

Null realloc

(P) An attempt was made to realloc NULL.

NULL regexp argument

(P) The internal pattern matching routines blew it big time.

NULL regexp parameter

(P) The internal pattern matching routines are out of their gourd.

Number too long

(F) Perl limits the representation of decimal numbers in programs to about about 250 characters. You've exceeded that length. Future versions of Perl are likely to eliminate this arbitrary limitation. In the meantime, try using scientific notation (e.g. "1e6" instead of "1_000_000").

Octal number in vector unsupported

(F) Numbers with a leading are not currently allowed in vectors. The octal number interpretation of such numbers may be supported in a future version.

Octal number 037777777777 non–portable

(W portable) The octal number you specified is larger than 2**32–1 (4294967295) and therefore non–portable between systems. See *perlport* for more on portability concerns.

See also *perlport* for writing portable code.

Odd number of arguments for overload::constant

(W) The call to overload::constant contained an odd number of arguments. The arguments should come in pairs.

Odd number of elements in hash assignment

(W misc) You specified an odd number of elements to initialize a hash, which is odd, because hashes come in key/value pairs.

Offset outside string

(F) You tried to do a read/write/send/recv operation with an offset pointing outside the buffer. This is difficult to imagine. The sole exception to this is that `sysread()`ing past the buffer will extend the buffer and zero pad the new area.

–%s on unopened filehandle %s

(W unopened) You tried to invoke a file test operator on a filehandle that isn't open. Check your logic. See also *–X*.

`%s()` on unopened %s %s

(W unopened) An I/O operation was attempted on a filehandle that was never initialized. You need to do an `open()`, a `sysopen()`, or a `socket()` call, or call a constructor from the FileHandle package.

oops: oopsAV

(S internal) An internal warning that the grammar is screwed up.

oops: oopsHV

(S internal) An internal warning that the grammar is screwed up.

Operation '%s': no method found, %s

(F) An attempt was made to perform an overloaded operation for which no handler was defined. While some handlers can be autogenerated in terms of other handlers, there is no default handler for any operation, unless `fallback` overloading key is specified to be true. See *overload*.

Operator or semicolon missing before %s

(S ambiguous) You used a variable or subroutine call where the parser was expecting an operator. The parser has assumed you really meant to use an operator, but this is highly likely to be incorrect. For example, if you say "*foo *foo" it will be interpreted as if you said "*foo * 'foo'".

"our" variable %s redeclared

(W misc) You seem to have already declared the same global once before in the current lexical scope.

Out of memory!

(X) The `malloc()` function returned 0, indicating there was insufficient remaining memory (or virtual memory) to satisfy the request. Perl has no option but to exit immediately.

Out of memory during "large" request for %s

(F) The `malloc()` function returned 0, indicating there was insufficient remaining memory (or virtual memory) to satisfy the request. However, the request was judged large enough (compile–time default is 64K), so a possibility to shut down by trapping this error is granted.

Out of memory during request for %s

(X|F) The `malloc()` function returned 0, indicating there was insufficient remaining memory (or virtual memory) to satisfy the request.

The request was judged to be small, so the possibility to trap it depends on the way perl was compiled. By default it is not trappable. However, if compiled for this, Perl may use the contents of `$^M` as an emergency pool after `die()`ing with this message. In this case the error is trappable *once*, and the error message will include the line and file where the failed request happened.

Out of memory during ridiculously large request

(F) You can't allocate more than 2^31+"small amount" bytes. This error is most likely to be caused by a typo in the Perl program. e.g., `$arr[time]` instead of `$arr[$time]`.

Out of memory for yacc stack

(F) The yacc parser wanted to grow its stack so it could continue parsing, but `realloc()` wouldn't give it more memory, virtual or otherwise.

@ outside of string

(F) You had a pack template that specified an absolute position outside the string being unpacked. See *pack*.

%s package attribute may clash with future reserved word: %s

(W reserved) A lowercase attribute name was used that had a package−specific handler. That name might have a meaning to Perl itself some day, even though it doesn't yet. Perhaps you should use a mixed−case attribute name, instead. See *attributes*.

page overflow

(W io) A single call to `write()` produced more lines than can fit on a page. See *perlform*.

panic: %s

(P) An internal error.

panic: ck_grep

(P) Failed an internal consistency check trying to compile a grep.

panic: ck_split

(P) Failed an internal consistency check trying to compile a split.

panic: corrupt saved stack index

(P) The savestack was requested to restore more localized values than there are in the savestack.

panic: del_backref

(P) Failed an internal consistency check while trying to reset a weak reference.

panic: die %s

(P) We popped the context stack to an eval context, and then discovered it wasn't an eval context.

panic: do_match

(P) The internal `pp_match()` routine was called with invalid operational data.

panic: do_split

(P) Something terrible went wrong in setting up for the split.

panic: do_subst

(P) The internal `pp_subst()` routine was called with invalid operational data.

panic: do_trans

(P) The internal `do_trans()` routine was called with invalid operational data.

panic: frexp

(P) The library function `frexp()` failed, making printf("%f") impossible.

panic: goto

(P) We popped the context stack to a context with the specified label, and then discovered it wasn't a context we know how to do a goto in.

panic: INTERPCASEMOD

(P) The lexer got into a bad state at a case modifier.

panic: INTERPCONCAT

(P) The lexer got into a bad state parsing a string with brackets.

panic: kid popen errno read

(F) forked child returned an incomprehensible message about its errno.

panic: last

(P) We popped the context stack to a block context, and then discovered it wasn't a block context.

panic: leave_scope clearsv

(P) A writable lexical variable became read-only somehow within the scope.

panic: leave_scope inconsistency

(P) The savestack probably got out of sync. At least, there was an invalid enum on the top of it.

panic: magic_killbackrefs

(P) Failed an internal consistency check while trying to reset all weak references to an object.

panic: malloc

(P) Something requested a negative number of bytes of malloc.

panic: mapstart

(P) The compiler is screwed up with respect to the `map()` function.

panic: null array

(P) One of the internal array routines was passed a null AV pointer.

panic: pad_alloc

(P) The compiler got confused about which scratch pad it was allocating and freeing temporaries and lexicals from.

panic: pad_free curpad

(P) The compiler got confused about which scratch pad it was allocating and freeing temporaries and lexicals from.

panic: pad_free po

(P) An invalid scratch pad offset was detected internally.

panic: pad_reset curpad

(P) The compiler got confused about which scratch pad it was allocating and freeing temporaries and lexicals from.

panic: pad_sv po

(P) An invalid scratch pad offset was detected internally.

panic: pad_swipe curpad

(P) The compiler got confused about which scratch pad it was allocating and freeing temporaries and lexicals from.

panic: pad_swipe po

(P) An invalid scratch pad offset was detected internally.

panic: pp_iter

(P) The foreach iterator got called in a non-loop context frame.

panic: realloc

(P) Something requested a negative number of bytes of realloc.

panic: restartop

(P) Some internal routine requested a goto (or something like it), and didn't supply the destination.

panic: return

(P) We popped the context stack to a subroutine or eval context, and then discovered it wasn't a subroutine or eval context.

panic: scan_num

(P) `scan_num()` got called on something that wasn't a number.

panic: sv_insert

(P) The `sv_insert()` routine was told to remove more string than there was string.

panic: top_env

(P) The compiler attempted to do a goto, or something weird like that.

panic: yylex

(P) The lexer got into a bad state while processing a case modifier.

panic: utf16_to_utf8: odd bytelen

(P) Something tried to call utf16_to_utf8 with an odd (as opposed to even) byte length.

Parentheses missing around "%s" list

(W parenthesis) You said something like

```
my $foo, $bar = @_;
```

when you meant

```
my ($foo, $bar) = @_;
```

Remember that "my", "our", and "local" bind tighter than comma.

Perl %s required—this is only version %s, stopped

(F) The module in question uses features of a version of Perl more recent than the currently running version. How long has it been since you upgraded, anyway? See *require*.

PERL_SH_DIR too long

(F) An error peculiar to OS/2. PERL_SH_DIR is the directory to find the `sh`–shell in. See "PERL_SH_DIR" in *perlos2*.

perl: warning: Setting locale failed.

(S) The whole warning message will look something like:

```
perl: warning: Setting locale failed.
perl: warning: Please check that your locale settings:
        LC_ALL = "En_US",
        LANG = (unset)
    are supported and installed on your system.
perl: warning: Falling back to the standard locale ("C").
```

Exactly what were the failed locale settings varies. In the above the settings were that the LC_ALL was "En_US" and the LANG had no value. This error means that Perl detected that you and/or your operating system supplier and/or system administrator have set up the so–called locale system but Perl could not use those settings. This was not dead serious, fortunately: there is a "default locale" called "C" that Perl can and will use, the script will be run. Before you really fix the problem, however, you will get the same error message each time you run Perl. How to really fix the problem can be found in *perllocale* section **LOCALE PROBLEMS**.

perlio: unknown layer "%s"

(S) An attempt was made to push an unknown layer onto the Perl I/O system. (Layers take care of transforming data between external and internal representations.) Note that some layers, such as `mmap`, are not supported in all environments. If your program didn't explicitly request the failing operation, it may be the result of the value of the environment variable PERLIO.

Permission denied

(F) The setuid emulator in suidperl decided you were up to no good.

pid %x not a child

(W exec) A warning peculiar to VMS. `Waitpid()` was asked to wait for a process which isn't a subprocess of the current process. While this is fine from VMS' perspective, it's probably not what you intended.

POSIX syntax [%s] belongs inside character classes

(W unsafe) The character class constructs [: :], [= =], and [. .] go *inside* character classes, the [] are part of the construct, for example: /[012[:alpha:]345]/. Note that [= =] and [. .] are not currently implemented; they are simply placeholders for future extensions and will cause fatal errors.

POSIX syntax [. .] is reserved for future extensions

(F regexp) Within regular expression character classes ([]) the syntax beginning with "[." and ending with ".]" is reserved for future extensions. If you need to represent those character sequences inside a regular expression character class, just quote the square brackets with the backslash: "\[." and ".\]".

POSIX syntax [= =] is reserved for future extensions

(F) Within regular expression character classes ([]) the syntax beginning with "[=" and ending with "=]" is reserved for future extensions. If you need to represent those character sequences inside a regular expression character class, just quote the square brackets with the backslash: "\[=" and "=\]".

POSIX class [:%s:] unknown

(F) The class in the character class [: :] syntax is unknown. See *perlre*.

POSIX getpgrp can't take an argument

(F) Your system has POSIX `getpgrp()`, which takes no argument, unlike the BSD version, which takes a pid.

Possible attempt to put comments in `qw()` list

(W qw) `qw()` lists contain items separated by whitespace; as with literal strings, comment characters are not ignored, but are instead treated as literal data. (You may have used different delimiters than the parentheses shown here; braces are also frequently used.)

You probably wrote something like this:

```
@list = qw(
    a # a comment
    b # another comment
);
```

when you should have written this:

```
@list = qw(
    a
    b
);
```

If you really want comments, build your list the old-fashioned way, with quotes and commas:

```
@list = (
    'a',    # a comment
    'b',    # another comment
);
```

Possible attempt to separate words with commas

(W qw) `qw()` lists contain items separated by whitespace; therefore commas aren't needed to separate the items. (You may have used different delimiters than the parentheses shown here; braces are also

frequently used.)

You probably wrote something like this:

```
qw! a, b, c !;
```

which puts literal commas into some of the list items. Write it without commas if you don't want them to appear in your data:

```
qw! a b c !;
```

Possible memory corruption: %s overflowed 3rd argument

(F) An `ioctl()` or `fcntl()` returned more than Perl was bargaining for. Perl guesses a reasonable buffer size, but puts a sentinel byte at the end of the buffer just in case. This sentinel byte got clobbered, and Perl assumes that memory is now corrupted. See *ioctl*.

Possible Y2K bug: %s

(W y2k) You are concatenating the number 19 with another number, which could be a potential Year 2000 problem.

pragma "attrs" is deprecated, use "sub NAME : ATTRS" instead

(W deprecated) You have written something like this:

```
sub doit
{
    use attrs qw(locked);
}
```

You should use the new declaration syntax instead.

```
sub doit : locked
{
    ...
```

The `use attrs` pragma is now obsolete, and is only provided for backward–compatibility. See *Subroutine Attributes in perlsub*.

Precedence problem: open %s should be open(%s)

(S precedence) The old irregular construct

```
open FOO || die;
```

is now misinterpreted as

```
open(FOO || die);
```

because of the strict regularization of Perl 5's grammar into unary and list operators. (The old open was a little of both.) You must put parentheses around the filehandle, or use the new "or" operator instead of "||".

Premature end of script headers

See Server error.

`printf()` on closed filehandle %s

(W closed) The filehandle you're writing to got itself closed sometime before now. Check your logic flow.

`print()` on closed filehandle %s

(W closed) The filehandle you're printing on got itself closed sometime before now. Check your logic flow.

Process terminated by SIG%s

(W) This is a standard message issued by OS/2 applications, while *nix applications die in silence. It is considered a feature of the OS/2 port. One can easily disable this by appropriate sighandlers, see *Signals in perlipc*. See also "Process terminated by SIGTERM/SIGINT" in *perlos2*.

Prototype mismatch: %s vs %s

(S unsafe) The subroutine being declared or defined had previously been declared or defined with a different function prototype.

Quantifier in {,} bigger than %d before << HERE in regex m/%s/

(F) There is currently a limit to the size of the min and max values of the {min,max} construct. The << HERE shows in the regular expression about where the problem was discovered. See *perlre*.

Quantifier unexpected on zero-length expression before << HERE in regex m/%s/

(W regexp) You applied a regular expression quantifier in a place where it makes no sense, such as on a zero-width assertion. Try putting the quantifier inside the assertion instead. For example, the way to match "abc" provided that it is followed by three repetitions of "xyz" is `/abc(?=(?:xyz){3})/`, not `/abc(?=xyz){3}/`.

Range iterator outside integer range

(F) One (or both) of the numeric arguments to the range operator ".." are outside the range which can be represented by integers internally. One possible workaround is to force Perl to use magical string increment by prepending "0" to your numbers.

`readline()` on closed filehandle %s

(W closed) The filehandle you're reading from got itself closed sometime before now. Check your logic flow.

Reallocation too large: %lx

(F) You can't allocate more than 64K on an MS-DOS machine.

`realloc()` of freed memory ignored

(S malloc) An internal routine called `realloc()` on something that had already been freed.

Recompile perl with **-D**DEBUGGING to use **-D** switch

(F debugging) You can't use the **-D** option unless the code to produce the desired output is compiled into Perl, which entails some overhead, which is why it's currently left out of your copy.

Recursive inheritance detected in package '%s'

(F) More than 100 levels of inheritance were used. Probably indicates an unintended loop in your inheritance hierarchy.

Recursive inheritance detected while looking for method %s

(F) More than 100 levels of inheritance were encountered while invoking a method. Probably indicates an unintended loop in your inheritance hierarchy.

Reference found where even-sized list expected

(W misc) You gave a single reference where Perl was expecting a list with an even number of elements (for assignment to a hash). This usually means that you used the anon hash constructor when you meant to use parens. In any case, a hash requires key/value **pairs**.

```
%hash = { one => 1, two => 2, };    # WRONG
%hash = [ qw/ an anon array / ];    # WRONG
%hash = ( one => 1, two => 2, );    # right
%hash = qw( one 1 two 2 );                  # also fine
```

Reference is already weak

(W misc) You have attempted to weaken a reference that is already weak. Doing so has no effect.

Reference miscount in `sv_replace()`

(W internal) The internal `sv_replace()` function was handed a new SV with a reference count of other than 1.

Reference to nonexistent group before << HERE in regex m/%s/

(F) You used something like `\7` in your regular expression, but there are not at least seven sets of capturing parentheses in the expression. If you wanted to have the character with value 7 inserted into the regular expression, prepend a zero to make the number at least two digits: `\07`

The << HERE shows in the regular expression about where the problem was discovered.

regexp memory corruption

(P) The regular expression engine got confused by what the regular expression compiler gave it.

Regexp out of space

(P) A "can't happen" error, because `safemalloc()` should have caught it earlier.

Repeat count in pack overflows

(F) You can't specify a repeat count so large that it overflows your signed integers. See *pack*.

Repeat count in unpack overflows

(F) You can't specify a repeat count so large that it overflows your signed integers. See *unpack*.

Reversed %s= operator

(W syntax) You wrote your assignment operator backwards. The = must always comes last, to avoid ambiguity with subsequent unary operators.

Runaway format

(F) Your format contained the ~~ repeat–until–blank sequence, but it produced 200 lines at once, and the 200th line looked exactly like the 199th line. Apparently you didn't arrange for the arguments to exhaust themselves, either by using ^ instead of @ (for scalar variables), or by shifting or popping (for array variables). See *perlform*.

Scalar value @%s[%s] better written as `$%s[%s]`

(W syntax) You've used an array slice (indicated by @) to select a single element of an array. Generally it's better to ask for a scalar value (indicated by `$`). The difference is that `$foo[&bar]` always behaves like a scalar, both when assigning to it and when evaluating its argument, while `@foo[&bar]` behaves like a list when you assign to it, and provides a list context to its subscript, which can do weird things if you're expecting only one subscript.

On the other hand, if you were actually hoping to treat the array element as a list, you need to look into how references work, because Perl will not magically convert between scalars and lists for you. See *perlref*.

Scalar value @%s{%s} better written as `$%s{%s}`

(W syntax) You've used a hash slice (indicated by @) to select a single element of a hash. Generally it's better to ask for a scalar value (indicated by `$`). The difference is that `$foo{&bar}` always behaves like a scalar, both when assigning to it and when evaluating its argument, while `@foo{&bar}` behaves like a list when you assign to it, and provides a list context to its subscript, which can do weird things if you're expecting only one subscript.

On the other hand, if you were actually hoping to treat the hash element as a list, you need to look into how references work, because Perl will not magically convert between scalars and lists for you. See *perlref*.

Script is not setuid/setgid in suidperl

(F) Oddly, the suidperl program was invoked on a script without a setuid or setgid bit set. This doesn't make much sense.

Search pattern not terminated

(F) The lexer couldn't find the final delimiter of a // or m{} construct. Remember that bracketing delimiters count nesting level. Missing the leading `$` from a variable `$m` may cause this error.

`%sseek()` on unopened filehandle

(W unopened) You tried to use the `seek()` or `sysseek()` function on a filehandle that was either never opened or has since been closed.

select not implemented

(F) This machine doesn't implement the `select()` system call.

Self–ties of arrays and hashes are not supported

(F) Self–ties are of arrays and hashes are not supported in the current implementation.

Semicolon seems to be missing

(W semicolon) A nearby syntax error was probably caused by a missing semicolon, or possibly some other missing operator, such as a comma.

semi–panic: attempt to dup freed string

(S internal) The internal `newSVsv()` routine was called to duplicate a scalar that had previously been marked as free.

sem%s not implemented

(F) You don't have System V semaphore IPC on your system.

`send()` on closed socket %s

(W closed) The socket you're sending to got itself closed sometime before now. Check your logic flow.

Sequence (? incomplete before << HERE mark in regex m/%s/

(F) A regular expression ended with an incomplete extension (?. The <<<HERE shows in the regular expression about where the problem was discovered. See *perlre*.

Sequence (?{...}) not terminated or not {}–balanced in regex m/%s/

(F) If the contents of a (?{...}) clause contains braces, they must balance for Perl to properly detect the end of the clause. See *perlre*.

Sequence (?%s...) not implemented before << HERE mark in regex m/%s/

(F) A proposed regular expression extension has the character reserved but has not yet been written. The << HERE shows in the regular expression about where the problem was discovered. See *perlre*.

Sequence (?%s...) not recognized before << HERE mark in regex m/%s/

(F) You used a regular expression extension that doesn't make sense. The << HERE shows in the regular expression about where the problem was discovered. See *perlre*.

Sequence (?#... not terminated in regex m/%s/

(F) A regular expression comment must be terminated by a closing parenthesis. Embedded parentheses aren't allowed. See *perlre*.

500 Server error

See Server error.

Server error

This is the error message generally seen in a browser window when trying to run a CGI program (including SSI) over the web. The actual error text varies widely from server to server. The most frequently-seen variants are "500 Server error", "Method (something) not permitted", "Document contains no data", "Premature end of script headers", and "Did not produce a valid header".

This is a CGI error, not a Perl error.

You need to make sure your script is executable, is accessible by the user CGI is running the script under (which is probably not the user account you tested it under), does not rely on any environment variables (like PATH) from the user it isn't running under, and isn't in a location where the CGI server can't find it, basically, more or less. Please see the following for more information:

```
http://www.perl.com/CPAN/doc/FAQs/cgi/idiots-guide.html
http://www.perl.com/CPAN/doc/FAQs/cgi/perl-cgi-faq.html
ftp://rtfm.mit.edu/pub/usenet/news.answers/www/cgi-faq
http://hoohoo.ncsa.uiuc.edu/cgi/interface.html
http://www-genome.wi.mit.edu/WWW/faqs/www-security-faq.html
```

You should also look at *perlfaq9*.

`setegid()` not implemented

(F) You tried to assign to `$)`, and your operating system doesn't support the `setegid()` system call (or equivalent), or at least Configure didn't think so.

`seteuid()` not implemented

(F) You tried to assign to `< $`, and your operating system doesn't support the `seteuid()` system call (or equivalent), or at least Configure didn't think so.

setpgrp can't take arguments

(F) Your system has the `setpgrp()` from BSD 4.2, which takes no arguments, unlike POSIX `setpgid()`, which takes a process ID and process group ID.

`setrgid()` not implemented

(F) You tried to assign to `$(`, and your operating system doesn't support the `setrgid()` system call (or equivalent), or at least Configure didn't think so.

`setruid()` not implemented

(F) You tried to assign to `$<`, and your operating system doesn't support the `setruid()` system call (or equivalent), or at least Configure didn't think so.

`setsockopt()` on closed socket %s

(W closed) You tried to set a socket option on a closed socket. Did you forget to check the return value of your `socket()` call? See *setsockopt*.

Setuid/gid script is writable by world

(F) The setuid emulator won't run a script that is writable by the world, because the world might have written on it already.

shm%s not implemented

(F) You don't have System V shared memory IPC on your system.

< should be quotes

(F) You wrote `< require <file` when you should have written `require 'file'`.

/%s/ should probably be written as "%s"

(W syntax) You have used a pattern where Perl expected to find a string, as in the first argument to `join`. Perl will treat the true or false result of matching the pattern against `$_` as the string, which is probably not what you had in mind.

`shutdown()` on closed socket %s

(W closed) You tried to do a shutdown on a closed socket. Seems a bit superfluous.

SIG%s handler "%s" not defined

(W signal) The signal handler named in %SIG doesn't, in fact, exist. Perhaps you put it into the wrong package?

sort is now a reserved word

(F) An ancient error message that almost nobody ever runs into anymore. But before sort was a keyword, people sometimes used it as a filehandle.

Sort subroutine didn't return a numeric value

(F) A sort comparison routine must return a number. You probably blew it by not using `<` `<=` or `cmp`, or by not using them correctly. See *sort*.

Sort subroutine didn't return single value

(F) A sort comparison subroutine may not return a list value with more or less than one element. See *sort*.

Split loop

(P) The split was looping infinitely. (Obviously, a split shouldn't iterate more times than there are characters of input, which is what happened.) See *split*.

Statement unlikely to be reached

(W exec) You did an `exec()` with some statement after it other than a `die()`. This is almost always an error, because `exec()` never returns unless there was a failure. You probably wanted to use `system()` instead, which does return. To suppress this warning, put the `exec()` in a block by itself.

`stat()` on unopened filehandle %s

(W unopened) You tried to use the `stat()` function on a filehandle that was either never opened or has since been closed.

Stub found while resolving method '%s' overloading %s

(P) Overloading resolution over @ISA tree may be broken by importation stubs. Stubs should never be implicitly created, but explicit calls to `can` may break this.

Subroutine %s redefined

(W redefine) You redefined a subroutine. To suppress this warning, say

```
{
    no warnings;
    eval "sub name { ... }";
}
```

Substitution loop

(P) The substitution was looping infinitely. (Obviously, a substitution shouldn't iterate more times than there are characters of input, which is what happened.) See the discussion of substitution in *Quote and Quote-like Operators in perlop*.

Substitution pattern not terminated

(F) The lexer couldn't find the interior delimiter of a s/// or s{}{} construct. Remember that bracketing delimiters count nesting level. Missing the leading `$` from variable `$s` may cause this error.

Substitution replacement not terminated

(F) The lexer couldn't find the final delimiter of a s/// or s{}{} construct. Remember that bracketing delimiters count nesting level. Missing the leading `$` from variable `$s` may cause this error.

substr outside of string

(W substr),(F) You tried to reference a `substr()` that pointed outside of a string. That is, the absolute value of the offset was larger than the length of the string. See *substr*. This warning is fatal if substr is used in an lvalue context (as the left hand side of an assignment or as a subroutine argument for example).

suidperl is no longer needed since %s

(F) Your Perl was compiled with **−D**SETUID_SCRIPTS_ARE_SECURE_NOW, but a version of the setuid emulator somehow got run anyway.

Switch (?(condition)... contains too many branches before << HERE in regex m/%s/

(F) A (?(condition)if−clauselelse−clause) construct can have at most two branches (the if−clause and the else−clause). If you want one or both to contain alternation, such as using `this|that|other`, enclose it in clustering parentheses:

```
(?(condition)(?:this|that|other)|else-clause)
```

The << HERE shows in the regular expression about where the problem was discovered. See *perlre*.

Switch condition not recognized before << HERE in regex m/%s/

(F) If the argument to the (?(...)if−clauselelse−clause) construct is a number, it can be only a number. The << HERE shows in the regular expression about where the problem was discovered. See *perlre*.

switching effective %s is not implemented

(F) While under the `use filetest` pragma, we cannot switch the real and effective uids or gids.

syntax error

(F) Probably means you had a syntax error. Common reasons include:

```
A keyword is misspelled.
A semicolon is missing.
A comma is missing.
An opening or closing parenthesis is missing.
An opening or closing brace is missing.
A closing quote is missing.
```

Often there will be another error message associated with the syntax error giving more information. (Sometimes it helps to turn on **−w**.) The error message itself often tells you where it was in the line when it decided to give up. Sometimes the actual error is several tokens before this, because Perl is good at understanding random input. Occasionally the line number may be misleading, and once in a blue moon the only way to figure out what's triggering the error is to call `perl -c` repeatedly, chopping away half the program each time to see if the error went away. Sort of the cybernetic version of 20 questions.

syntax error at line %d: '%s' unexpected

(A) You've accidentally run your script through the Bourne shell instead of Perl. Check the #! line, or manually feed your script into Perl yourself.

%s syntax OK

(F) The final summary message when a `perl -c` succeeds.

System V %s is not implemented on this machine

(F) You tried to do something with a function beginning with "sem", "shm", or "msg" but that System V IPC is not implemented in your machine. In some machines the functionality can exist but be unconfigured. Consult your system support.

`syswrite()` on closed filehandle %s

(W closed) The filehandle you're writing to got itself closed sometime before now. Check your logic flow.

Target of goto is too deeply nested

(F) You tried to use `goto` to reach a label that was too deeply nested for Perl to reach. Perl is doing you a favor by refusing.

`tell()` on unopened filehandle

(W unopened) You tried to use the `tell()` function on a filehandle that was either never opened or has since been closed.

That use of `$[` is unsupported

(F) Assignment to `$[` is now strictly circumscribed, and interpreted as a compiler directive. You may say only one of

```
$[ = 0;
$[ = 1;
...
local $[ = 0;
local $[ = 1;
...
```

This is to prevent the problem of one module changing the array base out from under another module inadvertently. See *$[*.

The `crypt()` function is unimplemented due to excessive paranoia

(F) Configure couldn't find the `crypt()` function on your machine, probably because your vendor didn't supply it, probably because they think the U.S. Government thinks it's a secret, or at least that they will continue to pretend that it is. And if you quote me on that, I will deny it.

The %s function is unimplemented

The function indicated isn't implemented on this architecture, according to the probings of Configure.

The stat preceding %s wasn't an lstat

(F) It makes no sense to test the current stat buffer for symbolic linkhood if the last stat that wrote to the stat buffer already went past the symlink to get to the real file. Use an actual filename instead.

This Perl can't reset CRTL environ elements (%s)
This Perl can't set CRTL environ elements (%s=%s)

(W internal) Warnings peculiar to VMS. You tried to change or delete an element of the CRTL's internal environ array, but your copy of Perl wasn't built with a CRTL that contained the `setenv()` function. You'll need to rebuild Perl with a CRTL that does, or redefine ***PERL_ENV_TABLES*** (see *perlvms*) so that the environ array isn't the target of the change to %ENV which produced the warning.

times not implemented

(F) Your version of the C library apparently doesn't do `times()`. I suspect you're not running on Unix.

Too few args to syscall

(F) There has to be at least one argument to `syscall()` to specify the system call to call, silly dilly.

Too late for "**–T**" option

(X) The #! line (or local equivalent) in a Perl script contains the **–T** option, but Perl was not invoked with **–T** in its command line. This is an error because, by the time Perl discovers a **–T** in a script, it's too late to properly taint everything from the environment. So Perl gives up.

If the Perl script is being executed as a command using the #! mechanism (or its local equivalent), this error can usually be fixed by editing the #! line so that the **–T** option is a part of Perl's first argument: e.g. change `perl -n -T` to `perl -T -n`.

If the Perl script is being executed as `perl scriptname`, then the **–T** option must appear on the command line: `perl -T scriptname`.

Too late for "–%s" option

(X) The #! line (or local equivalent) in a Perl script contains the **–M** or **–m** option. This is an error because **–M** and **–m** options are not intended for use inside scripts. Use the `use` pragma instead.

Too late to run %s block

(W void) A CHECK or INIT block is being defined during run time proper, when the opportunity to run them has already passed. Perhaps you are loading a file with `require` or `do` when you should be using `use` instead. Or perhaps you should put the `require` or `do` inside a BEGIN block.

Too many args to syscall

(F) Perl supports a maximum of only 14 args to `syscall()`.

Too many arguments for %s

(F) The function requires fewer arguments than you specified.

Too many)'s

(A) You've accidentally run your script through **csh** instead of Perl. Check the #! line, or manually feed your script into Perl yourself.

Too many ('s

trailing \ in regexp

(F) The regular expression ends with an unbackslashed backslash. Backslash it. See *perlre*.

Transliteration pattern not terminated

(F) The lexer couldn't find the interior delimiter of a tr/// or tr[][] or y/// or y[][] construct. Missing the leading `$` from variables `$tr` or `$y` may cause this error.

Transliteration replacement not terminated

(F) The lexer couldn't find the final delimiter of a tr/// or tr[][] construct.

truncate not implemented

(F) Your machine doesn't implement a file truncation mechanism that Configure knows about.

Type of arg %d to %s must be %s (not %s)

(F) This function requires the argument in that position to be of a certain type. Arrays must be @NAME or `@{EXPR}`. Hashes must be %NAME or `%{EXPR}`. No implicit dereferencing is allowed—use the {EXPR} forms as an explicit dereference. See *perlref*.

umask: argument is missing initial 0

(W umask) A umask of 222 is incorrect. It should be 0222, because octal literals always start with 0 in Perl, as in C.

umask not implemented

(F) Your machine doesn't implement the umask function and you tried to use it to restrict permissions for yourself (EXPR & 0700).

Unable to create sub named "%s"

(F) You attempted to create or access a subroutine with an illegal name.

Unbalanced context: %d more PUSHes than POPs

(W internal) The exit code detected an internal inconsistency in how many execution contexts were entered and left.

Unbalanced saves: %d more saves than restores

(W internal) The exit code detected an internal inconsistency in how many values were temporarily localized.

Unbalanced scopes: %d more ENTERs than LEAVEs

(W internal) The exit code detected an internal inconsistency in how many blocks were entered and left.

Unbalanced tmps: %d more allocs than frees

(W internal) The exit code detected an internal inconsistency in how many mortal scalars were allocated and freed.

Undefined format "%s" called

(F) The format indicated doesn't seem to exist. Perhaps it's really in another package? See *perlform*.

Undefined sort subroutine "%s" called

(F) The sort comparison routine specified doesn't seem to exist. Perhaps it's in a different package? See *sort*.

Undefined subroutine `&%s` called

(F) The subroutine indicated hasn't been defined, or if it was, it has since been undefined.

Undefined subroutine called

(F) The anonymous subroutine you're trying to call hasn't been defined, or if it was, it has since been undefined.

Undefined subroutine in sort

(F) The sort comparison routine specified is declared but doesn't seem to have been defined yet. See *sort*.

Undefined top format "%s" called

(F) The format indicated doesn't seem to exist. Perhaps it's really in another package? See *perlform*.

Undefined value assigned to typeglob

(W misc) An undefined value was assigned to a typeglob, a la `*foo = undef`. This does nothing. It's possible that you really mean `undef *foo`.

%s: Undefined variable

(A) You've accidentally run your script through **csh** instead of Perl. Check the #! line, or manually feed your script into Perl yourself.

unexec of %s into %s failed!

(F) The `unexec()` routine failed for some reason. See your local FSF representative, who probably put it there in the first place.

Unknown BYTEORDER

(F) There are no byte-swapping functions for a machine with this byte order.

Unknown switch condition (?(%.2s before << HERE in regex m/%s/

(F) The condition of a (?(condition)if-clauseelse-clause) construct is not known. The condition may be lookaround (the condition is true if the lookaround is true), a (?{...}) construct (the condition is true if the code evaluates to a true value), or a number (the condition is true if the set of capturing parentheses named by the number is defined).

The << HERE shows in the regular expression about where the problem was discovered. See *perlre*.

Unknown `open()` mode '%s'

(F) The second argument of 3-argument `open()` is not among the list of valid modes: `< > >> +< +> +>> -| |-`.

Unknown process %x sent message to prime_env_iter: %s

(P) An error peculiar to VMS. Perl was reading values for %ENV before iterating over it, and someone else stuck a message in the stream of data Perl expected. Someone's very confused, or

perhaps trying to subvert Perl's population of %ENV for nefarious purposes.

unmatched [before << HERE mark in regex m/%s/

(F) The brackets around a character class must match. If you wish to include a closing bracket in a character class, backslash it or put it first. See *perlre*. The << HERE shows in the regular expression about where the escape was discovered.

unmatched (in regexp before << HERE mark in regex m/%s/

(F) Unbackslashed parentheses must always be balanced in regular expressions. If you're a vi user, the % key is valuable for finding the matching parenthesis. See *perlre*.

Unmatched right %s bracket

(F) The lexer counted more closing curly or square brackets than opening ones, so you're probably missing a matching opening bracket. As a general rule, you'll find the missing one (so to speak) near the place you were last editing.

Unquoted string "%s" may clash with future reserved word

(W reserved) You used a bareword that might someday be claimed as a reserved word. It's best to put such a word in quotes, or capitalize it somehow, or insert an underbar into it. You might also declare it as a subroutine.

Unrecognized character %s

(F) The Perl parser has no idea what to do with the specified character in your Perl script (or eval). Perhaps you tried to run a compressed script, a binary program, or a directory as a Perl program.

/%s/: Unrecognized escape \\%c in character class passed through

(W regexp) You used a backslash–character combination which is not recognized by Perl inside character classes. The character was understood literally.

Unrecognized escape \\%c passed through before << HERE in m/%s/

(W regexp) You used a backslash–character combination which is not recognized by Perl. This combination appears in an interpolated variable or a '–delimited regular expression. The character was understood literally. The << HERE shows in the regular expression about where the escape was discovered.

Unrecognized escape \\%c passed through

(W misc) You used a backslash–character combination which is not recognized by Perl.

Unrecognized signal name "%s"

(F) You specified a signal name to the `kill()` function that was not recognized. Say `kill -l` in your shell to see the valid signal names on your system.

Unrecognized switch: –%s (–h will show valid options)

(F) You specified an illegal option to Perl. Don't do that. (If you think you didn't do that, check the #! line to see if it's supplying the bad switch on your behalf.)

Unsuccessful %s on filename containing newline

(W newline) A file operation was attempted on a filename, and that operation failed, PROBABLY because the filename contained a newline, PROBABLY because you forgot to `chop()` or `chomp()` it off. See *chomp*.

Unsupported directory function "%s" called

(F) Your machine doesn't support `opendir()` and `readdir()`.

Unsupported function %s

(F) This machine doesn't implement the indicated function, apparently. At least, Configure doesn't think so.

Unsupported function fork

(F) Your version of executable does not support forking.

Note that under some systems, like OS/2, there may be different flavors of Perl executables, some of which may support fork, some not. Try changing the name you call Perl by to `perl_`, `perl__`, and so on.

Unsupported script encoding

(F) Your program file begins with a Unicode Byte Order Mark (BOM) which declares it to be in a Unicode encoding that Perl cannot yet read.

Unsupported socket function "%s" called

(F) Your machine doesn't support the Berkeley socket mechanism, or at least that's what Configure thought.

Unterminated attribute list

(F) The lexer found something other than a simple identifier at the start of an attribute, and it wasn't a semicolon or the start of a block. Perhaps you terminated the parameter list of the previous attribute too soon. See *attributes*.

Unterminated attribute parameter in attribute list

(F) The lexer saw an opening (left) parenthesis character while parsing an attribute list, but the matching closing (right) parenthesis character was not found. You may need to add (or remove) a backslash character to get your parentheses to balance. See *attributes*.

Unterminated compressed integer

(F) An argument to unpack("w",...) was incompatible with the BER compressed integer format and could not be converted to an integer. See *pack*.

Unterminated < operator

(F) The lexer saw a left angle bracket in a place where it was expecting a term, so it's looking for the corresponding right angle bracket, and not finding it. Chances are you left some needed parentheses out earlier in the line, and you really meant a "less than".

untie attempted while %d inner references still exist

(W untie) A copy of the object returned from `tie` (or `tied`) was still valid when `untie` was called.

Useless use of %s in void context

(W void) You did something without a side effect in a context that does nothing with the return value, such as a statement that doesn't return a value from a block, or the left side of a scalar comma operator. Very often this points not to stupidity on your part, but a failure of Perl to parse your program the way you thought it would. For example, you'd get this if you mixed up your C precedence with Python precedence and said

```
$one, $two = 1, 2;
```

when you meant to say

```
($one, $two) = (1, 2);
```

Another common error is to use ordinary parentheses to construct a list reference when you should be using square or curly brackets, for example, if you say

```
$array = (1,2);
```

when you should have said

```
$array = [1,2];
```

The square brackets explicitly turn a list value into a scalar value, while parentheses do not. So when a parenthesized list is evaluated in a scalar context, the comma is treated like C's comma operator, which

throws away the left argument, which is not what you want. See *perlref* for more on this.

Useless use of "re" pragma

(W) You did `use re;` without any arguments. That isn't very useful.

"use" not allowed in expression

(F) The "use" keyword is recognized and executed at compile time, and returns no useful value. See *perlmod*.

Use of bare << to mean <<"" is deprecated

(D deprecated) You are now encouraged to use the explicitly quoted form if you wish to use an empty line as the terminator of the here–document.

Use of implicit split to @_ is deprecated

(D deprecated) It makes a lot of work for the compiler when you clobber a subroutine's argument list, so it's better if you assign the results of a `split()` explicitly to an array (or list).

Use of inherited AUTOLOAD for non–method `%s()` is deprecated

(D deprecated) As an (ahem) accidental feature, `AUTOLOAD` subroutines are looked up as methods (using the `@ISA` hierarchy) even when the subroutines to be autoloaded were called as plain functions (e.g. `Foo::bar()`), not as methods (e.g. `< Foo-bar()` or `< $obj-bar()`).

This bug will be rectified in future by using method lookup only for methods' `AUTOLOAD`s. However, there is a significant base of existing code that may be using the old behavior. So, as an interim step, Perl currently issues an optional warning when non–methods use inherited `AUTOLOAD`s.

The simple rule is: Inheritance will not work when autoloading non–methods. The simple fix for old code is: In any module that used to depend on inheriting `AUTOLOAD` for non–methods from a base class named `BaseClass`, execute `*AUTOLOAD = \&BaseClass::AUTOLOAD` during startup.

In code that currently says `use AutoLoader; @ISA = qw(AutoLoader);` you should remove AutoLoader from @ISA and change `use AutoLoader;` to `use AutoLoader 'AUTOLOAD';`.

Use of %s in printf format not supported

(F) You attempted to use a feature of printf that is accessible from only C. This usually means there's a better way to do it in Perl.

Use of `$*` is deprecated

(D deprecated) This variable magically turned on multi–line pattern matching, both for you and for any luckless subroutine that you happen to call. You should use the new `//m` and `//s` modifiers now to do that without the dangerous action–at–a–distance effects of `$*`.

Use of %s is deprecated

(D deprecated) The construct indicated is no longer recommended for use, generally because there's a better way to do it, and also because the old way has bad side effects.

Use of `$#` is deprecated

(D deprecated) This was an ill–advised attempt to emulate a poorly defined **awk** feature. Use an explicit `printf()` or `sprintf()` instead.

Use of reserved word "%s" is deprecated

(D deprecated) The indicated bareword is a reserved word. Future versions of perl may use it as a keyword, so you're better off either explicitly quoting the word in a manner appropriate for its context of use, or using a different name altogether. The warning can be suppressed for subroutine names by either adding a `&` prefix, or using a package qualifier, e.g. `&our()`, or `Foo::our()`.

Use of uninitialized value%s

(W uninitialized) An undefined value was used as if it were already defined. It was interpreted as a "" or a 0, but maybe it was a mistake. To suppress this warning assign a defined value to your variables.

To help you figure out what was undefined, perl tells you what operation you used the undefined value in. Note, however, that perl optimizes your program and the operation displayed in the warning may not necessarily appear literally in your program. For example, `"that $foo"` is usually optimized into `"that " . $foo`, and the warning will refer to the `concatenation (.)` operator, even though there is no `.` in your program.

Value of %s can be "0"; test with `defined()`

(W misc) In a conditional expression, you used <HANDLE, <* (glob), `each()`, or `readdir()` as a boolean value. Each of these constructs can return a value of "0"; that would make the conditional expression false, which is probably not what you intended. When using these constructs in conditional expressions, test their values with the `defined` operator.

Value of CLI symbol "%s" too long

(W misc) A warning peculiar to VMS. Perl tried to read the value of an %ENV element from a CLI symbol table, and found a resultant string longer than 1024 characters. The return value has been truncated to 1024 characters.

Variable "%s" is not imported%s

(F) While "use strict" in effect, you referred to a global variable that you apparently thought was imported from another module, because something else of the same name (usually a subroutine) is exported by that module. It usually means you put the wrong funny character on the front of your variable.

"%s" variable %s masks earlier declaration in same %s

(W misc) A "my" or "our" variable has been redeclared in the current scope or statement, effectively eliminating all access to the previous instance. This is almost always a typographical error. Note that the earlier variable will still exist until the end of the scope or until all closure referents to it are destroyed.

Variable "%s" may be unavailable

(W closure) An inner (nested) *anonymous* subroutine is inside a *named* subroutine, and outside that is another subroutine; and the anonymous (innermost) subroutine is referencing a lexical variable defined in the outermost subroutine. For example:

```
sub outermost { my $a; sub middle { sub { $a } } }
```

If the anonymous subroutine is called or referenced (directly or indirectly) from the outermost subroutine, it will share the variable as you would expect. But if the anonymous subroutine is called or referenced when the outermost subroutine is not active, it will see the value of the shared variable as it was before and during the *first* call to the outermost subroutine, which is probably not what you want.

In these circumstances, it is usually best to make the middle subroutine anonymous, using the `sub {}` syntax. Perl has specific support for shared variables in nested anonymous subroutines; a named subroutine in between interferes with this feature.

Variable syntax

(A) You've accidentally run your script through **csh** instead of Perl. Check the #! line, or manually feed your script into Perl yourself.

Variable "%s" will not stay shared

(W closure) An inner (nested) *named* subroutine is referencing a lexical variable defined in an outer subroutine.

When the inner subroutine is called, it will probably see the value of the outer subroutine's variable as it was before and during the *first* call to the outer subroutine; in this case, after the first call to the outer subroutine is complete, the inner and outer subroutines will no longer share a common value for the variable. In other words, the variable will no longer be shared.

Furthermore, if the outer subroutine is anonymous and references a lexical variable outside itself, then the outer and inner subroutines will *never* share the given variable.

This problem can usually be solved by making the inner subroutine anonymous, using the `sub {}` syntax. When inner anonymous subs that reference variables in outer subroutines are called or referenced, they are automatically rebound to the current values of such variables.

Variable length lookbehind not implemented before << HERE in regex m/%s/

(F) Lookbehind is allowed only for subexpressions whose length is fixed and known at compile time. The << HERE shows in the regular expression about where the problem was discovered.

Version number must be a constant number

(P) The attempt to translate a `use Module n.n LIST` statement into its equivalent `BEGIN` block found an internal inconsistency with the version number.

Warning: something's wrong

(W) You passed `warn()` an empty string (the equivalent of `warn ""`) or you called it with no args and `$_` was empty.

Warning: unable to close filehandle %s properly

(S) The implicit `close()` done by an `open()` got an error indication on the `close()`. This usually indicates your file system ran out of disk space.

Warning: Use of "%s" without parentheses is ambiguous

(S ambiguous) You wrote a unary operator followed by something that looks like a binary operator that could also have been interpreted as a term or unary operator. For instance, if you know that the rand function has a default argument of 1.0, and you write

```
rand + 5;
```

you may THINK you wrote the same thing as

```
rand() + 5;
```

but in actual fact, you got

```
rand(+5);
```

So put in parentheses to say what you really mean.

Wide character in %s

(F) Perl met a wide character (255) when it wasn't expecting one.

`write()` on closed filehandle %s

(W closed) The filehandle you're writing to got itself closed sometime before now. Check your logic flow.

X outside of string

(F) You had a pack template that specified a relative position before the beginning of the string being unpacked. See *pack*.

x outside of string

(F) You had a pack template that specified a relative position after the end of the string being unpacked. See *pack*.

Xsub "%s" called in sort

(F) The use of an external subroutine as a sort comparison is not yet supported.

Xsub called in sort

(F) The use of an external subroutine as a sort comparison is not yet supported.

You can't use `-l` on a filehandle

(F) A filehandle represents an opened file, and when you opened the file it already went past any symlink you are presumably trying to look for. Use a filename instead.

YOU HAVEN'T DISABLED SET-ID SCRIPTS IN THE KERNEL YET!

(F) And you probably never will, because you probably don't have the sources to your kernel, and your vendor probably doesn't give a rip about what you want. Your best bet is to use the wrapsuid script in the eg directory to put a setuid C wrapper around your script.

You need to quote "%s"

(W syntax) You assigned a bareword as a signal handler name. Unfortunately, you already have a subroutine of that name declared, which means that Perl 5 will try to call the subroutine when the assignment is executed, which is probably not what you want. (If it IS what you want, put an `&` in front.)

NAME

perldsc – Perl Data Structures Cookbook

DESCRIPTION

The single feature most sorely lacking in the Perl programming language prior to its 5.0 release was complex data structures. Even without direct language support, some valiant programmers did manage to emulate them, but it was hard work and not for the faint of heart. You could occasionally get away with the `$m{$AoA,$b}` notation borrowed from **awk** in which the keys are actually more like a single concatenated string `"$AoA$b"`, but traversal and sorting were difficult. More desperate programmers even hacked Perl's internal symbol table directly, a strategy that proved hard to develop and maintain—to put it mildly.

The 5.0 release of Perl let us have complex data structures. You may now write something like this and all of a sudden, you'd have a array with three dimensions!

```
for $x (1 .. 10) {
    for $y (1 .. 10) {
        for $z (1 .. 10) {
            $AoA[$x][$y][$z] =
                $x ** $y + $z;
        }
    }
}
```

Alas, however simple this may appear, underneath it's a much more elaborate construct than meets the eye!

How do you print it out? Why can't you say just `print @AoA`? How do you sort it? How can you pass it to a function or get one of these back from a function? Is is an object? Can you save it to disk to read back later? How do you access whole rows or columns of that matrix? Do all the values have to be numeric?

As you see, it's quite easy to become confused. While some small portion of the blame for this can be attributed to the reference–based implementation, it's really more due to a lack of existing documentation with examples designed for the beginner.

This document is meant to be a detailed but understandable treatment of the many different sorts of data structures you might want to develop. It should also serve as a cookbook of examples. That way, when you need to create one of these complex data structures, you can just pinch, pilfer, or purloin a drop–in example from here.

Let's look at each of these possible constructs in detail. There are separate sections on each of the following:

- arrays of arrays
- hashes of arrays
- arrays of hashes
- hashes of hashes
- more elaborate constructs

But for now, let's look at general issues common to all these types of data structures.

REFERENCES

The most important thing to understand about all data structures in Perl — including multidimensional arrays—is that even though they might appear otherwise, Perl `@ARRAY`s and `%HASH`es are all internally one–dimensional. They can hold only scalar values (meaning a string, number, or a reference). They cannot directly contain other arrays or hashes, but instead contain *references* to other arrays or hashes.

You can't use a reference to a array or hash in quite the same way that you would a real array or hash. For C or C++ programmers unused to distinguishing between arrays and pointers to the same, this can be confusing. If so, just think of it as the difference between a structure and a pointer to a structure.

You can (and should) read more about references in the perlref(1) man page. Briefly, references are rather like pointers that know what they point to. (Objects are also a kind of reference, but we won't be needing them right away—if ever.) This means that when you have something which looks to you like an access to a two−or−more−dimensional array and/or hash, what's really going on is that the base type is merely a one−dimensional entity that contains references to the next level. It's just that you can *use* it as though it were a two−dimensional one. This is actually the way almost all C multidimensional arrays work as well.

```
$array[7][12]                       # array of arrays
$array[7]{string}                   # array of hashes
$hash{string}[7]                    # hash of arrays
$hash{string}{'another string'}     # hash of hashes
```

Now, because the top level contains only references, if you try to print out your array in with a simple `print()` function, you'll get something that doesn't look very nice, like this:

```
  @AoA = ( [2, 3], [4, 5, 7], [0] );
  print $AoA[1][2];
7
  print @AoA;
ARRAY(0x83c38)ARRAY(0x8b194)ARRAY(0x8b1d0)
```

That's because Perl doesn't (ever) implicitly dereference your variables. If you want to get at the thing a reference is referring to, then you have to do this yourself using either prefix typing indicators, like `${$blah}`, `@{$blah}`, `@{$blah[$i]}`, or else postfix pointer arrows, like `$a->[3]`, `$h->{fred}`, or even `$ob->method()->[3]`.

COMMON MISTAKES

The two most common mistakes made in constructing something like an array of arrays is either accidentally counting the number of elements or else taking a reference to the same memory location repeatedly. Here's the case where you just get the count instead of a nested array:

```
for $i (1..10) {
    @array = somefunc($i);
    $AoA[$i] = @array;      # WRONG!
}
```

That's just the simple case of assigning an array to a scalar and getting its element count. If that's what you really and truly want, then you might do well to consider being a tad more explicit about it, like this:

```
for $i (1..10) {
    @array = somefunc($i);
    $counts[$i] = scalar @array;
}
```

Here's the case of taking a reference to the same memory location again and again:

```
for $i (1..10) {
    @array = somefunc($i);
    $AoA[$i] = \@array;     # WRONG!
}
```

So, what's the big problem with that? It looks right, doesn't it? After all, I just told you that you need an array of references, so by golly, you've made me one!

Unfortunately, while this is true, it's still broken. All the references in @AoA refer to the *very same place*, and they will therefore all hold whatever was last in @array! It's similar to the problem demonstrated in the following C program:

```
#include <pwd.h>
main() {
    struct passwd *getpwnam(), *rp, *dp;
```

```
    rp = getpwnam("root");
    dp = getpwnam("daemon");

    printf("daemon name is %s\nroot name is %s\n",
            dp->pw_name, rp->pw_name);
}
```

Which will print

```
daemon name is daemon
root name is daemon
```

The problem is that both rp and dp are pointers to the same location in memory! In C, you'd have to remember to malloc() yourself some new memory. In Perl, you'll want to use the array constructor [] or the hash constructor {} instead. Here's the right way to do the preceding broken code fragments:

```
for $i (1..10) {
    @array = somefunc($i);
    $AoA[$i] = [ @array ];
}
```

The square brackets make a reference to a new array with a *copy* of what's in @array at the time of the assignment. This is what you want.

Note that this will produce something similar, but it's much harder to read:

```
for $i (1..10) {
    @array = 0 .. $i;
    @{$AoA[$i]} = @array;
}
```

Is it the same? Well, maybe so—and maybe not. The subtle difference is that when you assign something in square brackets, you know for sure it's always a brand new reference with a new *copy* of the data. Something else could be going on in this new case with the @{$AoA[$i]} dereference on the left-hand-side of the assignment. It all depends on whether $AoA[$i] had been undefined to start with, or whether it already contained a reference. If you had already populated @AoA with references, as in

```
$AoA[3] = \@another_array;
```

Then the assignment with the indirection on the left-hand-side would use the existing reference that was already there:

```
@{$AoA[3]} = @array;
```

Of course, this *would* have the "interesting" effect of clobbering @another_array. (Have you ever noticed how when a programmer says something is "interesting", that rather than meaning "intriguing", they're disturbingly more apt to mean that it's "annoying", "difficult", or both? :-)

So just remember always to use the array or hash constructors with [] or {}, and you'll be fine, although it's not always optimally efficient.

Surprisingly, the following dangerous-looking construct will actually work out fine:

```
for $i (1..10) {
    my @array = somefunc($i);
    $AoA[$i] = \@array;
}
```

That's because my() is more of a run-time statement than it is a compile-time declaration *per se*. This means that the my() variable is remade afresh each time through the loop. So even though it *looks* as though you stored the same variable reference each time, you actually did not! This is a subtle distinction that can produce more efficient code at the risk of misleading all but the most experienced of programmers. So I usually advise against teaching it to beginners. In fact, except for passing arguments to functions, I

seldom like to see the gimme–a–reference operator (backslash) used much at all in code. Instead, I advise beginners that they (and most of the rest of us) should try to use the much more easily understood constructors `[]` and `{}` instead of relying upon lexical (or dynamic) scoping and hidden reference–counting to do the right thing behind the scenes.

In summary:

```
$AoA[$i] = [ @array ];      # usually best
$AoA[$i] = \@array;         # perilous; just how my() was that array?
@{ $AoA[$i] } = @array;     # way too tricky for most programmers
```

CAVEAT ON PRECEDENCE

Speaking of things like `@{$AoA[$i]}`, the following are actually the same thing:

```
$aref->[2][2]       # clear
$$aref[2][2]        # confusing
```

That's because Perl's precedence rules on its five prefix dereferencers (which look like someone swearing: `$ @ * % &`) make them bind more tightly than the postfix subscripting brackets or braces! This will no doubt come as a great shock to the C or C++ programmer, who is quite accustomed to using `*a[i]` to mean what's pointed to by the *i'th* element of `a`. That is, they first take the subscript, and only then dereference the thing at that subscript. That's fine in C, but this isn't C.

The seemingly equivalent construct in Perl, `$$aref[$i]` first does the deref of `$aref`, making it take `$aref` as a reference to an array, and then dereference that, and finally tell you the *i'th* value of the array pointed to by `$AoA`. If you wanted the C notion, you'd have to write `${$AoA[$i]}` to force the `$AoA[$i]` to get evaluated first before the leading `$` dereferencer.

WHY YOU SHOULD ALWAYS `use strict`

If this is starting to sound scarier than it's worth, relax. Perl has some features to help you avoid its most common pitfalls. The best way to avoid getting confused is to start every program like this:

```
#!/usr/bin/perl -w
use strict;
```

This way, you'll be forced to declare all your variables with `my()` and also disallow accidental "symbolic dereferencing". Therefore if you'd done this:

```
my $aref = [
    [ "fred", "barney", "pebbles", "bambam", "dino", ],
    [ "homer", "bart", "marge", "maggie", ],
    [ "george", "jane", "elroy", "judy", ],
];

print $aref[2][2];
```

The compiler would immediately flag that as an error *at compile time*, because you were accidentally accessing `@aref`, an undeclared variable, and it would thereby remind you to write instead:

```
print $aref->[2][2]
```

DEBUGGING

Before version 5.002, the standard Perl debugger didn't do a very nice job of printing out complex data structures. With 5.002 or above, the debugger includes several new features, including command line editing as well as the `x` command to dump out complex data structures. For example, given the assignment to `$AoA` above, here's the debugger output:

```
DB<1> x $AoA
$AoA = ARRAY(0x13b5a0)
   0  ARRAY(0x1f0a24)
      0  'fred'
```

```
        1  'barney'
        2  'pebbles'
        3  'bambam'
        4  'dino'
    1   ARRAY(0x13b558)
        0  'homer'
        1  'bart'
        2  'marge'
        3  'maggie'
    2   ARRAY(0x13b540)
        0  'george'
        1  'jane'
        2  'elroy'
        3  'judy'
```

CODE EXAMPLES

Presented with little comment (these will get their own manpages someday) here are short code examples illustrating access of various types of data structures.

ARRAYS OF ARRAYS

Declaration of a ARRAY OF ARRAYS

```
@AoA = (
       [ "fred", "barney" ],
       [ "george", "jane", "elroy" ],
       [ "homer", "marge", "bart" ],
     );
```

Generation of a ARRAY OF ARRAYS

```
# reading from file
while ( <> ) {
    push @AoA, [ split ];
}

# calling a function
for $i ( 1 .. 10 ) {
    $AoA[$i] = [ somefunc($i) ];
}

# using temp vars
for $i ( 1 .. 10 ) {
    @tmp = somefunc($i);
    $AoA[$i] = [ @tmp ];
}

# add to an existing row
push @{ $AoA[0] }, "wilma", "betty";
```

Access and Printing of a ARRAY OF ARRAYS

```
# one element
$AoA[0][0] = "Fred";

# another element
$AoA[1][1] =~ s/(\w)/\u$1/;

# print the whole thing with refs
for $aref ( @AoA ) {
    print "\t [ @$aref ],\n";
}
```

```
# print the whole thing with indices
for $i ( 0 .. $#AoA ) {
    print "\t [ @{$AoA[$i]} ],\n";
}

# print the whole thing one at a time
for $i ( 0 .. $#AoA ) {
    for $j ( 0 .. $#{ $AoA[$i] } ) {
        print "elt $i $j is $AoA[$i][$j]\n";
    }
}
```

HASHES OF ARRAYS

Declaration of a HASH OF ARRAYS

```
%HoA = (
       flintstones        => [ "fred", "barney" ],
       jetsons            => [ "george", "jane", "elroy" ],
       simpsons           => [ "homer", "marge", "bart" ],
     );
```

Generation of a HASH OF ARRAYS

```
# reading from file
# flintstones: fred barney wilma dino
while ( <> ) {
    next unless s/^(.*?):\s*//;
    $HoA{$1} = [ split ];
}

# reading from file; more temps
# flintstones: fred barney wilma dino
while ( $line = <> ) {
    ($who, $rest) = split /:\s*/, $line, 2;
    @fields = split ' ', $rest;
    $HoA{$who} = [ @fields ];
}

# calling a function that returns a list
for $group ( "simpsons", "jetsons", "flintstones" ) {
    $HoA{$group} = [ get_family($group) ];
}

# likewise, but using temps
for $group ( "simpsons", "jetsons", "flintstones" ) {
    @members = get_family($group);
    $HoA{$group} = [ @members ];
}

# append new members to an existing family
push @{ $HoA{"flintstones"} }, "wilma", "betty";
```

Access and Printing of a HASH OF ARRAYS

```
# one element
$HoA{flintstones}[0] = "Fred";

# another element
$HoA{simpsons}[1] =~ s/(\w)/\u$1/;

# print the whole thing
```

```
foreach $family ( keys %HoA ) {
    print "$family: @{ $HoA{$family} }\n"
}

# print the whole thing with indices
foreach $family ( keys %HoA ) {
    print "family: ";
    foreach $i ( 0 .. $#{ $HoA{$family} } ) {
        print " $i = $HoA{$family}[$i]";
    }
    print "\n";
}

# print the whole thing sorted by number of members
foreach $family ( sort { @{$HoA{$b}} <=> @{$HoA{$a}} } keys %HoA ) {
    print "$family: @{ $HoA{$family} }\n"
}

# print the whole thing sorted by number of members and name
foreach $family ( sort {
                            @{$HoA{$b}} <=> @{$HoA{$a}}
                                        ||
                                    $a cmp $b
            } keys %HoA )
{
    print "$family: ", join(", ", sort @{ $HoA{$family} }), "\n";
}
```

ARRAYS OF HASHES

Declaration of a ARRAY OF HASHES

```
@AoH = (
       {
           Lead     => "fred",
           Friend   => "barney",
       },
       {
           Lead     => "george",
           Wife     => "jane",
           Son      => "elroy",
       },
       {
           Lead     => "homer",
           Wife     => "marge",
           Son      => "bart",
       }
 );
```

Generation of a ARRAY OF HASHES

```
# reading from file
# format: LEAD=fred FRIEND=barney
while ( <> ) {
    $rec = {};
    for $field ( split ) {
        ($key, $value) = split /=/, $field;
        $rec->{$key} = $value;
    }
```

```
    push @AoH, $rec;
}

# reading from file
# format: LEAD=fred FRIEND=barney
# no temp
while ( <> ) {
    push @AoH, { split /[\s+=]/ };
}

# calling a function  that returns a key/value pair list, like
# "lead","fred","daughter","pebbles"
while ( %fields = getnextpairset() ) {
    push @AoH, { %fields };
}

# likewise, but using no temp vars
while (<>) {
    push @AoH, { parsepairs($_) };
}

# add key/value to an element
$AoH[0]{pet} = "dino";
$AoH[2]{pet} = "santa's little helper";
```

Access and Printing of a ARRAY OF HASHES

```
# one element
$AoH[0]{lead} = "fred";

# another element
$AoH[1]{lead} =~ s/(\w)/\u$1/;

# print the whole thing with refs
for $href ( @AoH ) {
    print "{ ";
    for $role ( keys %$href ) {
        print "$role=$href->{$role} ";
    }
    print "}\n";
}

# print the whole thing with indices
for $i ( 0 .. $#AoH ) {
    print "$i is { ";
    for $role ( keys %{ $AoH[$i] } ) {
        print "$role=$AoH[$i]{$role} ";
    }
    print "}\n";
}

# print the whole thing one at a time
for $i ( 0 .. $#AoH ) {
    for $role ( keys %{ $AoH[$i] } ) {
        print "elt $i $role is $AoH[$i]{$role}\n";
    }
}
```

HASHES OF HASHES

Declaration of a HASH OF HASHES

```
%HoH = (
       flintstones => {
               lead      => "fred",
               pal       => "barney",
       },
       jetsons     => {
               lead      => "george",
               wife      => "jane",
               "his boy" => "elroy",
       },
       simpsons    => {
               lead      => "homer",
               wife      => "marge",
               kid       => "bart",
       },
);
```

Generation of a HASH OF HASHES

```
# reading from file
# flintstones: lead=fred pal=barney wife=wilma pet=dino
while ( <> ) {
    next unless s/^(.*?):\s*//;
    $who = $1;
    for $field ( split ) {
        ($key, $value) = split /=/, $field;
        $HoH{$who}{$key} = $value;
    }

# reading from file; more temps
while ( <> ) {
    next unless s/^(.*?):\s*//;
    $who = $1;
    $rec = {};
    $HoH{$who} = $rec;
    for $field ( split ) {
        ($key, $value) = split /=/, $field;
        $rec->{$key} = $value;
    }
}

# calling a function  that returns a key,value hash
for $group ( "simpsons", "jetsons", "flintstones" ) {
    $HoH{$group} = { get_family($group) };
}

# likewise, but using temps
for $group ( "simpsons", "jetsons", "flintstones" ) {
    %members = get_family($group);
    $HoH{$group} = { %members };
}

# append new members to an existing family
%new_folks = (
    wife => "wilma",
```

```
    pet  => "dino",
);

for $what (keys %new_folks) {
    $HoH{flintstones}{$what} = $new_folks{$what};
}
```

Access and Printing of a HASH OF HASHES

```
# one element
$HoH{flintstones}{wife} = "wilma";

# another element
$HoH{simpsons}{lead} =~ s/(\w)/\u$1/;

# print the whole thing
foreach $family ( keys %HoH ) {
    print "$family: { ";
    for $role ( keys %{ $HoH{$family} } ) {
        print "$role=$HoH{$family}{$role} ";
    }
    print "}\n";
}

# print the whole thing  somewhat sorted
foreach $family ( sort keys %HoH ) {
    print "$family: { ";
    for $role ( sort keys %{ $HoH{$family} } ) {
        print "$role=$HoH{$family}{$role} ";
    }
    print "}\n";
}

# print the whole thing sorted by number of members
foreach $family ( sort { keys %{$HoH{$b}} <=> keys %{$HoH{$a}} } keys %HoH ) {
    print "$family: { ";
    for $role ( sort keys %{ $HoH{$family} } ) {
        print "$role=$HoH{$family}{$role} ";
    }
    print "}\n";
}

# establish a sort order (rank) for each role
$i = 0;
for ( qw(lead wife son daughter pal pet) ) { $rank{$_} = ++$i }

# now print the whole thing sorted by number of members
foreach $family ( sort { keys %{ $HoH{$b} } <=> keys %{ $HoH{$a} } } keys %HoH ) {
    print "$family: { ";
    # and print these according to rank order
    for $role ( sort { $rank{$a} <=> $rank{$b} }  keys %{ $HoH{$family} } ) {
        print "$role=$HoH{$family}{$role} ";
    }
    print "}\n";
}
```

MORE ELABORATE RECORDS

Declaration of MORE ELABORATE RECORDS

Here‘s a sample showing how to create and use a record whose fields are of many different sorts:

```
$rec = {
    TEXT      => $string,
    SEQUENCE  => [ @old_values ],
    LOOKUP    => { %some_table },
    THATCODE  => \&some_function,
    THISCODE  => sub { $_[0] ** $_[1] },
    HANDLE    => \*STDOUT,
};

print $rec->{TEXT};

print $rec->{SEQUENCE}[0];
$last = pop @ { $rec->{SEQUENCE} };

print $rec->{LOOKUP}{"key"};
($first_k, $first_v) = each %{ $rec->{LOOKUP} };

$answer = $rec->{THATCODE}->($arg);
$answer = $rec->{THISCODE}->($arg1, $arg2);

# careful of extra block braces on fh ref
print { $rec->{HANDLE} } "a string\n";

use FileHandle;
$rec->{HANDLE}->autoflush(1);
$rec->{HANDLE}->print(" a string\n");
```

Declaration of a HASH OF COMPLEX RECORDS

```
%TV = (
   flintstones => {
       series   => "flintstones",
       nights   => [ qw(monday thursday friday) ],
       members  => [
           { name => "fred",    role => "lead", age  => 36, },
           { name => "wilma",   role => "wife", age  => 31, },
           { name => "pebbles", role => "kid",  age  =>  4, },
       ],
   },

   jetsons     => {
       series   => "jetsons",
       nights   => [ qw(wednesday saturday) ],
       members  => [
           { name => "george",  role => "lead", age  => 41, },
           { name => "jane",    role => "wife", age  => 39, },
           { name => "elroy",   role => "kid",  age  =>  9, },
       ],
    },

   simpsons    => {
       series   => "simpsons",
       nights   => [ qw(monday) ],
       members  => [
           { name => "homer", role => "lead", age  => 34, },
           { name => "marge", role => "wife", age => 37, },
           { name => "bart",  role => "kid",  age  =>  11, },
       ],
    },
 );
```

Generation of a HASH OF COMPLEX RECORDS

```
# reading from file
# this is most easily done by having the file itself be
# in the raw data format as shown above.  perl is happy
# to parse complex data structures if declared as data, so
# sometimes it's easiest to do that

# here's a piece by piece build up
$rec = {};
$rec->{series} = "flintstones";
$rec->{nights} = [ find_days() ];

@members = ();
# assume this file in field=value syntax
while (<>) {
    %fields = split /[\s=]+/;
    push @members, { %fields };
}
$rec->{members} = [ @members ];

# now remember the whole thing
$TV{ $rec->{series} } = $rec;

###########################################################
# now, you might want to make interesting extra fields that
# include pointers back into the same data structure so if
# change one piece, it changes everywhere, like for example
# if you wanted a {kids} field that was a reference
# to an array of the kids' records without having duplicate
# records and thus update problems.
###########################################################
foreach $family (keys %TV) {
    $rec = $TV{$family}; # temp pointer
    @kids = ();
    for $person ( @{ $rec->{members} } ) {
        if ($person->{role} =~ /kid|son|daughter/) {
            push @kids, $person;
        }
    }
    # REMEMBER: $rec and $TV{$family} point to same data!!
    $rec->{kids} = [ @kids ];
}

# you copied the array, but the array itself contains pointers
# to uncopied objects. this means that if you make bart get
# older via

$TV{simpsons}{kids}[0]{age}++;

# then this would also change in
print $TV{simpsons}{members}[2]{age};

# because $TV{simpsons}{kids}[0] and $TV{simpsons}{members}[2]
# both point to the same underlying anonymous hash table

# print the whole thing
foreach $family ( keys %TV ) {
    print "the $family";
```

```
            print " is on during @{ $TV{$family}{nights} }\n";
            print "its members are:\n";
            for $who ( @{ $TV{$family}{members} } ) {
                print " $who->{name} ($who->{role}), age $who->{age}\n";
            }
            print "it turns out that $TV{$family}{lead} has ";
            print scalar ( @{ $TV{$family}{kids} } ), " kids named ";
            print join (", ", map { $_->{name} } @{ $TV{$family}{kids} } );
            print "\n";
        }
```

Database Ties

You cannot easily tie a multilevel data structure (such as a hash of hashes) to a dbm file. The first problem is that all but GDBM and Berkeley DB have size limitations, but beyond that, you also have problems with how references are to be represented on disk. One experimental module that does partially attempt to address this need is the MLDBM module. Check your nearest CPAN site as described in *perlmodlib* for source code to MLDBM.

SEE ALSO

perlref(1), perllol(1), perldata(1), perlobj(1)

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NAME

perlebcdic − Considerations for running Perl on EBCDIC platforms

DESCRIPTION

An exploration of some of the issues facing Perl programmers on EBCDIC based computers. We do not cover localization, internationalization, or multi byte character set issues (yet).

Portions that are still incomplete are marked with XXX.

COMMON CHARACTER CODE SETS

ASCII

The American Standard Code for Information Interchange is a set of integers running from 0 to 127 (decimal) that imply character interpretation by the display and other system(s) of computers. The range 0..127 can be covered by setting the bits in a 7−bit binary digit, hence the set is sometimes referred to as a "7−bit ASCII". ASCII was described by the American National Standards Institute document ANSI X3.4−1986. It was also described by ISO 646:1991 (with localization for currency symbols). The full ASCII set is given in the table below as the first 128 elements. Languages that can be written adequately with the characters in ASCII include English, Hawaiian, Indonesian, Swahili and some Native American languages.

There are many character sets that extend the range of integers from 0..2**7−1 up to 2**8−1, or 8 bit bytes (octets if you prefer). One common one is the ISO 8859−1 character set.

ISO 8859

The ISO 8859−`$n` are a collection of character code sets from the International Organization for Standardization (ISO) each of which adds characters to the ASCII set that are typically found in European languages many of which are based on the Roman, or Latin, alphabet.

Latin 1 (ISO 8859−1)

A particular 8−bit extension to ASCII that includes grave and acute accented Latin characters. Languages that can employ ISO 8859−1 include all the languages covered by ASCII as well as Afrikaans, Albanian, Basque, Catalan, Danish, Faroese, Finnish, Norwegian, Portugese, Spanish, and Swedish. Dutch is covered albeit without the ij ligature. French is covered too but without the oe ligature. German can use ISO 8859−1 but must do so without German−style quotation marks. This set is based on Western European extensions to ASCII and is commonly encountered in world wide web work. In IBM character code set identification terminology ISO 8859−1 is also known as CCSID 819 (or sometimes 0819 or even 00819).

EBCDIC

The Extended Binary Coded Decimal Interchange Code refers to a large collection of slightly different single and multi byte coded character sets that are different from ASCII or ISO 8859−1 and typically run on host computers. The EBCDIC encodings derive from 8 bit byte extensions of Hollerith punched card encodings. The layout on the cards was such that high bits were set for the upper and lower case alphabet characters [a−z] and [A−Z], but there were gaps within each latin alphabet range.

Some IBM EBCDIC character sets may be known by character code set identification numbers (CCSID numbers) or code page numbers. Leading zero digits in CCSID numbers within this document are insignificant. E.g. CCSID 0037 may be referred to as 37 in places.

13 variant characters

Among IBM EBCDIC character code sets there are 13 characters that are often mapped to different integer values. Those characters are known as the 13 "variant" characters and are:

```
\ [ ] { } ^ ~ ! # | $ @ `
```

0037

Character code set ID 0037 is a mapping of the ASCII plus Latin−1 characters (i.e. ISO 8859−1) to an EBCDIC set. 0037 is used in North American English locales on the OS/400 operating system that runs on

AS/400 computers. CCSID 37 differs from ISO 8859−1 in 237 places, in other words they agree on only 19 code point values.

1047

Character code set ID 1047 is also a mapping of the ASCII plus Latin−1 characters (i.e. ISO 8859−1) to an EBCDIC set. 1047 is used under Unix System Services for OS/390, and OpenEdition for VM/ESA. CCSID 1047 differs from CCSID 0037 in eight places.

POSIX−BC

The EBCDIC code page in use on Siemens' BS2000 system is distinct from 1047 and 0037. It is identified below as the POSIX−BC set.

SINGLE OCTET TABLES

The following tables list the ASCII and Latin 1 ordered sets including the subsets: C0 controls (0..31), ASCII graphics (32..7e), delete (7f), C1 controls (80..9f), and Latin−1 (a.k.a. ISO 8859−1) (a0..ff). In the table non−printing control character names as well as the Latin 1 extensions to ASCII have been labelled with character names roughly corresponding to *The Unicode Standard, Version 2.0* albeit with substitutions such as s/LATIN// and s/VULGAR// in all cases, s/CAPITAL LETTER// in some cases, and s/SMALL LETTER ([A−Z])/\l$1/ in some other cases (the `charnames` pragma names unfortunately do not list explicit names for the C0 or C1 control characters). The "names" of the C1 control set (128..159 in ISO 8859−1) listed here are somewhat arbitrary. The differences between the 0037 and 1047 sets are flagged with ***. The differences between the 1047 and POSIX−BC sets are flagged with ###. All `ord()` numbers listed are decimal. If you would rather see this table listing octal values then run the table (that is, the pod version of this document since this recipe may not work with a pod2_other_format translation) through:

recipe 0

```
perl -ne 'if(/(.{33})(\d+)\s+(\d+)\s+(\d+)\s+(\d+)/)' \
 -e '{printf("%s%-9o%-9o%-9o%-9o\n",$1,$2,$3,$4,$5)}' perlebcdic.pod
```

If you would rather see this table listing hexadecimal values then run the table through:

recipe 1

```
perl -ne 'if(/(.{33})(\d+)\s+(\d+)\s+(\d+)\s+(\d+)/)' \
 -e '{printf("%s%-9X%-9X%-9X%-9X\n",$1,$2,$3,$4,$5)}' perlebcdic.pod
```

chr	8859-1 0819	0037	1047	POSIX-BC	
<NULL>	0	0	0	0	
<START OF HEADING>	1	1	1	1	
<START OF TEXT>	2	2	2	2	
<END OF TEXT>	3	3	3	3	
<END OF TRANSMISSION>	4	55	55	55	
<ENQUIRY>	5	45	45	45	
<ACKNOWLEDGE>	6	46	46	46	
<BELL>	7	47	47	47	
<BACKSPACE>	8	22	22	22	
<HORIZONTAL TABULATION>	9	5	5	5	
<LINE FEED>	10	37	21	21	***
<VERTICAL TABULATION>	11	11	11	11	
<FORM FEED>	12	12	12	12	
<CARRIAGE RETURN>	13	13	13	13	
<SHIFT OUT>	14	14	14	14	
<SHIFT IN>	15	15	15	15	
<DATA LINK ESCAPE>	16	16	16	16	
<DEVICE CONTROL ONE>	17	17	17	17	

<DEVICE CONTROL TWO>	18	18	18	18
<DEVICE CONTROL THREE>	19	19	19	19
<DEVICE CONTROL FOUR>	20	60	60	60
<NEGATIVE ACKNOWLEDGE>	21	61	61	61
<SYNCHRONOUS IDLE>	22	50	50	50
<END OF TRANSMISSION BLOCK>	23	38	38	38
<CANCEL>	24	24	24	24
<END OF MEDIUM>	25	25	25	25
<SUBSTITUTE>	26	63	63	63
<ESCAPE>	27	39	39	39
<FILE SEPARATOR>	28	28	28	28
<GROUP SEPARATOR>	29	29	29	29
<RECORD SEPARATOR>	30	30	30	30
<UNIT SEPARATOR>	31	31	31	31
<SPACE>	32	64	64	64
!	33	90	90	90
"	34	127	127	127
#	35	123	123	123
$	36	91	91	91
%	37	108	108	108
&	38	80	80	80
'	39	125	125	125
(	40	77	77	77
)	41	93	93	93
*	42	92	92	92
+	43	78	78	78
,	44	107	107	107
-	45	96	96	96
.	46	75	75	75
/	47	97	97	97
0	48	240	240	240
1	49	241	241	241
2	50	242	242	242
3	51	243	243	243
4	52	244	244	244
5	53	245	245	245
6	54	246	246	246
7	55	247	247	247
8	56	248	248	248
9	57	249	249	249
:	58	122	122	122
;	59	94	94	94
<	60	76	76	76
=	61	126	126	126
>	62	110	110	110
?	63	111	111	111
@	64	124	124	124
A	65	193	193	193
B	66	194	194	194
C	67	195	195	195
D	68	196	196	196
E	69	197	197	197
F	70	198	198	198
G	71	199	199	199

H	72	200	200	200
I	73	201	201	201
J	74	209	209	209
K	75	210	210	210
L	76	211	211	211
M	77	212	212	212
N	78	213	213	213
O	79	214	214	214
P	80	215	215	215
Q	81	216	216	216
R	82	217	217	217
S	83	226	226	226
T	84	227	227	227
U	85	228	228	228
V	86	229	229	229
W	87	230	230	230
X	88	231	231	231
Y	89	232	232	232
Z	90	233	233	233
[	91	186	173	187 *** ###
\	92	224	224	188 ###
]	93	187	189	189 ***
^	94	176	95	106 *** ###
_	95	109	109	109
`	96	121	121	74 ###
a	97	129	129	129
b	98	130	130	130
c	99	131	131	131
d	100	132	132	132
e	101	133	133	133
f	102	134	134	134
g	103	135	135	135
h	104	136	136	136
i	105	137	137	137
j	106	145	145	145
k	107	146	146	146
l	108	147	147	147
m	109	148	148	148
n	110	149	149	149
o	111	150	150	150
p	112	151	151	151
q	113	152	152	152
r	114	153	153	153
s	115	162	162	162
t	116	163	163	163
u	117	164	164	164
v	118	165	165	165
w	119	166	166	166
x	120	167	167	167
y	121	168	168	168
z	122	169	169	169
{	123	192	192	251 ###
|	124	79	79	79
}	125	208	208	253 ###

~	126	161	161	255 ###
<DELETE>	127	7	7	7
<C1 0>	128	32	32	32
<C1 1>	129	33	33	33
<C1 2>	130	34	34	34
<C1 3>	131	35	35	35
<C1 4>	132	36	36	36
<C1 5>	133	21	37	37 ***
<C1 6>	134	6	6	6
<C1 7>	135	23	23	23
<C1 8>	136	40	40	40
<C1 9>	137	41	41	41
<C1 10>	138	42	42	42
<C1 11>	139	43	43	43
<C1 12>	140	44	44	44
<C1 13>	141	9	9	9
<C1 14>	142	10	10	10
<C1 15>	143	27	27	27
<C1 16>	144	48	48	48
<C1 17>	145	49	49	49
<C1 18>	146	26	26	26
<C1 19>	147	51	51	51
<C1 20>	148	52	52	52
<C1 21>	149	53	53	53
<C1 22>	150	54	54	54
<C1 23>	151	8	8	8
<C1 24>	152	56	56	56
<C1 25>	153	57	57	57
<C1 26>	154	58	58	58
<C1 27>	155	59	59	59
<C1 28>	156	4	4	4
<C1 29>	157	20	20	20
<C1 30>	158	62	62	62
<C1 31>	159	255	255	95 ###
<NON-BREAKING SPACE>	160	65	65	65
<INVERTED EXCLAMATION MARK>	161	170	170	170
<CENT SIGN>	162	74	74	176 ###
<POUND SIGN>	163	177	177	177
<CURRENCY SIGN>	164	159	159	159
<YEN SIGN>	165	178	178	178
<BROKEN BAR>	166	106	106	208 ###
<SECTION SIGN>	167	181	181	181
<DIAERESIS>	168	189	187	121 *** ###
<COPYRIGHT SIGN>	169	180	180	180
<FEMININE ORDINAL INDICATOR>	170	154	154	154
<LEFT POINTING GUILLEMET>	171	138	138	138
<NOT SIGN>	172	95	176	186 *** ###
<SOFT HYPHEN>	173	202	202	202
<REGISTERED TRADE MARK SIGN>	174	175	175	175
<MACRON>	175	188	188	161 ###
<DEGREE SIGN>	176	144	144	144
<PLUS-OR-MINUS SIGN>	177	143	143	143
<SUPERSCRIPT TWO>	178	234	234	234
<SUPERSCRIPT THREE>	179	250	250	250

<ACUTE ACCENT>	180	190	190	190
<MICRO SIGN>	181	160	160	160
<PARAGRAPH SIGN>	182	182	182	182
<MIDDLE DOT>	183	179	179	179
<CEDILLA>	184	157	157	157
<SUPERSCRIPT ONE>	185	218	218	218
<MASC. ORDINAL INDICATOR>	186	155	155	155
<RIGHT POINTING GUILLEMET>	187	139	139	139
<FRACTION ONE QUARTER>	188	183	183	183
<FRACTION ONE HALF>	189	184	184	184
<FRACTION THREE QUARTERS>	190	185	185	185
<INVERTED QUESTION MARK>	191	171	171	171
<A WITH GRAVE>	192	100	100	100
<A WITH ACUTE>	193	101	101	101
<A WITH CIRCUMFLEX>	194	98	98	98
<A WITH TILDE>	195	102	102	102
<A WITH DIAERESIS>	196	99	99	99
<A WITH RING ABOVE>	197	103	103	103
<CAPITAL LIGATURE AE>	198	158	158	158
<C WITH CEDILLA>	199	104	104	104
<E WITH GRAVE>	200	116	116	116
<E WITH ACUTE>	201	113	113	113
<E WITH CIRCUMFLEX>	202	114	114	114
<E WITH DIAERESIS>	203	115	115	115
<I WITH GRAVE>	204	120	120	120
<I WITH ACUTE>	205	117	117	117
<I WITH CIRCUMFLEX>	206	118	118	118
<I WITH DIAERESIS>	207	119	119	119
<CAPITAL LETTER ETH>	208	172	172	172
<N WITH TILDE>	209	105	105	105
<O WITH GRAVE>	210	237	237	237
<O WITH ACUTE>	211	238	238	238
<O WITH CIRCUMFLEX>	212	235	235	235
<O WITH TILDE>	213	239	239	239
<O WITH DIAERESIS>	214	236	236	236
<MULTIPLICATION SIGN>	215	191	191	191
<O WITH STROKE>	216	128	128	128
<U WITH GRAVE>	217	253	253	224 ###
<U WITH ACUTE>	218	254	254	254
<U WITH CIRCUMFLEX>	219	251	251	221 ###
<U WITH DIAERESIS>	220	252	252	252
<Y WITH ACUTE>	221	173	186	173 *** ###
<CAPITAL LETTER THORN>	222	174	174	174
<SMALL LETTER SHARP S>	223	89	89	89
<a WITH GRAVE>	224	68	68	68
<a WITH ACUTE>	225	69	69	69
<a WITH CIRCUMFLEX>	226	66	66	66
<a WITH TILDE>	227	70	70	70
<a WITH DIAERESIS>	228	67	67	67
<a WITH RING ABOVE>	229	71	71	71
<SMALL LIGATURE ae>	230	156	156	156
<c WITH CEDILLA>	231	72	72	72
<e WITH GRAVE>	232	84	84	84
<e WITH ACUTE>	233	81	81	81

```
<e WITH CIRCUMFLEX>          234      82       82       82
<e WITH DIAERESIS>           235      83       83       83
<i WITH GRAVE>               236      88       88       88
<i WITH ACUTE>               237      85       85       85
<i WITH CIRCUMFLEX>          238      86       86       86
<i WITH DIAERESIS>           239      87       87       87
<SMALL LETTER eth>           240      140      140      140
<n WITH TILDE>               241      73       73       73
<o WITH GRAVE>               242      205      205      205
<o WITH ACUTE>               243      206      206      206
<o WITH CIRCUMFLEX>          244      203      203      203
<o WITH TILDE>               245      207      207      207
<o WITH DIAERESIS>           246      204      204      204
<DIVISION SIGN>              247      225      225      225
<o WITH STROKE>              248      112      112      112
<u WITH GRAVE>               249      221      221      192 ###
<u WITH ACUTE>               250      222      222      222
<u WITH CIRCUMFLEX>          251      219      219      219
<u WITH DIAERESIS>           252      220      220      220
<y WITH ACUTE>               253      141      141      141
<SMALL LETTER thorn>         254      142      142      142
<y WITH DIAERESIS>           255      223      223      223
```

If you would rather see the above table in CCSID 0037 order rather than ASCII + Latin−1 order then run the table through:

recipe 2

```
perl -ne 'if(/.{33}\d{1,3}\s{6,8}\d{1,3}\s{6,8}\d{1,3}\s{6,8}\d{1,3}/)'\
 -e '{push(@l,$_)}' \
 -e 'END{print map{$_->[0]}' \
 -e '          sort{$a->[1] <=> $b->[1]}' \
 -e '          map{[$_,substr($_,42,3)]}@l;}' perlebcdic.pod
```

If you would rather see it in CCSID 1047 order then change the digit 42 in the last line to 51, like this:

recipe 3

```
perl -ne 'if(/.{33}\d{1,3}\s{6,8}\d{1,3}\s{6,8}\d{1,3}\s{6,8}\d{1,3}/)'\
 -e '{push(@l,$_)}' \
 -e 'END{print map{$_->[0]}' \
 -e '          sort{$a->[1] <=> $b->[1]}' \
 -e '          map{[$_,substr($_,51,3)]}@l;}' perlebcdic.pod
```

If you would rather see it in POSIX−BC order then change the digit 51 in the last line to 60, like this:

recipe 4

```
perl -ne 'if(/.{33}\d{1,3}\s{6,8}\d{1,3}\s{6,8}\d{1,3}\s{6,8}\d{1,3}/)'\
 -e '{push(@l,$_)}' \
 -e 'END{print map{$_->[0]}' \
 -e '          sort{$a->[1] <=> $b->[1]}' \
 -e '          map{[$_,substr($_,60,3)]}@l;}' perlebcdic.pod
```

IDENTIFYING CHARACTER CODE SETS

To determine the character set you are running under from perl one could use the return value of `ord()` or `chr()` to test one or more character values. For example:

```
$is_ascii  = "A" eq chr(65);
```

```
$is_ebcdic = "A" eq chr(193);
```

Also, "\t" is a HORIZONTAL TABULATION character so that:

```
$is_ascii  = ord("\t") == 9;
$is_ebcdic = ord("\t") == 5;
```

To distinguish EBCDIC code pages try looking at one or more of the characters that differ between them. For example:

```
$is_ebcdic_37   = "\n" eq chr(37);
$is_ebcdic_1047 = "\n" eq chr(21);
```

Or better still choose a character that is uniquely encoded in any of the code sets, e.g.:

```
$is_ascii           = ord('[') == 91;
$is_ebcdic_37       = ord('[') == 186;
$is_ebcdic_1047     = ord('[') == 173;
$is_ebcdic_POSIX_BC = ord('[') == 187;
```

However, it would be unwise to write tests such as:

```
$is_ascii = "\r" ne chr(13);  #  WRONG
$is_ascii = "\n" ne chr(10);  #  ILL ADVISED
```

Obviously the first of these will fail to distinguish most ASCII machines from either a CCSID 0037, a 1047, or a POSIX-BC EBCDIC machine since "\r" eq chr(13) under all of those coded character sets. But note too that because "\n" is chr(13) and "\r" is chr(10) on the MacIntosh (which is an ASCII machine) the second `$is_ascii` test will lead to trouble there.

To determine whether or not perl was built under an EBCDIC code page you can use the Config module like so:

```
use Config;
$is_ebcdic = $Config{'ebcdic'} eq 'define';
```

CONVERSIONS

tr///

In order to convert a string of characters from one character set to another a simple list of numbers, such as in the right columns in the above table, along with perl's tr/// operator is all that is needed. The data in the table are in ASCII order hence the EBCDIC columns provide easy to use ASCII to EBCDIC operations that are also easily reversed.

For example, to convert ASCII to code page 037 take the output of the second column from the output of recipe 0 (modified to add \\ characters) and use it in tr/// like so:

```
$cp_037 =
'\000\001\002\003\234\011\206\177\227\215\216\013\014\015\016\017' .
'\020\021\022\023\235\205\010\207\030\031\222\217\034\035\036\037' .
'\200\201\202\203\204\012\027\033\210\211\212\213\214\005\006\007' .
'\220\221\026\223\224\225\226\004\230\231\232\233\024\025\236\032' .
'\040\240\342\344\340\341\343\345\347\361\242\056\074\050\053\174' .
'\046\351\352\353\350\355\356\357\354\337\041\044\052\051\073\254' .
'\055\057\302\304\300\301\303\305\307\321\246\054\045\137\076\077' .
'\370\311\312\313\310\315\316\317\314\140\072\043\100\047\075\042' .
'\330\141\142\143\144\145\146\147\150\151\253\273\360\375\376\261' .
'\260\152\153\154\155\156\157\160\161\162\252\272\346\270\306\244' .
'\265\176\163\164\165\166\167\170\171\172\241\277\320\335\336\256' .
'\136\243\245\267\251\247\266\274\275\276\133\135\257\250\264\327' .
'\173\101\102\103\104\105\106\107\110\111\255\364\366\362\363\365' .
'\175\112\113\114\115\116\117\120\121\122\271\373\374\371\372\377' .
```

```
'\134\367\123\124\125\126\127\130\131\132\262\324\326\322\323\325' .
'\060\061\062\063\064\065\066\067\070\071\263\333\334\331\332\237' ;

my $ebcdic_string = $ascii_string;
eval '$ebcdic_string =~ tr/\000-\377/' . $cp_037 . '/';
```

To convert from EBCDIC 037 to ASCII just reverse the order of the tr/// arguments like so:

```
my $ascii_string = $ebcdic_string;
eval '$ascii_string = tr/' . $cp_037 . '/\000-\377/';
```

Similarly one could take the output of the third column from recipe 0 to obtain a `$cp_1047` table. The fourth column of the output from recipe 0 could provide a `$cp_posix_bc` table suitable for transcoding as well.

iconv

XPG operability often implies the presence of an *iconv* utility available from the shell or from the C library. Consult your system's documentation for information on iconv.

On OS/390 see the iconv(1) man page. One way to invoke the iconv shell utility from within perl would be to:

```
# OS/390 example
$ascii_data = `echo '$ebcdic_data'| iconv -f IBM-1047 -t ISO8859-1`
```

or the inverse map:

```
# OS/390 example
$ebcdic_data = `echo '$ascii_data'| iconv -f ISO8859-1 -t IBM-1047`
```

For other perl based conversion options see the Convert::* modules on CPAN.

C RTL

The OS/390 C run time library provides `_atoe()` and `_etoa()` functions.

OPERATOR DIFFERENCES

The `..` range operator treats certain character ranges with care on EBCDIC machines. For example the following array will have twenty six elements on either an EBCDIC machine or an ASCII machine:

```
@alphabet = ('A'..'Z');    #  $#alphabet == 25
```

The bitwise operators such as `& ^ |` may return different results when operating on string or character data in a perl program running on an EBCDIC machine than when run on an ASCII machine. Here is an example adapted from the one in *perlop*:

```
# EBCDIC-based examples
print "j p \n" ^ " a h";                    # prints "JAPH\n"
print "JA" | "  ph\n";                      # prints "japh\n"
print "JAPH\nJunk" & "\277\277\277\277\277"; # prints "japh\n";
print 'p N$' ^ " E<H\n";                    # prints "Perl\n";
```

An interesting property of the 32 C0 control characters in the ASCII table is that they can "literally" be constructed as control characters in perl, e.g. `(chr(0) eq "\c@") (chr(1) eq "\cA")`, and so on. Perl on EBCDIC machines has been ported to take "\c@" to chr(0) and "\cA" to chr(1) as well, but the thirty three characters that result depend on which code page you are using. The table below uses the character names from the previous table but with substitutions such as s/START OF/S.O./; s/END OF /E.O./; s/TRANSMISSION/TRANS./; s/TABULATION/TAB./; s/VERTICAL/VERT./; s/HORIZONTAL/HORIZ./; s/DEVICE CONTROL/D.C./; s/SEPARATOR/SEP./; s/NEGATIVE ACKNOWLEDGE/NEG. ACK./;. The POSIX-BC and 1047 sets are identical throughout this range and differ from the 0037 set at only one spot (21 decimal). Note that the `LINE FEED` character may be generated by "\cJ" on ASCII machines but by "\cU" on 1047 or POSIX-BC machines and cannot be generated as a `"\c.letter."` control character on 0037 machines. Note also that "\c\\" maps to two

characters not one.

```
chr   ord  8859-1               0037                1047 && POSIX-BC
------------------------------------------------------------------------
"\c?" 127  <DELETE>             "                   "               ***><
"\c@"   0  <NULL>               <NULL>              <NULL>          ***><
"\cA"   1  <S.O. HEADING>       <S.O. HEADING>      <S.O. HEADING>
"\cB"   2  <S.O. TEXT>          <S.O. TEXT>         <S.O. TEXT>
"\cC"   3  <E.O. TEXT>          <E.O. TEXT>         <E.O. TEXT>
"\cD"   4  <E.O. TRANS.>        <C1 28>             <C1 28>
"\cE"   5  <ENQUIRY>            <HORIZ. TAB.>       <HORIZ. TAB.>
"\cF"   6  <ACKNOWLEDGE>        <C1 6>              <C1 6>
"\cG"   7  <BELL>               <DELETE>            <DELETE>
"\cH"   8  <BACKSPACE>          <C1 23>             <C1 23>
"\cI"   9  <HORIZ. TAB.>        <C1 13>             <C1 13>
"\cJ"  10  <LINE FEED>          <C1 14>             <C1 14>
"\cK"  11  <VERT. TAB.>         <VERT. TAB.>        <VERT. TAB.>
"\cL"  12  <FORM FEED>          <FORM FEED>         <FORM FEED>
"\cM"  13  <CARRIAGE RETURN>    <CARRIAGE RETURN>   <CARRIAGE RETURN>
"\cN"  14  <SHIFT OUT>          <SHIFT OUT>         <SHIFT OUT>
"\cO"  15  <SHIFT IN>           <SHIFT IN>          <SHIFT IN>
"\cP"  16  <DATA LINK ESCAPE>   <DATA LINK ESCAPE>  <DATA LINK ESCAPE>
"\cQ"  17  <D.C. ONE>           <D.C. ONE>          <D.C. ONE>
"\cR"  18  <D.C. TWO>           <D.C. TWO>          <D.C. TWO>
"\cS"  19  <D.C. THREE>         <D.C. THREE>        <D.C. THREE>
"\cT"  20  <D.C. FOUR>          <C1 29>             <C1 29>
"\cU"  21  <NEG. ACK.>          <C1 5>              <LINE FEED>    ***
"\cV"  22  <SYNCHRONOUS IDLE>   <BACKSPACE>         <BACKSPACE>
"\cW"  23  <E.O. TRANS. BLOCK>  <C1 7>              <C1 7>
"\cX"  24  <CANCEL>             <CANCEL>            <CANCEL>
"\cY"  25  <E.O. MEDIUM>        <E.O. MEDIUM>       <E.O. MEDIUM>
"\cZ"  26  <SUBSTITUTE>         <C1 18>             <C1 18>
"\c["  27  <ESCAPE>             <C1 15>             <C1 15>
"\c\\" 28  <FILE SEP.>\         <FILE SEP.>\        <FILE SEP.>\
"\c]"  29  <GROUP SEP.>         <GROUP SEP.>        <GROUP SEP.>
"\c^"  30  <RECORD SEP.>        <RECORD SEP.>       <RECORD SEP.>  ***><
"\c_"  31  <UNIT SEP.>          <UNIT SEP.>         <UNIT SEP.>    ***><
```

FUNCTION DIFFERENCES

`chr()` `chr()` must be given an EBCDIC code number argument to yield a desired character return value on an EBCDIC machine. For example:

```
$CAPITAL_LETTER_A = chr(193);
```

`ord()` `ord()` will return EBCDIC code number values on an EBCDIC machine. For example:

```
$the_number_193 = ord("A");
```

`pack()` The c and C templates for `pack()` are dependent upon character set encoding. Examples of usage on EBCDIC include:

```
$foo = pack("CCCC",193,194,195,196);
# $foo eq "ABCD"
$foo = pack("C4",193,194,195,196);
# same thing

$foo = pack("ccxxcc",193,194,195,196);
# $foo eq "AB\0\0CD"
```

print() One must be careful with scalars and strings that are passed to print that contain ASCII encodings. One common place for this to occur is in the output of the MIME type header for CGI script writing. For example, many perl programming guides recommend something similar to:

```
print "Content-type:\ttext/html\015\012\015\012";
# this may be wrong on EBCDIC
```

Under the IBM OS/390 USS Web Server for example you should instead write that as:

```
print "Content-type:\ttext/html\r\n\r\n"; # OK for DGW et alia
```

That is because the translation from EBCDIC to ASCII is done by the web server in this case (such code will not be appropriate for the Macintosh however). Consult your web server's documentation for further details.

`printf()`

The formats that can convert characters to numbers and vice versa will be different from their ASCII counterparts when executed on an EBCDIC machine. Examples include:

```
printf("%c%c%c",193,194,195);  # prints ABC
```

`sort()` EBCDIC sort results may differ from ASCII sort results especially for mixed case strings. This is discussed in more detail below.

`sprintf()`

See the discussion of `printf()` above. An example of the use of sprintf would be:

```
$CAPITAL_LETTER_A = sprintf("%c",193);
```

`unpack()`

See the discussion of `pack()` above.

REGULAR EXPRESSION DIFFERENCES

As of perl 5.005_03 the letter range regular expression such as [A–Z] and [a–z] have been especially coded to not pick up gap characters. For example, characters such as ô `o WITH CIRCUMFLEX` that lie between I and J would not be matched by the regular expression range `/[H–K]/`.

If you do want to match the alphabet gap characters in a single octet regular expression try matching the hex or octal code such as `/Ë/` on EBCDIC or `/ô/` on ASCII machines to have your regular expression match `o WITH CIRCUMFLEX`.

Another construct to be wary of is the inappropriate use of hex or octal constants in regular expressions. Consider the following set of subs:

```
sub is_c0 {
    my $char = substr(shift,0,1);
    $char =~ /[\000-\037]/;
}

sub is_print_ascii {
    my $char = substr(shift,0,1);
    $char =~ /[\040-\176]/;
}

sub is_delete {
    my $char = substr(shift,0,1);
    $char eq "\177";
}

sub is_c1 {
    my $char = substr(shift,0,1);
```

```
    $char =~ /[\200-\237]/;
}

sub is_latin_1 {
    my $char = substr(shift,0,1);
    $char =~ /[\240-\377]/;
}
```

The above would be adequate if the concern was only with numeric code points. However, the concern may be with characters rather than code points and on an EBCDIC machine it may be desirable for constructs such as `if (is_print_ascii("A")) {print "A is a printable character\n";}` to print out the expected message. One way to represent the above collection of character classification subs that is capable of working across the four coded character sets discussed in this document is as follows:

```
sub Is_c0 {
    my $char = substr(shift,0,1);
    if (ord('^')==94)  { # ascii
        return $char =~ /[\000-\037]/;
    }
    if (ord('^')==176) { # 37
        return $char =~ /[\000-\003\067\055-\057\026\005\045\013-\023\074\075\062
    }
    if (ord('^')==95 || ord('^')==106) { # 1047 || posix-bc
        return $char =~ /[\000-\003\067\055-\057\026\005\025\013-\023\074\075\062
    }
}

sub Is_print_ascii {
    my $char = substr(shift,0,1);
    $char =~ /[ !"\#\$%&'()*+,\-.\/0-9:;<=>?\@A-Z[\\\]^_`a-z{|}~]/;
}

sub Is_delete {
    my $char = substr(shift,0,1);
    if (ord('^')==94)  { # ascii
        return $char eq "\177";
    }
    else  {              # ebcdic
        return $char eq "\007";
    }
}

sub Is_c1 {
    my $char = substr(shift,0,1);
    if (ord('^')==94)  { # ascii
        return $char =~ /[\200-\237]/;
    }
    if (ord('^')==176) { # 37
        return $char =~ /[\040-\044\025\006\027\050-\054\011\012\033\060\061\032\
    }
    if (ord('^')==95)  { # 1047
        return $char =~ /[\040-\045\006\027\050-\054\011\012\033\060\061\032\063-
    }
    if (ord('^')==106) { # posix-bc
        return $char =~
          /[\040-\045\006\027\050-\054\011\012\033\060\061\032\063-\066\010\070-\
    }
```

```
}

sub Is_latin_1 {
    my $char = substr(shift,0,1);
    if (ord('^')==94)  { # ascii
        return $char =~ /[\240-\377]/;
    }
    if (ord('^')==176) { # 37
        return $char =~
          /[\101\252\112\261\237\262\152\265\275\264\232\212\137\312\257\274\220\
    }
    if (ord('^')==95)  { # 1047
        return $char =~
          /[\101\252\112\261\237\262\152\265\273\264\232\212\260\312\257\274\220\
    }
    if (ord('^')==106) { # posix-bc
        return $char =~
          /[\101\252\260\261\237\262\320\265\171\264\232\212\272\312\257\241\220\
    }
}
```

Note however that only the `Is_ascii_print()` sub is really independent of coded character set. Another way to write `Is_latin_1()` would be to use the characters in the range explicitly:

```
sub Is_latin_1 {
    my $char = substr(shift,0,1);
    $char =~ /[ ¡¢£¤¥¦§¨©ª«¬-®¯°±²³´µ¶·¸¹º»¼½¾¿ÀÁÂÃÄÅÆÇÈÉÊËÌÍÎÏÐÑÒÓÔÕÖ×ØÙÚÛÜÝÞßàá
}
```

Although that form may run into trouble in network transit (due to the presence of 8 bit characters) or on non ISO-Latin character sets.

SOCKETS

Most socket programming assumes ASCII character encodings in network byte order. Exceptions can include CGI script writing under a host web server where the server may take care of translation for you. Most host web servers convert EBCDIC data to ISO-8859-1 or Unicode on output.

SORTING

One big difference between ASCII based character sets and EBCDIC ones are the relative positions of upper and lower case letters and the letters compared to the digits. If sorted on an ASCII based machine the two letter abbreviation for a physician comes before the two letter for drive, that is:

```
@sorted = sort(qw(Dr. dr.));  # @sorted holds ('Dr.','dr.') on ASCII,
                              # but ('dr.','Dr.') on EBCDIC
```

The property of lower case before uppercase letters in EBCDIC is even carried to the Latin 1 EBCDIC pages such as 0037 and 1047. An example would be that Ë `E WITH DIAERESIS` (203) comes before ë `e WITH DIAERESIS` (235) on an ASCII machine, but the latter (83) comes before the former (115) on an EBCDIC machine. (Astute readers will note that the upper case version of `SMALL LETTER SHARP S` is simply "SS" and that the upper case version of ÿ `y WITH DIAERESIS` is not in the 0..255 range but it is at U+x0178 in Unicode, or `"\x{178}"` in a Unicode enabled Perl).

The sort order will cause differences between results obtained on ASCII machines versus EBCDIC machines. What follows are some suggestions on how to deal with these differences.

Ignore ASCII vs. EBCDIC sort differences.

This is the least computationally expensive strategy. It may require some user education.

MONO CASE then sort data.

In order to minimize the expense of mono casing mixed test try to `tr///` towards the character set case most employed within the data. If the data are primarily UPPERCASE non Latin 1 then apply tr/[a–z]/[A–Z]/ then `sort()`. If the data are primarily lowercase non Latin 1 then apply tr/[A–Z]/[a–z]/ before sorting. If the data are primarily UPPERCASE and include Latin–1 characters then apply:

```
tr/[a-z]/[A-Z]/;
tr/[àáâãäåæçèéêëìíîïðñòóôõöøùúûüýþ]/[ÀÁÂÃÄÅÆÇÈÉÊËÌÍÎÏÐÑÒÓÔÕÖØÙÚÛÜÝÞ]/;
s/ß/SS/g;
```

then `sort()`. Do note however that such Latin–1 manipulation does not address the ÿ `y WITH DIAERESIS` character that will remain at code point 255 on ASCII machines, but 223 on most EBCDIC machines where it will sort to a place less than the EBCDIC numerals. With a Unicode enabled Perl you might try:

```
tr/^?/\x{178}/;
```

The strategy of mono casing data before sorting does not preserve the case of the data and may not be acceptable for that reason.

Convert, sort data, then re convert.

This is the most expensive proposition that does not employ a network connection.

Perform sorting on one type of machine only.

This strategy can employ a network connection. As such it would be computationally expensive.

TRANFORMATION FORMATS

There are a variety of ways of transforming data with an intra character set mapping that serve a variety of purposes. Sorting was discussed in the previous section and a few of the other more popular mapping techniques are discussed next.

URL decoding and encoding

Note that some URLs have hexadecimal ASCII code points in them in an attempt to overcome character or protocol limitation issues. For example the tilde character is not on every keyboard hence a URL of the form:

```
http://www.pvhp.com/~pvhp/
```

may also be expressed as either of:

```
http://www.pvhp.com/%7Epvhp/
```

```
http://www.pvhp.com/%7epvhp/
```

where 7E is the hexadecimal ASCII code point for '~'. Here is an example of decoding such a URL under CCSID 1047:

```
$url = 'http://www.pvhp.com/%7Epvhp/';
# this array assumes code page 1047
my @a2e_1047 = (
      0,  1,  2,  3, 55, 45, 46, 47, 22,  5, 21, 11, 12, 13, 14, 15,
     16, 17, 18, 19, 60, 61, 50, 38, 24, 25, 63, 39, 28, 29, 30, 31,
     64, 90,127,123, 91,108, 80,125, 77, 93, 92, 78,107, 96, 75, 97,
    240,241,242,243,244,245,246,247,248,249,122, 94, 76,126,110,111,
    124,193,194,195,196,197,198,199,200,201,209,210,211,212,213,214,
    215,216,217,226,227,228,229,230,231,232,233,173,224,189, 95,109,
    121,129,130,131,132,133,134,135,136,137,145,146,147,148,149,150,
    151,152,153,162,163,164,165,166,167,168,169,192, 79,208,161,  7,
     32, 33, 34, 35, 36, 37,  6, 23, 40, 41, 42, 43, 44,  9, 10, 27,
     48, 49, 26, 51, 52, 53, 54,  8, 56, 57, 58, 59,  4, 20, 62,255,
```

```
     65,170, 74,177,159,178,106,181,187,180,154,138,176,202,175,188,
    144,143,234,250,190,160,182,179,157,218,155,139,183,184,185,171,
    100,101, 98,102, 99,103,158,104,116,113,114,115,120,117,118,119,
    172,105,237,238,235,239,236,191,128,253,254,251,252,186,174, 89,
     68, 69, 66, 70, 67, 71,156, 72, 84, 81, 82, 83, 88, 85, 86, 87,
    140, 73,205,206,203,207,204,225,112,221,222,219,220,141,142,223
);
$url =~ s/%([0-9a-fA-F]{2})/pack("c",$a2e_1047[hex($1)])/ge;
```

Conversely, here is a partial solution for the task of encoding such a URL under the 1047 code page:

```
$url = 'http://www.pvhp.com/~pvhp/';
# this array assumes code page 1047
my @e2a_1047 = (
      0,  1,  2,  3,156,  9,134,127,151,141,142, 11, 12, 13, 14, 15,
     16, 17, 18, 19,157, 10,  8,135, 24, 25,146,143, 28, 29, 30, 31,
    128,129,130,131,132,133, 23, 27,136,137,138,139,140,  5,  6,  7,
    144,145, 22,147,148,149,150,  4,152,153,154,155, 20, 21,158, 26,
     32,160,226,228,224,225,227,229,231,241,162, 46, 60, 40, 43,124,
     38,233,234,235,232,237,238,239,236,223, 33, 36, 42, 41, 59, 94,
     45, 47,194,196,192,193,195,197,199,209,166, 44, 37, 95, 62, 63,
    248,201,202,203,200,205,206,207,204, 96, 58, 35, 64, 39, 61, 34,
    216, 97, 98, 99,100,101,102,103,104,105,171,187,240,253,254,177,
    176,106,107,108,109,110,111,112,113,114,170,186,230,184,198,164,
    181,126,115,116,117,118,119,120,121,122,161,191,208, 91,222,174,
    172,163,165,183,169,167,182,188,189,190,221,168,175, 93,180,215,
    123, 65, 66, 67, 68, 69, 70, 71, 72, 73,173,244,246,242,243,245,
    125, 74, 75, 76, 77, 78, 79, 80, 81, 82,185,251,252,249,250,255,
     92,247, 83, 84, 85, 86, 87, 88, 89, 90,178,212,214,210,211,213,
     48, 49, 50, 51, 52, 53, 54, 55, 56, 57,179,219,220,217,218,159
);
# The following regular expression does not address the
# mappings for: ('.' => '%2E', '/' => '%2F', ':' => '%3A')
$url =~ s/([\t "#%&\(\),;<=>\?\@\[\\\]^`{|}~])/sprintf("%%%02X",$e2a_1047[ord($1)
```

where a more complete solution would split the URL into components and apply a full s/// substitution only to the appropriate parts.

In the remaining examples a @e2a or @a2e array may be employed but the assignment will not be shown explicitly. For code page 1047 you could use the @a2e_1047 or @e2a_1047 arrays just shown.

uu encoding and decoding

The `u` template to `pack()` or `unpack()` will render EBCDIC data in EBCDIC characters equivalent to their ASCII counterparts. For example, the following will print "Yes indeed\n" on either an ASCII or EBCDIC computer:

```
$all_byte_chrs = '';
for (0..255) { $all_byte_chrs .= chr($_); }
$uuencode_byte_chrs = pack('u', $all_byte_chrs);
($uu = <<'    ENDOFHEREDOC') =~ s/^\s*//gm;
M``$"`P0%!@<("0H+#`T.#Q`1$A,4%187&!D:&QP='A\@(2(C)"4F)R@I*BLL
M+2XO,#$R,S0U-C<X.3H[/#T^/T!!0D-$149'2$E*2TQ-3D]045)35%565UA9
M6EM<75Y?8&%B8V1E9F=H:6IK;&UN;W!Q<G-T=79W>'EZ>WQ]?G^`@8*#A(6&
MAXB)BHN,C8Z/D)&2DY25EI>8F9J;G)V>GZ"AHJ.DI::GJ*FJJZRMKJ^PL;*S
MM+6VM[BYNKN\O;Z_P,'"P\3%QL?(R<K+S,W.S]#1TM/4U=;7V-G:V]S=WM_@
?X>+CY.7FY^CIZNOL[>[O\/'R\_3U]O?X^?K[_/W^_P``
ENDOFHEREDOC
```

```
if ($uuencode_byte_chrs eq $uu) {
    print "Yes ";
}
$uudecode_byte_chrs = unpack('u', $uuencode_byte_chrs);
if ($uudecode_byte_chrs eq $all_byte_chrs) {
    print "indeed\n";
}
```

Here is a very spartan uudecoder that will work on EBCDIC provided that the @e2a array is filled in appropriately:

```
#!/usr/local/bin/perl
@e2a = ( # this must be filled in
       );
$_ = <> until ($mode,$file) = /^begin\s*(\d*)\s*(\S*)/;
open(OUT, "> $file") if $file ne "";
while(<>) {
    last if /^end/;
    next if /[a-z]/;
    next unless int((($e2a[ord()] - 32 ) & 077) + 2) / 3) ==
        int(length() / 4);
    print OUT unpack("u", $_);
}
close(OUT);
chmod oct($mode), $file;
```

Quoted–Printable encoding and decoding

On ASCII encoded machines it is possible to strip characters outside of the printable set using:

```
# This QP encoder works on ASCII only
$qp_string =~ s/([=\x00-\x1F\x80-\xFF])/sprintf("=%02X",ord($1))/ge;
```

Whereas a QP encoder that works on both ASCII and EBCDIC machines would look somewhat like the following (where the EBCDIC branch @e2a array is omitted for brevity):

```
if (ord('A') == 65) {    # ASCII
    $delete = "\x7F";    # ASCII
    @e2a = (0 .. 255)    # ASCII to ASCII identity map
}
else {                   # EBCDIC
    $delete = "\x07";    # EBCDIC
    @e2a =               # EBCDIC to ASCII map (as shown above)
}
$qp_string =~
  s/([^ !"\#\$%&'()*+,\-.\/0-9:;<>?\@A-Z[\\\]^_`a-z{|}~$delete])/sprintf("=%02X",
```

(although in production code the substitutions might be done in the EBCDIC branch with the @e2a array and separately in the ASCII branch without the expense of the identity map).

Such QP strings can be decoded with:

```
# This QP decoder is limited to ASCII only
$string =~ s/=([0-9A-Fa-f][0-9A-Fa-f])/chr hex $1/ge;
$string =~ s/=[\n\r]+$//;
```

Whereas a QP decoder that works on both ASCII and EBCDIC machines would look somewhat like the following (where the @a2e array is omitted for brevity):

```
$string =~ s/=([0-9A-Fa-f][0-9A-Fa-f])/chr $a2e[hex $1]/ge;
$string =~ s/=[\n\r]+$//;
```

Caesarian cyphers

The practice of shifting an alphabet one or more characters for encipherment dates back thousands of years and was explicitly detailed by Gaius Julius Caesar in his **Gallic Wars** text. A single alphabet shift is sometimes referred to as a rotation and the shift amount is given as a number `$n` after the string 'rot' or "rot`$n`". Rot0 and rot26 would designate identity maps on the 26 letter English version of the Latin alphabet. Rot13 has the interesting property that alternate subsequent invocations are identity maps (thus rot13 is its own non-trivial inverse in the group of 26 alphabet rotations). Hence the following is a rot13 encoder and decoder that will work on ASCII and EBCDIC machines:

```
#!/usr/local/bin/perl

while(<>){
    tr/n-za-mN-ZA-M/a-zA-Z/;
    print;
}
```

In one-liner form:

```
perl -ne 'tr/n-za-mN-ZA-M/a-zA-Z/;print'
```

Hashing order and checksums

XXX

I18N AND L10N

Internationalization(I18N) and localization(L10N) are supported at least in principle even on EBCDIC machines. The details are system dependent and discussed under the *OS ISSUES* section below.

MULTI OCTET CHARACTER SETS

Multi byte EBCDIC code pages; Unicode, UTF-8, UTF-EBCDIC, XXX.

OS ISSUES

There may be a few system dependent issues of concern to EBCDIC Perl programmers.

OS/400

The PASE environment.

IFS access

XXX.

OS/390

Perl runs under Unix Systems Services or USS.

chcp

chcp is supported as a shell utility for displaying and changing one's code page. See also *chcp*.

dataset access

For sequential data set access try:

```
my @ds_records = `cat //DSNAME`;
```

or:

```
my @ds_records = `cat //'HLQ.DSNAME'`;
```

See also the OS390::Stdio module on CPAN.

OS/390 iconv

iconv is supported as both a shell utility and a C RTL routine. See also the iconv(1) and iconv(3) manual pages.

locales On OS/390 see *locale* for information on locales. The L10N files are in ***/usr/nls/locale***. `$Config{d_setlocale}` is 'define' on OS/390.

VM/ESA?

XXX.

POSIX-BC?

XXX.

BUGS

This pod document contains literal Latin 1 characters and may encounter translation difficulties. In particular one popular nroff implementation was known to strip accented characters to their unaccented counterparts while attempting to view this document through the **pod2man** program (for example, you may see a plain `y` rather than one with a diaeresis as in ÿ). Another nroff truncated the resultant man page at the first occurence of 8 bit characters.

Not all shells will allow multiple `-e` string arguments to perl to be concatenated together properly as recipes 2, 3, and 4 might seem to imply.

Perl does not yet work with any Unicode features on EBCDIC platforms.

SEE ALSO

perllocale, *perlfunc*.

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NAME

perlembed – how to embed perl in your C program

DESCRIPTION

PREAMBLE

Do you want to:

Use C from Perl?

Read *perlxstut*, *perlxs*, *h2xs*, *perlguts*, and *perlapi*.

Use a Unix program from Perl?

Read about back–quotes and about `system` and `exec` in *perlfunc*.

Use Perl from Perl?

Read about *do* and *eval* and *require* and *use*.

Use C from C?

Rethink your design.

Use Perl from C?

Read on...

ROADMAP

Compiling your C program

If you have trouble compiling the scripts in this documentation, you're not alone. The cardinal rule: COMPILE THE PROGRAMS IN EXACTLY THE SAME WAY THAT YOUR PERL WAS COMPILED. (Sorry for yelling.)

Also, every C program that uses Perl must link in the *perl library*. What's that, you ask? Perl is itself written in C; the perl library is the collection of compiled C programs that were used to create your perl executable (*/usr/bin/perl* or equivalent). (Corollary: you can't use Perl from your C program unless Perl has been compiled on your machine, or installed properly—that's why you shouldn't blithely copy Perl executables from machine to machine without also copying the *lib* directory.)

When you use Perl from C, your C program will—usually—allocate, "run", and deallocate a *PerlInterpreter* object, which is defined by the perl library.

If your copy of Perl is recent enough to contain this documentation (version 5.002 or later), then the perl library (and *EXTERN.h* and *perl.h*, which you'll also need) will reside in a directory that looks like this:

```
/usr/local/lib/perl5/your_architecture_here/CORE
```

or perhaps just

```
/usr/local/lib/perl5/CORE
```

or maybe something like

```
/usr/opt/perl5/CORE
```

Execute this statement for a hint about where to find CORE:

```
perl -MConfig -e 'print $Config{archlib}'
```

Here's how you'd compile the example in the next section, *Adding a Perl interpreter to your C program*, on my Linux box:

```
% gcc -O2 -Dbool=char -DHAS_BOOL -I/usr/local/include
-I/usr/local/lib/perl5/i586-linux/5.003/CORE
-L/usr/local/lib/perl5/i586-linux/5.003/CORE
-o interp interp.c -lperl -lm
```

(That's all one line.) On my DEC Alpha running old 5.003_05, the incantation is a bit different:

```
% cc -O2 -Olimit 2900 -DSTANDARD_C -I/usr/local/include
-I/usr/local/lib/perl5/alpha-dec_osf/5.00305/CORE
-L/usr/local/lib/perl5/alpha-dec_osf/5.00305/CORE -L/usr/local/lib
-D__LANGUAGE_C__ -D_NO_PROTO -o interp interp.c -lperl -lm
```

How can you figure out what to add? Assuming your Perl is post-5.001, execute a `perl -V` command and pay special attention to the "cc" and "ccflags" information.

You'll have to choose the appropriate compiler (*cc*, *gcc*, et al.) for your machine: `perl -MConfig -e 'print $Config{cc}'` will tell you what to use.

You'll also have to choose the appropriate library directory (*/usr/local/lib/...*) for your machine. If your compiler complains that certain functions are undefined, or that it can't locate *-lperl*, then you need to change the path following the `-L`. If it complains that it can't find *EXTERN.h* and *perl.h*, you need to change the path following the `-I`.

You may have to add extra libraries as well. Which ones? Perhaps those printed by

```
perl -MConfig -e 'print $Config{libs}'
```

Provided your perl binary was properly configured and installed the **ExtUtils::Embed** module will determine all of this information for you:

```
% cc -o interp interp.c `perl -MExtUtils::Embed -e ccopts -e ldopts`
```

If the **ExtUtils::Embed** module isn't part of your Perl distribution, you can retrieve it from http://www.perl.com/perl/CPAN/modules/by-module/ExtUtils/. (If this documentation came from your Perl distribution, then you're running 5.004 or better and you already have it.)

The **ExtUtils::Embed** kit on CPAN also contains all source code for the examples in this document, tests, additional examples and other information you may find useful.

Adding a Perl interpreter to your C program

In a sense, perl (the C program) is a good example of embedding Perl (the language), so I'll demonstrate embedding with *miniperlmain.c*, included in the source distribution. Here's a bastardized, nonportable version of *miniperlmain.c* containing the essentials of embedding:

```
#include <EXTERN.h>               /* from the Perl distribution     */
#include <perl.h>                 /* from the Perl distribution     */

static PerlInterpreter *my_perl;  /***    The Perl interpreter    ***/

int main(int argc, char **argv, char **env)
{
    my_perl = perl_alloc();
    perl_construct(my_perl);
    perl_parse(my_perl, NULL, argc, argv, (char **)NULL);
    perl_run(my_perl);
```

```
    perl_destruct(my_perl);
    perl_free(my_perl);
}
```

Notice that we don't use the `env` pointer. Normally handed to `perl_parse` as its final argument, `env` here is replaced by `NULL`, which means that the current environment will be used.

Now compile this program (I'll call it *interp.c*) into an executable:

```
% cc -o interp interp.c `perl -MExtUtils::Embed -e ccopts -e ldopts`
```

After a successful compilation, you'll be able to use *interp* just like perl itself:

```
% interp
print "Pretty Good Perl \n";
print "10890 - 9801 is ", 10890 - 9801;
<CTRL-D>
Pretty Good Perl
10890 - 9801 is 1089
```

or

```
% interp -e 'printf("%x", 3735928559)'
deadbeef
```

You can also read and execute Perl statements from a file while in the midst of your C program, by placing the filename in *argv[1]* before calling *perl_run*.

Calling a Perl subroutine from your C program

To call individual Perl subroutines, you can use any of the **call_*** functions documented in *perlcall*. In this example we'll use `call_argv`.

That's shown below, in a program I'll call *showtime.c*.

```
#include <EXTERN.h>
#include <perl.h>

static PerlInterpreter *my_perl;

int main(int argc, char **argv, char **env)
{
    char *args[] = { NULL };
    my_perl = perl_alloc();
    perl_construct(my_perl);

    perl_parse(my_perl, NULL, argc, argv, NULL);

    /*** skipping perl_run() ***/

    call_argv("showtime", G_DISCARD | G_NOARGS, args);

    perl_destruct(my_perl);
    perl_free(my_perl);
}
```

where *showtime* is a Perl subroutine that takes no arguments (that's the *G_NOARGS*) and for which I'll ignore the return value (that's the *G_DISCARD*). Those flags, and others, are discussed in *perlcall*.

I'll define the *showtime* subroutine in a file called *showtime.pl*:

```
print "I shan't be printed.";

sub showtime {
    print time;
}
```

Simple enough. Now compile and run:

```
% cc -o showtime showtime.c `perl -MExtUtils::Embed -e ccopts -e ldopts`

% showtime showtime.pl
818284590
```

yielding the number of seconds that elapsed between January 1, 1970 (the beginning of the Unix epoch), and the moment I began writing this sentence.

In this particular case we don't have to call *perl_run*, but in general it's considered good practice to ensure proper initialization of library code, including execution of all object `DESTROY` methods and package `END {}` blocks.

If you want to pass arguments to the Perl subroutine, you can add strings to the `NULL`-terminated `args` list passed to *call_argv*. For other data types, or to examine return values, you'll need to manipulate the Perl stack. That's demonstrated in *Fiddling with the Perl stack from your C program*.

Evaluating a Perl statement from your C program

Perl provides two API functions to evaluate pieces of Perl code. These are *eval_sv* and *eval_pv*.

Arguably, these are the only routines you'll ever need to execute snippets of Perl code from within your C program. Your code can be as long as you wish; it can contain multiple statements; it can employ *use*, *require*, and *do* to include external Perl files.

eval_pv lets us evaluate individual Perl strings, and then extract variables for coercion into C types. The following program, *string.c*, executes three Perl strings, extracting an `int` from the first, a `float` from the second, and a `char *` from the third.

```
#include <EXTERN.h>
#include <perl.h>

static PerlInterpreter *my_perl;

main (int argc, char **argv, char **env)
{
    STRLEN n_a;
    char *embedding[] = { "", "-e", "0" };

    my_perl = perl_alloc();
    perl_construct( my_perl );

    perl_parse(my_perl, NULL, 3, embedding, NULL);
    perl_run(my_perl);

    /** Treat $a as an integer **/
    eval_pv("$a = 3; $a **= 2", TRUE);
    printf("a = %d\n", SvIV(get_sv("a", FALSE)));

    /** Treat $a as a float **/
    eval_pv("$a = 3.14; $a **= 2", TRUE);
    printf("a = %f\n", SvNV(get_sv("a", FALSE)));

    /** Treat $a as a string **/
    eval_pv("$a = 'rekcaH lreP rehtonA tsuJ'; $a = reverse($a);", TRUE);
    printf("a = %s\n", SvPV(get_sv("a", FALSE), n_a));

    perl_destruct(my_perl);
    perl_free(my_perl);
}
```

All of those strange functions with *sv* in their names help convert Perl scalars to C types. They're described in *perlguts* and *perlapi*.

If you compile and run *string.c*, you'll see the results of using *SvIV()* to create an int, *SvNV()* to create a float, and *SvPV()* to create a string:

```
a = 9
a = 9.859600
a = Just Another Perl Hacker
```

In the example above, we've created a global variable to temporarily store the computed value of our eval'd expression. It is also possible and in most cases a better strategy to fetch the return value from *eval_pv()* instead. Example:

```
...
STRLEN n_a;
SV *val = eval_pv("reverse 'rekcaH lreP rehtonA tsuJ'", TRUE);
printf("%s\n", SvPV(val,n_a));
...
```

This way, we avoid namespace pollution by not creating global variables and we've simplified our code as well.

Performing Perl pattern matches and substitutions from your C program

The *eval_sv()* function lets us evaluate strings of Perl code, so we can define some functions that use it to "specialize" in matches and substitutions: *match()*, *substitute()*, and *matches()*.

```
I32 match(SV *string, char *pattern);
```

Given a string and a pattern (e.g., m/clasp/ or /\b\w*\b/, which in your C program might appear as "/\\b\\w*\\b/"), match() returns 1 if the string matches the pattern and 0 otherwise.

```
int substitute(SV **string, char *pattern);
```

Given a pointer to an SV and an =~ operation (e.g., s/bob/robert/g or tr[A-Z][a-z]), substitute() modifies the string within the AV at according to the operation, returning the number of substitutions made.

```
int matches(SV *string, char *pattern, AV **matches);
```

Given an SV, a pattern, and a pointer to an empty AV, matches() evaluates $string =~ $pattern in a list context, and fills in *matches* with the array elements, returning the number of matches found.

Here's a sample program, *match.c*, that uses all three (long lines have been wrapped here):

```
#include <EXTERN.h>
#include <perl.h>

/** my_eval_sv(code, error_check)
** kinda like eval_sv(),
** but we pop the return value off the stack
**/
SV* my_eval_sv(SV *sv, I32 croak_on_error)
{
    dSP;
    SV* retval;
    STRLEN n_a;

    PUSHMARK(SP);
    eval_sv(sv, G_SCALAR);

    SPAGAIN;
    retval = POPs;
    PUTBACK;
```

```
    if (croak_on_error && SvTRUE(ERRSV))
       croak(SvPVx(ERRSV, n_a));

    return retval;
}

/** match(string, pattern)
**
** Used for matches in a scalar context.
**
** Returns 1 if the match was successful; 0 otherwise.
**/

I32 match(SV *string, char *pattern)
{
    SV *command = NEWSV(1099, 0), *retval;
    STRLEN n_a;

    sv_setpvf(command, "my $string = '%s'; $string =~ %s",
              SvPV(string,n_a), pattern);

    retval = my_eval_sv(command, TRUE);
    SvREFCNT_dec(command);

    return SvIV(retval);
}

/** substitute(string, pattern)
**
** Used for =~ operations that modify their left-hand side (s/// and tr///)
**
** Returns the number of successful matches, and
** modifies the input string if there were any.
**/

I32 substitute(SV **string, char *pattern)
{
    SV *command = NEWSV(1099, 0), *retval;
    STRLEN n_a;

    sv_setpvf(command, "$string = '%s'; ($string =~ %s)",
              SvPV(*string,n_a), pattern);

    retval = my_eval_sv(command, TRUE);
    SvREFCNT_dec(command);

    *string = get_sv("string", FALSE);
    return SvIV(retval);
}

/** matches(string, pattern, matches)
**
** Used for matches in a list context.
**
** Returns the number of matches,
** and fills in **matches with the matching substrings
**/

I32 matches(SV *string, char *pattern, AV **match_list)
{
    SV *command = NEWSV(1099, 0);
```

```
    I32 num_matches;
    STRLEN n_a;

    sv_setpvf(command, "my $string = '%s'; @array = ($string =~ %s)",
              SvPV(string,n_a), pattern);

    my_eval_sv(command, TRUE);
    SvREFCNT_dec(command);

    *match_list = get_av("array", FALSE);
    num_matches = av_len(*match_list) + 1; /** assume $[ is 0 **/

    return num_matches;
}

main (int argc, char **argv, char **env)
{
    PerlInterpreter *my_perl = perl_alloc();
    char *embedding[] = { "", "-e", "0" };
    AV *match_list;
    I32 num_matches, i;
    SV *text = NEWSV(1099,0);
    STRLEN n_a;

    perl_construct(my_perl);
    perl_parse(my_perl, NULL, 3, embedding, NULL);

    sv_setpv(text, "When he is at a convenience store and the bill comes to some amo

    if (match(text, "m/quarter/")) /** Does text contain 'quarter'? **/
       printf("match: Text contains the word 'quarter'.\n\n");
    else
       printf("match: Text doesn't contain the word 'quarter'.\n\n");

    if (match(text, "m/eighth/")) /** Does text contain 'eighth'? **/
       printf("match: Text contains the word 'eighth'.\n\n");
    else
       printf("match: Text doesn't contain the word 'eighth'.\n\n");

    /** Match all occurrences of /wi../ **/
    num_matches = matches(text, "m/(wi..)/g", &match_list);
    printf("matches: m/(wi..)/g found %d matches...\n", num_matches);

    for (i = 0; i < num_matches; i++)
       printf("match: %s\n", SvPV(*av_fetch(match_list, i, FALSE),n_a));
    printf("\n");

    /** Remove all vowels from text **/
    num_matches = substitute(&text, "s/[aeiou]//gi");
    if (num_matches) {
       printf("substitute: s/[aeiou]//gi...%d substitutions made.\n",
              num_matches);
       printf("Now text is: %s\n\n", SvPV(text,n_a));
    }

    /** Attempt a substitution **/
    if (!substitute(&text, "s/Perl/C/")) {
       printf("substitute: s/Perl/C...No substitution made.\n\n");
    }

    SvREFCNT_dec(text);
```

```
    PL_perl_destruct_level = 1;
    perl_destruct(my_perl);
    perl_free(my_perl);
}
```

which produces the output (again, long lines have been wrapped here)

```
match: Text contains the word 'quarter'.

match: Text doesn't contain the word 'eighth'.

matches: m/(wi..)/g found 2 matches...
match: will
match: with

substitute: s/[aeiou]//gi...139 substitutions made.
Now text is: Whn h s t  cnvnnc str nd th bll cms t sm mnt lk 76 cnts,
Mynrd s wr tht thr s smthng h *shld* d, smthng tht wll nbl hm t gt bck
qrtr, bt h hs n d *wht*.  H fmbls thrgh hs rd sqzy chngprs nd gvs th by
thr xtr pnns wth hs dllr, hpng tht h mght lck nt th crrct mnt.  Th by gvs
hm bck tw f hs wn pnns nd thn th bg shny qrtr tht s hs prz. -RCHH

substitute: s/Perl/C...No substitution made.
```

Fiddling with the Perl stack from your C program

When trying to explain stacks, most computer science textbooks mumble something about spring–loaded columns of cafeteria plates: the last thing you pushed on the stack is the first thing you pop off. That'll do for our purposes: your C program will push some arguments onto "the Perl stack", shut its eyes while some magic happens, and then pop the results—the return value of your Perl subroutine—off the stack.

First you'll need to know how to convert between C types and Perl types, with `newSViv()` and `sv_setnv()` and `newAV()` and all their friends. They're described in *perlguts* and *perlapi*.

Then you'll need to know how to manipulate the Perl stack. That's described in *perlcall*.

Once you've understood those, embedding Perl in C is easy.

Because C has no builtin function for integer exponentiation, let's make Perl's ** operator available to it (this is less useful than it sounds, because Perl implements ** with C's *pow()* function). First I'll create a stub exponentiation function in *power.pl*:

```
sub expo {
    my ($a, $b) = @_;
    return $a ** $b;
}
```

Now I'll create a C program, *power.c*, with a function *PerlPower()* that contains all the perlguts necessary to push the two arguments into *expo()* and to pop the return value out. Take a deep breath...

```
#include <EXTERN.h>
#include <perl.h>

static PerlInterpreter *my_perl;

static void
PerlPower(int a, int b)
{
  dSP;                            /* initialize stack pointer      */
  ENTER;                          /* everything created after here */
  SAVETMPS;                       /* ...is a temporary variable.   */
  PUSHMARK(SP);                   /* remember the stack pointer    */
  XPUSHs(sv_2mortal(newSViv(a))); /* push the base onto the stack  */
```

```
    XPUSHs(sv_2mortal(newSViv(b))); /* push the exponent onto stack  */
    PUTBACK;                       /* make local stack pointer global */
    call_pv("expo", G_SCALAR);       /* call the function             */
    SPAGAIN;                         /* refresh stack pointer         */
                                   /* pop the return value from stack */
    printf ("%d to the %dth power is %d.\n", a, b, POPi);
    PUTBACK;
    FREETMPS;                        /* free that return value        */
    LEAVE;                       /* ...and the XPUSHed "mortal" args.*/
}

int main (int argc, char **argv, char **env)
{
  char *my_argv[] = { "", "power.pl" };

  my_perl = perl_alloc();
  perl_construct( my_perl );

  perl_parse(my_perl, NULL, 2, my_argv, (char **)NULL);
  perl_run(my_perl);

  PerlPower(3, 4);                       /*** Compute 3 ** 4 ***/

  perl_destruct(my_perl);
  perl_free(my_perl);
}
```

Compile and run:

```
% cc -o power power.c `perl -MExtUtils::Embed -e ccopts -e ldopts`

% power
3 to the 4th power is 81.
```

Maintaining a persistent interpreter

When developing interactive and/or potentially long-running applications, it's a good idea to maintain a persistent interpreter rather than allocating and constructing a new interpreter multiple times. The major reason is speed: since Perl will only be loaded into memory once.

However, you have to be more cautious with namespace and variable scoping when using a persistent interpreter. In previous examples we've been using global variables in the default package `main`. We knew exactly what code would be run, and assumed we could avoid variable collisions and outrageous symbol table growth.

Let's say your application is a server that will occasionally run Perl code from some arbitrary file. Your server has no way of knowing what code it's going to run. Very dangerous.

If the file is pulled in by `perl_parse()`, compiled into a newly constructed interpreter, and subsequently cleaned out with `perl_destruct()` afterwards, you're shielded from most namespace troubles.

One way to avoid namespace collisions in this scenario is to translate the filename into a guaranteed-unique package name, and then compile the code into that package using *eval*. In the example below, each file will only be compiled once. Or, the application might choose to clean out the symbol table associated with the file after it's no longer needed. Using *call_argv*, We'll call the subroutine `Embed::Persistent::eval_file` which lives in the file `persistent.pl` and pass the filename and boolean cleanup/cache flag as arguments.

Note that the process will continue to grow for each file that it uses. In addition, there might be `AUTOLOAD`ed subroutines and other conditions that cause Perl's symbol table to grow. You might want to add some logic that keeps track of the process size, or restarts itself after a certain number of requests, to ensure that memory consumption is minimized. You'll also want to scope your variables with *my* whenever

possible.

```
package Embed::Persistent;
#persistent.pl

use strict;
our %Cache;
use Symbol qw(delete_package);

sub valid_package_name {
    my($string) = @_;
    $string =~ s/([^A-Za-z0-9\/])/sprintf("_%2x",unpack("C",$1))/eg;
    # second pass only for words starting with a digit
    $string =~ s|/(\d)|sprintf("/_%2x",unpack("C",$1))|eg;

    # Dress it up as a real package name
    $string =~ s|/|::|g;
    return "Embed" . $string;
}

sub eval_file {
    my($filename, $delete) = @_;
    my $package = valid_package_name($filename);
    my $mtime = -M $filename;
    if(defined $Cache{$package}{mtime}
       &&
       $Cache{$package}{mtime} <= $mtime)
    {
       # we have compiled this subroutine already,
       # it has not been updated on disk, nothing left to do
       print STDERR "already compiled $package->handler\n";
    }
    else {
       local *FH;
       open FH, $filename or die "open '$filename' $!";
       local($/) = undef;
       my $sub = <FH>;
       close FH;

       #wrap the code into a subroutine inside our unique package
       my $eval = qq{package $package; sub handler { $sub; }};
       {
           # hide our variables within this block
           my($filename,$mtime,$package,$sub);
           eval $eval;
       }
       die $@ if $@;

       #cache it unless we're cleaning out each time
       $Cache{$package}{mtime} = $mtime unless $delete;
    }

    eval {$package->handler;};
    die $@ if $@;

    delete_package($package) if $delete;

    #take a look if you want
    #print Devel::Symdump->rnew($package)->as_string, $/;
```

```
}

1;

__END__

/* persistent.c */
#include <EXTERN.h>
#include <perl.h>

/* 1 = clean out filename's symbol table after each request, 0 = don't */
#ifndef DO_CLEAN
#define DO_CLEAN 0
#endif

static PerlInterpreter *perl = NULL;

int
main(int argc, char **argv, char **env)
{
    char *embedding[] = { "", "persistent.pl" };
    char *args[] = { "", DO_CLEAN, NULL };
    char filename [1024];
    int exitstatus = 0;
    STRLEN n_a;

    if((perl = perl_alloc()) == NULL) {
       fprintf(stderr, "no memory!");
       exit(1);
    }
    perl_construct(perl);

    exitstatus = perl_parse(perl, NULL, 2, embedding, NULL);

    if(!exitstatus) {
       exitstatus = perl_run(perl);

       while(printf("Enter file name: ") && gets(filename)) {

           /* call the subroutine, passing it the filename as an argument */
           args[0] = filename;
           call_argv("Embed::Persistent::eval_file",
                          G_DISCARD | G_EVAL, args);

           /* check $@ */
           if(SvTRUE(ERRSV))
               fprintf(stderr, "eval error: %s\n", SvPV(ERRSV,n_a));
       }
    }

    PL_perl_destruct_level = 0;
    perl_destruct(perl);
    perl_free(perl);
    exit(exitstatus);
}
```

Now compile:

```
% cc -o persistent persistent.c `perl -MExtUtils::Embed -e ccopts -e ldopts`
```

Here's a example script file:

```
#test.pl
my $string = "hello";
foo($string);

sub foo {
    print "foo says: @_\n";
}
```

Now run:

```
% persistent
Enter file name: test.pl
foo says: hello
Enter file name: test.pl
already compiled Embed::test_2epl->handler
foo says: hello
Enter file name: ^C
```

Maintaining multiple interpreter instances

Some rare applications will need to create more than one interpreter during a session. Such an application might sporadically decide to release any resources associated with the interpreter.

The program must take care to ensure that this takes place *before* the next interpreter is constructed. By default, the global variable `PL_perl_destruct_level` is set to , since extra cleaning isn't needed when a program has only one interpreter.

Setting `PL_perl_destruct_level` to `1` makes everything squeaky clean:

```
PL_perl_destruct_level = 1;

while(1) {
    ...
    /* reset global variables here with PL_perl_destruct_level = 1 */
    perl_construct(my_perl);
    ...
    /* clean and reset _everything_ during perl_destruct */
    perl_destruct(my_perl);
    perl_free(my_perl);
    ...
    /* let's go do it again! */
}
```

When *`perl_destruct()`* is called, the interpreter's syntax parse tree and symbol tables are cleaned up, and global variables are reset.

Now suppose we have more than one interpreter instance running at the same time. This is feasible, but only if you used the `-DMULTIPLICITY` flag when building Perl. By default, that sets `PL_perl_destruct_level` to `1`.

Let's give it a try:

```
#include <EXTERN.h>
#include <perl.h>

/* we're going to embed two interpreters */
/* we're going to embed two interpreters */

#define SAY_HELLO "-e", "print qq(Hi, I'm $^X\n)"

int main(int argc, char **argv, char **env)
{
    PerlInterpreter
```

```
        *one_perl = perl_alloc(),
        *two_perl = perl_alloc();
    char *one_args[] = { "one_perl", SAY_HELLO };
    char *two_args[] = { "two_perl", SAY_HELLO };

    perl_construct(one_perl);
    perl_construct(two_perl);

    perl_parse(one_perl, NULL, 3, one_args, (char **)NULL);
    perl_parse(two_perl, NULL, 3, two_args, (char **)NULL);

    perl_run(one_perl);
    perl_run(two_perl);

    perl_destruct(one_perl);
    perl_destruct(two_perl);

    perl_free(one_perl);
    perl_free(two_perl);
}
```

Compile as usual:

```
% cc -o multiplicity multiplicity.c `perl -MExtUtils::Embed -e ccopts -e ldopts`
```

Run it, Run it:

```
% multiplicity
Hi, I'm one_perl
Hi, I'm two_perl
```

Using Perl modules, which themselves use C libraries, from your C program

If you've played with the examples above and tried to embed a script that *use()*s a Perl module (such as *Socket*) which itself uses a C or C++ library, this probably happened:

```
Can't load module Socket, dynamic loading not available in this perl.
  (You may need to build a new perl executable which either supports
  dynamic loading or has the Socket module statically linked into it.)
```

What's wrong?

Your interpreter doesn't know how to communicate with these extensions on its own. A little glue will help. Up until now you've been calling *perl_parse()*, handing it NULL for the second argument:

```
perl_parse(my_perl, NULL, argc, my_argv, NULL);
```

That's where the glue code can be inserted to create the initial contact between Perl and linked C/C++ routines. Let's take a look some pieces of *perlmain.c* to see how Perl does this:

```
static void xs_init (pTHX);

EXTERN_C void boot_DynaLoader (pTHX_ CV* cv);
EXTERN_C void boot_Socket (pTHX_ CV* cv);

EXTERN_C void
xs_init(pTHX)
{
        char *file = __FILE__;
        /* DynaLoader is a special case */
        newXS("DynaLoader::boot_DynaLoader", boot_DynaLoader, file);
        newXS("Socket::bootstrap", boot_Socket, file);
}
```

Simply put: for each extension linked with your Perl executable (determined during its initial configuration on your computer or when adding a new extension), a Perl subroutine is created to incorporate the extension's routines. Normally, that subroutine is named *Module::bootstrap()* and is invoked when you say *use Module*. In turn, this hooks into an XSUB, *boot_Module*, which creates a Perl counterpart for each of the extension's XSUBs. Don't worry about this part; leave that to the *xsubpp* and extension authors. If your extension is dynamically loaded, DynaLoader creates *Module::bootstrap()* for you on the fly. In fact, if you have a working DynaLoader then there is rarely any need to link in any other extensions statically.

Once you have this code, slap it into the second argument of *perl_parse()*:

```
perl_parse(my_perl, xs_init, argc, my_argv, NULL);
```

Then compile:

```
% cc -o interp interp.c `perl -MExtUtils::Embed -e ccopts -e ldopts`
```

```
% interp
  use Socket;
  use SomeDynamicallyLoadedModule;

  print "Now I can use extensions!\n"'
```

ExtUtils::Embed can also automate writing the *xs_init* glue code.

```
% perl -MExtUtils::Embed -e xsinit -- -o perlxsi.c
% cc -c perlxsi.c `perl -MExtUtils::Embed -e ccopts`
% cc -c interp.c  `perl -MExtUtils::Embed -e ccopts`
% cc -o interp perlxsi.o interp.o `perl -MExtUtils::Embed -e ldopts`
```

Consult *perlxs*, *perlguts*, and *perlapi* for more details.

Embedding Perl under Win32

In general, all of the source code shown here should work unmodified under Windows.

However, there are some caveats about the command-line examples shown. For starters, backticks won't work under the Win32 native command shell. The ExtUtils::Embed kit on CPAN ships with a script called **genmake**, which generates a simple makefile to build a program from a single C source file. It can be used like this:

```
C:\ExtUtils-Embed\eg> perl genmake interp.c
C:\ExtUtils-Embed\eg> nmake
C:\ExtUtils-Embed\eg> interp -e "print qq{I'm embedded in Win32!\n}"
```

You may wish to use a more robust environment such as the Microsoft Developer Studio. In this case, run this to generate perlxsi.c:

```
perl -MExtUtils::Embed -e xsinit
```

Create a new project and Insert - Files into Project: perlxsi.c, perl.lib, and your own source files, e.g. interp.c. Typically you'll find perl.lib in **C:\perl\lib\CORE**, if not, you should see the **CORE** directory relative to `perl -V:archlib`. The studio will also need this path so it knows where to find Perl include files. This path can be added via the Tools - Options - Directories menu. Finally, select Build - Build interp.exe and you're ready to go.

MORAL

You can sometimes *write faster code* in C, but you can always *write code faster* in Perl. Because you can use each from the other, combine them as you wish.

AUTHOR

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Doug MacEachern has an article on embedding in Volume 1, Issue 4 of The Perl Journal (http://tpj.com). Doug is also the developer of the most widely−used Perl embedding: the mod_perl system (perl.apache.org), which embeds Perl in the Apache web server. Oracle, Binary Evolution, ActiveState, and Ben Sugars's nsapi_perl have used this model for Oracle, Netscape and Internet Information Server Perl plugins.

July 22, 1998

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NAME

perlfaq – frequently asked questions about Perl (`$Date: 1999/05/23 20:38:02 $`)

DESCRIPTION

This document is structured into the following sections:

perlfaq: Structural overview of the FAQ.

This document.

perlfaq1: General Questions About Perl

Very general, high–level information about Perl.

- What is Perl?
- Who supports Perl? Who develops it? Why is it free?
- Which version of Perl should I use?
- What are perl4 and perl5?
- What is perl6?
- How stable is Perl?
- Is Perl difficult to learn?
- How does Perl compare with other languages like Java, Python, REXX, Scheme, or Tcl?
- Can I do [task] in Perl?
- When shouldn't I program in Perl?
- What's the difference between "perl" and "Perl"?
- Is it a Perl program or a Perl script?
- What is a JAPH?
- Where can I get a list of Larry Wall witticisms?
- How can I convince my sysadmin/supervisor/employees to use (version 5/5.005/Perl) instead of some other language?

perlfaq2: Obtaining and Learning about Perl

Where to find source and documentation to Perl, support, and related matters.

- What machines support Perl? Where do I get it?
- How can I get a binary version of Perl?
- I don't have a C compiler on my system. How can I compile perl?
- I copied the Perl binary from one machine to another, but scripts don't work.
- I grabbed the sources and tried to compile but gdbm/dynamic loading/malloc/linking/... failed. How do I make it work?
- What modules and extensions are available for Perl? What is CPAN? What does CPAN/src/... mean?
- Is there an ISO or ANSI certified version of Perl?
- Where can I get information on Perl?
- What are the Perl newsgroups on USENET? Where do I post questions?
- Where should I post source code?
- Perl Books
- Perl in Magazines
- Perl on the Net: FTP and WWW Access
- What mailing lists are there for perl?
- Archives of comp.lang.perl.misc
- Where can I buy a commercial version of Perl?
- Where do I send bug reports?
- What is perl.com?

perlfaq3: **Programming Tools**

Programmer tools and programming support.

- How do I do (anything)?
- How can I use Perl interactively?
- Is there a Perl shell?
- How do I debug my Perl programs?
- How do I profile my Perl programs?
- How do I cross–reference my Perl programs?
- Is there a pretty–printer (formatter) for Perl?
- Is there a ctags for Perl?
- Is there an IDE or Windows Perl Editor?
- Where can I get Perl macros for vi?
- Where can I get perl–mode for emacs?
- How can I use curses with Perl?
- How can I use X or Tk with Perl?
- How can I generate simple menus without using CGI or Tk?
- What is undump?
- How can I make my Perl program run faster?
- How can I make my Perl program take less memory?
- Is it unsafe to return a pointer to local data?
- How can I free an array or hash so my program shrinks?
- How can I make my CGI script more efficient?
- How can I hide the source for my Perl program?
- How can I compile my Perl program into byte code or C?
- How can I compile Perl into Java?
- How can I get `#!perl` to work on [MS–DOS,NT,...]?
- Can I write useful perl programs on the command line?
- Why don't perl one–liners work on my DOS/Mac/VMS system?
- Where can I learn about CGI or Web programming in Perl?
- Where can I learn about object–oriented Perl programming?
- Where can I learn about linking C with Perl? [h2xs, xsubpp]
- I've read perlembed, perlguts, etc., but I can't embed perl in my C program; what am I doing wrong?
- When I tried to run my script, I got this message. What does it mean?
- What's MakeMaker?

perlfaq4: Data Manipulation

Manipulating numbers, dates, strings, arrays, hashes, and miscellaneous data issues.

- Why am I getting long decimals (eg, 19.9499999999999) instead of the numbers I should be getting (eg, 19.95)?
- Why isn't my octal data interpreted correctly?
- Does Perl have a `round()` function? What about `ceil()` and `floor()`? Trig functions?
- How do I convert bits into ints?
- Why doesn't `&` work the way I want it to?
- How do I multiply matrices?
- How do I perform an operation on a series of integers?
- How can I output Roman numerals?
- Why aren't my random numbers random?
- How do I find the week–of–the–year/day–of–the–year?
- How do I find the current century or millennium?

- How can I compare two dates and find the difference?
- How can I take a string and turn it into epoch seconds?
- How can I find the Julian Day?
- How do I find yesterday's date?
- Does Perl have a year 2000 problem? Is Perl Y2K compliant?
- How do I validate input?
- How do I unescape a string?
- How do I remove consecutive pairs of characters?
- How do I expand function calls in a string?
- How do I find matching/nesting anything?
- How do I reverse a string?
- How do I expand tabs in a string?
- How do I reformat a paragraph?
- How can I access/change the first N letters of a string?
- How do I change the Nth occurrence of something?
- How can I count the number of occurrences of a substring within a string?
- How do I capitalize all the words on one line?
- How can I split a [character] delimited string except when inside [character]? (Comma–separated files)
- How do I strip blank space from the beginning/end of a string?
- How do I pad a string with blanks or pad a number with zeroes?
- How do I extract selected columns from a string?
- How do I find the soundex value of a string?
- How can I expand variables in text strings?
- What's wrong with always quoting "`$vars`"?
- Why don't my <<HERE documents work?
- What is the difference between a list and an array?
- What is the difference between `$array[1]` and @array[1]?
- How can I remove duplicate elements from a list or array?
- How can I tell whether a list or array contains a certain element?
- How do I compute the difference of two arrays? How do I compute the intersection of two arrays?
- How do I test whether two arrays or hashes are equal?
- How do I find the first array element for which a condition is true?
- How do I handle linked lists?
- How do I handle circular lists?
- How do I shuffle an array randomly?
- How do I process/modify each element of an array?
- How do I select a random element from an array?
- How do I permute N elements of a list?
- How do I sort an array by (anything)?
- How do I manipulate arrays of bits?
- Why does `defined()` return true on empty arrays and hashes?
- How do I process an entire hash?
- What happens if I add or remove keys from a hash while iterating over it?
- How do I look up a hash element by value?
- How can I know how many entries are in a hash?
- How do I sort a hash (optionally by value instead of key)?
- How can I always keep my hash sorted?
- What's the difference between "delete" and "undef" with hashes?
- Why don't my tied hashes make the defined/exists distinction?
- How do I reset an `each()` operation part–way through?

- How can I get the unique keys from two hashes?
- How can I store a multidimensional array in a DBM file?
- How can I make my hash remember the order I put elements into it?
- Why does passing a subroutine an undefined element in a hash create it?
- How can I make the Perl equivalent of a C structure/C++ class/hash or array of hashes or arrays?
- How can I use a reference as a hash key?
- How do I handle binary data correctly?
- How do I determine whether a scalar is a number/whole/integer/float?
- How do I keep persistent data across program calls?
- How do I print out or copy a recursive data structure?
- How do I define methods for every class/object?
- How do I verify a credit card checksum?
- How do I pack arrays of doubles or floats for XS code?

perlfaq5: Files and Formats

I/O and the "f" issues: filehandles, flushing, formats and footers.

- How do I flush/unbuffer an output filehandle? Why must I do this?
- How do I change one line in a file/delete a line in a file/insert a line in the middle of a file/append to the beginning of a file?
- How do I count the number of lines in a file?
- How do I make a temporary file name?
- How can I manipulate fixed–record–length files?
- How can I make a filehandle local to a subroutine? How do I pass filehandles between subroutines? How do I make an array of filehandles?
- How can I use a filehandle indirectly?
- How can I set up a footer format to be used with `write()`?
- How can I `write()` into a string?
- How can I output my numbers with commas added?
- How can I translate tildes (~) in a filename?
- How come when I open a file read–write it wipes it out?
- Why do I sometimes get an "Argument list too long" when I use <*?
- Is there a leak/bug in `glob()`?
- How can I open a file with a leading "" or trailing blanks?
- How can I reliably rename a file?
- How can I lock a file?
- Why can't I just open(FH, "file.lock")?
- I still don't get locking. I just want to increment the number in the file. How can I do this?
- How do I randomly update a binary file?
- How do I get a file's timestamp in perl?
- How do I set a file's timestamp in perl?
- How do I print to more than one file at once?
- How can I read in an entire file all at once?
- How can I read in a file by paragraphs?
- How can I read a single character from a file? From the keyboard?
- How can I tell whether there's a character waiting on a filehandle?
- How do I do a `tail -f` in perl?
- How do I `dup()` a filehandle in Perl?
- How do I close a file descriptor by number?
- Why can't I use "C:\temp\foo" in DOS paths? What doesn't 'C:\temp\foo.exe' work?
- Why doesn't glob("*.*") get all the files?
- Why does Perl let me delete read–only files? Why does `-i` clobber protected files? Isn't this a bug in Perl?

- How do I select a random line from a file?
- Why do I get weird spaces when I print an array of lines?

perlfaq6: Regexps

Pattern matching and regular expressions.

- How can I hope to use regular expressions without creating illegible and unmaintainable code?
- I'm having trouble matching over more than one line. What's wrong?
- How can I pull out lines between two patterns that are themselves on different lines?
- I put a regular expression into `$/` but it didn't work. What's wrong?
- How do I substitute case insensitively on the LHS while preserving case on the RHS?
- How can I make `\w` match national character sets?
- How can I match a locale–smart version of `/[a-zA-Z]/`?
- How can I quote a variable to use in a regex?
- What is `/o` really for?
- How do I use a regular expression to strip C style comments from a file?
- Can I use Perl regular expressions to match balanced text?
- What does it mean that regexes are greedy? How can I get around it?
- How do I process each word on each line?
- How can I print out a word–frequency or line–frequency summary?
- How can I do approximate matching?
- How do I efficiently match many regular expressions at once?
- Why don't word–boundary searches with `\b` work for me?
- Why does using `$&`, `$`` , or `$'` slow my program down?
- What good is `\G` in a regular expression?
- Are Perl regexes DFAs or NFAs? Are they POSIX compliant?
- What's wrong with using grep or map in a void context?
- How can I match strings with multibyte characters?
- How do I match a pattern that is supplied by the user?

perlfaq7: General Perl Language Issues

General Perl language issues that don't clearly fit into any of the other sections.

- Can I get a BNF/yacc/RE for the Perl language?
- What are all these `$@%&*` punctuation signs, and how do I know when to use them?
- Do I always/never have to quote my strings or use semicolons and commas?
- How do I skip some return values?
- How do I temporarily block warnings?
- What's an extension?
- Why do Perl operators have different precedence than C operators?
- How do I declare/create a structure?
- How do I create a module?
- How do I create a class?
- How can I tell if a variable is tainted?
- What's a closure?
- What is variable suicide and how can I prevent it?
- How can I pass/return a {Function, FileHandle, Array, Hash, Method, Regex}?
- How do I create a static variable?
- What's the difference between dynamic and lexical (static) scoping? Between `local()` and `my()`?
- How can I access a dynamic variable while a similarly named lexical is in scope?
- What's the difference between deep and shallow binding?
- Why doesn't "my(`$foo`) = <FILE;" work right?

- How do I redefine a builtin function, operator, or method?
- What's the difference between calling a function as `&foo` and `foo()`?
- How do I create a switch or case statement?
- How can I catch accesses to undefined variables/functions/methods?
- Why can't a method included in this same file be found?
- How can I find out my current package?
- How can I comment out a large block of perl code?
- How do I clear a package?
- How can I use a variable as a variable name?

perlfaq8: System Interaction

Interprocess communication (IPC), control over the user–interface (keyboard, screen and pointing devices).

- How do I find out which operating system I'm running under?
- How come `exec()` doesn't return?
- How do I do fancy stuff with the keyboard/screen/mouse?
- How do I print something out in color?
- How do I read just one key without waiting for a return key?
- How do I check whether input is ready on the keyboard?
- How do I clear the screen?
- How do I get the screen size?
- How do I ask the user for a password?
- How do I read and write the serial port?
- How do I decode encrypted password files?
- How do I start a process in the background?
- How do I trap control characters/signals?
- How do I modify the shadow password file on a Unix system?
- How do I set the time and date?
- How can I `sleep()` or `alarm()` for under a second?
- How can I measure time under a second?
- How can I do an `atexit()` or `setjmp()/longjmp()`? (Exception handling)
- Why doesn't my sockets program work under System V (Solaris)? What does the error message "Protocol not supported" mean?

- How can I call my system's unique C functions from Perl?
- Where do I get the include files to do `ioctl()` or `syscall()`?
- Why do setuid perl scripts complain about kernel problems?
- How can I open a pipe both to and from a command?
- Why can't I get the output of a command with `system()`?
- How can I capture STDERR from an external command?
- Why doesn't `open()` return an error when a pipe open fails?
- What's wrong with using backticks in a void context?
- How can I call backticks without shell processing?
- Why can't my script read from STDIN after I gave it EOF (^D on Unix, ^Z on MS–DOS)?
- How can I convert my shell script to perl?
- Can I use perl to run a telnet or ftp session?
- How can I write expect in Perl?
- Is there a way to hide perl's command line from programs such as "ps"?
- I {changed directory, modified my environment} in a perl script. How come the change disappeared when I exited the script? How do I get my changes to be visible?

- How do I close a process's filehandle without waiting for it to complete?
- How do I fork a daemon process?
- How do I make my program run with sh and csh?

- How do I find out if I'm running interactively or not?
- How do I timeout a slow event?
- How do I set CPU limits?
- How do I avoid zombies on a Unix system?
- How do I use an SQL database?
- How do I make a `system()` exit on control–C?
- How do I open a file without blocking?
- How do I install a module from CPAN?
- What's the difference between require and use?
- How do I keep my own module/library directory?
- How do I add the directory my program lives in to the module/library search path?
- How do I add a directory to my include path at runtime?
- What is socket.ph and where do I get it?

perlfaq9: Networking

Networking, the Internet, and a few on the web.

- My CGI script runs from the command line but not the browser. (500 Server Error)
- How can I get better error messages from a CGI program?
- How do I remove HTML from a string?
- How do I extract URLs?
- How do I download a file from the user's machine? How do I open a file on another machine?
- How do I make a pop–up menu in HTML?
- How do I fetch an HTML file?
- How do I automate an HTML form submission?
- How do I decode or create those %–encodings on the web?
- How do I redirect to another page?
- How do I put a password on my web pages?
- How do I edit my .htpasswd and .htgroup files with Perl?
- How do I make sure users can't enter values into a form that cause my CGI script to do bad things?
- How do I parse a mail header?
- How do I decode a CGI form?
- How do I check a valid mail address?
- How do I decode a MIME/BASE64 string?
- How do I return the user's mail address?
- How do I send mail?
- How do I read mail?
- How do I find out my hostname/domainname/IP address?
- How do I fetch a news article or the active newsgroups?
- How do I fetch/put an FTP file?
- How can I do RPC in Perl?

Where to get this document

This document is posted regularly to comp.lang.perl.announce and several other related newsgroups. It is available in a variety of formats from CPAN in the /CPAN/doc/FAQs/FAQ/ directory or on the web at http://www.perl.com/perl/faq/ .

How to contribute to this document

You may mail corrections, additions, and suggestions to perlfaq–suggestions@perl.com . This alias should not be used to *ask* FAQs. It's for fixing the current FAQ. Send questions to the comp.lang.perl.misc newsgroup.

What will happen if you mail your Perl programming problems to the authors

Your questions will probably go unread, unless they're suggestions of new questions to add to the FAQ, in which case they should have gone to the perlfaq-suggestions@perl.com instead.

You should have read section 2 of this faq. There you would have learned that comp.lang.perl.misc is the appropriate place to go for free advice. If your question is really important and you require a prompt and correct answer, you should hire a consultant.

Credits

When I first began the Perl FAQ in the late 80s, I never realized it would have grown to over a hundred pages, nor that Perl would ever become so popular and widespread. This document could not have been written without the tremendous help provided by Larry Wall and the rest of the Perl Porters.

Author and Copyright Information

Bundled Distributions

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Changes

1/November/2000

A few grammatical fixes and updates implemented by John Borwick.

23/May/99

Extensive updates from the net in preparation for 5.6 release.

13/April/99

More minor touch-ups. Added new question at the end of perlfaq7 on variable names within variables.

7/January/99

Small touchups here and there. Added all questions in this document as a sort of table of contents.

22/June/98

Significant changes throughout in preparation for the 5.005 release.

24/April/97

Style and whitespace changes from Chip, new question on reading one character at a time from a terminal using POSIX from Tom.

23/April/97

Added http://www.oasis.leo.org/perl/ to *perlfaq2*. Style fix to *perlfaq3*. Added floating point precision, fixed complex number arithmetic, cross-references, caveat for Text::Wrap, alternative answer for initial capitalizing, fixed incorrect regexp, added example of Tie::IxHash to *perlfaq4*. Added example of passing and storing filehandles, added commify to *perlfaq5*. Restored variable suicide, and added mass commenting to *perlfaq7*. Added Net::Telnet, fixed backticks, added

reader/writer pair to telnet question, added FindBin, grouped module questions together in *perlfaq8*. Expanded caveats for the simple URL extractor, gave LWP example, added CGI security question, expanded on the mail address answer in *perlfaq9*.

25/March/97

Added more info to the binary distribution section of *perlfaq2*. Added Net::Telnet to *perlfaq6*. Fixed typos in *perlfaq8*. Added mail sending example to *perlfaq9*. Added Merlyn's columns to *perlfaq2*.

18/March/97

Added the DATE to the NAME section, indicating which sections have changed.

Mentioned SIGPIPE and *perlipc* in the forking open answer in *perlfaq8*.

Fixed description of a regular expression in *perlfaq4*.

17/March/97 Version

Various typos fixed throughout.

Added new question on Perl BNF on *perlfaq7*.

Initial Release: 11/March/97

This is the initial release of version 3 of the FAQ; consequently there have been no changes since its initial release.

NAME

perlfaq1 – General Questions About Perl (`$Revision: 1.23 $, $Date: 1999/05/23 16:08:30 $`)

DESCRIPTION

This section of the FAQ answers very general, high–level questions about Perl.

What is Perl?

Perl is a high–level programming language with an eclectic heritage written by Larry Wall and a cast of thousands. It derives from the ubiquitous C programming language and to a lesser extent from sed, awk, the Unix shell, and at least a dozen other tools and languages. Perl's process, file, and text manipulation facilities make it particularly well–suited for tasks involving quick prototyping, system utilities, software tools, system management tasks, database access, graphical programming, networking, and world wide web programming. These strengths make it especially popular with system administrators and CGI script authors, but mathematicians, geneticists, journalists, and even managers also use Perl. Maybe you should, too.

Who supports Perl? Who develops it? Why is it free?

The original culture of the pre–populist Internet and the deeply–held beliefs of Perl's author, Larry Wall, gave rise to the free and open distribution policy of perl. Perl is supported by its users. The core, the standard Perl library, the optional modules, and the documentation you're reading now were all written by volunteers. See the personal note at the end of the README file in the perl source distribution for more details. See *perlhist* (new as of 5.005) for Perl's milestone releases.

In particular, the core development team (known as the Perl Porters) are a rag–tag band of highly altruistic individuals committed to producing better software for free than you could hope to purchase for money. You may snoop on pending developments via nntp://news.perl.com/perl.porters–gw/ and the Deja archive at http://www.deja.com/ using the perl.porters–gw newsgroup, or you can subscribe to the mailing list by sending perl5–porters–request@perl.org a subscription request.

While the GNU project includes Perl in its distributions, there's no such thing as "GNU Perl". Perl is not produced nor maintained by the Free Software Foundation. Perl's licensing terms are also more open than GNU software's tend to be.

You can get commercial support of Perl if you wish, although for most users the informal support will more than suffice. See the answer to "Where can I buy a commercial version of perl?" for more information.

Which version of Perl should I use?

You should definitely use version 5. Version 4 is old, limited, and no longer maintained; its last patch (4.036) was in 1992, long ago and far away. Sure, it's stable, but so is anything that's dead; in fact, perl4 had been called a dead, flea–bitten camel carcass. The most recent production release is 5.6 (although 5.005_03 is still supported). The most cutting–edge development release is 5.7. Further references to the Perl language in this document refer to the production release unless otherwise specified. There may be one or more official bug fixes by the time you read this, and also perhaps some experimental versions on the way to the next release. All releases prior to 5.004 were subject to buffer overruns, a grave security issue.

What are perl4 and perl5?

Perl4 and perl5 are informal names for different versions of the Perl programming language. It's easier to say "perl5" than it is to say "the 5(.004) release of Perl", but some people have interpreted this to mean there's a language called "perl5", which isn't the case. Perl5 is merely the popular name for the fifth major release (October 1994), while perl4 was the fourth major release (March 1991). There was also a perl1 (in January 1988), a perl2 (June 1988), and a perl3 (October 1989).

The 5.0 release is, essentially, a ground–up rewrite of the original perl source code from releases 1 through 4. It has been modularized, object–oriented, tweaked, trimmed, and optimized until it almost doesn't look like the old code. However, the interface is mostly the same, and compatibility with previous releases is very high. See *Perl4 to Perl5 Traps in perltrap*.

To avoid the "what language is perl5?" confusion, some people prefer to simply use "perl" to refer to the latest version of perl and avoid using "perl5" altogether. It's not really that big a deal, though.

See *perlhist* for a history of Perl revisions.

What is perl6?

At The Second O'Reilly Open Source Software Convention, Larry Wall announced Perl6 development would begin in earnest. Perl6 was an oft used term for Chip Salzenberg's project to rewrite Perl in C++ named Topaz. However, Topaz should not be confused with the nisus to rewrite Perl while keeping the lessons learned from other software, as well as Perl5, in mind.

If you have a desire to help in the crusade to make Perl a better place then peruse the Perl6 developers page at http://www.perl.org/perl6/ and get involved.

The first alpha release is expected by Summer 2001.

"We're really serious about reinventing everything that needs reinventing." —Larry Wall

How stable is Perl?

Production releases, which incorporate bug fixes and new functionality, are widely tested before release. Since the 5.000 release, we have averaged only about one production release per year.

Larry and the Perl development team occasionally make changes to the internal core of the language, but all possible efforts are made toward backward compatibility. While not quite all perl4 scripts run flawlessly under perl5, an update to perl should nearly never invalidate a program written for an earlier version of perl (barring accidental bug fixes and the rare new keyword).

Is Perl difficult to learn?

No, Perl is easy to start learning—and easy to keep learning. It looks like most programming languages you're likely to have experience with, so if you've ever written a C program, an awk script, a shell script, or even a BASIC program, you're already partway there.

Most tasks only require a small subset of the Perl language. One of the guiding mottos for Perl development is "there's more than one way to do it" (TMTOWTDI, sometimes pronounced "tim toady"). Perl's learning curve is therefore shallow (easy to learn) and long (there's a whole lot you can do if you really want).

Finally, because Perl is frequently (but not always, and certainly not by definition) an interpreted language, you can write your programs and test them without an intermediate compilation step, allowing you to experiment and test/debug quickly and easily. This ease of experimentation flattens the learning curve even more.

Things that make Perl easier to learn: Unix experience, almost any kind of programming experience, an understanding of regular expressions, and the ability to understand other people's code. If there's something you need to do, then it's probably already been done, and a working example is usually available for free. Don't forget the new perl modules, either. They're discussed in Part 3 of this FAQ, along with CPAN, which is discussed in Part 2.

How does Perl compare with other languages like Java, Python, REXX, Scheme, or Tcl?

Favorably in some areas, unfavorably in others. Precisely which areas are good and bad is often a personal choice, so asking this question on Usenet runs a strong risk of starting an unproductive Holy War.

Probably the best thing to do is try to write equivalent code to do a set of tasks. These languages have their own newsgroups in which you can learn about (but hopefully not argue about) them.

Some comparison documents can be found at http://language.perl.com/versus/ if you really can't stop yourself.

Can I do [task] in Perl?

Perl is flexible and extensible enough for you to use on virtually any task, from one−line file−processing tasks to large, elaborate systems. For many people, Perl serves as a great replacement for shell scripting. For others, it serves as a convenient, high−level replacement for most of what they'd program in low−level languages like C or C++. It's ultimately up to you (and possibly your management) which tasks you'll use Perl for and which you won't.

If you have a library that provides an API, you can make any component of it available as just another Perl function or variable using a Perl extension written in C or C++ and dynamically linked into your main perl interpreter. You can also go the other direction, and write your main program in C or C++, and then link in some Perl code on the fly, to create a powerful application. See *perlembed*.

That said, there will always be small, focused, special−purpose languages dedicated to a specific problem domain that are simply more convenient for certain kinds of problems. Perl tries to be all things to all people, but nothing special to anyone. Examples of specialized languages that come to mind include prolog and matlab.

When shouldn't I program in Perl?

When your manager forbids it—but do consider replacing them :−).

Actually, one good reason is when you already have an existing application written in another language that's all done (and done well), or you have an application language specifically designed for a certain task (e.g. prolog, make).

For various reasons, Perl is probably not well−suited for real−time embedded systems, low−level operating systems development work like device drivers or context−switching code, complex multi−threaded shared−memory applications, or extremely large applications. You'll notice that perl is not itself written in Perl.

The new, native−code compiler for Perl may eventually reduce the limitations given in the previous statement to some degree, but understand that Perl remains fundamentally a dynamically typed language, not a statically typed one. You certainly won't be chastised if you don't trust nuclear−plant or brain−surgery monitoring code to it. And Larry will sleep easier, too—Wall Street programs not withstanding. :−)

What's the difference between "perl" and "Perl"?

One bit. Oh, you weren't talking ASCII? :−) Larry now uses "Perl" to signify the language proper and "perl" the implementation of it, i.e. the current interpreter. Hence Tom's quip that "Nothing but perl can parse Perl." You may or may not choose to follow this usage. For example, parallelism means "awk and perl" and "Python and Perl" look OK, while "awk and Perl" and "Python and perl" do not. But never write "PERL", because perl isn't really an acronym, apocryphal folklore and post−facto expansions notwithstanding.

Is it a Perl program or a Perl script?

Larry doesn't really care. He says (half in jest) that "a script is what you give the actors. A program is what you give the audience."

Originally, a script was a canned sequence of normally interactive commands—that is, a chat script. Something like a UUCP or PPP chat script or an expect script fits the bill nicely, as do configuration scripts run by a program at its start up, such ***.cshrc*** or ***.ircrc***, for example. Chat scripts were just drivers for existing programs, not stand−alone programs in their own right.

A computer scientist will correctly explain that all programs are interpreted and that the only question is at what level. But if you ask this question of someone who isn't a computer scientist, they might tell you that a *program* has been compiled to physical machine code once and can then be run multiple times, whereas a *script* must be translated by a program each time it's used.

Perl programs are (usually) neither strictly compiled nor strictly interpreted. They can be compiled to a byte−code form (something of a Perl virtual machine) or to completely different languages, like C or assembly language. You can't tell just by looking at it whether the source is destined for a pure interpreter, a parse−tree interpreter, a byte−code interpreter, or a native−code compiler, so it's hard to give a definitive answer here.

Now that "script" and "scripting" are terms that have been seized by unscrupulous or unknowing marketeers for their own nefarious purposes, they have begun to take on strange and often pejorative meanings, like "non serious" or "not real programming". Consequently, some Perl programmers prefer to avoid them altogether.

What is a JAPH?

These are the "just another perl hacker" signatures that some people sign their postings with. Randal Schwartz made these famous. About 100 of the earlier ones are available from http://www.perl.com/CPAN/misc/japh .

Where can I get a list of Larry Wall witticisms?

Over a hundred quips by Larry, from postings of his or source code, can be found at http://www.perl.com/CPAN/misc/lwall-quotes.txt.gz .

Newer examples can be found by perusing Larry's postings:

```
http://x1.dejanews.com/dnquery.xp?QRY=*&DBS=2&ST=PS&defaultOp=AND&LNG=ALL&format=
```

How can I convince my sysadmin/supervisor/employees to use (version 5/5.005/Perl) instead of some other language?

If your manager or employees are wary of unsupported software, or software which doesn't officially ship with your operating system, you might try to appeal to their self-interest. If programmers can be more productive using and utilizing Perl constructs, functionality, simplicity, and power, then the typical manager/supervisor/employee may be persuaded. Regarding using Perl in general, it's also sometimes helpful to point out that delivery times may be reduced using Perl compared to other languages.

If you have a project which has a bottleneck, especially in terms of translation or testing, Perl almost certainly will provide a viable, quick solution. In conjunction with any persuasion effort, you should not fail to point out that Perl is used, quite extensively, and with extremely reliable and valuable results, at many large computer software and hardware companies throughout the world. In fact, many Unix vendors now ship Perl by default. Support is usually just a news-posting away, if you can't find the answer in the *comprehensive* documentation, including this FAQ.

See http://www.perl.org/advocacy/ for more information.

If you face reluctance to upgrading from an older version of perl, then point out that version 4 is utterly unmaintained and unsupported by the Perl Development Team. Another big sell for Perl5 is the large number of modules and extensions which greatly reduce development time for any given task. Also mention that the difference between version 4 and version 5 of Perl is like the difference between awk and C++. (Well, OK, maybe it's not quite that distinct, but you get the idea.) If you want support and a reasonable guarantee that what you're developing will continue to work in the future, then you have to run the supported version. That probably means running the 5.005 release, although 5.004 isn't that bad. Several important bugs were fixed from the 5.000 through 5.003 versions, though, so try upgrading past them if possible.

Of particular note is the massive bug hunt for buffer overflow problems that went into the 5.004 release. All releases prior to that, including perl4, are considered insecure and should be upgraded as soon as possible.

AUTHOR AND COPYRIGHT

NAME

perlfaq2 – Obtaining and Learning about Perl (`$Revision: 1.32 $, $Date: 1999/10/14 18:46:09 $`)

DESCRIPTION

This section of the FAQ answers questions about where to find source and documentation for Perl, support, and related matters.

What machines support Perl? Where do I get it?

The standard release of Perl (the one maintained by the perl development team) is distributed only in source code form. You can find this at http://www.perl.com/CPAN/src/latest.tar.gz , which in standard Internet format (a gzipped archive in POSIX tar format).

Perl builds and runs on a bewildering number of platforms. Virtually all known and current Unix derivatives are supported (Perl's native platform), as are other systems like VMS, DOS, OS/2, Windows, QNX, BeOS, and the Amiga. There are also the beginnings of support for MPE/iX.

Binary distributions for some proprietary platforms, including Apple systems, can be found http://www.perl.com/CPAN/ports/ directory. Because these are not part of the standard distribution, they may and in fact do differ from the base Perl port in a variety of ways. You'll have to check their respective release notes to see just what the differences are. These differences can be either positive (e.g. extensions for the features of the particular platform that are not supported in the source release of perl) or negative (e.g. might be based upon a less current source release of perl).

How can I get a binary version of Perl?

If you don't have a C compiler because your vendor for whatever reasons did not include one with your system, the best thing to do is grab a binary version of gcc from the net and use that to compile perl with. CPAN only has binaries for systems that are terribly hard to get free compilers for, not for Unix systems.

Some URLs that might help you are:

```
http://language.perl.com/info/software.html
http://www.perl.com/pub/language/info/software.html#binary
http://www.perl.com/CPAN/ports/
```

Someone looking for a Perl for Win16 might look to Laszlo Molnar's djgpp port in http://www.perl.com/CPAN/ports/msdos/ , which comes with clear installation instructions. A simple installation guide for MS−DOS using Ilya Zakharevich's OS/2 port is available at http://www.cs.ruu.nl/%7Epiet/perl5dos.html and similarly for Windows 3.1 at http://www.cs.ruu.nl/%7Epiet/perlwin3.html .

I don't have a C compiler on my system. How can I compile perl?

Since you don't have a C compiler, you're doomed and your vendor should be sacrificed to the Sun gods. But that doesn't help you.

What you need to do is get a binary version of gcc for your system first. Consult the Usenet FAQs for your operating system for information on where to get such a binary version.

I copied the Perl binary from one machine to another, but scripts don't work.

That's probably because you forgot libraries, or library paths differ. You really should build the whole distribution on the machine it will eventually live on, and then type `make install`. Most other approaches are doomed to failure.

One simple way to check that things are in the right place is to print out the hard−coded @INC that perl looks through for libraries:

```
% perl -e 'print join("\n",@INC)'
```

If this command lists any paths that don't exist on your system, then you may need to move the appropriate libraries to these locations, or create symbolic links, aliases, or shortcuts appropriately. @INC is also printed as part of the output of

```
% perl -V
```

You might also want to check out *How do I keep my own module/library directory? in perlfaq8*.

I grabbed the sources and tried to compile but gdbm/dynamic loading/malloc/linking/... failed. How do I make it work?

Read the ***INSTALL*** file, which is part of the source distribution. It describes in detail how to cope with most idiosyncrasies that the Configure script can't work around for any given system or architecture.

What modules and extensions are available for Perl? What is CPAN? What does CPAN/src/... mean?

CPAN stands for Comprehensive Perl Archive Network, a huge archive replicated on dozens of machines all over the world. CPAN contains source code, non-native ports, documentation, scripts, and many third-party modules and extensions, designed for everything from commercial database interfaces to keyboard/screen control to web walking and CGI scripts. The master machine for CPAN is ftp://ftp.funet.fi/pub/languages/perl/CPAN/, but you can use the address http://www.perl.com/CPAN/CPAN.html to fetch a copy from a "site near you". See http://www.perl.com/CPAN (without a slash at the end) for how this process works.

CPAN/path/... is a naming convention for files available on CPAN sites. CPAN indicates the base directory of a CPAN mirror, and the rest of the path is the path from that directory to the file. For instance, if you're using ftp://ftp.funet.fi/pub/languages/perl/CPAN as your CPAN site, the file CPAN/misc/japh file is downloadable as ftp://ftp.funet.fi/pub/languages/perl/CPAN/misc/japh .

Considering that there are hundreds of existing modules in the archive, one probably exists to do nearly anything you can think of. Current categories under CPAN/modules/by-category/ include Perl core modules; development support; operating system interfaces; networking, devices, and interprocess communication; data type utilities; database interfaces; user interfaces; interfaces to other languages; filenames, file systems, and file locking; internationalization and locale; world wide web support; server and daemon utilities; archiving and compression; image manipulation; mail and news; control flow utilities; filehandle and I/O; Microsoft Windows modules; and miscellaneous modules.

Is there an ISO or ANSI certified version of Perl?

Certainly not. Larry expects that he'll be certified before Perl is.

Where can I get information on Perl?

The complete Perl documentation is available with the Perl distribution. If you have Perl installed locally, you probably have the documentation installed as well: type `man perl` if you're on a system resembling Unix. This will lead you to other important man pages, including how to set your `$MANPATH`. If you're not on a Unix system, access to the documentation will be different; for example, documentation might only be in HTML format. All proper Perl installations have fully-accessible documentation.

You might also try `perldoc perl` in case your system doesn't have a proper man command, or it's been misinstalled. If that doesn't work, try looking in /usr/local/lib/perl5/pod for documentation.

If all else fails, consult the CPAN/doc directory, which contains the complete documentation in various formats, including native pod, troff, html, and plain text. There's also a web page at http://www.perl.com/perl/info/documentation.html that might help.

Many good books have been written about Perl—see the section below for more details.

Tutorial documents are included in current or upcoming Perl releases include *perltoot* for objects or *perlboot* for a beginner's approach to objects, *perlopentut* for file opening semantics, *perlreftut* for managing references, *perlretut* for regular expressions, *perlthrtut* for threads, *perldebtut* for debugging, and *perlxstut* for linking C and Perl together. There may be more by the time you read this. The following URLs might also be of assistance:

```
http://language.perl.com/info/documentation.html
http://reference.perl.com/query.cgi?tutorials
```

What are the Perl newsgroups on Usenet? Where do I post questions?

The now defunct comp.lang.perl newsgroup has been superseded by the following groups:

```
comp.lang.perl.announce             Moderated announcement group
comp.lang.perl.misc                 Very busy group about Perl in general
comp.lang.perl.moderated            Moderated discussion group
comp.lang.perl.modules              Use and development of Perl modules
comp.lang.perl.tk                   Using Tk (and X) from Perl

comp.infosystems.www.authoring.cgi  Writing CGI scripts for the Web.
```

There is also Usenet gateway to the mailing list used by the crack Perl development team (perl5−porters) at news://news.perl.com/perl.porters−gw/ .

Where should I post source code?

You should post source code to whichever group is most appropriate, but feel free to cross−post to comp.lang.perl.misc. If you want to cross−post to alt.sources, please make sure it follows their posting standards, including setting the Followup−To header line to NOT include alt.sources; see their FAQ (http://www.faqs.org/faqs/alt−sources−intro/) for details.

If you‘re just looking for software, first use AltaVista (http://www.altavista.com), Deja (http://www.deja.com), and search CPAN. This is faster and more productive than just posting a request.

Perl Books

A number of books on Perl and/or CGI programming are available. A few of these are good, some are OK, but many aren‘t worth your money. Tom Christiansen maintains a list of these books, some with extensive reviews, at http://www.perl.com/perl/critiques/index.html .

The incontestably definitive reference book on Perl, written by the creator of Perl, is now (July 2000) in its third edition:

```
Programming Perl (the "Camel Book"):
    by Larry Wall, Tom Christiansen, and Jon Orwant
    0−596−00027−8  [3rd edition July 2000]
    http://www.oreilly.com/catalog/pperl3/
(English, translations to several languages are also available)
```

The companion volume to the Camel containing thousands of real−world examples, mini−tutorials, and complete programs (first premiered at the 1998 Perl Conference), is:

```
The Perl Cookbook (the "Ram Book"):
    by Tom Christiansen and Nathan Torkington,
        with Foreword by Larry Wall
    ISBN 1−56592−243−3 [1st Edition August 1998]
    http://perl.oreilly.com/cookbook/
```

If you‘re already a hard−core systems programmer, then the Camel Book might suffice for you to learn Perl from. If you‘re not, check out

```
Learning Perl (the "Llama Book"):
    by Randal Schwartz and Tom Christiansen
                with Foreword by Larry Wall
    ISBN 1−56592−284−0 [2nd Edition July 1997]
    http://www.oreilly.com/catalog/lperl2/
```

Despite the picture at the URL above, the second edition of "Llama Book" really has a blue cover and was updated for the 5.004 release of Perl. Various foreign language editions are available, including *Learning Perl on Win32 Systems* (the "Gecko Book").

If you‘re not an accidental programmer, but a more serious and possibly even degreed computer scientist

who doesn't need as much hand-holding as we try to provide in the Llama or its defurred cousin the Gecko, please check out the delightful book, *Perl: The Programmer's Companion*, written by Nigel Chapman.

You can order O'Reilly books directly from O'Reilly & Associates, 1-800-998-9938. Local/overseas is 1-707-829-0515. If you can locate an O'Reilly order form, you can also fax to 1-707-829-0104. See http://www.ora.com/ on the Web.

What follows is a list of the books that the FAQ authors found personally useful. Your mileage may (but, we hope, probably won't) vary.

Recommended books on (or mostly on) Perl follow.

References

```
Programming Perl
    by Larry Wall, Tom Christiansen, and Jon Orwant
    ISBN 0-596-00027-8 [3rd edition July 2000]
    http://www.oreilly.com/catalog/pperl3/

Perl 5 Pocket Reference
    by Johan Vromans
    ISBN 0-596-00032-4 [3rd edition May 2000]
    http://www.oreilly.com/catalog/perlpr3/

Perl in a Nutshell
    by Ellen Siever, Stephan Spainhour, and Nathan Patwardhan
    ISBN 1-56592-286-7 [1st edition December 1998]
    http://www.oreilly.com/catalog/perlnut/
```

Tutorials

```
Elements of Programming with Perl
    by Andrew L. Johnson
    ISBN 1884777805 [1st edition October 1999]
    http://www.manning.com/Johnson/

Learning Perl
    by Randal L. Schwartz and Tom Christiansen
        with foreword by Larry Wall
    ISBN 1-56592-284-0 [2nd edition July 1997]
    http://www.oreilly.com/catalog/lperl2/

Learning Perl on Win32 Systems
    by Randal L. Schwartz, Erik Olson, and Tom Christiansen,
        with foreword by Larry Wall
    ISBN 1-56592-324-3 [1st edition August 1997]
    http://www.oreilly.com/catalog/lperlwin/

Perl: The Programmer's Companion
    by Nigel Chapman
    ISBN 0-471-97563-X  [1st edition October 1997]
    http://catalog.wiley.com/title.cgi?isbn=047197563X

Cross-Platform Perl
    by Eric Foster-Johnson
    ISBN 1-55851-483-X [2nd edition September 2000]
    http://www.pconline.com/~erc/perlbook.htm

MacPerl: Power and Ease
    by Vicki Brown and Chris Nandor,
        with foreword by Matthias Neeracher
    ISBN 1-881957-32-2 [1st edition May 1998]
```

```
    http://www.macperl.com/ptf_book/
```

Task–Oriented

```
The Perl Cookbook
    by Tom Christiansen and Nathan Torkington
        with foreword by Larry Wall
    ISBN 1-56592-243-3 [1st edition August 1998]
    http://www.oreilly.com/catalog/cookbook/

Perl5 Interactive Course
    by Jon Orwant
    ISBN 1571690646 [1st edition June 1997]

Advanced Perl Programming
    by Sriram Srinivasan
    ISBN 1-56592-220-4 [1st edition August 1997]
    http://www.oreilly.com/catalog/advperl/

Effective Perl Programming
    by Joseph Hall
    ISBN 0-201-41975-0 [1st edition 1998]
    http://www.awl.com/
```

Special Topics

```
Mastering Regular Expressions
    by Jeffrey E. F. Friedl
    ISBN 1-56592-257-3 [1st edition January 1997]
    http://www.oreilly.com/catalog/regex/

How to Set up and Maintain a World Wide Web Site
    by Lincoln Stein
    ISBN 0-201-63389-2 [1st edition 1995]
    http://www.awl.com/

Object Oriented Perl
    Damian Conway
        with foreword by Randal L. Schwartz
    ISBN 1884777791 [1st edition August 1999]
    http://www.manning.com/Conway/

Learning Perl/Tk
    by Nancy Walsh
    ISBN 1-56592-314-6 [1st edition January 1999]
    http://www.oreilly.com/catalog/lperltk/
```

Perl in Magazines

The first and only periodical devoted to All Things Perl, *The Perl Journal* contains tutorials, demonstrations, case studies, announcements, contests, and much more. *TPJ* has columns on web development, databases, Win32 Perl, graphical programming, regular expressions, and networking, and sponsors the Obfuscated Perl Contest. It is published quarterly under the gentle hand of its editor, Jon Orwant. See http://www.tpj.com/ or send mail to subscriptions@tpj.com .

Beyond this, magazines that frequently carry high–quality articles on Perl are *Web Techniques* (see http://www.webtechniques.com/), *Performance Computing* (http://www.performance–computing.com/), and Usenix's newsletter/magazine to its members, *login:*, at http://www.usenix.org/. Randal's Web Technique's columns are available on the web at http://www.stonehenge.com/merlyn/WebTechniques/ .

Perl on the Net: FTP and WWW Access

To get the best performance, pick a site from the list below and use it to grab the complete list of mirror sites. From there you can find the quickest site for you. Remember, the following list is *not* the complete list of CPAN mirrors (the complete list contains 136 sites as of July 2000):

```
http://www.perl.com/CPAN/
http://www.cpan.org/CPAN/
http://download.sourceforge.net/mirrors/CPAN/
ftp://ftp.digital.com/pub/plan/perl/CPAN/
ftp://ftp.flirble.org/pub/languages/perl/CPAN/
ftp://ftp.uvsq.fr/pub/perl/CPAN/
ftp://ftp.funet.fi/pub/languages/perl/CPAN/
ftp://ftp.dti.ad.jp/pub/lang/CPAN/
ftp://mirror.aarnet.edu.au/pub/perl/CPAN/
ftp://cpan.if.usp.br/pub/mirror/CPAN/
```

What mailing lists are there for Perl?

Most of the major modules (Tk, CGI, libwww−perl) have their own mailing lists. Consult the documentation that came with the module for subscription information. The Perl Mongers attempt to maintain a list of mailing lists at:

```
http://www.perl.org/support/online_support.html#mail
```

Archives of comp.lang.perl.misc

Have you tried Deja or AltaVista? Those are the best archives. Just look up "*perl*" as a newsgroup.

```
http://www.deja.com/dnquery.xp?QRY=&DBS=2&ST=PS&defaultOp=AND&LNG=ALL&format=ters
```

You might want to trim that down a bit, though.

You'll probably want more a sophisticated query and retrieval mechanism than a file listing, preferably one that allows you to retrieve articles using a fast−access indices, keyed on at least author, date, subject, thread (as in "trn") and probably keywords. The best solution the FAQ authors know of is the MH pick command, but it is very slow to select on 18000 articles.

If you have, or know where can be found, the missing sections, please let perlfaq−suggestions@perl.com know.

Where can I buy a commercial version of Perl?

In a real sense, Perl already *is* commercial software: it has a license that you can grab and carefully read to your manager. It is distributed in releases and comes in well−defined packages. There is a very large user community and an extensive literature. The comp.lang.perl.* newsgroups and several of the mailing lists provide free answers to your questions in near real−time. Perl has traditionally been supported by Larry, scores of software designers and developers, and myriads of programmers, all working for free to create a useful thing to make life better for everyone.

However, these answers may not suffice for managers who require a purchase order from a company whom they can sue should anything go awry. Or maybe they need very serious hand−holding and contractual obligations. Shrink−wrapped CDs with Perl on them are available from several sources if that will help. For example, many Perl books include a distribution of Perl, as do the O'Reilly Perl Resource Kits (in both the Unix flavor and in the proprietary Microsoft flavor); the free Unix distributions also all come with Perl.

Alternatively, you can purchase commercial incidence based support through the Perl Clinic. The following is a commercial from them:

"The Perl Clinic is a commercial Perl support service operated by ActiveState Tool Corp. and The Ingram Group. The operators have many years of in−depth experience with Perl applications and Perl internals on a wide range of platforms.

"Through our group of highly experienced and well−trained support engineers, we will put our best effort into understanding your problem, providing an explanation of the situation, and a recommendation on how to proceed."

Contact The Perl Clinic at

```
www.PerlClinic.com

North America Pacific Standard Time (GMT-8)
Tel:    1 604 606-4611 hours 8am-6pm
Fax:    1 604 606-4640

Europe (GMT)
Tel:    00 44 1483 862814
Fax:    00 44 1483 862801
```

See also www.perl.com for updates on tutorials, training, and support.

Where do I send bug reports?

If you are reporting a bug in the perl interpreter or the modules shipped with Perl, use the *perlbug* program in the Perl distribution or mail your report to perlbug@perl.org .

If you are posting a bug with a non−standard port (see the answer to "What platforms is Perl available for?"), a binary distribution, or a non−standard module (such as Tk, CGI, etc), then please see the documentation that came with it to determine the correct place to post bugs.

Read the perlbug(1) man page (perl5.004 or later) for more information.

What is perl.com? Perl Mongers? pm.org? perl.org?

The perl.com domain is owned by Tom Christiansen, who created it as a public service long before perl.org came about. Despite the name, it's a pretty non−commercial site meant to be a clearinghouse for information about all things Perlian, accepting no paid advertisements, bouncy happy GIFs, or silly Java applets on its pages. The Perl Home Page at http://www.perl.com/ is currently hosted on a T3 line courtesy of Songline Systems, a software−oriented subsidiary of O'Reilly and Associates. Other starting points include

```
http://language.perl.com/
http://conference.perl.com/
http://reference.perl.com/
```

Perl Mongers is an advocacy organization for the Perl language. For details, see the Perl Mongers web site at http://www.perlmongers.org/.

Perl Mongers uses the pm.org domain for services related to Perl user groups. See the Perl user group web site at http://www.pm.org/ for more information about joining, starting, or requesting services for a Perl user group.

Perl Mongers also maintains the perl.org domain to provide general support services to the Perl community, including the hosting of mailing lists, web sites, and other services. The web site http://www.perl.org/ is a general advocacy site for the Perl language, and there are many other sub−domains for special topics, such as

```
http://history.perl.org/
http://bugs.perl.org/
http://www.news.perl.org/
```

AUTHOR AND COPYRIGHT

Irrespective of its distribution, all code examples here are in the public domain. You are permitted and encouraged to use this code and any derivatives thereof in your own programs for fun or for profit as you see fit. A simple comment in the code giving credit to the FAQ would be courteous but is not required.

NAME

perlfaq3 – Programming Tools (`$Revision: 1.38 $, $Date: 1999/05/23 16:08:30 $`)

DESCRIPTION

This section of the FAQ answers questions related to programmer tools and programming support.

How do I do (anything)?

Have you looked at CPAN (see *perlfaq2*)? The chances are that someone has already written a module that can solve your problem. Have you read the appropriate man pages? Here's a brief index:

```
Basics           perldata, perlvar, perlsyn, perlop, perlsub
Execution        perlrun, perldebug
Functions        perlfunc
Objects          perlref, perlmod, perlobj, perltie
Data Structures  perlref, perllol, perldsc
Modules          perlmod, perlmodlib, perlsub
Regexes          perlre, perlfunc, perlop, perllocale
Moving to perl5  perltrap, perl
Linking w/C      perlxstut, perlxs, perlcall, perlguts, perlembed
Various          http://www.perl.com/CPAN/doc/FMTEYEWTK/index.html
                 (not a man-page but still useful)
```

A crude table of contents for the Perl man page set is found in *perltoc*.

How can I use Perl interactively?

The typical approach uses the Perl debugger, described in the perldebug(1) man page, on an ''empty'' program, like this:

```
perl -de 42
```

Now just type in any legal Perl code, and it will be immediately evaluated. You can also examine the symbol table, get stack backtraces, check variable values, set breakpoints, and other operations typically found in symbolic debuggers.

Is there a Perl shell?

In general, no. The Shell.pm module (distributed with Perl) makes Perl try commands which aren't part of the Perl language as shell commands. perlsh from the source distribution is simplistic and uninteresting, but may still be what you want.

How do I debug my Perl programs?

Have you tried `use warnings` or used `-w`? They enable warnings to detect dubious practices.

Have you tried `use strict`? It prevents you from using symbolic references, makes you predeclare any subroutines that you call as bare words, and (probably most importantly) forces you to predeclare your variables with `my`, `our`, or `use vars`.

Did you check the return values of each and every system call? The operating system (and thus Perl) tells you whether they worked, and if not why.

```
open(FH, "> /etc/cantwrite")
  or die "Couldn't write to /etc/cantwrite: $!\n";
```

Did you read *perltrap*? It's full of gotchas for old and new Perl programmers and even has sections for those of you who are upgrading from languages like *awk* and *C*.

Have you tried the Perl debugger, described in *perldebug*? You can step through your program and see what it's doing and thus work out why what it's doing isn't what it should be doing.

How do I profile my Perl programs?

You should get the Devel::DProf module from CPAN and also use Benchmark.pm from the standard distribution. Benchmark lets you time specific portions of your code, while Devel::DProf gives detailed breakdowns of where your code spends its time.

Here's a sample use of Benchmark:

```
use Benchmark;

@junk = `cat /etc/motd`;
$count = 10_000;

timethese($count, {
          'map' => sub { my @a = @junk;
                         map { s/a/b/ } @a;
                         return @a
                       },
          'for' => sub { my @a = @junk;
                         local $_;
                         for (@a) { s/a/b/ };
                         return @a },
        });
```

This is what it prints (on one machine—your results will be dependent on your hardware, operating system, and the load on your machine):

```
Benchmark: timing 10000 iterations of for, map...
       for:  4 secs ( 3.97 usr  0.01 sys =  3.98 cpu)
       map:  6 secs ( 4.97 usr  0.00 sys =  4.97 cpu)
```

Be aware that a good benchmark is very hard to write. It only tests the data you give it and proves little about the differing complexities of contrasting algorithms.

How do I cross–reference my Perl programs?

The B::Xref module, shipped with the new, alpha–release Perl compiler (not the general distribution prior to the 5.005 release), can be used to generate cross–reference reports for Perl programs.

```
perl -MO=Xref[,OPTIONS] scriptname.plx
```

Is there a pretty–printer (formatter) for Perl?

There is no program that will reformat Perl as much as indent(1) does for C. The complex feedback between the scanner and the parser (this feedback is what confuses the vgrind and emacs programs) makes it challenging at best to write a stand–alone Perl parser.

Of course, if you simply follow the guidelines in *perlstyle*, you shouldn't need to reformat. The habit of formatting your code as you write it will help prevent bugs. Your editor can and should help you with this. The perl–mode or newer cperl–mode for emacs can provide remarkable amounts of help with most (but not all) code, and even less programmable editors can provide significant assistance. Tom swears by the following settings in vi and its clones:

```
set ai sw=4
map! ^O {^M}^[O^T
```

Now put that in your ***.exrc*** file (replacing the caret characters with control characters) and away you go. In insert mode, ^T is for indenting, ^D is for undenting, and ^O is for blockdenting— as it were. If you haven't used the last one, you're missing a lot. A more complete example, with comments, can be found at http://www.perl.com/CPAN–local/authors/id/TOMC/scripts/toms.exrc.gz

If you are used to using the *vgrind* program for printing out nice code to a laser printer, you can take a stab at this using http://www.perl.com/CPAN/doc/misc/tips/working.vgrind.entry, but the results are not particularly

satisfying for sophisticated code.

The a2ps at http://www.infres.enst.fr/%7Edemaille/a2ps/ does lots of things related to generating nicely printed output of documents.

Is there a ctags for Perl?

There's a simple one at http://www.perl.com/CPAN/authors/id/TOMC/scripts/ptags.gz which may do the trick. And if not, it's easy to hack into what you want.

Is there an IDE or Windows Perl Editor?

If you're on Unix, you already have an IDE—Unix itself. This powerful IDE derives from its interoperability, flexibility, and configurability. If you really want to get a feel for Unix−qua−IDE, the best thing to do is to find some high−powered programmer whose native language is Unix. Find someone who has been at this for many years, and just sit back and watch them at work. They have created their own IDE, one that suits their own tastes and aptitudes. Quietly observe them edit files, move them around, compile them, debug them, test them, etc. The entire development *is* integrated, like a top−of−the−line German sports car: functional, powerful, and elegant. You will be absolutely astonished at the speed and ease exhibited by the native speaker of Unix in his home territory. The art and skill of a virtuoso can only be seen to be believed. That is the path to mastery—all these cobbled little IDEs are expensive toys designed to sell a flashy demo using cheap tricks, and being optimized for immediate but shallow understanding rather than enduring use, are but a dim palimpsest of real tools.

In short, you just have to learn the toolbox. However, if you're not on Unix, then your vendor probably didn't bother to provide you with a proper toolbox on the so−called complete system that you forked out your hard−earned cash for.

PerlBuilder (http://www.solutionsoft.com/perl.htm) is an integrated development environment for Windows that supports Perl development. Perl programs are just plain text, though, so you could download emacs for Windows (http://www.gnu.org/software/emacs/windows/ntemacs.html) or a vi clone (vim) which runs on for win32 (http://www.cs.vu.nl/%7Etmgil/vi.html). If you're transferring Windows files to Unix be sure to transfer them in ASCII mode so the ends of lines are appropriately mangled.

Where can I get Perl macros for vi?

For a complete version of Tom Christiansen's vi configuration file, see http://www.perl.com/CPAN/authors/Tom_Christiansen/scripts/toms.exrc.gz , the standard benchmark file for vi emulators. The file runs best with nvi, the current version of vi out of Berkeley, which incidentally can be built with an embedded Perl interpreter—see http://www.perl.com/CPAN/src/misc.

Where can I get perl−mode for emacs?

Since Emacs version 19 patchlevel 22 or so, there have been both a perl−mode.el and support for the Perl debugger built in. These should come with the standard Emacs 19 distribution.

In the Perl source directory, you'll find a directory called "emacs", which contains a cperl−mode that color−codes keywords, provides context−sensitive help, and other nifty things.

Note that the perl−mode of emacs will have fits with `"main'foo"` (single quote), and mess up the indentation and highlighting. You are probably using `"main::foo"` in new Perl code anyway, so this shouldn't be an issue.

How can I use curses with Perl?

The Curses module from CPAN provides a dynamically loadable object module interface to a curses library. A small demo can be found at the directory http://www.perl.com/CPAN/authors/Tom_Christiansen/scripts/rep; this program repeats a command and updates the screen as needed, rendering **rep ps axu** similar to **top**.

How can I use X or Tk with Perl?

Tk is a completely Perl−based, object−oriented interface to the Tk toolkit that doesn't force you to use Tcl just to get at Tk. Sx is an interface to the Athena Widget set. Both are available from CPAN. See the directory http://www.perl.com/CPAN/modules/by−category/08_User_Interfaces/

Invaluable for Perl/Tk programming are the Perl/Tk FAQ at http://w4.lns.cornell.edu/%7Epvhp/ptk/ptkTOC.html , the Perl/Tk Reference Guide available at http://www.perl.com/CPAN−local/authors/Stephen_O_Lidie/ , and the online manpages at http://www−users.cs.umn.edu/%7Eamundson/perl/perltk/toc.html .

How can I generate simple menus without using CGI or Tk?

The http://www.perl.com/CPAN/authors/id/SKUNZ/perlmenu.v4.0.tar.gz module, which is curses−based, can help with this.

What is undump?

See the next question on ''How can I make my Perl program run faster?''

How can I make my Perl program run faster?

The best way to do this is to come up with a better algorithm. This can often make a dramatic difference. Jon Bentley's book ''Programming Pearls'' (that's not a misspelling!) has some good tips on optimization, too. Advice on benchmarking boils down to: benchmark and profile to make sure you're optimizing the right part, look for better algorithms instead of microtuning your code, and when all else fails consider just buying faster hardware.

A different approach is to autoload seldom−used Perl code. See the AutoSplit and AutoLoader modules in the standard distribution for that. Or you could locate the bottleneck and think about writing just that part in C, the way we used to take bottlenecks in C code and write them in assembler. Similar to rewriting in C, modules that have critical sections can be written in C (for instance, the PDL module from CPAN).

In some cases, it may be worth it to use the backend compiler to produce byte code (saving compilation time) or compile into C, which will certainly save compilation time and sometimes a small amount (but not much) execution time. See the question about compiling your Perl programs for more on the compiler—the wins aren't as obvious as you'd hope.

If you're currently linking your perl executable to a shared *libc.so*, you can often gain a 10−25% performance benefit by rebuilding it to link with a static libc.a instead. This will make a bigger perl executable, but your Perl programs (and programmers) may thank you for it. See the ***INSTALL*** file in the source distribution for more information.

Unsubstantiated reports allege that Perl interpreters that use sfio outperform those that don't (for I/O intensive applications). To try this, see the ***INSTALL*** file in the source distribution, especially the ''Selecting File I/O mechanisms'' section.

The undump program was an old attempt to speed up your Perl program by storing the already−compiled form to disk. This is no longer a viable option, as it only worked on a few architectures, and wasn't a good solution anyway.

How can I make my Perl program take less memory?

When it comes to time−space tradeoffs, Perl nearly always prefers to throw memory at a problem. Scalars in Perl use more memory than strings in C, arrays take more than that, and hashes use even more. While there's still a lot to be done, recent releases have been addressing these issues. For example, as of 5.004, duplicate hash keys are shared amongst all hashes using them, so require no reallocation.

In some cases, using `substr()` or `vec()` to simulate arrays can be highly beneficial. For example, an array of a thousand booleans will take at least 20,000 bytes of space, but it can be turned into one 125−byte bit vector—a considerable memory savings. The standard Tie::SubstrHash module can also help for certain types of data structure. If you're working with specialist data structures (matrices, for instance) modules that implement these in C may use less memory than equivalent Perl modules.

Another thing to try is learning whether your Perl was compiled with the system malloc or with Perl's builtin malloc. Whichever one it is, try using the other one and see whether this makes a difference. Information about malloc is in the ***INSTALL*** file in the source distribution. You can find out whether you are using perl's malloc by typing `perl -V:usemymalloc`.

Is it unsafe to return a pointer to local data?

No, Perl's garbage collection system takes care of this.

```
sub makeone {
    my @a = ( 1 .. 10 );
    return \@a;
}

for $i ( 1 .. 10 ) {
    push @many, makeone();
}

print $many[4][5], "\n";

print "@many\n";
```

How can I free an array or hash so my program shrinks?

You can't. On most operating systems, memory allocated to a program can never be returned to the system. That's why long−running programs sometimes re−exec themselves. Some operating systems (notably, FreeBSD and Linux) allegedly reclaim large chunks of memory that is no longer used, but it doesn't appear to happen with Perl (yet). The Mac appears to be the only platform that will reliably (albeit, slowly) return memory to the OS.

We've had reports that on Linux (Redhat 5.1) on Intel, `undef $scalar` will return memory to the system, while on Solaris 2.6 it won't. In general, try it yourself and see.

However, judicious use of `my()` on your variables will help make sure that they go out of scope so that Perl can free up that space for use in other parts of your program. A global variable, of course, never goes out of scope, so you can't get its space automatically reclaimed, although `undef()`ing and/or `delete()`ing it will achieve the same effect. In general, memory allocation and de−allocation isn't something you can or should be worrying about much in Perl, but even this capability (preallocation of data types) is in the works.

How can I make my CGI script more efficient?

Beyond the normal measures described to make general Perl programs faster or smaller, a CGI program has additional issues. It may be run several times per second. Given that each time it runs it will need to be re−compiled and will often allocate a megabyte or more of system memory, this can be a killer. Compiling into C **isn't going to help you** because the process start−up overhead is where the bottleneck is.

There are two popular ways to avoid this overhead. One solution involves running the Apache HTTP server (available from http://www.apache.org/) with either of the mod_perl or mod_fastcgi plugin modules.

With mod_perl and the Apache::Registry module (distributed with mod_perl), httpd will run with an embedded Perl interpreter which pre−compiles your script and then executes it within the same address space without forking. The Apache extension also gives Perl access to the internal server API, so modules written in Perl can do just about anything a module written in C can. For more on mod_perl, see http://perl.apache.org/

With the FCGI module (from CPAN) and the mod_fastcgi module (available from http://www.fastcgi.com/) each of your Perl programs becomes a permanent CGI daemon process.

Both of these solutions can have far−reaching effects on your system and on the way you write your CGI programs, so investigate them with care.

See http://www.perl.com/CPAN/modules/by−category/15_World_Wide_Web_HTML_HTTP_CGI/ .

A non−free, commercial product, ''The Velocity Engine for Perl'', (http://www.binevolve.com/ or http://www.binevolve.com/velocigen/) might also be worth looking at. It will allow you to increase the performance of your Perl programs, running programs up to 25 times faster than normal CGI Perl when running in persistent Perl mode or 4 to 5 times faster without any modification to your existing CGI programs. Fully functional evaluation copies are available from the web site.

How can I hide the source for my Perl program?

Delete it. :–) Seriously, there are a number of (mostly unsatisfactory) solutions with varying levels of ‘‘security’’.

First of all, however, you *can't* take away read permission, because the source code has to be readable in order to be compiled and interpreted. (That doesn't mean that a CGI script's source is readable by people on the web, though—only by people with access to the filesystem.) So you have to leave the permissions at the socially friendly 0755 level.

Some people regard this as a security problem. If your program does insecure things and relies on people not knowing how to exploit those insecurities, it is not secure. It is often possible for someone to determine the insecure things and exploit them without viewing the source. Security through obscurity, the name for hiding your bugs instead of fixing them, is little security indeed.

You can try using encryption via source filters (Filter::* from CPAN), but any decent programmer will be able to decrypt it. You can try using the byte code compiler and interpreter described below, but the curious might still be able to de–compile it. You can try using the native–code compiler described below, but crackers might be able to disassemble it. These pose varying degrees of difficulty to people wanting to get at your code, but none can definitively conceal it (true of every language, not just Perl).

If you're concerned about people profiting from your code, then the bottom line is that nothing but a restrictive license will give you legal security. License your software and pepper it with threatening statements like ‘‘This is unpublished proprietary software of XYZ Corp. Your access to it does not give you permission to use it blah blah blah.’’ We are not lawyers, of course, so you should see a lawyer if you want to be sure your license's wording will stand up in court.

How can I compile my Perl program into byte code or C?

Malcolm Beattie has written a multifunction backend compiler, available from CPAN, that can do both these things. It is included in the perl5.005 release, but is still considered experimental. This means it's fun to play with if you're a programmer but not really for people looking for turn–key solutions.

Merely compiling into C does not in and of itself guarantee that your code will run very much faster. That's because except for lucky cases where a lot of native type inferencing is possible, the normal Perl run–time system is still present and so your program will take just as long to run and be just as big. Most programs save little more than compilation time, leaving execution no more than 10–30% faster. A few rare programs actually benefit significantly (even running several times faster), but this takes some tweaking of your code.

You'll probably be astonished to learn that the current version of the compiler generates a compiled form of your script whose executable is just as big as the original perl executable, and then some. That's because as currently written, all programs are prepared for a full `eval()` statement. You can tremendously reduce this cost by building a shared *libperl.so* library and linking against that. See the ***INSTALL*** podfile in the Perl source distribution for details. If you link your main perl binary with this, it will make it minuscule. For example, on one author's system, ***/usr/bin/perl*** is only 11k in size!

In general, the compiler will do nothing to make a Perl program smaller, faster, more portable, or more secure. In fact, it can make your situation worse. The executable will be bigger, your VM system may take longer to load the whole thing, the binary is fragile and hard to fix, and compilation never stopped software piracy in the form of crackers, viruses, or bootleggers. The real advantage of the compiler is merely packaging, and once you see the size of what it makes (well, unless you use a shared *libperl.so*), you'll probably want a complete Perl install anyway.

How can I compile Perl into Java?

You can also integrate Java and Perl with the Perl Resource Kit from O'Reilly and Associates. See http://www.oreilly.com/catalog/prkunix/ .

Perl 5.6 comes with Java Perl Lingo, or JPL. JPL, still in development, allows Perl code to be called from Java. See jpl/README in the Perl source tree.

How can I get `#!perl` to work on [MS–DOS,NT,...]?

For OS/2 just use

```
extproc perl -S -your_switches
```

as the first line in `*.cmd` file (`-S` due to a bug in cmd.exe's 'extproc' handling). For DOS one should first invent a corresponding batch file and codify it in `ALTERNATIVE_SHEBANG` (see the ***INSTALL*** file in the source distribution for more information).

The Win95/NT installation, when using the ActiveState port of Perl, will modify the Registry to associate the `.pl` extension with the perl interpreter. If you install another port, perhaps even building your own Win95/NT Perl from the standard sources by using a Windows port of gcc (e.g., with cygwin or mingw32), then you'll have to modify the Registry yourself. In addition to associating `.pl` with the interpreter, NT people can use: `SET PATHEXT=%PATHEXT%;.PL` to let them run the program `install-linux.pl` merely by typing `install-linux`.

Macintosh Perl programs will have the appropriate Creator and Type, so that double–clicking them will invoke the Perl application.

IMPORTANT!: Whatever you do, PLEASE don't get frustrated, and just throw the perl interpreter into your cgi–bin directory, in order to get your programs working for a web server. This is an EXTREMELY big security risk. Take the time to figure out how to do it correctly.

Can I write useful Perl programs on the command line?

Yes. Read *perlrun* for more information. Some examples follow. (These assume standard Unix shell quoting rules.)

```
# sum first and last fields
perl -lane 'print $F[0] + $F[-1]' *

# identify text files
perl -le 'for(@ARGV) {print if -f && -T _}' *

# remove (most) comments from C program
perl -0777 -pe 's{/\*.*?\*/}{}gs' foo.c

# make file a month younger than today, defeating reaper daemons
perl -e '$X=24*60*60; utime(time(),time() + 30 * $X,@ARGV)' *

# find first unused uid
perl -le '$i++ while getpwuid($i); print $i'

# display reasonable manpath
echo $PATH | perl -nl -072 -e '
    s![^/+]*$!man!&&-d&&!$s{$_}++&&push@m,$_;END{print"@m"}'
```

OK, the last one was actually an Obfuscated Perl Contest entry. :–)

Why don't Perl one–liners work on my DOS/Mac/VMS system?

The problem is usually that the command interpreters on those systems have rather different ideas about quoting than the Unix shells under which the one–liners were created. On some systems, you may have to change single–quotes to double ones, which you must *NOT* do on Unix or Plan9 systems. You might also have to change a single % to a %%.

For example:

```
# Unix
perl -e 'print "Hello world\n"'

# DOS, etc.
perl -e "print \"Hello world\n\""
```

```
# Mac
print "Hello world\n"
 (then Run "Myscript" or Shift-Command-R)

# VMS
perl -e "print ""Hello world\n"""
```

The problem is that none of these examples are reliable: they depend on the command interpreter. Under Unix, the first two often work. Under DOS, it's entirely possible that neither works. If 4DOS was the command shell, you'd probably have better luck like this:

```
perl -e "print <Ctrl-x>"Hello world\n<Ctrl-x>""
```

Under the Mac, it depends which environment you are using. The MacPerl shell, or MPW, is much like Unix shells in its support for several quoting variants, except that it makes free use of the Mac's non-ASCII characters as control characters.

Using `qq()`, `q()`, and `qx()`, instead of "double quotes", 'single quotes', and 'backticks', may make one-liners easier to write.

There is no general solution to all of this. It is a mess, pure and simple. Sucks to be away from Unix, huh? :-)

[Some of this answer was contributed by Kenneth Albanowski.]

Where can I learn about CGI or Web programming in Perl?

For modules, get the CGI or LWP modules from CPAN. For textbooks, see the two especially dedicated to web stuff in the question on books. For problems and questions related to the web, like ''Why do I get 500 Errors'' or ''Why doesn't it run from the browser right when it runs fine on the command line'', see these sources:

```
WWW Security FAQ
    http://www.w3.org/Security/Faq/

Web FAQ
    http://www.boutell.com/faq/

CGI FAQ
    http://www.webthing.com/tutorials/cgifaq.html

HTTP Spec
    http://www.w3.org/pub/WWW/Protocols/HTTP/

HTML Spec
    http://www.w3.org/TR/REC-html40/
    http://www.w3.org/pub/WWW/MarkUp/

CGI Spec
    http://www.w3.org/CGI/

CGI Security FAQ
    http://www.go2net.com/people/paulp/cgi-security/safe-cgi.txt
```

Where can I learn about object-oriented Perl programming?

A good place to start is *perltoot*, and you can use *perlobj*, *perlboot*, and *perlbot* for reference. Perltoot didn't come out until the 5.004 release; you can get a copy (in pod, html, or postscript) from http://www.perl.com/CPAN/doc/FMTEYEWTK/ .

Where can I learn about linking C with Perl? [h2xs, xsubpp]

If you want to call C from Perl, start with *perlxstut*, moving on to *perlxs*, *xsubpp*, and *perlguts*. If you want to call Perl from C, then read *perlembed*, *perlcall*, and *perlguts*. Don't forget that you can learn a lot from looking at how the authors of existing extension modules wrote their code and solved their problems.

I've read perlembed, perlguts, etc., but I can't embed perl in

my C program; what am I doing wrong?

Download the ExtUtils::Embed kit from CPAN and run 'make test'. If the tests pass, read the pods again and again and again. If they fail, see *perlbug* and send a bug report with the output of `make test TEST_VERBOSE=1` along with `perl -V`.

When I tried to run my script, I got this message. What does it

mean?

A complete list of Perl's error messages and warnings with explanatory text can be found in *perldiag*. You can also use the splain program (distributed with Perl) to explain the error messages:

```
perl program 2>diag.out
splain [-v] [-p] diag.out
```

or change your program to explain the messages for you:

```
use diagnostics;
```

or

```
use diagnostics -verbose;
```

What's MakeMaker?

This module (part of the standard Perl distribution) is designed to write a Makefile for an extension module from a Makefile.PL. For more information, see *ExtUtils::MakeMaker*.

AUTHOR AND COPYRIGHT

NAME

perlfaq4 – Data Manipulation (`$Revision: 1.49 $, $Date: 1999/05/23 20:37:49 $`)

DESCRIPTION

The section of the FAQ answers questions related to the manipulation of data as numbers, dates, strings, arrays, hashes, and miscellaneous data issues.

Data: Numbers

Why am I getting long decimals (eg, 19.9499999999999) instead of the numbers I should be getting (eg, 19.95)?

The infinite set that a mathematician thinks of as the real numbers can only be approximated on a computer, since the computer only has a finite number of bits to store an infinite number of, um, numbers.

Internally, your computer represents floating−point numbers in binary. Floating−point numbers read in from a file or appearing as literals in your program are converted from their decimal floating−point representation (eg, 19.95) to an internal binary representation.

However, 19.95 can't be precisely represented as a binary floating−point number, just like 1/3 can't be exactly represented as a decimal floating−point number. The computer's binary representation of 19.95, therefore, isn't exactly 19.95.

When a floating−point number gets printed, the binary floating−point representation is converted back to decimal. These decimal numbers are displayed in either the format you specify with `printf()`, or the current output format for numbers. (See *$# in perlvar* if you use print. `$#` has a different default value in Perl5 than it did in Perl4. Changing `$#` yourself is deprecated.)

This affects **all** computer languages that represent decimal floating−point numbers in binary, not just Perl. Perl provides arbitrary−precision decimal numbers with the Math::BigFloat module (part of the standard Perl distribution), but mathematical operations are consequently slower.

To get rid of the superfluous digits, just use a format (eg, `printf("%.2f", 19.95)`) to get the required precision. See *Floating−point Arithmetic in perlop*.

Why isn't my octal data interpreted correctly?

Perl only understands octal and hex numbers as such when they occur as literals in your program. If they are read in from somewhere and assigned, no automatic conversion takes place. You must explicitly use `oct()` or `hex()` if you want the values converted. `oct()` interprets both hex ("0x350") numbers and octal ones ("0350" or even without the leading "0", like "377"), while `hex()` only converts hexadecimal ones, with or without a leading "0x", like "0x255", "3A", "ff", or "deadbeef".

This problem shows up most often when people try using `chmod()`, `mkdir()`, `umask()`, or `sysopen()`, which all want permissions in octal.

```
chmod(644,  $file); # WRONG -- perl -w catches this
chmod(0644, $file); # right
```

Does Perl have a `round()` function? What about `ceil()` and `floor()`? Trig functions?

Remember that `int()` merely truncates toward 0. For rounding to a certain number of digits, `sprintf()` or `printf()` is usually the easiest route.

```
printf("%.3f", 3.1415926535);       # prints 3.142
```

The POSIX module (part of the standard Perl distribution) implements `ceil()`, `floor()`, and a number of other mathematical and trigonometric functions.

```
use POSIX;
$ceil   = ceil(3.5);                        # 4
$floor  = floor(3.5);                       # 3
```

In 5.000 to 5.003 perls, trigonometry was done in the Math::Complex module. With 5.004, the Math::Trig

module (part of the standard Perl distribution) implements the trigonometric functions. Internally it uses the Math::Complex module and some functions can break out from the real axis into the complex plane, for example the inverse sine of 2.

Rounding in financial applications can have serious implications, and the rounding method used should be specified precisely. In these cases, it probably pays not to trust whichever system rounding is being used by Perl, but to instead implement the rounding function you need yourself.

To see why, notice how you'll still have an issue on half-way-point alternation:

```
for ($i = 0; $i < 1.01; $i += 0.05) { printf "%.1f ",$i}

0.0 0.1 0.1 0.2 0.2 0.2 0.3 0.3 0.4 0.4 0.5 0.5 0.6 0.7 0.7
0.8 0.8 0.9 0.9 1.0 1.0
```

Don't blame Perl. It's the same as in C. IEEE says we have to do this. Perl numbers whose absolute values are integers under 2**31 (on 32 bit machines) will work pretty much like mathematical integers. Other numbers are not guaranteed.

How do I convert bits into ints?

To turn a string of 1s and 0s like `10110110` into a scalar containing its binary value, use the `pack()` and `unpack()` functions (documented in *pack in perlfunc* and *unpack in perlfunc*):

```
$decimal = unpack('c', pack('B8', '10110110'));
```

This packs the string `10110110` into an eight bit binary structure. This is then unpacked as a character, which returns its ordinal value.

This does the same thing:

```
$decimal = ord(pack('B8', '10110110'));
```

Here's an example of going the other way:

```
$binary_string = unpack('B*', "\x29");
```

Why doesn't & work the way I want it to?

The behavior of binary arithmetic operators depends on whether they're used on numbers or strings. The operators treat a string as a series of bits and work with that (the string `"3"` is the bit pattern `00110011`). The operators work with the binary form of a number (the number `3` is treated as the bit pattern `00000011`).

So, saying `11 & 3` performs the "and" operation on numbers (yielding `1`). Saying `"11" & "3"` performs the "and" operation on strings (yielding `"1"`).

Most problems with `&` and `|` arise because the programmer thinks they have a number but really it's a string. The rest arise because the programmer says:

```
if ("\020\020" & "\101\101") {
    # ...
}
```

but a string consisting of two null bytes (the result of `"\020\020" & "\101\101"`) is not a false value in Perl. You need:

```
if ( ("\020\020" & "\101\101") !~ /[^\000]/) {
    # ...
}
```

How do I multiply matrices?

Use the Math::Matrix or Math::MatrixReal modules (available from CPAN) or the PDL extension (also available from CPAN).

How do I perform an operation on a series of integers?

To call a function on each element in an array, and collect the results, use:

```
@results = map { my_func($_) } @array;
```

For example:

```
@triple = map { 3 * $_ } @single;
```

To call a function on each element of an array, but ignore the results:

```
foreach $iterator (@array) {
    some_func($iterator);
}
```

To call a function on each integer in a (small) range, you **can** use:

```
@results = map { some_func($_) } (5 .. 25);
```

but you should be aware that the `..` operator creates an array of all integers in the range. This can take a lot of memory for large ranges. Instead use:

```
@results = ();
for ($i=5; $i < 500_005; $i++) {
    push(@results, some_func($i));
}
```

This situation has been fixed in Perl5.005. Use of `..` in a `for` loop will iterate over the range, without creating the entire range.

```
for my $i (5 .. 500_005) {
    push(@results, some_func($i));
}
```

will not create a list of 500,000 integers.

How can I output Roman numerals?

Get the http://www.perl.com/CPAN/modules/by-module/Roman module.

Why aren't my random numbers random?

If you're using a version of Perl before 5.004, you must call `srand` once at the start of your program to seed the random number generator. 5.004 and later automatically call `srand` at the beginning. Don't call `srand` more than once—you make your numbers less random, rather than more.

Computers are good at being predictable and bad at being random (despite appearances caused by bugs in your programs :-). http://www.perl.com/CPAN/doc/FMTEYEWTK/random , courtesy of Tom Phoenix, talks more about this. John von Neumann said, ''Anyone who attempts to generate random numbers by deterministic means is, of course, living in a state of sin.''

If you want numbers that are more random than `rand` with `srand` provides, you should also check out the Math::TrulyRandom module from CPAN. It uses the imperfections in your system's timer to generate random numbers, but this takes quite a while. If you want a better pseudorandom generator than comes with your operating system, look at ''Numerical Recipes in C'' at http://www.nr.com/ .

Data: Dates

How do I find the week-of-the-year/day-of-the-year?

The day of the year is in the array returned by `localtime()` (see *localtime in perlfunc*):

```
$day_of_year = (localtime(time()))[7];
```

or more legibly (in 5.004 or higher):

```
use Time::localtime;
$day_of_year = localtime(time())->yday;
```

You can find the week of the year by dividing this by 7:

```
$week_of_year = int($day_of_year / 7);
```

Of course, this believes that weeks start at zero. The Date::Calc module from CPAN has a lot of date calculation functions, including day of the year, week of the year, and so on. Note that not all businesses consider ‘‘week 1’’ to be the same; for example, American businesses often consider the first week with a Monday in it to be Work Week #1, despite ISO 8601, which considers WW1 to be the first week with a Thursday in it.

How do I find the current century or millennium?

Use the following simple functions:

```
sub get_century    {
    return int((((localtime(shift || time))[5] + 1999))/100);
}
sub get_millennium {
    return 1+int((((localtime(shift || time))[5] + 1899))/1000);
}
```

On some systems, you‘ll find that the POSIX module‘s `strftime()` function has been extended in a non−standard way to use a `%C` format, which they sometimes claim is the "century". It isn‘t, because on most such systems, this is only the first two digits of the four−digit year, and thus cannot be used to reliably determine the current century or millennium.

How can I compare two dates and find the difference?

If you‘re storing your dates as epoch seconds then simply subtract one from the other. If you‘ve got a structured date (distinct year, day, month, hour, minute, seconds values), then for reasons of accessibility, simplicity, and efficiency, merely use either timelocal or timegm (from the Time::Local module in the standard distribution) to reduce structured dates to epoch seconds. However, if you don‘t know the precise format of your dates, then you should probably use either of the Date::Manip and Date::Calc modules from CPAN before you go hacking up your own parsing routine to handle arbitrary date formats.

How can I take a string and turn it into epoch seconds?

If it‘s a regular enough string that it always has the same format, you can split it up and pass the parts to `timelocal` in the standard Time::Local module. Otherwise, you should look into the Date::Calc and Date::Manip modules from CPAN.

How can I find the Julian Day?

Use the Time::JulianDay module (part of the Time−modules bundle available from CPAN.)

Before you immerse yourself too deeply in this, be sure to verify that it is the *Julian* Day you really want. Are you really just interested in a way of getting serial days so that they can do date arithmetic? If you are interested in performing date arithmetic, this can be done using either Date::Manip or Date::Calc, without converting to Julian Day first.

There is too much confusion on this issue to cover in this FAQ, but the term is applied (correctly) to a calendar now supplanted by the Gregorian Calendar, with the Julian Calendar failing to adjust properly for leap years on centennial years (among other annoyances). The term is also used (incorrectly) to mean: [1] days in the Gregorian Calendar; and [2] days since a particular starting time or ‘epoch‘, usually 1970 in the Unix world and 1980 in the MS−DOS/Windows world. If you find that it is not the first meaning that you really want, then check out the Date::Manip and Date::Calc modules. (Thanks to David Cassell for most of this text.)

How do I find yesterday's date?

The `time()` function returns the current time in seconds since the epoch. Take twenty−four hours off that:

```
$yesterday = time() - ( 24 * 60 * 60 );
```

Then you can pass this to `localtime()` and get the individual year, month, day, hour, minute, seconds values.

Note very carefully that the code above assumes that your days are twenty−four hours each. For most people, there are two days a year when they aren't: the switch to and from summer time throws this off. A solution to this issue is offered by Russ Allbery.

```
sub yesterday {
    my $now  = defined $_[0] ? $_[0] : time;
    my $then = $now - 60 * 60 * 24;
    my $ndst = (localtime $now)[8] > 0;
    my $tdst = (localtime $then)[8] > 0;
    $then - ($tdst - $ndst) * 60 * 60;
}
# Should give you "this time yesterday" in seconds since epoch relative to
# the first argument or the current time if no argument is given and
# suitable for passing to localtime or whatever else you need to do with
# it.  $ndst is whether we're currently in daylight savings time; $tdst is
# whether the point 24 hours ago was in daylight savings time.  If $tdst
# and $ndst are the same, a boundary wasn't crossed, and the correction
# will subtract 0.  If $tdst is 1 and $ndst is 0, subtract an hour more
# from yesterday's time since we gained an extra hour while going off
# daylight savings time.  If $tdst is 0 and $ndst is 1, subtract a
# negative hour (add an hour) to yesterday's time since we lost an hour.
#
# All of this is because during those days when one switches off or onto
# DST, a "day" isn't 24 hours long; it's either 23 or 25.
#
# The explicit settings of $ndst and $tdst are necessary because localtime
# only says it returns the system tm struct, and the system tm struct at
# least on Solaris doesn't guarantee any particular positive value (like,
# say, 1) for isdst, just a positive value.  And that value can
# potentially be negative, if DST information isn't available (this sub
# just treats those cases like no DST).
#
# Note that between 2am and 3am on the day after the time zone switches
# off daylight savings time, the exact hour of "yesterday" corresponding
# to the current hour is not clearly defined.  Note also that if used
# between 2am and 3am the day after the change to daylight savings time,
# the result will be between 3am and 4am of the previous day; it's
# arguable whether this is correct.
#
# This sub does not attempt to deal with leap seconds (most things don't).
#
# Copyright relinquished 1999 by Russ Allbery <rra@stanford.edu>
# This code is in the public domain
```

Does Perl have a Year 2000 problem? Is Perl Y2K compliant?

Short answer: No, Perl does not have a Year 2000 problem. Yes, Perl is Y2K compliant (whatever that means). The programmers you've hired to use it, however, probably are not.

Long answer: The question belies a true understanding of the issue. Perl is just as Y2K compliant as your pencil—no more, and no less. Can you use your pencil to write a non−Y2K−compliant memo? Of course you can. Is that the pencil's fault? Of course it isn't.

The date and time functions supplied with Perl (gmtime and localtime) supply adequate information to determine the year well beyond 2000 (2038 is when trouble strikes for 32−bit machines). The year returned by these functions when used in a list context is the year minus 1900. For years between 1910 and 1999 this *happens* to be a 2−digit decimal number. To avoid the year 2000 problem simply do not treat the year as a 2−digit number. It isn't.

When `gmtime()` and `localtime()` are used in scalar context they return a timestamp string that contains a fully−expanded year. For example, `$timestamp = gmtime(1005613200)` sets `$timestamp` to "Tue Nov 13 01:00:00 2001". There's no year 2000 problem here.

That doesn't mean that Perl can't be used to create non−Y2K compliant programs. It can. But so can your pencil. It's the fault of the user, not the language. At the risk of inflaming the NRA: ''Perl doesn't break Y2K, people do.'' See http://language.perl.com/news/y2k.html for a longer exposition.

Data: Strings

How do I validate input?

The answer to this question is usually a regular expression, perhaps with auxiliary logic. See the more specific questions (numbers, mail addresses, etc.) for details.

How do I unescape a string?

It depends just what you mean by ''escape''. URL escapes are dealt with in *perlfaq9*. Shell escapes with the backslash (\) character are removed with

```
s/\\(.)/$1/g;
```

This won't expand `"\n"` or `"\t"` or any other special escapes.

How do I remove consecutive pairs of characters?

To turn `"abbcccd"` into `"abcd"`:

```
s/(.)\1/$1/g;       # add /s to include newlines
```

Here's a solution that turns "abbcccd" to "abcd":

```
y///cs;     # y == tr, but shorter :-)
```

How do I expand function calls in a string?

This is documented in *perlref*. In general, this is fraught with quoting and readability problems, but it is possible. To interpolate a subroutine call (in list context) into a string:

```
print "My sub returned @{[mysub(1,2,3)]} that time.\n";
```

If you prefer scalar context, similar chicanery is also useful for arbitrary expressions:

```
print "That yields ${\($n + 5)} widgets\n";
```

Version 5.004 of Perl had a bug that gave list context to the expression in `${...}`, but this is fixed in version 5.005.

See also ''How can I expand variables in text strings?'' in this section of the FAQ.

How do I find matching/nesting anything?

This isn't something that can be done in one regular expression, no matter how complicated. To find something between two single characters, a pattern like `/x([^x]*)x/` will get the intervening bits in `$1`. For multiple ones, then something more like `/alpha(.*?)omega/` would be needed. But none of these deals with nested patterns, nor can they. For that you'll have to write a parser.

If you are serious about writing a parser, there are a number of modules or oddities that will make your life a lot easier. There are the CPAN modules Parse::RecDescent, Parse::Yapp, and Text::Balanced; and the byacc

program.

One simple destructive, inside–out approach that you might try is to pull out the smallest nesting parts one at a time:

```
while (s/BEGIN((?:(?!BEGIN)(?!END).)*)END//gs) {
    # do something with $1
}
```

A more complicated and sneaky approach is to make Perl's regular expression engine do it for you. This is courtesy Dean Inada, and rather has the nature of an Obfuscated Perl Contest entry, but it really does work:

```
# $_ contains the string to parse
# BEGIN and END are the opening and closing markers for the
# nested text.

@( = ('(','');
@) = (')','');
($re=$_)=~s/((BEGIN)|(END)|.)/$)[!$3]\Q$1\E$([!$2]/gs;
@$ = (eval{/$re/},$@!~/unmatched/);
print join("\n",@$[0..$#$]) if( $$[-1] );
```

How do I reverse a string?

Use `reverse()` in scalar context, as documented in *reverse*.

```
$reversed = reverse $string;
```

How do I expand tabs in a string?

You can do it yourself:

```
1 while $string =~ s/\t+/' ' x (length($&) * 8 - length($`) % 8)/e;
```

Or you can just use the Text::Tabs module (part of the standard Perl distribution).

```
use Text::Tabs;
@expanded_lines = expand(@lines_with_tabs);
```

How do I reformat a paragraph?

Use Text::Wrap (part of the standard Perl distribution):

```
use Text::Wrap;
print wrap("\t", '  ', @paragraphs);
```

The paragraphs you give to Text::Wrap should not contain embedded newlines. Text::Wrap doesn't justify the lines (flush–right).

How can I access/change the first N letters of a string?

There are many ways. If you just want to grab a copy, use `substr()`:

```
$first_byte = substr($a, 0, 1);
```

If you want to modify part of a string, the simplest way is often to use `substr()` as an lvalue:

```
substr($a, 0, 3) = "Tom";
```

Although those with a pattern matching kind of thought process will likely prefer

```
$a =~ s/^.../Tom/;
```

How do I change the Nth occurrence of something?

You have to keep track of N yourself. For example, let's say you want to change the fifth occurrence of `"whoever"` or `"whomever"` into `"whosoever"` or `"whomsoever"`, case insensitively. These all assume that `$_` contains the string to be altered.

```
$count = 0;
s{((whom?)ever)}{
    ++$count == 5   # is it the 5th?
        ? "${2}soever#"yes, swap
        : $1        # renege and leave it there
}ige;
```

In the more general case, you can use the `/g` modifier in a `while` loop, keeping count of matches.

```
$WANT = 3;
$count = 0;
$_ = "One fish two fish red fish blue fish";
while (/(\w+)\s+fish\b/gi) {
    if (++$count == $WANT) {
        print "The third fish is a $1 one.\n";
    }
}
```

That prints out: `"The third fish is a red one."` You can also use a repetition count and repeated pattern like this:

```
/(?:\w+\s+fish\s+){2}(\w+)\s+fish/i;
```

How can I count the number of occurrences of a substring within a string?

There are a number of ways, with varying efficiency. If you want a count of a certain single character (X) within a string, you can use the `tr///` function like so:

```
$string = "ThisXlineXhasXsomeXx'sXinXit";
$count = ($string =~ tr/X//);
print "There are $count X characters in the string";
```

This is fine if you are just looking for a single character. However, if you are trying to count multiple character substrings within a larger string, `tr///` won't work. What you can do is wrap a `while()` loop around a global pattern match. For example, let's count negative integers:

```
$string = "-9 55 48 -2 23 -76 4 14 -44";
while ($string =~ /-\d+/g) { $count++ }
print "There are $count negative numbers in the string";
```

How do I capitalize all the words on one line?

To make the first letter of each word upper case:

```
$line =~ s/\b(\w)/\U$1/g;
```

This has the strange effect of turning `"don't do it"` into `"Don'T Do It"`. Sometimes you might want this. Other times you might need a more thorough solution (Suggested by brian d. foy):

```
$string =~ s/ (
              (^\w)    #at the beginning of the line
                |      # or
              (\s\w)   #preceded by whitespace
                )
             /\U$1/xg;
$string =~ /([\w']+)/\u\L$1/g;
```

To make the whole line upper case:

```
$line = uc($line);
```

To force each word to be lower case, with the first letter upper case:

```
$line =~ s/(\w+)/\u\L$1/g;
```

You can (and probably should) enable locale awareness of those characters by placing a `use locale` pragma in your program. See *perllocale* for endless details on locales.

This is sometimes referred to as putting something into "title case", but that's not quite accurate. Consider the proper capitalization of the movie *Dr. Strangelove or: How I Learned to Stop Worrying and Love the Bomb*, for example.

How can I split a [character] delimited string except when inside

[character]? (Comma–separated files)

Take the example case of trying to split a string that is comma–separated into its different fields. (We'll pretend you said comma–separated, not comma–delimited, which is different and almost never what you mean.) You can't use `split(/,/)` because you shouldn't split if the comma is inside quotes. For example, take a data line like this:

```
SAR001,"","Cimetrix, Inc","Bob Smith","CAM",N,8,1,0,7,"Error, Core Dumped"
```

Due to the restriction of the quotes, this is a fairly complex problem. Thankfully, we have Jeffrey Friedl, author of a highly recommended book on regular expressions, to handle these for us. He suggests (assuming your string is contained in `$text`):

```
@new = ();
push(@new, $+) while $text =~ m{
     "([^\"\\]*(?:\\.[^\"\\]*)*)",?  # groups the phrase inside the quotes
   | ([^,]+),?
   | ,
}gx;
push(@new, undef) if substr($text,-1,1) eq ',';
```

If you want to represent quotation marks inside a quotation–mark–delimited field, escape them with backslashes (eg, `"like \"this\""`. Unescaping them is a task addressed earlier in this section.

Alternatively, the Text::ParseWords module (part of the standard Perl distribution) lets you say:

```
use Text::ParseWords;
@new = quotewords(",", 0, $text);
```

There's also a Text::CSV (Comma–Separated Values) module on CPAN.

How do I strip blank space from the beginning/end of a string?

Although the simplest approach would seem to be

```
$string =~ s/^\s*(.*?)\s*$/$1/;
```

not only is this unnecessarily slow and destructive, it also fails with embedded newlines. It is much faster to do this operation in two steps:

```
$string =~ s/^\s+//;
$string =~ s/\s+$//;
```

Or more nicely written as:

```
for ($string) {
    s/^\s+//;
    s/\s+$//;
}
```

This idiom takes advantage of the `foreach` loop's aliasing behavior to factor out common code. You can do this on several strings at once, or arrays, or even the values of a hash if you use a slice:

```
# trim whitespace in the scalar, the array,
# and all the values in the hash
foreach ($scalar, @array, @hash{keys %hash}) {
```

```
    s/^\s+//;
    s/\s+$//;
}
```

How do I pad a string with blanks or pad a number with zeroes?

(This answer contributed by Uri Guttman, with kibitzing from Bart Lateur.)

In the following examples, `$pad_len` is the length to which you wish to pad the string, `$text` or `$num` contains the string to be padded, and `$pad_char` contains the padding character. You can use a single character string constant instead of the `$pad_char` variable if you know what it is in advance. And in the same way you can use an integer in place of `$pad_len` if you know the pad length in advance.

The simplest method uses the `sprintf` function. It can pad on the left or right with blanks and on the left with zeroes and it will not truncate the result. The `pack` function can only pad strings on the right with blanks and it will truncate the result to a maximum length of `$pad_len`.

```
# Left padding a string with blanks (no truncation):
$padded = sprintf("%${pad_len}s", $text);

# Right padding a string with blanks (no truncation):
$padded = sprintf("%-${pad_len}s", $text);

# Left padding a number with 0 (no truncation):
$padded = sprintf("%0${pad_len}d", $num);

# Right padding a string with blanks using pack (will truncate):
$padded = pack("A$pad_len",$text);
```

If you need to pad with a character other than blank or zero you can use one of the following methods. They all generate a pad string with the `x` operator and combine that with `$text`. These methods do not truncate `$text`.

Left and right padding with any character, creating a new string:

```
$padded = $pad_char x ( $pad_len - length( $text ) ) . $text;
$padded = $text . $pad_char x ( $pad_len - length( $text ) );
```

Left and right padding with any character, modifying `$text` directly:

```
substr( $text, 0, 0 ) = $pad_char x ( $pad_len - length( $text ) );
$text .= $pad_char x ( $pad_len - length( $text ) );
```

How do I extract selected columns from a string?

Use `substr()` or `unpack()`, both documented in *perlfunc*. If you prefer thinking in terms of columns instead of widths, you can use this kind of thing:

```
# determine the unpack format needed to split Linux ps output
# arguments are cut columns
my $fmt = cut2fmt(8, 14, 20, 26, 30, 34, 41, 47, 59, 63, 67, 72);

sub cut2fmt {
    my(@positions) = @_;
    my $template  = '';
    my $lastpos   = 1;
    for my $place (@positions) {
        $template .= "A" . ($place - $lastpos) . " ";
        $lastpos   = $place;
    }
    $template .= "A*";
    return $template;
}
```

How do I find the soundex value of a string?

Use the standard Text::Soundex module distributed with Perl. Before you do so, you may want to determine whether 'soundex' is in fact what you think it is. Knuth's soundex algorithm compresses words into a small space, and so it does not necessarily distinguish between two words which you might want to appear separately. For example, the last names 'Knuth' and 'Kant' are both mapped to the soundex code K530. If Text::Soundex does not do what you are looking for, you might want to consider the String::Approx module available at CPAN.

How can I expand variables in text strings?

Let's assume that you have a string like:

```
$text = 'this has a $foo in it and a $bar';
```

If those were both global variables, then this would suffice:

```
$text =~ s/\$(\w+)/${$1}/g;  # no /e needed
```

But since they are probably lexicals, or at least, they could be, you'd have to do this:

```
$text =~ s/(\$\w+)/$1/eeg;
die if $@;                    # needed /ee, not /e
```

It's probably better in the general case to treat those variables as entries in some special hash. For example:

```
%user_defs = (
    foo  => 23,
    bar  => 19,
);
$text =~ s/\$(\w+)/$user_defs{$1}/g;
```

See also ''How do I expand function calls in a string?'' in this section of the FAQ.

What's wrong with always quoting `"$vars"`?

The problem is that those double-quotes force stringification— coercing numbers and references into strings—even when you don't want them to be strings. Think of it this way: double-quote expansion is used to produce new strings. If you already have a string, why do you need more?

If you get used to writing odd things like these:

```
print "$var";       # BAD
$new = "$old";      # BAD
somefunc("$var");   # BAD
```

You'll be in trouble. Those should (in 99.8% of the cases) be the simpler and more direct:

```
print $var;
$new = $old;
somefunc($var);
```

Otherwise, besides slowing you down, you're going to break code when the thing in the scalar is actually neither a string nor a number, but a reference:

```
func(\@array);
sub func {
    my $aref = shift;
    my $oref = "$aref";  # WRONG
}
```

You can also get into subtle problems on those few operations in Perl that actually do care about the difference between a string and a number, such as the magical ++ autoincrement operator or the `syscall()` function.

Stringification also destroys arrays.

```
@lines = `command`;
print "@lines";             # WRONG - extra blanks
print @lines;               # right
```

Why don't my <<HERE documents work?

Check for these three things:

1. There must be no space after the << part.
2. There (probably) should be a semicolon at the end.
3. You can't (easily) have any space in front of the tag.

If you want to indent the text in the here document, you can do this:

```
# all in one
($VAR = <<HERE_TARGET) =~ s/^\s+//gm;
    your text
    goes here
HERE_TARGET
```

But the HERE_TARGET must still be flush against the margin. If you want that indented also, you'll have to quote in the indentation.

```
($quote = <<'    FINIS') =~ s/^\s+//gm;
        ...we will have peace, when you and all your works have
        perished--and the works of your dark master to whom you
        would deliver us. You are a liar, Saruman, and a corrupter
        of men's hearts.  --Theoden in /usr/src/perl/taint.c
    FINIS
$quote =~ s/\s*--/\n--/;
```

A nice general-purpose fixer-upper function for indented here documents follows. It expects to be called with a here document as its argument. It looks to see whether each line begins with a common substring, and if so, strips that substring off. Otherwise, it takes the amount of leading whitespace found on the first line and removes that much off each subsequent line.

```
sub fix {
    local $_ = shift;
    my ($white, $leader);  # common whitespace and common leading string
    if (/^\s*(?:([^\w\s]+)(\s*).*\n)(?:\s*\1\2?.*\n)+$/) {
        ($white, $leader) = ($2, quotemeta($1));
    } else {
        ($white, $leader) = (/^(\s+)/, '');
    }
    s/^\s*?$leader(?:$white)?//gm;
    return $_;
}
```

This works with leading special strings, dynamically determined:

```
$remember_the_main = fix<<'    MAIN_INTERPRETER_LOOP';
    @@@ int
    @@@ runops() {
    @@@     SAVEI32(runlevel);
    @@@     runlevel++;
    @@@     while ( op = (*op->op_ppaddr)() );
    @@@     TAINT_NOT;
    @@@     return 0;
    @@@ }
```

```
MAIN_INTERPRETER_LOOP
```

Or with a fixed amount of leading whitespace, with remaining indentation correctly preserved:

```
$poem = fix<<EVER_ON_AND_ON;
   Now far ahead the Road has gone,
      And I must follow, if I can,
   Pursuing it with eager feet,
      Until it joins some larger way
   Where many paths and errands meet.
      And whither then? I cannot say.
            --Bilbo in /usr/src/perl/pp_ctl.c
EVER_ON_AND_ON
```

Data: Arrays

What is the difference between a list and an array?

An array has a changeable length. A list does not. An array is something you can push or pop, while a list is a set of values. Some people make the distinction that a list is a value while an array is a variable. Subroutines are passed and return lists, you put things into list context, you initialize arrays with lists, and you `foreach()` across a list. `@` variables are arrays, anonymous arrays are arrays, arrays in scalar context behave like the number of elements in them, subroutines access their arguments through the array `@_`, and push/pop/shift only work on arrays.

As a side note, there's no such thing as a list in scalar context. When you say

```
$scalar = (2, 5, 7, 9);
```

you're using the comma operator in scalar context, so it uses the scalar comma operator. There never was a list there at all! This causes the last value to be returned: 9.

What is the difference between `$array[1]` and @array[1]?

The former is a scalar value; the latter an array slice, making it a list with one (scalar) value. You should use `$` when you want a scalar value (most of the time) and `@` when you want a list with one scalar value in it (very, very rarely; nearly never, in fact).

Sometimes it doesn't make a difference, but sometimes it does. For example, compare:

```
$good[0] = 'some program that outputs several lines';
```

with

```
@bad[0]  = 'same program that outputs several lines';
```

The `use warnings` pragma and the **-w** flag will warn you about these matters.

How can I remove duplicate elements from a list or array?

There are several possible ways, depending on whether the array is ordered and whether you wish to preserve the ordering.

a) If @in is sorted, and you want @out to be sorted:

(this assumes all true values in the array)

```
$prev = 'nonesuch';
@out = grep($_ ne $prev && ($prev = $_, 1), @in);
```

This is nice in that it doesn't use much extra memory, simulating uniq(1)'s behavior of removing only adjacent duplicates. The ", 1" guarantees that the expression is true (so that grep picks it up) even if the `$_` is 0, "", or undef.

b) If you don't know whether @in is sorted:

```
undef %saw;
@out = grep(!$saw{$_}++, @in);
```

c) Like (b), but @in contains only small integers:

```
@out = grep(!$saw[$_]++, @in);
```

d) A way to do (b) without any loops or greps:

```
undef %saw;
@saw{@in} = ();
@out = sort keys %saw;  # remove sort if undesired
```

e) Like (d), but @in contains only small positive integers:

```
undef @ary;
@ary[@in] = @in;
@out = grep {defined} @ary;
```

But perhaps you should have been using a hash all along, eh?

How can I tell whether a list or array contains a certain element?

Hearing the word "in" is an *in*dication that you probably should have used a hash, not a list or array, to store your data. Hashes are designed to answer this question quickly and efficiently. Arrays aren't.

That being said, there are several ways to approach this. If you are going to make this query many times over arbitrary string values, the fastest way is probably to invert the original array and keep an associative array lying about whose keys are the first array's values.

```
@blues = qw/azure cerulean teal turquoise lapis-lazuli/;
undef %is_blue;
for (@blues) { $is_blue{$_} = 1 }
```

Now you can check whether `$is_blue{$some_color}`. It might have been a good idea to keep the blues all in a hash in the first place.

If the values are all small integers, you could use a simple indexed array. This kind of an array will take up less space:

```
@primes = (2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31);
undef @is_tiny_prime;
for (@primes) { $is_tiny_prime[$_] = 1 }
# or simply  @istiny_prime[@primes] = (1) x @primes;
```

Now you check whether `$is_tiny_prime[$some_number]`.

If the values in question are integers instead of strings, you can save quite a lot of space by using bit strings instead:

```
@articles = ( 1..10, 150..2000, 2017 );
undef $read;
for (@articles) { vec($read,$_,1) = 1 }
```

Now check whether `vec($read,$n,1)` is true for some `$n`.

Please do not use

```
($is_there) = grep $_ eq $whatever, @array;
```

or worse yet

```
($is_there) = grep /$whatever/, @array;
```

These are slow (checks every element even if the first matches), inefficient (same reason), and potentially buggy (what if there are regex characters in `$whatever?`). If you're only testing once, then use:

```
$is_there = 0;
foreach $elt (@array) {
    if ($elt eq $elt_to_find) {
```

```
            $is_there = 1;
            last;
        }
    }
    if ($is_there) { ... }
```

How do I compute the difference of two arrays? How do I compute the intersection of two arrays?

Use a hash. Here's code to do both and more. It assumes that each element is unique in a given array:

```
@union = @intersection = @difference = ();
%count = ();
foreach $element (@array1, @array2) { $count{$element}++ }
foreach $element (keys %count) {
    push @union, $element;
    push @{ $count{$element} > 1 ? \@intersection : \@difference }, $element;
}
```

Note that this is the *symmetric difference*, that is, all elements in either A or in B but not in both. Think of it as an xor operation.

How do I test whether two arrays or hashes are equal?

The following code works for single-level arrays. It uses a stringwise comparison, and does not distinguish defined versus undefined empty strings. Modify if you have other needs.

```
$are_equal = compare_arrays(\@frogs, \@toads);

sub compare_arrays {
    my ($first, $second) = @_;
    no warnings;  # silence spurious -w undef complaints
    return 0 unless @$first == @$second;
    for (my $i = 0; $i < @$first; $i++) {
        return 0 if $first->[$i] ne $second->[$i];
    }
    return 1;
}
```

For multilevel structures, you may wish to use an approach more like this one. It uses the CPAN module FreezeThaw:

```
use FreezeThaw qw(cmpStr);
@a = @b = ( "this", "that", [ "more", "stuff" ] );

printf "a and b contain %s arrays\n",
    cmpStr(\@a, \@b) == 0
        ? "the same"
        : "different";
```

This approach also works for comparing hashes. Here we'll demonstrate two different answers:

```
use FreezeThaw qw(cmpStr cmpStrHard);

%a = %b = ( "this" => "that", "extra" => [ "more", "stuff" ] );
$a{EXTRA} = \%b;
$b{EXTRA} = \%a;

printf "a and b contain %s hashes\n",
    cmpStr(\%a, \%b) == 0 ? "the same" : "different";

printf "a and b contain %s hashes\n",
    cmpStrHard(\%a, \%b) == 0 ? "the same" : "different";
```

The first reports that both those the hashes contain the same data, while the second reports that they do not. Which you prefer is left as an exercise to the reader.

How do I find the first array element for which a condition is true?

You can use this if you care about the index:

```
for ($i= 0; $i < @array; $i++) {
    if ($array[$i] eq "Waldo") {
        $found_index = $i;
        last;
    }
}
```

Now `$found_index` has what you want.

How do I handle linked lists?

In general, you usually don't need a linked list in Perl, since with regular arrays, you can push and pop or shift and unshift at either end, or you can use splice to add and/or remove arbitrary number of elements at arbitrary points. Both pop and shift are both O(1) operations on Perl's dynamic arrays. In the absence of shifts and pops, push in general needs to reallocate on the order every log(N) times, and unshift will need to copy pointers each time.

If you really, really wanted, you could use structures as described in *perldsc* or *perltoot* and do just what the algorithm book tells you to do. For example, imagine a list node like this:

```
$node = {
    VALUE => 42,
    LINK  => undef,
};
```

You could walk the list this way:

```
print "List: ";
for ($node = $head;  $node; $node = $node->{LINK}) {
    print $node->{VALUE}, " ";
}
print "\n";
```

You could add to the list this way:

```
my ($head, $tail);
$tail = append($head, 1);       # grow a new head
for $value ( 2 .. 10 ) {
    $tail = append($tail, $value);
}

sub append {
    my($list, $value) = @_;
    my $node = { VALUE => $value };
    if ($list) {
        $node->{LINK} = $list->{LINK};
        $list->{LINK} = $node;
    } else {
        $_[0] = $node;      # replace caller's version
    }
    return $node;
}
```

But again, Perl's built-in are virtually always good enough.

How do I handle circular lists?

Circular lists could be handled in the traditional fashion with linked lists, or you could just do something like this with an array:

```
unshift(@array, pop(@array));  # the last shall be first
push(@array, shift(@array));   # and vice versa
```

How do I shuffle an array randomly?

Use this:

```
# fisher_yates_shuffle( \@array ) :
# generate a random permutation of @array in place
sub fisher_yates_shuffle {
    my $array = shift;
    my $i;
    for ($i = @$array; --$i; ) {
        my $j = int rand ($i+1);
        @$array[$i,$j] = @$array[$j,$i];
    }
}

fisher_yates_shuffle( \@array );    # permutes @array in place
```

You've probably seen shuffling algorithms that work using splice, randomly picking another element to swap the current element with

```
srand;
@new = ();
@old = 1 .. 10;  # just a demo
while (@old) {
    push(@new, splice(@old, rand @old, 1));
}
```

This is bad because splice is already O(N), and since you do it N times, you just invented a quadratic algorithm; that is, O(N**2). This does not scale, although Perl is so efficient that you probably won't notice this until you have rather largish arrays.

How do I process/modify each element of an array?

Use `for`/`foreach`:

```
for (@lines) {
    s/foo/bar/;     # change that word
    y/XZ/ZX/;       # swap those letters
}
```

Here's another; let's compute spherical volumes:

```
for (@volumes = @radii) {   # @volumes has changed parts
    $_ **= 3;
    $_ *= (4/3) * 3.14159;  # this will be constant folded
}
```

If you want to do the same thing to modify the values of the hash, you may not use the `values` function, oddly enough. You need a slice:

```
for $orbit ( @orbits{keys %orbits} ) {
    ($orbit **= 3) *= (4/3) * 3.14159;
}
```

How do I select a random element from an array?

Use the `rand()` function (see *rand*):

```
# at the top of the program:
srand;                      # not needed for 5.004 and later

# then later on
$index   = rand @array;
$element = $array[$index];
```

Make sure you *only call srand once per program, if then*. If you are calling it more than once (such as before each call to rand), you're almost certainly doing something wrong.

How do I permute N elements of a list?

Here's a little program that generates all permutations of all the words on each line of input. The algorithm embodied in the `permute()` function should work on any list:

```
#!/usr/bin/perl -n
# tsc-permute: permute each word of input
permute([split], []);
sub permute {
    my @items = @{ $_[0] };
    my @perms = @{ $_[1] };
    unless (@items) {
        print "@perms\n";
    } else {
        my(@newitems,@newperms,$i);
        foreach $i (0 .. $#items) {
            @newitems = @items;
            @newperms = @perms;
            unshift(@newperms, splice(@newitems, $i, 1));
            permute([@newitems], [@newperms]);
        }
    }
}
```

How do I sort an array by (anything)?

Supply a comparison function to `sort()` (described in *sort*):

```
@list = sort { $a <=> $b } @list;
```

The default sort function is cmp, string comparison, which would sort `(1, 2, 10)` into `(1, 10, 2)`. `<=>`, used above, is the numerical comparison operator.

If you have a complicated function needed to pull out the part you want to sort on, then don't do it inside the sort function. Pull it out first, because the sort BLOCK can be called many times for the same element. Here's an example of how to pull out the first word after the first number on each item, and then sort those words case-insensitively.

```
@idx = ();
for (@data) {
    ($item) = /\d+\s*(\S+)/;
    push @idx, uc($item);
}
@sorted = @data[ sort { $idx[$a] cmp $idx[$b] } 0 .. $#idx ];
```

which could also be written this way, using a trick that's come to be known as the Schwartzian Transform:

```
@sorted = map  { $_->[0] }
```

```
            sort { $a->[1] cmp $b->[1] }
            map  { [ $_, uc( (/\d+\s*(\S+)/)[0]) ] } @data;
```

If you need to sort on several fields, the following paradigm is useful.

```
@sorted = sort { field1($a) <=> field1($b) ||
                 field2($a) cmp field2($b) ||
                 field3($a) cmp field3($b)
               }     @data;
```

This can be conveniently combined with precalculation of keys as given above.

See http://www.perl.com/CPAN/doc/FMTEYEWTK/sort.html for more about this approach.

See also the question below on sorting hashes.

How do I manipulate arrays of bits?

Use `pack()` and `unpack()`, or else `vec()` and the bitwise operations.

For example, this sets `$vec` to have bit N set if `$ints[N]` was set:

```
$vec = '';
foreach(@ints) { vec($vec,$_,1) = 1 }
```

And here's how, given a vector in `$vec`, you can get those bits into your @ints array:

```
sub bitvec_to_list {
    my $vec = shift;
    my @ints;
    # Find null-byte density then select best algorithm
    if ($vec =~ tr/\0// / length $vec > 0.95) {
        use integer;
        my $i;
        # This method is faster with mostly null-bytes
        while($vec =~ /[^\0]/g ) {
            $i = -9 + 8 * pos $vec;
            push @ints, $i if vec($vec, ++$i, 1);
            push @ints, $i if vec($vec, ++$i, 1);
            push @ints, $i if vec($vec, ++$i, 1);
            push @ints, $i if vec($vec, ++$i, 1);
            push @ints, $i if vec($vec, ++$i, 1);
            push @ints, $i if vec($vec, ++$i, 1);
            push @ints, $i if vec($vec, ++$i, 1);
            push @ints, $i if vec($vec, ++$i, 1);
        }
    } else {
        # This method is a fast general algorithm
        use integer;
        my $bits = unpack "b*", $vec;
        push @ints, 0 if $bits =~ s/^(\d)// && $1;
        push @ints, pos $bits while($bits =~ /1/g);
    }
    return \@ints;
}
```

This method gets faster the more sparse the bit vector is. (Courtesy of Tim Bunce and Winfried Koenig.)

Here's a demo on how to use `vec()`:

```
# vec demo
$vector = "\xff\x0f\xef\xfe";
```

```
print "Ilya's string \\xff\\x0f\\xef\\xfe represents the number ",
    unpack("N", $vector), "\n";
$is_set = vec($vector, 23, 1);
print "Its 23rd bit is ", $is_set ? "set" : "clear", ".\n";
pvec($vector);

set_vec(1,1,1);
set_vec(3,1,1);
set_vec(23,1,1);

set_vec(3,1,3);
set_vec(3,2,3);
set_vec(3,4,3);
set_vec(3,4,7);
set_vec(3,8,3);
set_vec(3,8,7);

set_vec(0,32,17);
set_vec(1,32,17);

sub set_vec {
    my ($offset, $width, $value) = @_;
    my $vector = '';
    vec($vector, $offset, $width) = $value;
    print "offset=$offset width=$width value=$value\n";
    pvec($vector);
}

sub pvec {
    my $vector = shift;
    my $bits = unpack("b*", $vector);
    my $i = 0;
    my $BASE = 8;

    print "vector length in bytes: ", length($vector), "\n";
    @bytes = unpack("A8" x length($vector), $bits);
    print "bits are: @bytes\n\n";
}
```

Why does `defined()` return true on empty arrays and hashes?

The short story is that you should probably only use defined on scalars or functions, not on aggregates (arrays and hashes). See *defined* in the 5.004 release or later of Perl for more detail.

Data: Hashes (Associative Arrays)

How do I process an entire hash?

Use the `each()` function (see *each*) if you don't care whether it's sorted:

```
while ( ($key, $value) = each %hash) {
    print "$key = $value\n";
}
```

If you want it sorted, you'll have to use `foreach()` on the result of sorting the keys as shown in an earlier question.

What happens if I add or remove keys from a hash while iterating over it?

Don't do that. :-)

[lwall] In Perl 4, you were not allowed to modify a hash at all while iterating over it. In Perl 5 you can delete from it, but you still can't add to it, because that might cause a doubling of the hash table, in which half the

entries get copied up to the new top half of the table, at which point you've totally bamboozled the iterator code. Even if the table doesn't double, there's no telling whether your new entry will be inserted before or after the current iterator position.

Either treasure up your changes and make them after the iterator finishes or use keys to fetch all the old keys at once, and iterate over the list of keys.

How do I look up a hash element by value?

Create a reverse hash:

```
%by_value = reverse %by_key;
$key = $by_value{$value};
```

That's not particularly efficient. It would be more space-efficient to use:

```
while (($key, $value) = each %by_key) {
    $by_value{$value} = $key;
}
```

If your hash could have repeated values, the methods above will only find one of the associated keys. This may or may not worry you. If it does worry you, you can always reverse the hash into a hash of arrays instead:

```
 while (($key, $value) = each %by_key) {
     push @{$key_list_by_value{$value}}, $key;
 }
```

How can I know how many entries are in a hash?

If you mean how many keys, then all you have to do is take the scalar sense of the `keys()` function:

```
$num_keys = scalar keys %hash;
```

The `keys()` function also resets the iterator, which in void context is faster for tied hashes than would be iterating through the whole hash, one key-value pair at a time.

How do I sort a hash (optionally by value instead of key)?

Internally, hashes are stored in a way that prevents you from imposing an order on key-value pairs. Instead, you have to sort a list of the keys or values:

```
@keys = sort keys %hash;    # sorted by key
@keys = sort {
                $hash{$a} cmp $hash{$b}
        } keys %hash;       # and by value
```

Here we'll do a reverse numeric sort by value, and if two keys are identical, sort by length of key, or if that fails, by straight ASCII comparison of the keys (well, possibly modified by your locale—see *perllocale*).

```
@keys = sort {
            $hash{$b} <=> $hash{$a}
                      ||
            length($b) <=> length($a)
                      ||
                  $a cmp $b
} keys %hash;
```

How can I always keep my hash sorted?

You can look into using the DB_File module and `tie()` using the `$DB_BTREE` hash bindings as documented in *In Memory Databases in DB_File*. The Tie::IxHash module from CPAN might also be instructive.

What's the difference between "delete" and "undef" with hashes?

Hashes are pairs of scalars: the first is the key, the second is the value. The key will be coerced to a string, although the value can be any kind of scalar: string, number, or reference. If a key `$key` is present in the array, `exists($key)` will return true. The value for a given key can be `undef`, in which case `$array{$key}` will be `undef` while `$exists{$key}` will return true. This corresponds to (`$key`, `undef`) being in the hash.

Pictures help... here's the `%ary` table:

```
  keys  values
+------+------+
|  a   |  3   |
|  x   |  7   |
|  d   |  0   |
|  e   |  2   |
+------+------+
```

And these conditions hold

```
$ary{'a'}                       is true
$ary{'d'}                       is false
defined $ary{'d'}               is true
defined $ary{'a'}               is true
exists $ary{'a'}                is true (Perl5 only)
grep ($_ eq 'a', keys %ary)     is true
```

If you now say

```
undef $ary{'a'}
```

your table now reads:

```
  keys  values
+------+------+
|  a   | undef|
|  x   |  7   |
|  d   |  0   |
|  e   |  2   |
+------+------+
```

and these conditions now hold; changes in caps:

```
$ary{'a'}                       is FALSE
$ary{'d'}                       is false
defined $ary{'d'}               is true
defined $ary{'a'}               is FALSE
exists $ary{'a'}                is true (Perl5 only)
grep ($_ eq 'a', keys %ary)     is true
```

Notice the last two: you have an undef value, but a defined key!

Now, consider this:

```
delete $ary{'a'}
```

your table now reads:

```
  keys  values
+------+------+
|  x   |  7   |
|  d   |  0   |
```

```
|  e   |  2   |
+------+------+
```

and these conditions now hold; changes in caps:

```
$ary{'a'}                       is false
$ary{'d'}                       is false
defined $ary{'d'}               is true
defined $ary{'a'}               is false
exists $ary{'a'}                is FALSE (Perl5 only)
grep ($_ eq 'a', keys %ary)     is FALSE
```

See, the whole entry is gone!

Why don't my tied hashes make the defined/exists distinction?

They may or may not implement the `EXISTS()` and `DEFINED()` methods differently. For example, there isn't the concept of undef with hashes that are tied to DBM* files. This means the true/false tables above will give different results when used on such a hash. It also means that exists and defined do the same thing with a DBM* file, and what they end up doing is not what they do with ordinary hashes.

How do I reset an `each()` operation part–way through?

Using `keys %hash` in scalar context returns the number of keys in the hash *and* resets the iterator associated with the hash. You may need to do this if you use `last` to exit a loop early so that when you re–enter it, the hash iterator has been reset.

How can I get the unique keys from two hashes?

First you extract the keys from the hashes into lists, then solve the "removing duplicates" problem described above. For example:

```
%seen = ();
for $element (keys(%foo), keys(%bar)) {
    $seen{$element}++;
}
@uniq = keys %seen;
```

Or more succinctly:

```
@uniq = keys %{{%foo,%bar}};
```

Or if you really want to save space:

```
%seen = ();
while (defined ($key = each %foo)) {
    $seen{$key}++;
}
while (defined ($key = each %bar)) {
    $seen{$key}++;
}
@uniq = keys %seen;
```

How can I store a multidimensional array in a DBM file?

Either stringify the structure yourself (no fun), or else get the MLDBM (which uses Data::Dumper) module from CPAN and layer it on top of either DB_File or GDBM_File.

How can I make my hash remember the order I put elements into it?

Use the Tie::IxHash from CPAN.

```
use Tie::IxHash;
tie(%myhash, Tie::IxHash);
for ($i=0; $i<20; $i++) {
    $myhash{$i} = 2*$i;
```

```
}
@keys = keys %myhash;
# @keys = (0,1,2,3,...)
```

Why does passing a subroutine an undefined element in a hash create it?

If you say something like:

```
somefunc($hash{"nonesuch key here"});
```

Then that element "autovivifies"; that is, it springs into existence whether you store something there or not. That's because functions get scalars passed in by reference. If `somefunc()` modifies `$_[0]`, it has to be ready to write it back into the caller's version.

This has been fixed as of Perl5.004.

Normally, merely accessing a key's value for a nonexistent key does *not* cause that key to be forever there. This is different than awk's behavior.

How can I make the Perl equivalent of a C structure/C++ class/hash or array of hashes or arrays?

Usually a hash ref, perhaps like this:

```
$record = {
    NAME   => "Jason",
    EMPNO  => 132,
    TITLE  => "deputy peon",
    AGE    => 23,
    SALARY => 37_000,
    PALS   => [ "Norbert", "Rhys", "Phineas"],
};
```

References are documented in *perlref* and the upcoming *perlreftut*. Examples of complex data structures are given in *perldsc* and *perllol*. Examples of structures and object–oriented classes are in *perltoot*.

How can I use a reference as a hash key?

You can't do this directly, but you could use the standard Tie::Refhash module distributed with Perl.

Data: Misc

How do I handle binary data correctly?

Perl is binary clean, so this shouldn't be a problem. For example, this works fine (assuming the files are found):

```
if (`cat /vmunix` =~ /gzip/) {
    print "Your kernel is GNU-zip enabled!\n";
}
```

On less elegant (read: Byzantine) systems, however, you have to play tedious games with "text" versus "binary" files. See *binmode in perlfunc* or *perlopentut*. Most of these ancient–thinking systems are curses out of Microsoft, who seem to be committed to putting the backward into backward compatibility.

If you're concerned about 8–bit ASCII data, then see *perllocale*.

If you want to deal with multibyte characters, however, there are some gotchas. See the section on Regular Expressions.

How do I determine whether a scalar is a number/whole/integer/float?

Assuming that you don't care about IEEE notations like "NaN" or "Infinity", you probably just want to use a regular expression.

```
if (/\D/)            { print "has nondigits\n" }
if (/^\d+$/)         { print "is a whole number\n" }
if (/^-?\d+$/)       { print "is an integer\n" }
```

```
if (/^[+-]?\d+$/)     { print "is a +/- integer\n" }
if (/^-?\d+\.?\d*$/) { print "is a real number\n" }
if (/^-?(?:\d+(?:\.\d*)?|\.\d+)$/) { print "is a decimal number" }
if (/^([+-]?)(?=\d|\.\d)\d*(\.\d*)?([Ee]([+-]?\d+))?$/)
                      { print "a C float" }
```

If you're on a POSIX system, Perl's supports the `POSIX::strtod` function. Its semantics are somewhat cumbersome, so here's a `getnum` wrapper function for more convenient access. This function takes a string and returns the number it found, or `undef` for input that isn't a C float. The `is_numeric` function is a front end to `getnum` if you just want to say, ''Is this a float?''

```
sub getnum {
    use POSIX qw(strtod);
    my $str = shift;
    $str =~ s/^\s+//;
    $str =~ s/\s+$//;
    $! = 0;
    my($num, $unparsed) = strtod($str);
    if (($str eq '') || ($unparsed != 0) || $!) {
        return undef;
    } else {
        return $num;
    }
}

sub is_numeric { defined getnum($_[0]) }
```

Or you could check out the String::Scanf module on CPAN instead. The POSIX module (part of the standard Perl distribution) provides the `strtod` and `strtol` for converting strings to double and longs, respectively.

How do I keep persistent data across program calls?

For some specific applications, you can use one of the DBM modules. See *AnyDBM_File*. More generically, you should consult the FreezeThaw, Storable, or Class::Eroot modules from CPAN. Here's one example using Storable's `store` and `retrieve` functions:

```
use Storable;
store(\%hash, "filename");

# later on...
$href = retrieve("filename");        # by ref
%hash = %{ retrieve("filename") };   # direct to hash
```

How do I print out or copy a recursive data structure?

The Data::Dumper module on CPAN (or the 5.005 release of Perl) is great for printing out data structures. The Storable module, found on CPAN, provides a function called `dclone` that recursively copies its argument.

```
use Storable qw(dclone);
$r2 = dclone($r1);
```

Where `$r1` can be a reference to any kind of data structure you'd like. It will be deeply copied. Because `dclone` takes and returns references, you'd have to add extra punctuation if you had a hash of arrays that you wanted to copy.

```
%newhash = %{ dclone(\%oldhash) };
```

How do I define methods for every class/object?

Use the UNIVERSAL class (see *UNIVERSAL*).

How do I verify a credit card checksum?

Get the Business::CreditCard module from CPAN.

How do I pack arrays of doubles or floats for XS code?

The kgbpack.c code in the PGPLOT module on CPAN does just this. If you're doing a lot of float or double processing, consider using the PDL module from CPAN instead—it makes number−crunching easy.

AUTHOR AND COPYRIGHT

NAME

perlfaq5 – Files and Formats (`$Revision: 1.38 $, $Date: 1999/05/23 16:08:30 $`)

DESCRIPTION

This section deals with I/O and the "f" issues: filehandles, flushing, formats, and footers.

How do I flush/unbuffer an output filehandle? Why must I do this?

The C standard I/O library (stdio) normally buffers characters sent to devices. This is done for efficiency reasons so that there isn't a system call for each byte. Any time you use `print()` or `write()` in Perl, you go though this buffering. `syswrite()` circumvents stdio and buffering.

In most stdio implementations, the type of output buffering and the size of the buffer varies according to the type of device. Disk files are block buffered, often with a buffer size of more than 2k. Pipes and sockets are often buffered with a buffer size between 1/2 and 2k. Serial devices (e.g. modems, terminals) are normally line–buffered, and stdio sends the entire line when it gets the newline.

Perl does not support truly unbuffered output (except insofar as you can `syswrite(OUT, $char, 1)`). What it does instead support is "command buffering", in which a physical write is performed after every output command. This isn't as hard on your system as unbuffering, but does get the output where you want it when you want it.

If you expect characters to get to your device when you print them there, you'll want to autoflush its handle. Use `select()` and the `$|` variable to control autoflushing (see *$|* and *select*):

```
$old_fh = select(OUTPUT_HANDLE);
$| = 1;
select($old_fh);
```

Or using the traditional idiom:

```
select((select(OUTPUT_HANDLE), $| = 1)[0]);
```

Or if don't mind slowly loading several thousand lines of module code just because you're afraid of the `$|` variable:

```
use FileHandle;
open(DEV, "+</dev/tty");      # ceci n'est pas une pipe
DEV->autoflush(1);
```

or the newer IO::* modules:

```
use IO::Handle;
open(DEV, ">/dev/printer");   # but is this?
DEV->autoflush(1);
```

or even this:

```
use IO::Socket;               # this one is kinda a pipe?
$sock = IO::Socket::INET->new(PeerAddr => 'www.perl.com',
                              PeerPort => 'http(80)',
                              Proto    => 'tcp');
die "$!" unless $sock;

$sock->autoflush();
print $sock "GET / HTTP/1.0" . "\015\012" x 2;
$document = join('', <$sock>);
print "DOC IS: $document\n";
```

Note the bizarrely hardcoded carriage return and newline in their octal equivalents. This is the ONLY way (currently) to assure a proper flush on all platforms, including Macintosh. That's the way things work in network programming: you really should specify the exact bit pattern on the network line terminator. In

practice, "\n\n" often works, but this is not portable.

See *perlfaq9* for other examples of fetching URLs over the web.

How do I change one line in a file/delete a line in a file/insert a line in the middle of a file/append to the beginning of a file?

Those are operations of a text editor. Perl is not a text editor. Perl is a programming language. You have to decompose the problem into low–level calls to read, write, open, close, and seek.

Although humans have an easy time thinking of a text file as being a sequence of lines that operates much like a stack of playing cards—or punch cards—computers usually see the text file as a sequence of bytes. In general, there's no direct way for Perl to seek to a particular line of a file, insert text into a file, or remove text from a file.

(There are exceptions in special circumstances. You can add or remove data at the very end of the file. A sequence of bytes can be replaced with another sequence of the same length. The $DB_RECNO array bindings as documented in *DB_File* also provide a direct way of modifying a file. Files where all lines are the same length are also easy to alter.)

The general solution is to create a temporary copy of the text file with the changes you want, then copy that over the original. This assumes no locking.

```
$old = $file;
$new = "$file.tmp.$$";
$bak = "$file.orig";

open(OLD, "< $old")         or die "can't open $old: $!";
open(NEW, "> $new")         or die "can't open $new: $!";

# Correct typos, preserving case
while (<OLD>) {
    s/\b(p)earl\b/${1}erl/i;
    (print NEW $_)          or die "can't write to $new: $!";
}

close(OLD)                  or die "can't close $old: $!";
close(NEW)                  or die "can't close $new: $!";

rename($old, $bak)          or die "can't rename $old to $bak: $!";
rename($new, $old)          or die "can't rename $new to $old: $!";
```

Perl can do this sort of thing for you automatically with the -i command–line switch or the closely–related $^I variable (see *perlrun* for more details). Note that -i may require a suffix on some non–Unix systems; see the platform–specific documentation that came with your port.

```
# Renumber a series of tests from the command line
perl -pi -e 's/(^\s+test\s+)\d+/ $1 . ++$count /e' t/op/taint.t

# form a script
local($^I, @ARGV) = ('.orig', glob("*.c"));
while (<>) {
    if ($. == 1) {
        print "This line should appear at the top of each file\n";
    }
    s/\b(p)earl\b/${1}erl/i;        # Correct typos, preserving case
    print;
    close ARGV if eof;              # Reset $.
}
```

If you need to seek to an arbitrary line of a file that changes infrequently, you could build up an index of byte positions of where the line ends are in the file. If the file is large, an index of every tenth or hundredth line

end would allow you to seek and read fairly efficiently. If the file is sorted, try the look.pl library (part of the standard perl distribution).

In the unique case of deleting lines at the end of a file, you can use `tell()` and `truncate()`. The following code snippet deletes the last line of a file without making a copy or reading the whole file into memory:

```
open (FH, "+< $file");
while ( <FH> ) { $addr = tell(FH) unless eof(FH) }
truncate(FH, $addr);
```

Error checking is left as an exercise for the reader.

How do I count the number of lines in a file?

One fairly efficient way is to count newlines in the file. The following program uses a feature of tr///, as documented in *perlop*. If your text file doesn't end with a newline, then it's not really a proper text file, so this may report one fewer line than you expect.

```
$lines = 0;
open(FILE, $filename) or die "Can't open `$filename': $!";
while (sysread FILE, $buffer, 4096) {
    $lines += ($buffer =~ tr/\n//);
}
close FILE;
```

This assumes no funny games with newline translations.

How do I make a temporary file name?

Use the `new_tmpfile` class method from the IO::File module to get a filehandle opened for reading and writing. Use it if you don't need to know the file's name:

```
use IO::File;
$fh = IO::File->new_tmpfile()
    or die "Unable to make new temporary file: $!";
```

If you do need to know the file's name, you can use the `tmpnam` function from the POSIX module to get a filename that you then open yourself:

```
use Fcntl;
use POSIX qw(tmpnam);

# try new temporary filenames until we get one that didn't already
# exist;  the check should be unnecessary, but you can't be too careful
do { $name = tmpnam() }
    until sysopen(FH, $name, O_RDWR|O_CREAT|O_EXCL);

# install atexit-style handler so that when we exit or die,
# we automatically delete this temporary file
END { unlink($name) or die "Couldn't unlink $name : $!" }

# now go on to use the file ...
```

If you're committed to creating a temporary file by hand, use the process ID and/or the current time-value. If you need to have many temporary files in one process, use a counter:

```
BEGIN {
    use Fcntl;
    my $temp_dir = -d '/tmp' ? '/tmp' : $ENV{TMP} || $ENV{TEMP};
    my $base_name = sprintf("%s/%d-%d-0000", $temp_dir, $$, time());
    sub temp_file {
        local *FH;
        my $count = 0;
```

```
            until (defined(fileno(FH)) || $count++ > 100) {
                $base_name =~ s/-(\d+)$/"-" . (1 + $1)/e;
                sysopen(FH, $base_name, O_WRONLY|O_EXCL|O_CREAT);
            }
            if (defined(fileno(FH))
                return (*FH, $base_name);
            } else {
                return ();
            }
        }
    }
```

How can I manipulate fixed–record–length files?

The most efficient way is using `pack()` and `unpack()`. This is faster than using `substr()` when taking many, many strings. It is slower for just a few.

Here is a sample chunk of code to break up and put back together again some fixed–format input lines, in this case from the output of a normal, Berkeley–style ps:

```
# sample input line:
#   15158 p5  T      0:00 perl /home/tchrist/scripts/now-what
$PS_T = 'A6 A4 A7 A5 A*';
open(PS, "ps|");
print scalar <PS>;
while (<PS>) {
    ($pid, $tt, $stat, $time, $command) = unpack($PS_T, $_);
    for $var (qw!pid tt stat time command!) {
        print "$var: <$$var>\n";
    }
    print 'line=', pack($PS_T, $pid, $tt, $stat, $time, $command),
            "\n";
}
```

We've used `$$var` in a way that forbidden by `use strict 'refs'`. That is, we've promoted a string to a scalar variable reference using symbolic references. This is ok in small programs, but doesn't scale well. It also only works on global variables, not lexicals.

How can I make a filehandle local to a subroutine? How do I pass filehandles between subroutines? How do I make an array of filehandles?

The fastest, simplest, and most direct way is to localize the typeglob of the filehandle in question:

```
local *TmpHandle;
```

Typeglobs are fast (especially compared with the alternatives) and reasonably easy to use, but they also have one subtle drawback. If you had, for example, a function named `TmpHandle()`, or a variable named %TmpHandle, you just hid it from yourself.

```
sub findme {
    local *HostFile;
    open(HostFile, "</etc/hosts") or die "no /etc/hosts: $!";
    local $_;               # <- VERY IMPORTANT
    while (<HostFile>) {
        print if /\b127\.(0\.0\.)?1\b/;
    }
    # *HostFile automatically closes/disappears here
}
```

Here's how to use typeglobs in a loop to open and store a bunch of filehandles. We'll use as values of the hash an ordered pair to make it easy to sort the hash in insertion order.

```
@names = qw(motd termcap passwd hosts);
my $i = 0;
foreach $filename (@names) {
    local *FH;
    open(FH, "/etc/$filename") || die "$filename: $!";
    $file{$filename} = [ $i++, *FH ];
}

# Using the filehandles in the array
foreach $name (sort { $file{$a}[0] <=> $file{$b}[0] } keys %file) {
    my $fh = $file{$name}[1];
    my $line = <$fh>;
    print "$name $. $line";
}
```

For passing filehandles to functions, the easiest way is to preface them with a star, as in func(*STDIN). See *Passing Filehandles in perlfaq7* for details.

If you want to create many anonymous handles, you should check out the Symbol, FileHandle, or IO::Handle (etc.) modules. Here's the equivalent code with Symbol::gensym, which is reasonably light–weight:

```
foreach $filename (@names) {
    use Symbol;
    my $fh = gensym();
    open($fh, "/etc/$filename") || die "open /etc/$filename: $!";
    $file{$filename} = [ $i++, $fh ];
}
```

Here's using the semi–object–oriented FileHandle module, which certainly isn't light–weight:

```
use FileHandle;

foreach $filename (@names) {
    my $fh = FileHandle->new("/etc/$filename") or die "$filename: $!";
    $file{$filename} = [ $i++, $fh ];
}
```

Please understand that whether the filehandle happens to be a (probably localized) typeglob or an anonymous handle from one of the modules in no way affects the bizarre rules for managing indirect handles. See the next question.

How can I use a filehandle indirectly?

An indirect filehandle is using something other than a symbol in a place that a filehandle is expected. Here are ways to get indirect filehandles:

```
$fh =   SOME_FH;       # bareword is strict-subs hostile
$fh =  "SOME_FH";      # strict-refs hostile; same package only
$fh =  *SOME_FH;       # typeglob
$fh = \*SOME_FH;       # ref to typeglob (bless-able)
$fh =  *SOME_FH{IO};   # blessed IO::Handle from *SOME_FH typeglob
```

Or, you can use the new method from the FileHandle or IO modules to create an anonymous filehandle, store that in a scalar variable, and use it as though it were a normal filehandle.

```
use FileHandle;
$fh = FileHandle->new();

use IO::Handle;                     # 5.004 or higher
$fh = IO::Handle->new();
```

Then use any of those as you would a normal filehandle. Anywhere that Perl is expecting a filehandle, an

indirect filehandle may be used instead. An indirect filehandle is just a scalar variable that contains a filehandle. Functions like `print`, `open`, `seek`, or the `< <FH` diamond operator will accept either a read filehandle or a scalar variable containing one:

```
($ifh, $ofh, $efh) = (*STDIN, *STDOUT, *STDERR);
print $ofh "Type it: ";
$got = <$ifh>
print $efh "What was that: $got";
```

If you're passing a filehandle to a function, you can write the function in two ways:

```
sub accept_fh {
    my $fh = shift;
    print $fh "Sending to indirect filehandle\n";
}
```

Or it can localize a typeglob and use the filehandle directly:

```
sub accept_fh {
    local *FH = shift;
    print  FH "Sending to localized filehandle\n";
}
```

Both styles work with either objects or typeglobs of real filehandles. (They might also work with strings under some circumstances, but this is risky.)

```
accept_fh(*STDOUT);
accept_fh($handle);
```

In the examples above, we assigned the filehandle to a scalar variable before using it. That is because only simple scalar variables, not expressions or subscripts of hashes or arrays, can be used with built-ins like `print`, `printf`, or the diamond operator. Using something other than a simple scalar varaible as a filehandle is illegal and won't even compile:

```
@fd = (*STDIN, *STDOUT, *STDERR);
print $fd[1] "Type it: ";                          # WRONG
$got = <$fd[0]>                                    # WRONG
print $fd[2] "What was that: $got";                # WRONG
```

With `print` and `printf`, you get around this by using a block and an expression where you would place the filehandle:

```
print  { $fd[1] } "funny stuff\n";
printf { $fd[1] } "Pity the poor %x.\n", 3_735_928_559;
# Pity the poor deadbeef.
```

That block is a proper block like any other, so you can put more complicated code there. This sends the message out to one of two places:

```
$ok = -x "/bin/cat";
print { $ok ? $fd[1] : $fd[2] } "cat stat $ok\n";
print { $fd[ 1+ ($ok || 0) ]  } "cat stat $ok\n";
```

This approach of treating `print` and `printf` like object methods calls doesn't work for the diamond operator. That's because it's a real operator, not just a function with a comma-less argument. Assuming you've been storing typeglobs in your structure as we did above, you can use the built-in function named `readline` to reads a record just as `< <` does. Given the initialization shown above for @fd, this would work, but only because `readline()` require a typeglob. It doesn't work with objects or strings, which might be a bug we haven't fixed yet.

```
$got = readline($fd[0]);
```

Let it be noted that the flakiness of indirect filehandles is not related to whether they're strings, typeglobs, objects, or anything else. It's the syntax of the fundamental operators. Playing the object game doesn't help you at all here.

How can I set up a footer format to be used with `write()`?

There's no builtin way to do this, but *perlform* has a couple of techniques to make it possible for the intrepid hacker.

How can I `write()` into a string?

See *Accessing Formatting Internals in perlform* for an `swrite()` function.

How can I output my numbers with commas added?

This one will do it for you:

```
sub commify {
    local $_  = shift;
    1 while s/^([-+]?\d+)(\d{3})/$1,$2/;
    return $_;
}

$n = 23659019423.2331;
print "GOT: ", commify($n), "\n";

GOT: 23,659,019,423.2331
```

You can't just:

```
s/^([-+]?\d+)(\d{3})/$1,$2/g;
```

because you have to put the comma in and then recalculate your position.

Alternatively, this code commifies all numbers in a line regardless of whether they have decimal portions, are preceded by + or –, or whatever:

```
# from Andrew Johnson <ajohnson@gpu.srv.ualberta.ca>
sub commify {
   my $input = shift;
    $input = reverse $input;
    $input =~ s<(\d\d\d)(?=\d)(?!\d*\.)><$1,>g;
    return scalar reverse $input;
}
```

How can I translate tildes (~) in a filename?

Use the `< (glob())` operator, documented in *perlfunc*. This requires that you have a shell installed that groks tildes, meaning csh or tcsh or (some versions of) ksh, and thus your code may have portability problems. The Glob::KGlob module (available from CPAN) gives more portable glob functionality.

Within Perl, you may use this directly:

```
$filename =~ s{
  ^ ~             # find a leading tilde
  (               # save this in $1
      [^/]        # a non-slash character
            *     # repeated 0 or more times (0 means me)
  )
}{
  $1
      ? (getpwnam($1))[7]
      : ( $ENV{HOME} || $ENV{LOGDIR} )
}ex;
```

How come when I open a file read–write it wipes it out?

Because you're using something like this, which truncates the file and *then* gives you read–write access:

```
open(FH, "+> /path/name");          # WRONG (almost always)
```

Whoops. You should instead use this, which will fail if the file doesn't exist.

```
open(FH, "+< /path/name");          # open for update
```

Using "" always clobbers or creates. Using "<" never does either. The "+" doesn't change this.

Here are examples of many kinds of file opens. Those using `sysopen()` all assume

```
use Fcntl;
```

To open file for reading:

```
open(FH, "< $path")                                 || die $!;
sysopen(FH, $path, O_RDONLY)                        || die $!;
```

To open file for writing, create new file if needed or else truncate old file:

```
open(FH, "> $path") || die $!;
sysopen(FH, $path, O_WRONLY|O_TRUNC|O_CREAT)        || die $!;
sysopen(FH, $path, O_WRONLY|O_TRUNC|O_CREAT, 0666)  || die $!;
```

To open file for writing, create new file, file must not exist:

```
sysopen(FH, $path, O_WRONLY|O_EXCL|O_CREAT)         || die $!;
sysopen(FH, $path, O_WRONLY|O_EXCL|O_CREAT, 0666)   || die $!;
```

To open file for appending, create if necessary:

```
open(FH, ">> $path") || die $!;
sysopen(FH, $path, O_WRONLY|O_APPEND|O_CREAT)       || die $!;
sysopen(FH, $path, O_WRONLY|O_APPEND|O_CREAT, 0666) || die $!;
```

To open file for appending, file must exist:

```
sysopen(FH, $path, O_WRONLY|O_APPEND)               || die $!;
```

To open file for update, file must exist:

```
open(FH, "+< $path")                                || die $!;
sysopen(FH, $path, O_RDWR)                          || die $!;
```

To open file for update, create file if necessary:

```
sysopen(FH, $path, O_RDWR|O_CREAT)                  || die $!;
sysopen(FH, $path, O_RDWR|O_CREAT, 0666)            || die $!;
```

To open file for update, file must not exist:

```
sysopen(FH, $path, O_RDWR|O_EXCL|O_CREAT)           || die $!;
sysopen(FH, $path, O_RDWR|O_EXCL|O_CREAT, 0666)     || die $!;
```

To open a file without blocking, creating if necessary:

```
sysopen(FH, "/tmp/somefile", O_WRONLY|O_NDELAY|O_CREAT)
        or die "can't open /tmp/somefile: $!":
```

Be warned that neither creation nor deletion of files is guaranteed to be an atomic operation over NFS. That is, two processes might both successfully create or unlink the same file! Therefore O_EXCL isn't as exclusive as you might wish.

See also the new *perlopentut* if you have it (new for 5.6).

Why do I sometimes get an "Argument list too long" when I use <*?

The `< <` operator performs a globbing operation (see above). In Perl versions earlier than v5.6.0, the internal `glob()` operator forks csh(1) to do the actual glob expansion, but csh can't handle more than 127 items and so gives the error message `Argument list too long`. People who installed tcsh as csh won't have this problem, but their users may be surprised by it.

To get around this, either upgrade to Perl v5.6.0 or later, do the glob yourself with `readdir()` and patterns, or use a module like Glob::KGlob, one that doesn't use the shell to do globbing.

Is there a leak/bug in `glob()`?

Due to the current implementation on some operating systems, when you use the `glob()` function or its angle-bracket alias in a scalar context, you may cause a memory leak and/or unpredictable behavior. It's best therefore to use `glob()` only in list context.

How can I open a file with a leading "" or trailing blanks?

Normally perl ignores trailing blanks in filenames, and interprets certain leading characters (or a trailing "|") to mean something special. To avoid this, you might want to use a routine like the one below. It turns incomplete pathnames into explicit relative ones, and tacks a trailing null byte on the name to make perl leave it alone:

```
sub safe_filename {
    local $_  = shift;
    s#^([^./])#./$1#;
    $_ .= "\0";
    return $_;
}

$badpath = "<<<something really wicked   ";
$fn = safe_filename($badpath");
open(FH, "> $fn") or "couldn't open $badpath: $!";
```

This assumes that you are using POSIX (portable operating systems interface) paths. If you are on a closed, non-portable, proprietary system, you may have to adjust the `"./"` above.

It would be a lot clearer to use `sysopen()`, though:

```
use Fcntl;
$badpath = "<<<something really wicked   ";
sysopen (FH, $badpath, O_WRONLY | O_CREAT | O_TRUNC)
    or die "can't open $badpath: $!";
```

For more information, see also the new *perlopentut* if you have it (new for 5.6).

How can I reliably rename a file?

Well, usually you just use Perl's `rename()` function. That may not work everywhere, though, particularly when renaming files across file systems. Some sub-Unix systems have broken ports that corrupt the semantics of `rename()`—for example, WinNT does this right, but Win95 and Win98 are broken. (The last two parts are not surprising, but the first is. :-)

If your operating system supports a proper mv(1) program or its moral equivalent, this works:

```
rename($old, $new) or system("mv", $old, $new);
```

It may be more compelling to use the File::Copy module instead. You just copy to the new file to the new name (checking return values), then delete the old one. This isn't really the same semantically as a real `rename()`, though, which preserves metainformation like permissions, timestamps, inode info, etc.

Newer versions of File::Copy exports a `move()` function.

How can I lock a file?

Perl's builtin `flock()` function (see *perlfunc* for details) will call flock(2) if that exists, fcntl(2) if it doesn't (on perl version 5.004 and later), and lockf(3) if neither of the two previous system calls exists. On some systems, it may even use a different form of native locking. Here are some gotchas with Perl's `flock()`:

1 Produces a fatal error if none of the three system calls (or their close equivalent) exists.

2 lockf(3) does not provide shared locking, and requires that the filehandle be open for writing (or appending, or read/writing).

3 Some versions of `flock()` can't lock files over a network (e.g. on NFS file systems), so you'd need to force the use of fcntl(2) when you build Perl. But even this is dubious at best. See the flock entry of *perlfunc* and the ***INSTALL*** file in the source distribution for information on building Perl to do this.

Two potentially non-obvious but traditional flock semantics are that it waits indefinitely until the lock is granted, and that its locks are *merely advisory*. Such discretionary locks are more flexible, but offer fewer guarantees. This means that files locked with `flock()` may be modified by programs that do not also use `flock()`. Cars that stop for red lights get on well with each other, but not with cars that don't stop for red lights. See the perlport manpage, your port's specific documentation, or your system-specific local manpages for details. It's best to assume traditional behavior if you're writing portable programs. (If you're not, you should as always feel perfectly free to write for your own system's idiosyncrasies (sometimes called "features"). Slavish adherence to portability concerns shouldn't get in the way of your getting your job done.)

For more information on file locking, see also *File Locking in perlopentut* if you have it (new for 5.6).

Why can't I just open(FH, "file.lock")?

A common bit of code **NOT TO USE** is this:

```
sleep(3) while -e "file.lock";      # PLEASE DO NOT USE
open(LCK, "> file.lock");           # THIS BROKEN CODE
```

This is a classic race condition: you take two steps to do something which must be done in one. That's why computer hardware provides an atomic test-and-set instruction. In theory, this "ought" to work:

```
sysopen(FH, "file.lock", O_WRONLY|O_EXCL|O_CREAT)
            or die "can't open  file.lock: $!":
```

except that lamentably, file creation (and deletion) is not atomic over NFS, so this won't work (at least, not every time) over the net. Various schemes involving `link()` have been suggested, but these tend to involve busy-wait, which is also subdesirable.

I still don't get locking. I just want to increment the number in the file. How can I do this?

Didn't anyone ever tell you web-page hit counters were useless? They don't count number of hits, they're a waste of time, and they serve only to stroke the writer's vanity. It's better to pick a random number; they're more realistic.

Anyway, this is what you can do if you can't help yourself.

```
use Fcntl qw(:DEFAULT :flock);
sysopen(FH, "numfile", O_RDWR|O_CREAT)       or die "can't open numfile: $!";
flock(FH, LOCK_EX)                           or die "can't flock numfile: $!";
$num = <FH> || 0;
seek(FH, 0, 0)                               or die "can't rewind numfile: $!";
truncate(FH, 0)                              or die "can't truncate numfile: $!";
(print FH $num+1, "\n")                      or die "can't write numfile: $!";
close FH                                     or die "can't close numfile: $!";
```

Here's a much better web-page hit counter:

```
$hits = int( (time() - 850_000_000) / rand(1_000) );
```

If the count doesn't impress your friends, then the code might. :-)

How do I randomly update a binary file?

If you're just trying to patch a binary, in many cases something as simple as this works:

```
perl -i -pe 's{window manager}{window mangler}g' /usr/bin/emacs
```

However, if you have fixed sized records, then you might do something more like this:

```
$RECSIZE = 220; # size of record, in bytes
$recno   = 37;  # which record to update
open(FH, "+<somewhere") || die "can't update somewhere: $!";
seek(FH, $recno * $RECSIZE, 0);
read(FH, $record, $RECSIZE) == $RECSIZE || die "can't read record $recno: $!";
# munge the record
seek(FH, -$RECSIZE, 1);
print FH $record;
close FH;
```

Locking and error checking are left as an exercise for the reader. Don't forget them or you'll be quite sorry.

How do I get a file's timestamp in perl?

If you want to retrieve the time at which the file was last read, written, or had its meta-data (owner, etc) changed, you use the **-M**, **-A**, or **-C** filetest operations as documented in *perlfunc*. These retrieve the age of the file (measured against the start-time of your program) in days as a floating point number. To retrieve the "raw" time in seconds since the epoch, you would call the stat function, then use `localtime()`, `gmtime()`, or `POSIX::strftime()` to convert this into human-readable form.

Here's an example:

```
$write_secs = (stat($file))[9];
printf "file %s updated at %s\n", $file,
    scalar localtime($write_secs);
```

If you prefer something more legible, use the File::stat module (part of the standard distribution in version 5.004 and later):

```
# error checking left as an exercise for reader.
use File::stat;
use Time::localtime;
$date_string = ctime(stat($file)->mtime);
print "file $file updated at $date_string\n";
```

The `POSIX::strftime()` approach has the benefit of being, in theory, independent of the current locale. See *perllocale* for details.

How do I set a file's timestamp in perl?

You use the `utime()` function documented in *utime*. By way of example, here's a little program that copies the read and write times from its first argument to all the rest of them.

```
if (@ARGV < 2) {
    die "usage: cptimes timestamp_file other_files ...\n";
}
$timestamp = shift;
($atime, $mtime) = (stat($timestamp))[8,9];
utime $atime, $mtime, @ARGV;
```

Error checking is, as usual, left as an exercise for the reader.

Note that `utime()` currently doesn't work correctly with Win95/NT ports. A bug has been reported. Check it carefully before using `utime()` on those platforms.

How do I print to more than one file at once?

If you only have to do this once, you can do this:

```
for $fh (FH1, FH2, FH3) { print $fh "whatever\n" }
```

To connect up to one filehandle to several output filehandles, it's easiest to use the tee(1) program if you have it, and let it take care of the multiplexing:

```
open (FH, "| tee file1 file2 file3");
```

Or even:

```
# make STDOUT go to three files, plus original STDOUT
open (STDOUT, "| tee file1 file2 file3") or die "Teeing off: $!\n";
print "whatever\n"                       or die "Writing: $!\n";
close(STDOUT)                           or die "Closing: $!\n";
```

Otherwise you'll have to write your own multiplexing print function—or your own tee program—or use Tom Christiansen's, at http://www.perl.com/CPAN/authors/id/TOMC/scripts/tct.gz , which is written in Perl and offers much greater functionality than the stock version.

How can I read in an entire file all at once?

The customary Perl approach for processing all the lines in a file is to do so one line at a time:

```
open (INPUT, $file)         || die "can't open $file: $!";
while (<INPUT>) {
    chomp;
    # do something with $_
}
close(INPUT)                || die "can't close $file: $!";
```

This is tremendously more efficient than reading the entire file into memory as an array of lines and then processing it one element at a time, which is often—if not almost always—the wrong approach. Whenever you see someone do this:

```
@lines = <INPUT>;
```

you should think long and hard about why you need everything loaded at once. It's just not a scalable solution. You might also find it more fun to use the standard DB_File module's `$DB_RECNO` bindings, which allow you to tie an array to a file so that accessing an element the array actually accesses the corresponding line in the file.

On very rare occasion, you may have an algorithm that demands that the entire file be in memory at once as one scalar. The simplest solution to that is

```
$var = `cat $file`;
```

Being in scalar context, you get the whole thing. In list context, you'd get a list of all the lines:

```
@lines = `cat $file`;
```

This tiny but expedient solution is neat, clean, and portable to all systems on which decent tools have been installed. For those who prefer not to use the toolbox, you can of course read the file manually, although this makes for more complicated code.

```
{
    local(*INPUT, $/);
    open (INPUT, $file)     || die "can't open $file: $!";
    $var = <INPUT>;
}
```

That temporarily undefs your record separator, and will automatically close the file at block exit. If the file is already open, just use this:

```
$var = do { local $/; <INPUT> };
```

How can I read in a file by paragraphs?

Use the `$/` variable (see *perlvar* for details). You can either set it to `""` to eliminate empty paragraphs (`"abc\n\n\n\ndef"`, for instance, gets treated as two paragraphs and not three), or `"\n\n"` to accept empty paragraphs.

Note that a blank line must have no blanks in it. Thus `"fred\n \nstuff\n\n"` is one paragraph, but `"fred\n\nstuff\n\n"` is two.

How can I read a single character from a file? From the keyboard?

You can use the builtin `getc()` function for most filehandles, but it won't (easily) work on a terminal device. For STDIN, either use the Term::ReadKey module from CPAN or use the sample code in *getc*.

If your system supports the portable operating system programming interface (POSIX), you can use the following code, which you'll note turns off echo processing as well.

```
#!/usr/bin/perl -w
use strict;
$| = 1;
for (1..4) {
    my $got;
    print "gimme: ";
    $got = getone();
    print "--> $got\n";
}
exit;

BEGIN {
    use POSIX qw(:termios_h);

    my ($term, $oterm, $echo, $noecho, $fd_stdin);

    $fd_stdin = fileno(STDIN);

    $term     = POSIX::Termios->new();
    $term->getattr($fd_stdin);
    $oterm     = $term->getlflag();

    $echo     = ECHO | ECHOK | ICANON;
    $noecho   = $oterm & ~$echo;

    sub cbreak {
        $term->setlflag($noecho);
        $term->setcc(VTIME, 1);
        $term->setattr($fd_stdin, TCSANOW);
    }

    sub cooked {
        $term->setlflag($oterm);
        $term->setcc(VTIME, 0);
        $term->setattr($fd_stdin, TCSANOW);
    }

    sub getone {
        my $key = '';
        cbreak();
        sysread(STDIN, $key, 1);
```

```
        cooked();
        return $key;
    }
}
END { cooked() }
```

The Term::ReadKey module from CPAN may be easier to use. Recent versions include also support for non−portable systems as well.

```
use Term::ReadKey;
open(TTY, "</dev/tty");
print "Gimme a char: ";
ReadMode "raw";
$key = ReadKey 0, *TTY;
ReadMode "normal";
printf "\nYou said %s, char number %03d\n",
    $key, ord $key;
```

For legacy DOS systems, Dan Carson <dbc@tc.fluke.COM reports the following:

To put the PC in "raw" mode, use ioctl with some magic numbers gleaned from msdos.c (Perl source file) and Ralf Brown's interrupt list (comes across the net every so often):

```
$old_ioctl = ioctl(STDIN,0,0);      # Gets device info
$old_ioctl &= 0xff;
ioctl(STDIN,1,$old_ioctl | 32);     # Writes it back, setting bit 5
```

Then to read a single character:

```
sysread(STDIN,$c,1);                # Read a single character
```

And to put the PC back to "cooked" mode:

```
ioctl(STDIN,1,$old_ioctl);          # Sets it back to cooked mode.
```

So now you have `$c`. If `ord($c) == 0`, you have a two byte code, which means you hit a special key. Read another byte with `sysread(STDIN,$c,1)`, and that value tells you what combination it was according to this table:

```
# PC 2-byte keycodes = ^@ + the following:

# HEX     KEYS
# ---     ----
# 0F      SHF TAB
# 10-19   ALT QWERTYUIOP
# 1E-26   ALT ASDFGHJKL
# 2C-32   ALT ZXCVBNM
# 3B-44   F1-F10
# 47-49   HOME,UP,PgUp
# 4B      LEFT
# 4D      RIGHT
# 4F-53   END,DOWN,PgDn,Ins,Del
# 54-5D   SHF F1-F10
# 5E-67   CTR F1-F10
# 68-71   ALT F1-F10
# 73-77   CTR LEFT,RIGHT,END,PgDn,HOME
# 78-83   ALT 1234567890-=
# 84      CTR PgUp
```

This is all trial and error I did a long time ago; I hope I'm reading the file that worked...

How can I tell whether there's a character waiting on a filehandle?

The very first thing you should do is look into getting the Term::ReadKey extension from CPAN. As we mentioned earlier, it now even has limited support for non−portable (read: not open systems, closed, proprietary, not POSIX, not Unix, etc) systems.

You should also check out the Frequently Asked Questions list in comp.unix.* for things like this: the answer is essentially the same. It's very system dependent. Here's one solution that works on BSD systems:

```
sub key_ready {
    my($rin, $nfd);
    vec($rin, fileno(STDIN), 1) = 1;
    return $nfd = select($rin,undef,undef,0);
}
```

If you want to find out how many characters are waiting, there's also the FIONREAD ioctl call to be looked at. The *h2ph* tool that comes with Perl tries to convert C include files to Perl code, which can be `required`. FIONREAD ends up defined as a function in the *sys/ioctl.ph* file:

```
require 'sys/ioctl.ph';

$size = pack("L", 0);
ioctl(FH, FIONREAD(), $size)    or die "Couldn't call ioctl: $!\n";
$size = unpack("L", $size);
```

If *h2ph* wasn't installed or doesn't work for you, you can *grep* the include files by hand:

```
% grep FIONREAD /usr/include/*/*
/usr/include/asm/ioctls.h:#define FIONREAD      0x541B
```

Or write a small C program using the editor of champions:

```
% cat > fionread.c
#include <sys/ioctl.h>
main() {
    printf("%#08x\n", FIONREAD);
}
^D
% cc -o fionread fionread.c
% ./fionread
0x4004667f
```

And then hard−code it, leaving porting as an exercise to your successor.

```
$FIONREAD = 0x4004667f;         # XXX: opsys dependent

$size = pack("L", 0);
ioctl(FH, $FIONREAD, $size)     or die "Couldn't call ioctl: $!\n";
$size = unpack("L", $size);
```

FIONREAD requires a filehandle connected to a stream, meaning that sockets, pipes, and tty devices work, but *not* files.

How do I do a `tail -f` in perl?

First try

```
seek(GWFILE, 0, 1);
```

The statement `seek(GWFILE, 0, 1)` doesn't change the current position, but it does clear the end−of−file condition on the handle, so that the next <GWFILE makes Perl try again to read something.

If that doesn't work (it relies on features of your stdio implementation), then you need something more like

this:

```
for (;;) {
  for ($curpos = tell(GWFILE); <GWFILE>; $curpos = tell(GWFILE)) {
    # search for some stuff and put it into files
  }
  # sleep for a while
  seek(GWFILE, $curpos, 0);  # seek to where we had been
}
```

If this still doesn't work, look into the POSIX module. POSIX defines the `clearerr()` method, which can remove the end of file condition on a filehandle. The method: read until end of file, `clearerr()`, read some more. Lather, rinse, repeat.

There's also a File::Tail module from CPAN.

How do I `dup()` a filehandle in Perl?

If you check *open*, you'll see that several of the ways to call `open()` should do the trick. For example:

```
open(LOG, ">>/tmp/logfile");
open(STDERR, ">&LOG");
```

Or even with a literal numeric descriptor:

```
$fd = $ENV{MHCONTEXTFD};
open(MHCONTEXT, "<&=$fd");   # like fdopen(3S)
```

Note that `"<&STDIN"` makes a copy, but `"<&=STDIN"` make an alias. That means if you close an aliased handle, all aliases become inaccessible. This is not true with a copied one.

Error checking, as always, has been left as an exercise for the reader.

How do I close a file descriptor by number?

This should rarely be necessary, as the Perl `close()` function is to be used for things that Perl opened itself, even if it was a dup of a numeric descriptor as with MHCONTEXT above. But if you really have to, you may be able to do this:

```
require 'sys/syscall.ph';
$rc = syscall(&SYS_close, $fd + 0);  # must force numeric
die "can't sysclose $fd: $!" unless $rc == -1;
```

Or, just use the fdopen(3S) feature of `open()`:

```
{
    local *F;
    open F, "<&=$fd" or die "Cannot reopen fd=$fd: $!";
    close F;
}
```

Why can't I use "C:\temp\foo" in DOS paths? What doesn't 'C:\temp\foo.exe' work?

Whoops! You just put a tab and a formfeed into that filename! Remember that within double quoted strings ("like\this"), the backslash is an escape character. The full list of these is in *Quote and Quote-like Operators*. Unsurprisingly, you don't have a file called "c:(tab)emp(formfeed)oo" or "c:(tab)emp(formfeed)oo.exe" on your legacy DOS filesystem.

Either single-quote your strings, or (preferably) use forward slashes. Since all DOS and Windows versions since something like MS-DOS 2.0 or so have treated / and \ the same in a path, you might as well use the one that doesn't clash with Perl—or the POSIX shell, ANSI C and C++, awk, Tcl, Java, or Python, just to mention a few. POSIX paths are more portable, too.

Why doesn't glob("*.*") get all the files?

Because even on non-Unix ports, Perl's glob function follows standard Unix globbing semantics. You'll need `glob("*")` to get all (non-hidden) files. This makes `glob()` portable even to legacy systems. Your port may include proprietary globbing functions as well. Check its documentation for details.

Why does Perl let me delete read-only files? Why does `-i` clobber protected files? Isn't this a bug in Perl?

This is elaborately and painstakingly described in the "Far More Than You Ever Wanted To Know" in http://www.perl.com/CPAN/doc/FMTEYEWTK/file-dir-perms .

The executive summary: learn how your filesystem works. The permissions on a file say what can happen to the data in that file. The permissions on a directory say what can happen to the list of files in that directory. If you delete a file, you're removing its name from the directory (so the operation depends on the permissions of the directory, not of the file). If you try to write to the file, the permissions of the file govern whether you're allowed to.

How do I select a random line from a file?

Here's an algorithm from the Camel Book:

```
srand;
rand($.) < 1 && ($line = $_) while <>;
```

This has a significant advantage in space over reading the whole file in. A simple proof by induction is available upon request if you doubt the algorithm's correctness.

Why do I get weird spaces when I print an array of lines?

Saying

```
print "@lines\n";
```

joins together the elements of `@lines` with a space between them. If `@lines` were `("little", "fluffy", "clouds")` then the above statement would print

```
little fluffy clouds
```

but if each element of `@lines` was a line of text, ending a newline character `("little\n", "fluffy\n", "clouds\n")` then it would print:

```
little
 fluffy
 clouds
```

If your array contains lines, just print them:

```
print @lines;
```

AUTHOR AND COPYRIGHT

NAME

perlfaq6 – Regexes ($Revision: 1.27 $, $Date: 1999/05/23 16:08:30 $)

DESCRIPTION

This section is surprisingly small because the rest of the FAQ is littered with answers involving regular expressions. For example, decoding a URL and checking whether something is a number are handled with regular expressions, but those answers are found elsewhere in this document (in *perlfaq9*: ''How do I decode or create those %–encodings on the web'' and *perfaq4*: ''How do I determine whether a scalar is a number/whole/integer/float'', to be precise).

How can I hope to use regular expressions without creating illegible and unmaintainable code?

Three techniques can make regular expressions maintainable and understandable.

Comments Outside the Regex

Describe what you're doing and how you're doing it, using normal Perl comments.

```
# turn the line into the first word, a colon, and the
# number of characters on the rest of the line
s/^(\w+)(.*)/ lc($1) . ":" . length($2) /meg;
```

Comments Inside the Regex

The /x modifier causes whitespace to be ignored in a regex pattern (except in a character class), and also allows you to use normal comments there, too. As you can imagine, whitespace and comments help a lot.

/x lets you turn this:

```
s{<(?:[^>'"]*|".*?"|'.*?')+>}{}gs;
```

into this:

```
s{ <                    # opening angle bracket
    (?:                 # Non-backreffing grouping paren
         [^>'"] *       # 0 or more things that are neither > nor ' nor "
            |           #    or else
         ".*?"          # a section between double quotes (stingy match)
            |           #    or else
         '.*?'          # a section between single quotes (stingy match)
    ) +                 #   all occurring one or more times
   >                    # closing angle bracket
}{}gsx;                 # replace with nothing, i.e. delete
```

It's still not quite so clear as prose, but it is very useful for describing the meaning of each part of the pattern.

Different Delimiters

While we normally think of patterns as being delimited with / characters, they can be delimited by almost any character. *perlre* describes this. For example, the s/// above uses braces as delimiters. Selecting another delimiter can avoid quoting the delimiter within the pattern:

```
s/\/usr\/local/\/usr\/share/g;      # bad delimiter choice
s#/usr/local#/usr/share#g;          # better
```

I'm having trouble matching over more than one line. What's wrong?

Either you don't have more than one line in the string you're looking at (probably), or else you aren't using the correct modifier(s) on your pattern (possibly).

There are many ways to get multiline data into a string. If you want it to happen automatically while reading input, you'll want to set $/ (probably to '' for paragraphs or undef for the whole file) to allow you to read more than one line at a time.

Read *perlre* to help you decide which of /s and /m (or both) you might want to use: /s allows dot to include newline, and /m allows caret and dollar to match next to a newline, not just at the end of the string. You do need to make sure that you've actually got a multiline string in there.

For example, this program detects duplicate words, even when they span line breaks (but not paragraph ones). For this example, we don't need /s because we aren't using dot in a regular expression that we want to cross line boundaries. Neither do we need /m because we aren't wanting caret or dollar to match at any point inside the record next to newlines. But it's imperative that $/ be set to something other than the default, or else we won't actually ever have a multiline record read in.

```
$/ = '';            # read in more whole paragraph, not just one line
while ( <> ) {
    while ( /\b([\w'-]+)(\s+\1)+\b/gi ) {   # word starts alpha
        print "Duplicate $1 at paragraph $.\n";
    }
}
```

Here's code that finds sentences that begin with "From " (which would be mangled by many mailers):

```
$/ = '';            # read in more whole paragraph, not just one line
while ( <> ) {
    while ( /^From /gm ) { # /m makes ^ match next to \n
        print "leading from in paragraph $.\n";
    }
}
```

Here's code that finds everything between START and END in a paragraph:

```
undef $/;           # read in whole file, not just one line or paragraph
while ( <> ) {
    while ( /START(.*?)END/sm ) { # /s makes . cross line boundaries
        print "$1\n";
    }
}
```

How can I pull out lines between two patterns that are themselves on different lines?

You can use Perl's somewhat exotic .. operator (documented in *perlop*):

```
perl -ne 'print if /START/ .. /END/' file1 file2 ...
```

If you wanted text and not lines, you would use

```
perl -0777 -ne 'print "$1\n" while /START(.*?)END/gs' file1 file2 ...
```

But if you want nested occurrences of START through END, you'll run up against the problem described in the question in this section on matching balanced text.

Here's another example of using ..:

```
while (<>) {
    $in_header =   1  .. /^$/;
    $in_body   = /^$/ .. eof();
    # now choose between them
} continue {
    reset if eof();         # fix $.
}
```

I put a regular expression into $/ but it didn't work. What's wrong?

$/ must be a string, not a regular expression. Awk has to be better for something. :–)

Actually, you could do this if you don't mind reading the whole file into memory:

```
undef $/;
@records = split /your_pattern/, <FH>;
```

The Net::Telnet module (available from CPAN) has the capability to wait for a pattern in the input stream, or timeout if it doesn't appear within a certain time.

```
## Create a file with three lines.
open FH, ">file";
print FH "The first line\nThe second line\nThe third line\n";
close FH;

## Get a read/write filehandle to it.
$fh = new FileHandle "+<file";

## Attach it to a "stream" object.
use Net::Telnet;
$file = new Net::Telnet (-fhopen => $fh);

## Search for the second line and print out the third.
$file->waitfor('/second line\n/');
print $file->getline;
```

How do I substitute case insensitively on the LHS while preserving case on the RHS?

Here's a lovely Perlish solution by Larry Rosler. It exploits properties of bitwise xor on ASCII strings.

```
$_= "this is a TEsT case";

$old = 'test';
$new = 'success';

s{(\Q$old\E)
 { uc $new | (uc $1 ^ $1) .
    (uc(substr $1, -1) ^ substr $1, -1) x
        (length($new) - length $1)
 }egi;

print;
```

And here it is as a subroutine, modelled after the above:

```
sub preserve_case($$) {
    my ($old, $new) = @_;
    my $mask = uc $old ^ $old;

    uc $new | $mask .
        substr($mask, -1) x (length($new) - length($old))
}

$a = "this is a TEsT case";
$a =~ s/(test)/preserve_case($1, "success")/egi;
print "$a\n";
```

This prints:

```
this is a SUcCESS case
```

Just to show that C programmers can write C in any programming language, if you prefer a more C-like solution, the following script makes the substitution have the same case, letter by letter, as the original. (It also happens to run about 240% slower than the Perlish solution runs.) If the substitution has more characters than the string being substituted, the case of the last character is used for the rest of the substitution.

```
# Original by Nathan Torkington, massaged by Jeffrey Friedl
#
```

```
sub preserve_case($$)
{
    my ($old, $new) = @_;
    my ($state) = 0; # 0 = no change; 1 = lc; 2 = uc
    my ($i, $oldlen, $newlen, $c) = (0, length($old), length($new));
    my ($len) = $oldlen < $newlen ? $oldlen : $newlen;

    for ($i = 0; $i < $len; $i++) {
        if ($c = substr($old, $i, 1), $c =~ /[\W\d_]/) {
            $state = 0;
        } elsif (lc $c eq $c) {
            substr($new, $i, 1) = lc(substr($new, $i, 1));
            $state = 1;
        } else {
            substr($new, $i, 1) = uc(substr($new, $i, 1));
            $state = 2;
        }
    }
    # finish up with any remaining new (for when new is longer than old)
    if ($newlen > $oldlen) {
        if ($state == 1) {
            substr($new, $oldlen) = lc(substr($new, $oldlen));
        } elsif ($state == 2) {
            substr($new, $oldlen) = uc(substr($new, $oldlen));
        }
    }
    return $new;
}
```

How can I make `\w` match national character sets?

See *perllocale*.

How can I match a locale–smart version of `/[a-zA-Z]/`?

One alphabetic character would be `/[^\W\d_]/`, no matter what locale you're in. Non–alphabetics would be `/[\W\d_]/` (assuming you don't consider an underscore a letter).

How can I quote a variable to use in a regex?

The Perl parser will expand `$variable` and @variable references in regular expressions unless the delimiter is a single quote. Remember, too, that the right–hand side of a `s///` substitution is considered a double–quoted string (see *perlop* for more details). Remember also that any regex special characters will be acted on unless you precede the substitution with \Q. Here's an example:

```
$string = "to die?";
$lhs = "die?";
$rhs = "sleep, no more";

$string =~ s/\Q$lhs/$rhs/;
# $string is now "to sleep no more"
```

Without the \Q, the regex would also spuriously match "di".

What is `/o` really for?

Using a variable in a regular expression match forces a re–evaluation (and perhaps recompilation) each time the regular expression is encountered. The `/o` modifier locks in the regex the first time it's used. This always happens in a constant regular expression, and in fact, the pattern was compiled into the internal format at the same time your entire program was.

Use of `/o` is irrelevant unless variable interpolation is used in the pattern, and if so, the regex engine will

neither know nor care whether the variables change after the pattern is evaluated the *very first* time.

`/o` is often used to gain an extra measure of efficiency by not performing subsequent evaluations when you know it won't matter (because you know the variables won't change), or more rarely, when you don't want the regex to notice if they do.

For example, here's a "paragrep" program:

```
$/ = '';  # paragraph mode
$pat = shift;
while (<>) {
    print if /$pat/o;
}
```

How do I use a regular expression to strip C style comments from a file?

While this actually can be done, it's much harder than you'd think. For example, this one-liner

```
perl -0777 -pe 's{/\*.*?\*/}{}gs' foo.c
```

will work in many but not all cases. You see, it's too simple-minded for certain kinds of C programs, in particular, those with what appear to be comments in quoted strings. For that, you'd need something like this, created by Jeffrey Friedl and later modified by Fred Curtis.

```
$/ = undef;
$_ = <>;
s#/\*[^*]*\*+([^/*][^*]*\*+)*/|("(\\.|[^"\\])*"|'(\\.|[^'\\])*'|.[^/"'\\]*)#$2#gs
print;
```

This could, of course, be more legibly written with the `/x` modifier, adding whitespace and comments. Here it is expanded, courtesy of Fred Curtis.

```
s{
   /\*         ##  Start of /* ... */ comment
   [^*]*\*+    ##  Non-* followed by 1-or-more *'s
   (
     [^/*][^*]*\*+
   )*          ##  0-or-more things which don't start with /
               ##    but do end with '*'
   /           ##  End of /* ... */ comment

 |         ##     OR  various things which aren't comments:

   (
     "           ##  Start of " ... " string
     (
       \\.           ##  Escaped char
     |               ##    OR
       [^"\\]        ##  Non "\
     )*
     "           ##  End of " ... " string

   |         ##     OR

     '           ##  Start of ' ... ' string
     (
       \\.           ##  Escaped char
     |               ##    OR
       [^'\\]        ##  Non '\
     )*
     '           ##  End of ' ... ' string
```

```
    |          ##     OR

      .            ##  Anything other char
      [^/"'\\]*    ##  Chars which doesn't start a comment, string or escape
    )
  }{$2}gxs;
```

A slight modification also removes C++ comments:

```
s#/\*[^*]*\*+([^/*][^*]*\*+)*/|//[^\n]*|("(\\.|[^"\\])*"|'(\\.|[^'\\])*'|.[^/"'\\
```

Can I use Perl regular expressions to match balanced text?

Although Perl regular expressions are more powerful than "mathematical" regular expressions because they feature conveniences like backreferences (`\1` and its ilk), they still aren't powerful enough—with the possible exception of bizarre and experimental features in the development-track releases of Perl. You still need to use non-regex techniques to parse balanced text, such as the text enclosed between matching parentheses or braces, for example.

An elaborate subroutine (for 7-bit ASCII only) to pull out balanced and possibly nested single chars, like ` and ', { and }, or (and) can be found in http://www.perl.com/CPAN/authors/id/TOMC/scripts/pull_quotes.gz .

The C::Scan module from CPAN contains such subs for internal use, but they are undocumented.

What does it mean that regexes are greedy? How can I get around it?

Most people mean that greedy regexes match as much as they can. Technically speaking, it's actually the quantifiers (`?`, `*`, `+`, `{}`) that are greedy rather than the whole pattern; Perl prefers local greed and immediate gratification to overall greed. To get non-greedy versions of the same quantifiers, use (`??`, `*?`, `+?`, `{}?`).

An example:

```
$s1 = $s2 = "I am very very cold";
$s1 =~ s/ve.*y //;      # I am cold
$s2 =~ s/ve.*?y //;     # I am very cold
```

Notice how the second substitution stopped matching as soon as it encountered "y ". The `*?` quantifier effectively tells the regular expression engine to find a match as quickly as possible and pass control on to whatever is next in line, like you would if you were playing hot potato.

How do I process each word on each line?

Use the split function:

```
while (<>) {
    foreach $word ( split ) {
        # do something with $word here
    }
}
```

Note that this isn't really a word in the English sense; it's just chunks of consecutive non-whitespace characters.

To work with only alphanumeric sequences (including underscores), you might consider

```
while (<>) {
    foreach $word (m/(\w+)/g) {
        # do something with $word here
    }
}
```

How can I print out a word–frequency or line–frequency summary?

To do this, you have to parse out each word in the input stream. We'll pretend that by word you mean chunk of alphabetics, hyphens, or apostrophes, rather than the non–whitespace chunk idea of a word given in the previous question:

```
while (<>) {
    while ( /(\b[^\W_\d][\w'-]+\b)/g ) {   # misses "`sheep'"
        $seen{$1}++;
    }
}
while ( ($word, $count) = each %seen ) {
    print "$count $word\n";
}
```

If you wanted to do the same thing for lines, you wouldn't need a regular expression:

```
while (<>) {
    $seen{$_}++;
}
while ( ($line, $count) = each %seen ) {
    print "$count $line";
}
```

If you want these output in a sorted order, see *perlfaq4*: ''How do I sort a hash (optionally by value instead of key)?''.

How can I do approximate matching?

See the module String::Approx available from CPAN.

How do I efficiently match many regular expressions at once?

The following is extremely inefficient:

```
# slow but obvious way
@popstates = qw(CO ON MI WI MN);
while (defined($line = <>)) {
    for $state (@popstates) {
        if ($line =~ /\b$state\b/i) {
            print $line;
            last;
        }
    }
}
```

That's because Perl has to recompile all those patterns for each of the lines of the file. As of the 5.005 release, there's a much better approach, one which makes use of the new `qr//` operator:

```
# use spiffy new qr// operator, with /i flag even
use 5.005;
@popstates = qw(CO ON MI WI MN);
@poppats   = map { qr/\b$_\b/i } @popstates;
while (defined($line = <>)) {
    for $patobj (@poppats) {
        print $line if $line =~ /$patobj/;
    }
}
```

Why don't word-boundary searches with \b work for me?

Two common misconceptions are that \b is a synonym for \s+ and that it's the edge between whitespace characters and non-whitespace characters. Neither is correct. \b is the place between a \w character and a \W character (that is, \b is the edge of a "word"). It's a zero-width assertion, just like ^, $, and all the other anchors, so it doesn't consume any characters. *perlre* describes the behavior of all the regex metacharacters.

Here are examples of the incorrect application of \b, with fixes:

```
"two words" =~ /(\w+)\b(\w+)/;            # WRONG
"two words" =~ /(\w+)\s+(\w+)/;           # right

" =matchless= text" =~ /\b=(\w+)=\b/;     # WRONG
" =matchless= text" =~ /=(\w+)=/;         # right
```

Although they may not do what you thought they did, \b and \B can still be quite useful. For an example of the correct use of \b, see the example of matching duplicate words over multiple lines.

An example of using \B is the pattern \Bis\B. This will find occurrences of "is" on the insides of words only, as in "thistle", but not "this" or "island".

Why does using $&, $`, or $' slow my program down?

Once Perl sees that you need one of these variables anywhere in the program, it provides them on each and every pattern match. The same mechanism that handles these provides for the use of $1, $2, etc., so you pay the same price for each regex that contains capturing parentheses. If you never use $&, etc., in your script, then regexes *without* capturing parentheses won't be penalized. So avoid $&, $', and $` if you can, but if you can't, once you've used them at all, use them at will because you've already paid the price. Remember that some algorithms really appreciate them. As of the 5.005 release. the $& variable is no longer "expensive" the way the other two are.

What good is \G in a regular expression?

The notation \G is used in a match or substitution in conjunction with the /g modifier to anchor the regular expression to the point just past where the last match occurred, i.e. the pos() point. A failed match resets the position of \G unless the /c modifier is in effect. \G can be used in a match without the /g modifier; it acts the same (i.e. still anchors at the pos() point) but of course only matches once and does not update pos(), as non-/g expressions never do. \G in an expression applied to a target string that has never been matched against a /g expression before or has had its pos() reset is functionally equivalent to \A, which matches at the beginning of the string.

For example, suppose you had a line of text quoted in standard mail and Usenet notation, (that is, with leading > characters), and you want change each leading > into a corresponding :. You could do so in this way:

```
s/^(>+)/':' x length($1)/gem;
```

Or, using \G, the much simpler (and faster):

```
s/\G>/:/g;
```

A more sophisticated use might involve a tokenizer. The following lex-like example is courtesy of Jeffrey Friedl. It did not work in 5.003 due to bugs in that release, but does work in 5.004 or better. (Note the use of /c, which prevents a failed match with /g from resetting the search position back to the beginning of the string.)

```
while (<>) {
  chomp;
  PARSER: {
       m/ \G( \d+\b    )/gcx    && do { print "number: $1\n";  redo; };
       m/ \G( \w+      )/gcx    && do { print "word:   $1\n";  redo; };
       m/ \G( \s+      )/gcx    && do { print "space:  $1\n";  redo; };
```

```
            m/ \G( [^\w\d]+ )/gcx    && do { print "other:  $1\n";  redo; };
    }
}
```

Of course, that could have been written as

```
while (<>) {
  chomp;
  PARSER: {
       if ( /\G( \d+\b    )/gcx  {
            print "number: $1\n";
            redo PARSER;
       }
       if ( /\G( \w+      )/gcx  {
            print "word: $1\n";
            redo PARSER;
       }
       if ( /\G( \s+      )/gcx  {
            print "space: $1\n";
            redo PARSER;
       }
       if ( /\G( [^\w\d]+ )/gcx  {
            print "other: $1\n";
            redo PARSER;
       }
  }
}
```

but then you lose the vertical alignment of the regular expressions.

Are Perl regexes DFAs or NFAs? Are they POSIX compliant?

While it‘s true that Perl‘s regular expressions resemble the DFAs (deterministic finite automata) of the egrep(1) program, they are in fact implemented as NFAs (non−deterministic finite automata) to allow backtracking and backreferencing. And they aren‘t POSIX−style either, because those guarantee worst−case behavior for all cases. (It seems that some people prefer guarantees of consistency, even when what‘s guaranteed is slowness.) See the book "Mastering Regular Expressions" (from O‘Reilly) by Jeffrey Friedl for all the details you could ever hope to know on these matters (a full citation appears in *perlfaq2*).

What‘s wrong with using grep or map in a void context?

Both grep and map build a return list, regardless of their context. This means you‘re making Perl go to the trouble of building up a return list that you then just ignore. That‘s no way to treat a programming language, you insensitive scoundrel!

How can I match strings with multibyte characters?

This is hard, and there‘s no good way. Perl does not directly support wide characters. It pretends that a byte and a character are synonymous. The following set of approaches was offered by Jeffrey Friedl, whose article in issue #5 of The Perl Journal talks about this very matter.

Let‘s suppose you have some weird Martian encoding where pairs of ASCII uppercase letters encode single Martian letters (i.e. the two bytes "CV" make a single Martian letter, as do the two bytes "SG", "VS", "XX", etc.). Other bytes represent single characters, just like ASCII.

So, the string of Martian "I am CVSGXX!" uses 12 bytes to encode the nine characters ‘I‘, ’ ‘, ‘a‘, ‘m‘, ’ ‘, ‘CV‘, ‘SG‘, ‘XX‘, ‘!’.

Now, say you want to search for the single character `/GX/`. Perl doesn‘t know about Martian, so it‘ll find the two bytes "GX" in the "I am CVSGXX!" string, even though that character isn‘t there: it just looks like it is because "SG" is next to "XX", but there‘s no real "GX". This is a big problem.

Here are a few ways, all painful, to deal with it:

```
$martian =~ s/([A-Z][A-Z])/ $1 /g; # Make sure adjacent ``martian'' bytes
                                   # are no longer adjacent.
print "found GX!\n" if $martian =~ /GX/;
```

Or like this:

```
@chars = $martian =~ m/([A-Z][A-Z]|[^A-Z])/g;
# above is conceptually similar to:     @chars = $text =~ m/(.)/g;
#
foreach $char (@chars) {
    print "found GX!\n", last if $char eq 'GX';
}
```

Or like this:

```
while ($martian =~ m/\G([A-Z][A-Z]|.)/gs) {  # \G probably unneeded
    print "found GX!\n", last if $1 eq 'GX';
}
```

Or like this:

```
 die "sorry, Perl doesn't (yet) have Martian support )-:\n";
```

There are many double-byte (and multi-byte) byte encodings commonly used these days. Some versions of these have 1-byte, 2-byte, 3-byte, and 4-byte characters, all mixed.

How do I match a pattern that is supplied by the user?

Well, if it's really a pattern, then just use

```
chomp($pattern = <STDIN>);
if ($line =~ /$pattern/) { }
```

Alternatively, since you have no guarantee that your user entered a valid regular expression, trap the exception this way:

```
if (eval { $line =~ /$pattern/ }) { }
```

If all you really want to search for a string, not a pattern, then you should either use the `index()` function, which is made for string searching, or if you can't be disabused of using a pattern match on a non-pattern, then be sure to use `\Q...\E`, documented in *perlre*.

```
$pattern = <STDIN>;

open (FILE, $input) or die "Couldn't open input $input: $!; aborting";
while (<FILE>) {
    print if /\Q$pattern\E/;
}
close FILE;
```

AUTHOR AND COPYRIGHT

NAME

perlfaq7 – Perl Language Issues (`$Revision: 1.28 $, $Date: 1999/05/23 20:36:18 $`)

DESCRIPTION

This section deals with general Perl language issues that don't clearly fit into any of the other sections.

Can I get a BNF/yacc/RE for the Perl language?

There is no BNF, but you can paw your way through the yacc grammar in perly.y in the source distribution if you're particularly brave. The grammar relies on very smart tokenizing code, so be prepared to venture into toke.c as well.

In the words of Chaim Frenkel: "Perl's grammar can not be reduced to BNF. The work of parsing perl is distributed between yacc, the lexer, smoke and mirrors."

What are all these `$@%&*` punctuation signs, and how do I know when to use them?

They are type specifiers, as detailed in *perldata*:

```
$ for scalar values (number, string or reference)
@ for arrays
% for hashes (associative arrays)
& for subroutines (aka functions, procedures, methods)
* for all types of that symbol name.  In version 4 you used them like
  pointers, but in modern perls you can just use references.
```

There are couple of other symbols that you're likely to encounter that aren't really type specifiers:

```
<> are used for inputting a record from a filehandle.
\  takes a reference to something.
```

Note that <FILE is *neither* the type specifier for files nor the name of the handle. It is the `< <` operator applied to the handle FILE. It reads one line (well, record—see *$/*) from the handle FILE in scalar context, or *all* lines in list context. When performing open, close, or any other operation besides `< <` on files, or even when talking about the handle, do *not* use the brackets. These are correct: `eof(FH)`, `seek(FH, 0, 2)` and "copying from STDIN to FILE".

Do I always/never have to quote my strings or use semicolons and commas?

Normally, a bareword doesn't need to be quoted, but in most cases probably should be (and must be under `use strict`). But a hash key consisting of a simple word (that isn't the name of a defined subroutine) and the left–hand operand to the `< =` operator both count as though they were quoted:

```
This                    is like this
------------            ---------------
$foo{line}              $foo{"line"}
bar => stuff            "bar" => stuff
```

The final semicolon in a block is optional, as is the final comma in a list. Good style (see *perlstyle*) says to put them in except for one–liners:

```
if ($whoops) { exit 1 }
@nums = (1, 2, 3);
```

```
if ($whoops) {
    exit 1;
}
@lines = (
    "There Beren came from mountains cold",
    "And lost he wandered under leaves",
);
```

How do I skip some return values?

One way is to treat the return values as a list and index into it:

```
$dir = (getpwnam($user))[7];
```

Another way is to use undef as an element on the left–hand–side:

```
($dev, $ino, undef, undef, $uid, $gid) = stat($file);
```

How do I temporarily block warnings?

If you are running Perl 5.6.0 or better, the `use warnings` pragma allows fine control of what warning are produced. See *perllexwarn* for more details.

```
{
    no warnings;          # temporarily turn off warnings
    $a = $b + $c;         # I know these might be undef
}
```

If you have an older version of Perl, the `$^W` variable (documented in *perlvar*) controls runtime warnings for a block:

```
{
    local $^W = 0;        # temporarily turn off warnings
    $a = $b + $c;         # I know these might be undef
}
```

Note that like all the punctuation variables, you cannot currently use `my()` on `$^W`, only `local()`.

What's an extension?

An extension is a way of calling compiled C code from Perl. Reading *perlxstut* is a good place to learn more about extensions.

Why do Perl operators have different precedence than C operators?

Actually, they don't. All C operators that Perl copies have the same precedence in Perl as they do in C. The problem is with operators that C doesn't have, especially functions that give a list context to everything on their right, eg. print, chmod, exec, and so on. Such functions are called "list operators" and appear as such in the precedence table in *perlop*.

A common mistake is to write:

```
unlink $file || die "snafu";
```

This gets interpreted as:

```
unlink ($file || die "snafu");
```

To avoid this problem, either put in extra parentheses or use the super low precedence `or` operator:

```
(unlink $file) || die "snafu";
unlink $file or die "snafu";
```

The "English" operators (`and`, `or`, `xor`, and `not`) deliberately have precedence lower than that of list operators for just such situations as the one above.

Another operator with surprising precedence is exponentiation. It binds more tightly even than unary minus, making `-2**2` product a negative not a positive four. It is also right–associating, meaning that `2**3**2` is two raised to the ninth power, not eight squared.

Although it has the same precedence as in C, Perl's `?:` operator produces an lvalue. This assigns `$x` to either `$a` or `$b`, depending on the trueness of `$maybe`:

```
($maybe ? $a : $b) = $x;
```

How do I declare/create a structure?

In general, you don't "declare" a structure. Just use a (probably anonymous) hash reference. See *perlref* and *perldsc* for details. Here's an example:

```
$person = {};                   # new anonymous hash
$person->{AGE}  = 24;           # set field AGE to 24
$person->{NAME} = "Nat";        # set field NAME to "Nat"
```

If you're looking for something a bit more rigorous, try *perltoot*.

How do I create a module?

A module is a package that lives in a file of the same name. For example, the Hello::There module would live in Hello/There.pm. For details, read *perlmod*. You'll also find *Exporter* helpful. If you're writing a C or mixed–language module with both C and Perl, then you should study *perlxstut*.

Here's a convenient template you might wish you use when starting your own module. Make sure to change the names appropriately.

```
package Some::Module;  # assumes Some/Module.pm

use strict;
use warnings;

BEGIN {
    use Exporter   ();
    our ($VERSION, @ISA, @EXPORT, @EXPORT_OK, %EXPORT_TAGS);

    ## set the version for version checking; uncomment to use
    ## $VERSION     = 1.00;

    # if using RCS/CVS, this next line may be preferred,
    # but beware two-digit versions.
    $VERSION = do{my@r=q$Revision: 1.28 $=~/\d+/g;sprintf '%d.'.'%02d'x$#r,@r};

    @ISA         = qw(Exporter);
    @EXPORT      = qw(&func1 &func2 &func3);
    %EXPORT_TAGS = ( );     # eg: TAG => [ qw!name1 name2! ],

    # your exported package globals go here,
    # as well as any optionally exported functions
    @EXPORT_OK   = qw($Var1 %Hashit);
}
our @EXPORT_OK;

# exported package globals go here
our $Var1;
our %Hashit;

# non-exported package globals go here
our @more;
our $stuff;

# initialize package globals, first exported ones
$Var1   = '';
%Hashit = ();

# then the others (which are still accessible as $Some::Module::stuff)
$stuff  = '';
@more   = ();

# all file-scoped lexicals must be created before
# the functions below that use them.
```

```
# file-private lexicals go here
my $priv_var    = '';
my %secret_hash = ();

# here's a file-private function as a closure,
# callable as &$priv_func;  it cannot be prototyped.
my $priv_func = sub {
    # stuff goes here.
};

# make all your functions, whether exported or not;
# remember to put something interesting in the {} stubs
sub func1      {}    # no prototype
sub func2()    {}    # proto'd void
sub func3($$)  {}    # proto'd to 2 scalars

# this one isn't exported, but could be called!
sub func4(\%)  {}    # proto'd to 1 hash ref

END { }       # module clean-up code here (global destructor)

1;            # modules must return true
```

The h2xs program will create stubs for all the important stuff for you:

```
% h2xs -XA -n My::Module
```

How do I create a class?

See *perltoot* for an introduction to classes and objects, as well as *perlobj* and *perlbot*.

How can I tell if a variable is tainted?

See *Laundering and Detecting Tainted Data in perlsec*. Here's an example (which doesn't use any system calls, because the `kill()` is given no processes to signal):

```
sub is_tainted {
    return ! eval { join('',@_), kill 0; 1; };
}
```

This is not `-w` clean, however. There is no `-w` clean way to detect taintedness—take this as a hint that you should untaint all possibly-tainted data.

What's a closure?

Closures are documented in *perlref*.

Closure is a computer science term with a precise but hard-to-explain meaning. Closures are implemented in Perl as anonymous subroutines with lasting references to lexical variables outside their own scopes. These lexicals magically refer to the variables that were around when the subroutine was defined (deep binding).

Closures make sense in any programming language where you can have the return value of a function be itself a function, as you can in Perl. Note that some languages provide anonymous functions but are not capable of providing proper closures: the Python language, for example. For more information on closures, check out any textbook on functional programming. Scheme is a language that not only supports but encourages closures.

Here's a classic function-generating function:

```
sub add_function_generator {
  return sub { shift + shift };
}

$add_sub = add_function_generator();
$sum = $add_sub->(4,5);                 # $sum is 9 now.
```

The closure works as a *function template* with some customization slots left out to be filled later. The anonymous subroutine returned by `add_function_generator()` isn't technically a closure because it refers to no lexicals outside its own scope.

Contrast this with the following `make_adder()` function, in which the returned anonymous function contains a reference to a lexical variable outside the scope of that function itself. Such a reference requires that Perl return a proper closure, thus locking in for all time the value that the lexical had when the function was created.

```
sub make_adder {
    my $addpiece = shift;
    return sub { shift + $addpiece };
}

$f1 = make_adder(20);
$f2 = make_adder(555);
```

Now `&$f1($n)` is always 20 plus whatever `$n` you pass in, whereas `&$f2($n)` is always 555 plus whatever `$n` you pass in. The `$addpiece` in the closure sticks around.

Closures are often used for less esoteric purposes. For example, when you want to pass in a bit of code into a function:

```
my $line;
timeout( 30, sub { $line = <STDIN> } );
```

If the code to execute had been passed in as a string, `< '$line = <STDIN'` , there would have been no way for the hypothetical `timeout()` function to access the lexical variable `$line` back in its caller's scope.

What is variable suicide and how can I prevent it?

Variable suicide is when you (temporarily or permanently) lose the value of a variable. It is caused by scoping through `my()` and `local()` interacting with either closures or aliased `foreach()` iterator variables and subroutine arguments. It used to be easy to inadvertently lose a variable's value this way, but now it's much harder. Take this code:

```
my $f = "foo";
sub T {
  while ($i++ < 3) { my $f = $f; $f .= "bar"; print $f, "\n" }
}
T;
print "Finally $f\n";
```

The `$f` that has "bar" added to it three times should be a new `$f` (`my $f` should create a new local variable each time through the loop). It isn't, however. This was a bug, now fixed in the latest releases (tested against 5.004_05, 5.005_03, and 5.005_56).

How can I pass/return a {Function, FileHandle, Array, Hash, Method, Regex}?

With the exception of regexes, you need to pass references to these objects. See *Pass by Reference in perlsub* for this particular question, and *perlref* for information on references.

See ''Passing Regexes'', below, for information on passing regular expressions.

Passing Variables and Functions

Regular variables and functions are quite easy to pass: just pass in a reference to an existing or anonymous variable or function:

```
func( \$some_scalar );

func( \@some_array  );
func( [ 1 .. 10 ]   );
```

```
func( \%some_hash   );
func( { this => 10, that => 20 }   );

func( \&some_func   );
func( sub { $_[0] ** $_[1] }   );
```

Passing Filehandles

To pass filehandles to subroutines, use the `*FH` or `\*FH` notations. These are "typeglobs"—see *Typeglobs and Filehandles in perldata* and especially *Pass by Reference in perlsub* for more information.

Here's an excerpt:

If you're passing around filehandles, you could usually just use the bare typeglob, like *STDOUT, but typeglobs references would be better because they'll still work properly under `use strict 'refs'`. For example:

```
splutter(\*STDOUT);
sub splutter {
    my $fh = shift;
    print $fh "her um well a hmmm\n";
}

$rec = get_rec(\*STDIN);
sub get_rec {
    my $fh = shift;
    return scalar <$fh>;
}
```

If you're planning on generating new filehandles, you could do this:

```
sub openit {
    my $name = shift;
    local *FH;
    return open (FH, $path) ? *FH : undef;
}
$fh = openit('< /etc/motd');
print <$fh>;
```

Passing Regexes

To pass regexes around, you'll need to be using a release of Perl sufficiently recent as to support the `qr//` construct, pass around strings and use an exception–trapping eval, or else be very, very clever.

Here's an example of how to pass in a string to be regex compared using `qr//`:

```
sub compare($$) {
    my ($val1, $regex) = @_;
    my $retval = $val1 =~ /$regex/;
    return $retval;
}
$match = compare("old McDonald", qr/d.*D/i);
```

Notice how `qr//` allows flags at the end. That pattern was compiled at compile time, although it was executed later. The nifty `qr//` notation wasn't introduced until the 5.005 release. Before that, you had to approach this problem much less intuitively. For example, here it is again if you don't have `qr//`:

```
sub compare($$) {
    my ($val1, $regex) = @_;
    my $retval = eval { $val1 =~ /$regex/ };
    die if $@;
```

```
    return $retval;
}

$match = compare("old McDonald", q/($?i)d.*D/);
```

Make sure you never say something like this:

```
return eval "\$val =~ /$regex/";   # WRONG
```

or someone can sneak shell escapes into the regex due to the double interpolation of the eval and the double-quoted string. For example:

```
$pattern_of_evil = 'danger ${ system("rm -rf * &") } danger';

eval "\$string =~ /$pattern_of_evil/";
```

Those preferring to be very, very clever might see the O'Reilly book, *Mastering Regular Expressions*, by Jeffrey Friedl. Page 273's `Build_MatchMany_Function()` is particularly interesting. A complete citation of this book is given in *perlfaq2*.

Passing Methods

To pass an object method into a subroutine, you can do this:

```
call_a_lot(10, $some_obj, "methname")
sub call_a_lot {
    my ($count, $widget, $trick) = @_;
    for (my $i = 0; $i < $count; $i++) {
        $widget->$trick();
    }
}
```

Or, you can use a closure to bundle up the object, its method call, and arguments:

```
my $whatnot =  sub { $some_obj->obfuscate(@args) };
func($whatnot);
sub func {
    my $code = shift;
    &$code();
}
```

You could also investigate the `can()` method in the UNIVERSAL class (part of the standard perl distribution).

How do I create a static variable?

As with most things in Perl, TMTOWTDI. What is a "static variable" in other languages could be either a function-private variable (visible only within a single function, retaining its value between calls to that function), or a file-private variable (visible only to functions within the file it was declared in) in Perl.

Here's code to implement a function-private variable:

```
BEGIN {
    my $counter = 42;
    sub prev_counter { return --$counter }
    sub next_counter { return $counter++ }
}
```

Now `prev_counter()` and `next_counter()` share a private variable `$counter` that was initialized at compile time.

To declare a file-private variable, you'll still use a `my()`, putting the declaration at the outer scope level at the top of the file. Assume this is in file Pax.pm:

```
package Pax;
```

```
my $started = scalar(localtime(time()));

sub begun { return $started }
```

When `use Pax` or `require Pax` loads this module, the variable will be initialized. It won't get garbage-collected the way most variables going out of scope do, because the `begun()` function cares about it, but no one else can get it. It is not called `$Pax::started` because its scope is unrelated to the package. It's scoped to the file. You could conceivably have several packages in that same file all accessing the same private variable, but another file with the same package couldn't get to it.

See *Persistent Private Variables in perlsub* for details.

What's the difference between dynamic and lexical (static) scoping? Between `local()` and `my()`?

`local($x)` saves away the old value of the global variable `$x` and assigns a new value for the duration of the subroutine *which is visible in other functions called from that subroutine*. This is done at run-time, so is called dynamic scoping. `local()` always affects global variables, also called package variables or dynamic variables.

`my($x)` creates a new variable that is only visible in the current subroutine. This is done at compile-time, so it is called lexical or static scoping. `my()` always affects private variables, also called lexical variables or (improperly) static(ly scoped) variables.

For instance:

```
sub visible {
    print "var has value $var\n";
}

sub dynamic {
    local $var = 'local';   # new temporary value for the still-global
    visible();              #   variable called $var
}

sub lexical {
    my $var = 'private';    # new private variable, $var
    visible();              # (invisible outside of sub scope)
}

$var = 'global';

visible();                  # prints global
dynamic();                  # prints local
lexical();                  # prints global
```

Notice how at no point does the value "private" get printed. That's because `$var` only has that value within the block of the `lexical()` function, and it is hidden from called subroutine.

In summary, `local()` doesn't make what you think of as private, local variables. It gives a global variable a temporary value. `my()` is what you're looking for if you want private variables.

See *"Private Variables via `my()`"* and *"Temporary Values via `local()`"* for excruciating details.

How can I access a dynamic variable while a similarly named lexical is in scope?

You can do this via symbolic references, provided you haven't set `use strict "refs"`. So instead of `$var`, use `${'var'}`.

```
local $var = "global";
my    $var = "lexical";

print "lexical is $var\n";

no strict 'refs';
```

```
print "global  is ${'var'}\n";
```

If you know your package, you can just mention it explicitly, as in `$Some_Pack::var`. Note that the notation `$::var` is *not* the dynamic `$var` in the current package, but rather the one in the `main` package, as though you had written `$main::var`. Specifying the package directly makes you hard–code its name, but it executes faster and avoids running afoul of `use strict "refs"`.

What's the difference between deep and shallow binding?

In deep binding, lexical variables mentioned in anonymous subroutines are the same ones that were in scope when the subroutine was created. In shallow binding, they are whichever variables with the same names happen to be in scope when the subroutine is called. Perl always uses deep binding of lexical variables (i.e., those created with `my()`). However, dynamic variables (aka global, local, or package variables) are effectively shallowly bound. Consider this just one more reason not to use them. See the answer to *"What's a closure?"*.

Why doesn't "my(`$foo`) = <FILE;" work right?

`my()` and `local()` give list context to the right hand side of `=`. The <FH read operation, like so many of Perl's functions and operators, can tell which context it was called in and behaves appropriately. In general, the `scalar()` function can help. This function does nothing to the data itself (contrary to popular myth) but rather tells its argument to behave in whatever its scalar fashion is. If that function doesn't have a defined scalar behavior, this of course doesn't help you (such as with `sort()`).

To enforce scalar context in this particular case, however, you need merely omit the parentheses:

```
local($foo) = <FILE>;           # WRONG
local($foo) = scalar(<FILE>);   # ok
local $foo  = <FILE>;           # right
```

You should probably be using lexical variables anyway, although the issue is the same here:

```
my($foo) = <FILE>;  # WRONG
my $foo  = <FILE>;  # right
```

How do I redefine a builtin function, operator, or method?

Why do you want to do that? :–)

If you want to override a predefined function, such as `open()`, then you'll have to import the new definition from a different module. See *Overriding Built–in Functions in perlsub*. There's also an example in *Class::Template in perltoot*.

If you want to overload a Perl operator, such as `+` or `**`, then you'll want to use the `use overload` pragma, documented in *overload*.

If you're talking about obscuring method calls in parent classes, see *Overridden Methods in perltoot*.

What's the difference between calling a function as `&foo` and `foo()`?

When you call a function as `&foo`, you allow that function access to your current @_ values, and you bypass prototypes. The function doesn't get an empty @_—it gets yours! While not strictly speaking a bug (it's documented that way in *perlsub*), it would be hard to consider this a feature in most cases.

When you call your function as `&foo()`, then you *do* get a new @_, but prototyping is still circumvented.

Normally, you want to call a function using `foo()`. You may only omit the parentheses if the function is already known to the compiler because it already saw the definition (`use` but not `require`), or via a forward reference or `use subs` declaration. Even in this case, you get a clean @_ without any of the old values leaking through where they don't belong.

How do I create a switch or case statement?

This is explained in more depth in the *perlsyn*. Briefly, there's no official case statement, because of the variety of tests possible in Perl (numeric comparison, string comparison, glob comparison, regex matching, overloaded comparisons, ...). Larry couldn't decide how best to do this, so he left it out, even though it's

been on the wish list since perl1.

The general answer is to write a construct like this:

```
for ($variable_to_test) {
    if    (/pat1/)  { }     # do something
    elsif (/pat2/)  { }     # do something else
    elsif (/pat3/)  { }     # do something else
    else            { }     # default
}
```

Here's a simple example of a switch based on pattern matching, this time lined up in a way to make it look more like a switch statement. We'll do a multi−way conditional based on the type of reference stored in `$whatchamacallit`:

```
SWITCH: for (ref $whatchamacallit) {

    /^$/            && die "not a reference";

    /SCALAR/        && do {
                            print_scalar($$ref);
                            last SWITCH;
                       };

    /ARRAY/         && do {
                            print_array(@$ref);
                            last SWITCH;
                       };

    /HASH/          && do {
                            print_hash(%$ref);
                            last SWITCH;
                       };

    /CODE/          && do {
                            warn "can't print function ref";
                            last SWITCH;
                       };

    # DEFAULT

    warn "User defined type skipped";

}
```

See `perlsyn/"Basic BLOCKs and Switch Statements"` for many other examples in this style.

Sometimes you should change the positions of the constant and the variable. For example, let's say you wanted to test which of many answers you were given, but in a case−insensitive way that also allows abbreviations. You can use the following technique if the strings all start with different characters or if you want to arrange the matches so that one takes precedence over another, as `"SEND"` has precedence over `"STOP"` here:

```
chomp($answer = <>);
if    ("SEND"  =~ /^\Q$answer/i) { print "Action is send\n"  }
elsif ("STOP"  =~ /^\Q$answer/i) { print "Action is stop\n"  }
elsif ("ABORT" =~ /^\Q$answer/i) { print "Action is abort\n" }
elsif ("LIST"  =~ /^\Q$answer/i) { print "Action is list\n"  }
elsif ("EDIT"  =~ /^\Q$answer/i) { print "Action is edit\n"  }
```

A totally different approach is to create a hash of function references.

```
my %commands = (
    "happy" => \&joy,
    "sad",  => \&sullen,
    "done"  => sub { die "See ya!" },
    "mad"   => \&angry,
);

print "How are you? ";
chomp($string = <STDIN>);
if ($commands{$string}) {
    $commands{$string}->();
} else {
    print "No such command: $string\n";
}
```

How can I catch accesses to undefined variables/functions/methods?

The AUTOLOAD method, discussed in *Autoloading in perlsub* and *AUTOLOAD: Proxy Methods in perltoot*, lets you capture calls to undefined functions and methods.

When it comes to undefined variables that would trigger a warning under `-w`, you can use a handler to trap the pseudo-signal `__WARN__` like this:

```
$SIG{__WARN__} = sub {

    for ( $_[0] ) {         # voici un switch statement

        /Use of uninitialized value/  && do {
            # promote warning to a fatal
            die $_;
        };

        # other warning cases to catch could go here;

        warn $_;
    }

};
```

Why can't a method included in this same file be found?

Some possible reasons: your inheritance is getting confused, you've misspelled the method name, or the object is of the wrong type. Check out *perltoot* for details about any of the above cases. You may also use `print ref($object)` to find out the class `$object` was blessed into.

Another possible reason for problems is because you've used the indirect object syntax (eg, `find Guru "Samy"`) on a class name before Perl has seen that such a package exists. It's wisest to make sure your packages are all defined before you start using them, which will be taken care of if you use the `use` statement instead of `require`. If not, make sure to use arrow notation (eg., `< Guru-find("Samy") )` instead. Object notation is explained in *perlobj*.

Make sure to read about creating modules in *perlmod* and the perils of indirect objects in *WARNING in perlobj*.

How can I find out my current package?

If you're just a random program, you can do this to find out what the currently compiled package is:

```
my $packname = __PACKAGE__;
```

But, if you're a method and you want to print an error message that includes the kind of object you were called on (which is not necessarily the same as the one in which you were compiled):

```
sub amethod {
    my $self  = shift;
```

```
    my $class = ref($self) || $self;
    warn "called me from a $class object";
}
```

How can I comment out a large block of perl code?

Use embedded POD to discard it:

```
# program is here

=for nobody
This paragraph is commented out

# program continues

=begin comment text

all of this stuff

here will be ignored
by everyone

=end comment text

=cut
```

This can't go just anywhere. You have to put a pod directive where the parser is expecting a new statement, not just in the middle of an expression or some other arbitrary yacc grammar production.

How do I clear a package?

Use this code, provided by Mark–Jason Dominus:

```
sub scrub_package {
    no strict 'refs';
    my $pack = shift;
    die "Shouldn't delete main package"
        if $pack eq "" || $pack eq "main";
    my $stash = *{$pack . '::'}{HASH};
    my $name;
    foreach $name (keys %$stash) {
        my $fullname = $pack . '::' . $name;
        # Get rid of everything with that name.
        undef $$fullname;
        undef @$fullname;
        undef %$fullname;
        undef &$fullname;
        undef *$fullname;
    }
}
```

Or, if you're using a recent release of Perl, you can just use the `Symbol::delete_package()` function instead.

How can I use a variable as a variable name?

Beginners often think they want to have a variable contain the name of a variable.

```
$fred    = 23;
$varname = "fred";
++$$varname;         # $fred now 24
```

This works *sometimes*, but it is a very bad idea for two reasons.

The first reason is that this technique *only works on global variables*. That means that if `$fred` is a lexical

variable created with `my()` in the above example, the code wouldn't work at all: you'd accidentally access the global and skip right over the private lexical altogether. Global variables are bad because they can easily collide accidentally and in general make for non-scalable and confusing code.

Symbolic references are forbidden under the `use strict` pragma. They are not true references and consequently are not reference counted or garbage collected.

The other reason why using a variable to hold the name of another variable is a bad idea is that the question often stems from a lack of understanding of Perl data structures, particularly hashes. By using symbolic references, you are just using the package's symbol-table hash (like `%main::`) instead of a user-defined hash. The solution is to use your own hash or a real reference instead.

```
$fred    = 23;
$varname = "fred";
$USER_VARS{$varname}++;  # not $$varname++
```

There we're using the %USER_VARS hash instead of symbolic references. Sometimes this comes up in reading strings from the user with variable references and wanting to expand them to the values of your perl program's variables. This is also a bad idea because it conflates the program-addressable namespace and the user-addressable one. Instead of reading a string and expanding it to the actual contents of your program's own variables:

```
$str = 'this has a $fred and $barney in it';
$str =~ s/(\$\w+)/$1/eeg;              # need double eval
```

it would be better to keep a hash around like %USER_VARS and have variable references actually refer to entries in that hash:

```
$str =~ s/\$(\w+)/$USER_VARS{$1}/g;   # no /e here at all
```

That's faster, cleaner, and safer than the previous approach. Of course, you don't need to use a dollar sign. You could use your own scheme to make it less confusing, like bracketed percent symbols, etc.

```
$str = 'this has a %fred% and %barney% in it';
$str =~ s/%(\w+)%/$USER_VARS{$1}/g;   # no /e here at all
```

Another reason that folks sometimes think they want a variable to contain the name of a variable is because they don't know how to build proper data structures using hashes. For example, let's say they wanted two hashes in their program: %fred and %barney, and that they wanted to use another scalar variable to refer to those by name.

```
$name = "fred";
$$name{WIFE} = "wilma";     # set %fred

$name = "barney";
$$name{WIFE} = "betty";     # set %barney
```

This is still a symbolic reference, and is still saddled with the problems enumerated above. It would be far better to write:

```
$folks{"fred"}{WIFE}   = "wilma";
$folks{"barney"}{WIFE} = "betty";
```

And just use a multilevel hash to start with.

The only times that you absolutely *must* use symbolic references are when you really must refer to the symbol table. This may be because it's something that can't take a real reference to, such as a format name. Doing so may also be important for method calls, since these always go through the symbol table for resolution.

In those cases, you would turn off `strict 'refs'` temporarily so you can play around with the symbol table. For example:

```
@colors = qw(red blue green yellow orange purple violet);
for my $name (@colors) {
    no strict 'refs';  # renege for the block
    *$name = sub { "<FONT COLOR='$name'>@_</FONT>" };
}
```

All those functions (`red()`, `blue()`, `green()`, etc.) appear to be separate, but the real code in the closure actually was compiled only once.

So, sometimes you might want to use symbolic references to directly manipulate the symbol table. This doesn't matter for formats, handles, and subroutines, because they are always global—you can't use `my()` on them. For scalars, arrays, and hashes, though—and usually for subroutines— you probably only want to use hard references.

AUTHOR AND COPYRIGHT

NAME

perlfaq8 – System Interaction (`$Revision: 1.39 $, $Date: 1999/05/23 18:37:57 $`)

DESCRIPTION

This section of the Perl FAQ covers questions involving operating system interaction. Topics include interprocess communication (IPC), control over the user–interface (keyboard, screen and pointing devices), and most anything else not related to data manipulation.

Read the FAQs and documentation specific to the port of perl to your operating system (eg, *perlvms*, *perlplan9*, ...). These should contain more detailed information on the vagaries of your perl.

How do I find out which operating system I'm running under?

The `$^O` variable (`$OSNAME` if you use English) contains an indication of the name of the operating system (not its release number) that your perl binary was built for.

How come `exec()` doesn't return?

Because that's what it does: it replaces your currently running program with a different one. If you want to keep going (as is probably the case if you're asking this question) use `system()` instead.

How do I do fancy stuff with the keyboard/screen/mouse?

How you access/control keyboards, screens, and pointing devices ("mice") is system–dependent. Try the following modules:

Keyboard

```
Term::Cap                   Standard perl distribution
Term::ReadKey               CPAN
Term::ReadLine::Gnu         CPAN
Term::ReadLine::Perl        CPAN
Term::Screen                CPAN
```

Screen

```
Term::Cap                   Standard perl distribution
Curses                      CPAN
Term::ANSIColor             CPAN
```

Mouse

```
Tk                          CPAN
```

Some of these specific cases are shown below.

How do I print something out in color?

In general, you don't, because you don't know whether the recipient has a color–aware display device. If you know that they have an ANSI terminal that understands color, you can use the Term::ANSIColor module from CPAN:

```
use Term::ANSIColor;
print color("red"), "Stop!\n", color("reset");
print color("green"), "Go!\n", color("reset");
```

Or like this:

```
use Term::ANSIColor qw(:constants);
print RED, "Stop!\n", RESET;
print GREEN, "Go!\n", RESET;
```

How do I read just one key without waiting for a return key?

Controlling input buffering is a remarkably system–dependent matter. On many systems, you can just use the **stty** command as shown in *getc*, but as you see, that's already getting you into portability snags.

```
open(TTY, "+</dev/tty") or die "no tty: $!";
system "stty  cbreak </dev/tty >/dev/tty 2>&1";
$key = getc(TTY);   # perhaps this works
# OR ELSE
sysread(TTY, $key, 1#;probably this does
system "stty -cbreak </dev/tty >/dev/tty 2>&1";
```

The Term::ReadKey module from CPAN offers an easy−to−use interface that should be more efficient than shelling out to **stty** for each key. It even includes limited support for Windows.

```
use Term::ReadKey;
ReadMode('cbreak');
$key = ReadKey(0);
ReadMode('normal');
```

However, using the code requires that you have a working C compiler and can use it to build and install a CPAN module. Here's a solution using the standard POSIX module, which is already on your systems (assuming your system supports POSIX).

```
use HotKey;
$key = readkey();
```

And here's the HotKey module, which hides the somewhat mystifying calls to manipulate the POSIX termios structures.

```
# HotKey.pm
package HotKey;

@ISA = qw(Exporter);
@EXPORT = qw(cbreak cooked readkey);

use strict;
use POSIX qw(:termios_h);
my ($term, $oterm, $echo, $noecho, $fd_stdin);

$fd_stdin = fileno(STDIN);
$term     = POSIX::Termios->new();
$term->getattr($fd_stdin);
$oterm     = $term->getlflag();

$echo     = ECHO | ECHOK | ICANON;
$noecho   = $oterm & ~$echo;

sub cbreak {
    $term->setlflag($noecho);  # ok, so i don't want echo either
    $term->setcc(VTIME, 1);
    $term->setattr($fd_stdin, TCSANOW);
}

sub cooked {
    $term->setlflag($oterm);
    $term->setcc(VTIME, 0);
    $term->setattr($fd_stdin, TCSANOW);
}

sub readkey {
    my $key = '';
    cbreak();
    sysread(STDIN, $key, 1);
    cooked();
    return $key;
```

```
}

END { cooked() }

1;
```

How do I check whether input is ready on the keyboard?

The easiest way to do this is to read a key in nonblocking mode with the Term::ReadKey module from CPAN, passing it an argument of −1 to indicate not to block:

```
use Term::ReadKey;

ReadMode('cbreak');

if (defined ($char = ReadKey(-1)) ) {
    # input was waiting and it was $char
} else {
    # no input was waiting
}

ReadMode('normal');                  # restore normal tty settings
```

How do I clear the screen?

If you only have do so infrequently, use `system`:

```
system("clear");
```

If you have to do this a lot, save the clear string so you can print it 100 times without calling a program 100 times:

```
$clear_string = `clear`;
print $clear_string;
```

If you're planning on doing other screen manipulations, like cursor positions, etc, you might wish to use Term::Cap module:

```
use Term::Cap;
$terminal = Term::Cap->Tgetent( {OSPEED => 9600} );
$clear_string = $terminal->Tputs('cl');
```

How do I get the screen size?

If you have Term::ReadKey module installed from CPAN, you can use it to fetch the width and height in characters and in pixels:

```
use Term::ReadKey;
($wchar, $hchar, $wpixels, $hpixels) = GetTerminalSize();
```

This is more portable than the raw `ioctl`, but not as illustrative:

```
require 'sys/ioctl.ph';
die "no TIOCGWINSZ " unless defined &TIOCGWINSZ;
open(TTY, "+</dev/tty")                     or die "No tty: $!";
unless (ioctl(TTY, &TIOCGWINSZ, $winsize='')) {
    die sprintf "$0: ioctl TIOCGWINSZ (%08x: $!)\n", &TIOCGWINSZ;
}
($row, $col, $xpixel, $ypixel) = unpack('S4', $winsize);
print "(row,col) = ($row,$col)";
print "  (xpixel,ypixel) = ($xpixel,$ypixel)" if $xpixel || $ypixel;
print "\n";
```

How do I ask the user for a password?

(This question has nothing to do with the web. See a different FAQ for that.)

There's an example of this in *crypt*). First, you put the terminal into "no echo" mode, then just read the password normally. You may do this with an old-style `ioctl()` function, POSIX terminal control (see *POSIX* or its documentation the Camel Book), or a call to the **stty** program, with varying degrees of portability.

You can also do this for most systems using the Term::ReadKey module from CPAN, which is easier to use and in theory more portable.

```
use Term::ReadKey;

ReadMode('noecho');
$password = ReadLine(0);
```

How do I read and write the serial port?

This depends on which operating system your program is running on. In the case of Unix, the serial ports will be accessible through files in /dev; on other systems, device names will doubtless differ. Several problem areas common to all device interaction are the following:

lockfiles

Your system may use lockfiles to control multiple access. Make sure you follow the correct protocol. Unpredictable behavior can result from multiple processes reading from one device.

open mode

If you expect to use both read and write operations on the device, you'll have to open it for update (see *open in perlfunc* for details). You may wish to open it without running the risk of blocking by using `sysopen()` and `O_RDWR|O_NDELAY|O_NOCTTY` from the Fcntl module (part of the standard perl distribution). See *sysopen in perlfunc* for more on this approach.

end of line

Some devices will be expecting a "\r" at the end of each line rather than a "\n". In some ports of perl, "\r" and "\n" are different from their usual (Unix) ASCII values of "\012" and "\015". You may have to give the numeric values you want directly, using octal ("\015"), hex ("0x0D"), or as a control-character specification ("\cM").

```
print DEV "atv1\012";        # wrong, for some devices
print DEV "atv1\015";        # right, for some devices
```

Even though with normal text files a "\n" will do the trick, there is still no unified scheme for terminating a line that is portable between Unix, DOS/Win, and Macintosh, except to terminate *ALL* line ends with "\015\012", and strip what you don't need from the output. This applies especially to socket I/O and autoflushing, discussed next.

flushing output

If you expect characters to get to your device when you `print()` them, you'll want to autoflush that filehandle. You can use `select()` and the `$|` variable to control autoflushing (see *$|* and *select*, or *perlfaq5*, ''How do I flush/unbuffer an output filehandle? Why must I do this?''):

```
$oldh = select(DEV);
$| = 1;
select($oldh);
```

You'll also see code that does this without a temporary variable, as in

```
select((select(DEV), $| = 1)[0]);
```

Or if you don't mind pulling in a few thousand lines of code just because you're afraid of a little `$|` variable:

```
    use IO::Handle;
    DEV->autoflush(1);
```

As mentioned in the previous item, this still doesn't work when using socket I/O between Unix and Macintosh. You'll need to hardcode your line terminators, in that case.

non-blocking input

If you are doing a blocking `read()` or `sysread()`, you'll have to arrange for an alarm handler to provide a timeout (see *alarm*). If you have a non-blocking open, you'll likely have a non-blocking read, which means you may have to use a 4-arg `select()` to determine whether I/O is ready on that device (see *select in perlfunc*.

While trying to read from his caller-id box, the notorious Jamie Zawinski <jwz@netscape.com, after much gnashing of teeth and fighting with sysread, sysopen, POSIX's tcgetattr business, and various other functions that go bump in the night, finally came up with this:

```
sub open_modem {
    use IPC::Open2;
    my $stty = '/bin/stty -g';
    open2( \*MODEM_IN, \*MODEM_OUT, "cu -l$modem_device -s2400 2>&1");
    # starting cu hoses /dev/tty's stty settings, even when it has
    # been opened on a pipe...
    system("/bin/stty $stty");
    $_ = <MODEM_IN>;
    chop;
    if ( !m/^Connected/ ) {
        print STDERR "$0: cu printed '$_' instead of 'Connected'\n";
    }
}
```

How do I decode encrypted password files?

You spend lots and lots of money on dedicated hardware, but this is bound to get you talked about.

Seriously, you can't if they are Unix password files—the Unix password system employs one-way encryption. It's more like hashing than encryption. The best you can check is whether something else hashes to the same string. You can't turn a hash back into the original string. Programs like Crack can forcibly (and intelligently) try to guess passwords, but don't (can't) guarantee quick success.

If you're worried about users selecting bad passwords, you should proactively check when they try to change their password (by modifying passwd(1), for example).

How do I start a process in the background?

You could use

```
system("cmd &")
```

or you could use fork as documented in *fork in perlfunc*, with further examples in *perlipc*. Some things to be aware of, if you're on a Unix-like system:

STDIN, STDOUT, and STDERR are shared

Both the main process and the backgrounded one (the "child" process) share the same STDIN, STDOUT and STDERR filehandles. If both try to access them at once, strange things can happen. You may want to close or reopen these for the child. You can get around this with `opening` a pipe (see *open in perlfunc*) but on some systems this means that the child process cannot outlive the parent.

Signals

You'll have to catch the SIGCHLD signal, and possibly SIGPIPE too. SIGCHLD is sent when the backgrounded process finishes. SIGPIPE is sent when you write to a filehandle whose child process has closed (an untrapped SIGPIPE can cause your program to silently die). This is not an issue with `system("cmd&")`.

Zombies

You have to be prepared to "reap" the child process when it finishes

```
$SIG{CHLD} = sub { wait };
```

See *Signals in perlipc* for other examples of code to do this. Zombies are not an issue with `system("prog &")`.

How do I trap control characters/signals?

You don't actually "trap" a control character. Instead, that character generates a signal which is sent to your terminal's currently foregrounded process group, which you then trap in your process. Signals are documented in *Signals in perlipc* and the section on ''Signals'' in the Camel.

Be warned that very few C libraries are re-entrant. Therefore, if you attempt to `print()` in a handler that got invoked during another stdio operation your internal structures will likely be in an inconsistent state, and your program will dump core. You can sometimes avoid this by using `syswrite()` instead of `print()`.

Unless you're exceedingly careful, the only safe things to do inside a signal handler are (1) set a variable and (2) exit. In the first case, you should only set a variable in such a way that `malloc()` is not called (eg, by setting a variable that already has a value).

For example:

```
$Interrupted = 0;   # to ensure it has a value
$SIG{INT} = sub {
    $Interrupted++;
    syswrite(STDERR, "ouch\n", 5);
}
```

However, because syscalls restart by default, you'll find that if you're in a "slow" call, such as <FH, `read()`, `connect()`, or `wait()`, that the only way to terminate them is by "longjumping" out; that is, by raising an exception. See the time-out handler for a blocking `flock()` in *Signals in perlipc* or the section on ''Signals'' in the Camel book.

How do I modify the shadow password file on a Unix system?

If perl was installed correctly and your shadow library was written properly, the `getpw*()` functions described in *perlfunc* should in theory provide (read-only) access to entries in the shadow password file. To change the file, make a new shadow password file (the format varies from system to system—see *passwd(5)* for specifics) and use pwd_mkdb(8) to install it (see *pwd_mkdb(8)* for more details).

How do I set the time and date?

Assuming you're running under sufficient permissions, you should be able to set the system-wide date and time by running the date(1) program. (There is no way to set the time and date on a per-process basis.) This mechanism will work for Unix, MS-DOS, Windows, and NT; the VMS equivalent is `set time`.

However, if all you want to do is change your timezone, you can probably get away with setting an environment variable:

```
$ENV{TZ} = "MST7MDT";                    # unixish
$ENV{'SYS$TIMEZONE_DIFFERENTIAL'}="-5" # vms
system "trn comp.lang.perl.misc";
```

How can I `sleep()` or `alarm()` for under a second?

If you want finer granularity than the 1 second that the `sleep()` function provides, the easiest way is to use the `select()` function as documented in *select in perlfunc*. Try the Time::HiRes and the BSD::Itimer modules (available from CPAN).

How can I measure time under a second?

In general, you may not be able to. The Time::HiRes module (available from CPAN) provides this functionality for some systems.

If your system supports both the `syscall()` function in Perl as well as a system call like gettimeofday(2), then you may be able to do something like this:

```
require 'sys/syscall.ph';

$TIMEVAL_T = "LL";

$done = $start = pack($TIMEVAL_T, ());

syscall(&SYS_gettimeofday, $start, 0) != -1
            or die "gettimeofday: $!";

   ##########################
   # DO YOUR OPERATION HERE #
   ##########################

syscall( &SYS_gettimeofday, $done, 0) != -1
       or die "gettimeofday: $!";

@start = unpack($TIMEVAL_T, $start);
@done  = unpack($TIMEVAL_T, $done);

# fix microseconds
for ($done[1], $start[1]) { $_ /= 1_000_000 }

$delta_time = sprintf "%.4f", ($done[0]  + $done[1]  )
                                                 -
                              ($start[0] + $start[1] );
```

How can I do an `atexit()` or `setjmp()/longjmp()`? (Exception handling)

Release 5 of Perl added the END block, which can be used to simulate `atexit()`. Each package's END block is called when the program or thread ends (see *perlmod* manpage for more details).

For example, you can use this to make sure your filter program managed to finish its output without filling up the disk:

```
END {
    close(STDOUT) || die "stdout close failed: $!";
}
```

The END block isn't called when untrapped signals kill the program, though, so if you use END blocks you should also use

```
    use sigtrap qw(die normal-signals);
```

Perl's exception–handling mechanism is its `eval()` operator. You can use `eval()` as setjmp and `die()` as longjmp. For details of this, see the section on signals, especially the time–out handler for a blocking `flock()` in *Signals in perlipc* or the section on ``Signals'' in the Camel Book.

If exception handling is all you're interested in, try the exceptions.pl library (part of the standard perl distribution).

If you want the `atexit()` syntax (and an `rmexit()` as well), try the AtExit module available from CPAN.

Why doesn't my sockets program work under System V (Solaris)? What does the error message "Protocol not supported" mean?

Some Sys–V based systems, notably Solaris 2.X, redefined some of the standard socket constants. Since these were constant across all architectures, they were often hardwired into perl code. The proper way to

deal with this is to "use Socket" to get the correct values.

Note that even though SunOS and Solaris are binary compatible, these values are different. Go figure.

How can I call my system's unique C functions from Perl?

In most cases, you write an external module to do it—see the answer to "Where can I learn about linking C with Perl? [h2xs, xsubpp]". However, if the function is a system call, and your system supports `syscall()`, you can use the syscall function (documented in *perlfunc*).

Remember to check the modules that came with your distribution, and CPAN as well—someone may already have written a module to do it.

Where do I get the include files to do `ioctl()` or `syscall()`?

Historically, these would be generated by the h2ph tool, part of the standard perl distribution. This program converts cpp(1) directives in C header files to files containing subroutine definitions, like `&SYS_getitimer`, which you can use as arguments to your functions. It doesn't work perfectly, but it usually gets most of the job done. Simple files like ***errno.h***, ***syscall.h***, and ***socket.h*** were fine, but the hard ones like ***ioctl.h*** nearly always need to hand−edited. Here's how to install the *.ph files:

```
1.  become super-user
2.  cd /usr/include
3.  h2ph *.h */*.h
```

If your system supports dynamic loading, for reasons of portability and sanity you probably ought to use h2xs (also part of the standard perl distribution). This tool converts C header files to Perl extensions. See *perlxstut* for how to get started with h2xs.

If your system doesn't support dynamic loading, you still probably ought to use h2xs. See *perlxstut* and *ExtUtils::MakeMaker* for more information (in brief, just use **make perl** instead of a plain **make** to rebuild perl with a new static extension).

Why do setuid perl scripts complain about kernel problems?

Some operating systems have bugs in the kernel that make setuid scripts inherently insecure. Perl gives you a number of options (described in *perlsec*) to work around such systems.

How can I open a pipe both to and from a command?

The IPC::Open2 module (part of the standard perl distribution) is an easy−to−use approach that internally uses `pipe()`, `fork()`, and `exec()` to do the job. Make sure you read the deadlock warnings in its documentation, though (see *IPC::Open2*). See
Bidirectional Communication with Another Process in perlipc and
Bidirectional Communication with Yourself in perlipc

You may also use the IPC::Open3 module (part of the standard perl distribution), but be warned that it has a different order of arguments from IPC::Open2 (see *IPC::Open3*).

Why can't I get the output of a command with `system()`?

You're confusing the purpose of `system()` and backticks (``). `system()` runs a command and returns exit status information (as a 16 bit value: the low 7 bits are the signal the process died from, if any, and the high 8 bits are the actual exit value). Backticks (``) run a command and return what it sent to STDOUT.

```
$exit_status   = system("mail-users");
$output_string = `ls`;
```

How can I capture STDERR from an external command?

There are three basic ways of running external commands:

```
system $cmd;                # using system()
$output = `$cmd`;           # using backticks (``)
open (PIPE, "cmd |");       # using open()
```

With `system()`, both STDOUT and STDERR will go the same place as the script's STDOUT and STDERR, unless the `system()` command redirects them. Backticks and `open()` read **only** the STDOUT of your command.

With any of these, you can change file descriptors before the call:

```
open(STDOUT, ">logfile");
system("ls");
```

or you can use Bourne shell file-descriptor redirection:

```
$output = `$cmd 2>some_file`;
open (PIPE, "cmd 2>some_file |");
```

You can also use file-descriptor redirection to make STDERR a duplicate of STDOUT:

```
$output = `$cmd 2>&1`;
open (PIPE, "cmd 2>&1 |");
```

Note that you *cannot* simply open STDERR to be a dup of STDOUT in your Perl program and avoid calling the shell to do the redirection. This doesn't work:

```
open(STDERR, ">&STDOUT");
$alloutput = `cmd args`;  # stderr still escapes
```

This fails because the `open()` makes STDERR go to where STDOUT was going at the time of the `open()`. The backticks then make STDOUT go to a string, but don't change STDERR (which still goes to the old STDOUT).

Note that you *must* use Bourne shell (sh(1)) redirection syntax in backticks, not csh(1)! Details on why Perl's `system()` and backtick and pipe opens all use the Bourne shell are in http://www.perl.com/CPAN/doc/FMTEYEWTK/versus/csh.whynot . To capture a command's STDERR and STDOUT together:

```
$output = `cmd 2>&1`;                       # either with backticks
$pid = open(PH, "cmd 2>&1 |");              # or with an open pipe
while (<PH>) { }                            #    plus a read
```

To capture a command's STDOUT but discard its STDERR:

```
$output = `cmd 2>/dev/null`;                # either with backticks
$pid = open(PH, "cmd 2>/dev/null |");       # or with an open pipe
while (<PH>) { }                            #    plus a read
```

To capture a command's STDERR but discard its STDOUT:

```
$output = `cmd 2>&1 1>/dev/null`;           # either with backticks
$pid = open(PH, "cmd 2>&1 1>/dev/null |");  # or with an open pipe
while (<PH>) { }                            #    plus a read
```

To exchange a command's STDOUT and STDERR in order to capture the STDERR but leave its STDOUT to come out our old STDERR:

```
$output = `cmd 3>&1 1>&2 2>&3 3>&-`;        # either with backticks
$pid = open(PH, "cmd 3>&1 1>&2 2>&3 3>&-|");# or with an open pipe
while (<PH>) { }                            #    plus a read
```

To read both a command's STDOUT and its STDERR separately, it's easiest and safest to redirect them separately to files, and then read from those files when the program is done:

```
system("program args 1>/tmp/program.stdout 2>/tmp/program.stderr");
```

Ordering is important in all these examples. That's because the shell processes file descriptor redirections in strictly left to right order.

```
system("prog args 1>tmpfile 2>&1");
system("prog args 2>&1 1>tmpfile");
```

The first command sends both standard out and standard error to the temporary file. The second command sends only the old standard output there, and the old standard error shows up on the old standard out.

Why doesn't `open()` return an error when a pipe open fails?

Because the pipe open takes place in two steps: first Perl calls `fork()` to start a new process, then this new process calls `exec()` to run the program you really wanted to open. The first step reports success or failure to your process, so `open()` can only tell you whether the `fork()` succeeded or not.

To find out if the `exec()` step succeeded, you have to catch SIGCHLD and `wait()` to get the exit status. You should also catch SIGPIPE if you're writing to the child—you may not have found out the `exec()` failed by the time you write. This is documented in *perlipc*.

In some cases, even this won't work. If the second argument to a piped `open()` contains shell metacharacters, perl `fork()`s, then `exec()`s a shell to decode the metacharacters and eventually run the desired program. Now when you call `wait()`, you only learn whether or not the *shell* could be successfully started...it's best to avoid shell metacharacters.

On systems that follow the `spawn()` paradigm, `open()` *might* do what you expect—unless perl uses a shell to start your command. In this case the `fork()/exec()` description still applies.

What's wrong with using backticks in a void context?

Strictly speaking, nothing. Stylistically speaking, it's not a good way to write maintainable code because backticks have a (potentially humongous) return value, and you're ignoring it. It's may also not be very efficient, because you have to read in all the lines of output, allocate memory for them, and then throw it away. Too often people are lulled to writing:

```
`cp file file.bak`;
```

And now they think "Hey, I'll just always use backticks to run programs." Bad idea: backticks are for capturing a program's output; the `system()` function is for running programs.

Consider this line:

```
`cat /etc/termcap`;
```

You haven't assigned the output anywhere, so it just wastes memory (for a little while). You forgot to check `$?` to see whether the program even ran correctly, too. Even if you wrote

```
print `cat /etc/termcap`;
```

this code could and probably should be written as

```
system("cat /etc/termcap") == 0
    or die "cat program failed!";
```

which will get the output quickly (as it is generated, instead of only at the end) and also check the return value.

`system()` also provides direct control over whether shell wildcard processing may take place, whereas backticks do not.

How can I call backticks without shell processing?

This is a bit tricky. Instead of writing

```
@ok = `grep @opts '$search_string' @filenames`;
```

You have to do this:

```
my @ok = ();
if (open(GREP, "-|")) {
    while (<GREP>) {
```

```
            chomp;
            push(@ok, $_);
        }
        close GREP;
    } else {
        exec 'grep', @opts, $search_string, @filenames;
    }
```

Just as with `system()`, no shell escapes happen when you `exec()` a list. Further examples of this can be found in *Safe Pipe Opens in perlipc*.

Note that if you're stuck on Microsoft, no solution to this vexing issue is even possible. Even if Perl were to emulate `fork()`, you'd still be hosed, because Microsoft gives no argc/argv-style API. Their API always reparses from a single string, which is fundamentally wrong, but you're not likely to get the Gods of Redmond to acknowledge this and fix it for you.

Why can't my script read from STDIN after I gave it EOF (^D on Unix, ^Z on MS-DOS)?

Some stdio's set error and eof flags that need clearing. The POSIX module defines `clearerr()` that you can use. That is the technically correct way to do it. Here are some less reliable workarounds:

1. Try keeping around the seekpointer and go there, like this:

   ```
   $where = tell(LOG);
   seek(LOG, $where, 0);
   ```

2. If that doesn't work, try seeking to a different part of the file and then back.

3. If that doesn't work, try seeking to a different part of the file, reading something, and then seeking back.

4. If that doesn't work, give up on your stdio package and use sysread.

How can I convert my shell script to perl?

Learn Perl and rewrite it. Seriously, there's no simple converter. Things that are awkward to do in the shell are easy to do in Perl, and this very awkwardness is what would make a shell-perl converter nigh-on impossible to write. By rewriting it, you'll think about what you're really trying to do, and hopefully will escape the shell's pipeline datastream paradigm, which while convenient for some matters, causes many inefficiencies.

Can I use perl to run a telnet or ftp session?

Try the Net::FTP, TCP::Client, and Net::Telnet modules (available from CPAN).
http://www.perl.com/CPAN/scripts/netstuff/telnet.emul.shar will also help for emulating the telnet protocol, but Net::Telnet is quite probably easier to use..

If all you want to do is pretend to be telnet but don't need the initial telnet handshaking, then the standard dual-process approach will suffice:

```
use IO::Socket;             # new in 5.004
$handle = IO::Socket::INET->new('www.perl.com:80')
        || die "can't connect to port 80 on www.perl.com: $!";
$handle->autoflush(1);
if (fork()) {               # XXX: undef means failure
    select($handle);
    print while <STDIN>;    # everything from stdin to socket
} else {
    print while <$handle>;  # everything from socket to stdout
}
close $handle;
exit;
```

How can I write expect in Perl?

Once upon a time, there was a library called chat2.pl (part of the standard perl distribution), which never really got finished. If you find it somewhere, *don't use it*. These days, your best bet is to look at the Expect module available from CPAN, which also requires two other modules from CPAN, IO::Pty and IO::Stty.

Is there a way to hide perl's command line from programs such as "ps"?

First of all note that if you're doing this for security reasons (to avoid people seeing passwords, for example) then you should rewrite your program so that critical information is never given as an argument. Hiding the arguments won't make your program completely secure.

To actually alter the visible command line, you can assign to the variable `$0` as documented in *perlvar*. This won't work on all operating systems, though. Daemon programs like sendmail place their state there, as in:

```
$0 = "orcus [accepting connections]";
```

I {changed directory, modified my environment} in a perl script. How come the change disappeared when I exited the script? How do I get my changes to be visible?

Unix

In the strictest sense, it can't be done—the script executes as a different process from the shell it was started from. Changes to a process are not reflected in its parent—only in any children created after the change. There is shell magic that may allow you to fake it by `eval()`ing the script's output in your shell; check out the comp.unix.questions FAQ for details.

How do I close a process's filehandle without waiting for it to complete?

Assuming your system supports such things, just send an appropriate signal to the process (see *kill in perlfunc*). It's common to first send a TERM signal, wait a little bit, and then send a KILL signal to finish it off.

How do I fork a daemon process?

If by daemon process you mean one that's detached (disassociated from its tty), then the following process is reported to work on most Unixish systems. Non–Unix users should check their Your_OS::Process module for other solutions.

- Open /dev/tty and use the TIOCNOTTY ioctl on it. See *tty(4)* for details. Or better yet, you can just use the `POSIX::setsid()` function, so you don't have to worry about process groups.
- Change directory to /
- Reopen STDIN, STDOUT, and STDERR so they're not connected to the old tty.
- Background yourself like this:

```
fork && exit;
```

The Proc::Daemon module, available from CPAN, provides a function to perform these actions for you.

How do I find out if I'm running interactively or not?

Good question. Sometimes `-t STDIN` and `-t STDOUT` can give clues, sometimes not.

```
if (-t STDIN && -t STDOUT) {
    print "Now what? ";
}
```

On POSIX systems, you can test whether your own process group matches the current process group of your controlling terminal as follows:

```
use POSIX qw/getpgrp tcgetpgrp/;
open(TTY, "/dev/tty") or die $!;
$tpgrp = tcgetpgrp(fileno(*TTY));
$pgrp = getpgrp();
```

```
if ($tpgrp == $pgrp) {
    print "foreground\n";
} else {
    print "background\n";
}
```

How do I timeout a slow event?

Use the `alarm()` function, probably in conjunction with a signal handler, as documented in *Signals in perlipc* and the section on ‘‘Signals‘‘ in the Camel. You may instead use the more flexible Sys::AlarmCall module available from CPAN.

How do I set CPU limits?

Use the BSD::Resource module from CPAN.

How do I avoid zombies on a Unix system?

Use the reaper code from *Signals in perlipc* to call `wait()` when a SIGCHLD is received, or else use the double−fork technique described in *fork*.

How do I use an SQL database?

There are a number of excellent interfaces to SQL databases. See the DBD::* modules available from http://www.perl.com/CPAN/modules/DBD . A lot of information on this can be found at http://www.symbolstone.org/technology/perl/DBI/

How do I make a `system()` exit on control−C?

You can‘t. You need to imitate the `system()` call (see *perlipc* for sample code) and then have a signal handler for the INT signal that passes the signal on to the subprocess. Or you can check for it:

```
$rc = system($cmd);
if ($rc & 127) { die "signal death" }
```

How do I open a file without blocking?

If you‘re lucky enough to be using a system that supports non−blocking reads (most Unixish systems do), you need only to use the O_NDELAY or O_NONBLOCK flag from the Fcntl module in conjunction with `sysopen()`:

```
use Fcntl;
sysopen(FH, "/tmp/somefile", O_WRONLY|O_NDELAY|O_CREAT, 0644)
    or die "can’t open /tmp/somefile: $!":
```

How do I install a module from CPAN?

The easiest way is to have a module also named CPAN do it for you. This module comes with perl version 5.004 and later. To manually install the CPAN module, or any well−behaved CPAN module for that matter, follow these steps:

1 Unpack the source into a temporary area.

2
```
perl Makefile.PL
```

3
```
make
```

4
```
make test
```

5
```
make install
```

If your version of perl is compiled without dynamic loading, then you just need to replace step 3 (**make**) with **make perl** and you will get a new ***perl*** binary with your extension linked in.

See *ExtUtils::MakeMaker* for more details on building extensions. See also the next question, ‘‘What‘s the difference between require and use?‘‘.

What‘s the difference between require and use?

Perl offers several different ways to include code from one file into another. Here are the deltas between the various inclusion constructs:

```
1)  do $file is like eval `cat $file`, except the former
    1.1: searches @INC and updates %INC.
    1.2: bequeaths an *unrelated* lexical scope on the eval'ed code.

2)  require $file is like do $file, except the former
    2.1: checks for redundant loading, skipping already loaded files.
    2.2: raises an exception on failure to find, compile, or execute $file.

3)  require Module is like require "Module.pm", except the former
    3.1: translates each "::" into your system's directory separator.
    3.2: primes the parser to disambiguate class Module as an indirect object.

4)  use Module is like require Module, except the former
    4.1: loads the module at compile time, not run-time.
    4.2: imports symbols and semantics from that package to the current one.
```

In general, you usually want `use` and a proper Perl module.

How do I keep my own module/library directory?

When you build modules, use the PREFIX option when generating Makefiles:

```
perl Makefile.PL PREFIX=/u/mydir/perl
```

then either set the PERL5LIB environment variable before you run scripts that use the modules/libraries (see *perlrun*) or say

```
use lib '/u/mydir/perl';
```

This is almost the same as

```
BEGIN {
    unshift(@INC, '/u/mydir/perl');
}
```

except that the lib module checks for machine–dependent subdirectories. See Perl‘s *lib* for more information.

How do I add the directory my program lives in to the module/library search path?

```
use FindBin;
use lib "$FindBin::Bin";
use your_own_modules;
```

How do I add a directory to my include path at runtime?

Here are the suggested ways of modifying your include path:

```
the PERLLIB environment variable
the PERL5LIB environment variable
the perl -Idir command line flag
the use lib pragma, as in
    use lib "$ENV{HOME}/myown_perllib";
```

The latter is particularly useful because it knows about machine dependent architectures. The lib.pm pragmatic module was first included with the 5.002 release of Perl.

What is socket.ph and where do I get it?

It's a perl4−style file defining values for system networking constants. Sometimes it is built using h2ph when Perl is installed, but other times it is not. Modern programs `use Socket;` instead.

AUTHOR AND COPYRIGHT

NAME

perlfaq9 – Networking (`$Revision: 1.26 $, $Date: 1999/05/23 16:08:30 $`)

DESCRIPTION

This section deals with questions related to networking, the internet, and a few on the web.

My CGI script runs from the command line but not the browser. (500 Server Error)

If you can demonstrate that you've read the following FAQs and that your problem isn't something simple that can be easily answered, you'll probably receive a courteous and useful reply to your question if you post it on comp.infosystems.www.authoring.cgi (if it's something to do with HTTP, HTML, or the CGI protocols). Questions that appear to be Perl questions but are really CGI ones that are posted to comp.lang.perl.misc may not be so well received.

The useful FAQs and related documents are:

```
CGI FAQ
    http://www.webthing.com/tutorials/cgifaq.html

Web FAQ
    http://www.boutell.com/faq/

WWW Security FAQ
    http://www.w3.org/Security/Faq/

HTTP Spec
    http://www.w3.org/pub/WWW/Protocols/HTTP/

HTML Spec
    http://www.w3.org/TR/REC-html40/
    http://www.w3.org/pub/WWW/MarkUp/

CGI Spec
    http://www.w3.org/CGI/

CGI Security FAQ
    http://www.go2net.com/people/paulp/cgi-security/safe-cgi.txt
```

How can I get better error messages from a CGI program?

Use the CGI::Carp module. It replaces `warn` and `die`, plus the normal Carp modules `carp`, `croak`, and `confess` functions with more verbose and safer versions. It still sends them to the normal server error log.

```
use CGI::Carp;
warn "This is a complaint";
die "But this one is serious";
```

The following use of CGI::Carp also redirects errors to a file of your choice, placed in a BEGIN block to catch compile–time warnings as well:

```
BEGIN {
    use CGI::Carp qw(carpout);
    open(LOG, ">>/var/local/cgi-logs/mycgi-log")
        or die "Unable to append to mycgi-log: $!\n";
    carpout(*LOG);
}
```

You can even arrange for fatal errors to go back to the client browser, which is nice for your own debugging, but might confuse the end user.

```
use CGI::Carp qw(fatalsToBrowser);
die "Bad error here";
```

Even if the error happens before you get the HTTP header out, the module will try to take care of this to avoid the dreaded server 500 errors. Normal warnings still go out to the server error log (or wherever you've sent them with `carpout`) with the application name and date stamp prepended.

How do I remove HTML from a string?

The most correct way (albeit not the fastest) is to use HTML::Parser from CPAN. Another mostly correct way is to use HTML::FormatText which not only removes HTML but also attempts to do a little simple formatting of the resulting plain text.

Many folks attempt a simple-minded regular expression approach, like `s/<.*?//g` , but that fails in many cases because the tags may continue over line breaks, they may contain quoted angle-brackets, or HTML comment may be present. Plus, folks forget to convert entities—like `<` for example.

Here's one "simple-minded" approach, that works for most files:

```
#!/usr/bin/perl -p0777
s/<(?:[^>'"]*|(['"]).*?\1)*>//gs
```

If you want a more complete solution, see the 3-stage striphtml program in http://www.perl.com/CPAN/authors/Tom_Christiansen/scripts/striphtml.gz .

Here are some tricky cases that you should think about when picking a solution:

```
<IMG SRC = "foo.gif" ALT = "A > B">

<IMG SRC = "foo.gif"
     ALT = "A > B">

<!-- <A comment> -->

<script>if (a<b && a>c)</script>

<# Just data #>

<![INCLUDE CDATA [ >>>>>>>>>>>> ]]>
```

If HTML comments include other tags, those solutions would also break on text like this:

```
<!-- This section commented out.
    <B>You can't see me!</B>
-->
```

How do I extract URLs?

A quick but imperfect approach is

```
#!/usr/bin/perl -n00
# qxurl - tchrist@perl.com
print "$2\n" while m{
    < \s*
      A \s+ HREF \s* = \s* (["']) (.*?) \1
    \s* >
}gsix;
```

This version does not adjust relative URLs, understand alternate bases, deal with HTML comments, deal with HREF and NAME attributes in the same tag, understand extra qualifiers like TARGET, or accept URLs themselves as arguments. It also runs about 100x faster than a more "complete" solution using the LWP suite of modules, such as the http://www.perl.com/CPAN/authors/Tom_Christiansen/scripts/xurl.gz program.

How do I download a file from the user's machine? How do I open a file on another machine?

In the context of an HTML form, you can use what's known as **multipart/form-data** encoding. The CGI.pm module (available from CPAN) supports this in the `start_multipart_form()` method, which isn't the same as the `startform()` method.

How do I make a pop–up menu in HTML?

Use the **< <SELECT** and **< <OPTION** tags. The CGI.pm module (available from CPAN) supports this widget, as well as many others, including some that it cleverly synthesizes on its own.

How do I fetch an HTML file?

One approach, if you have the lynx text–based HTML browser installed on your system, is this:

```
$html_code = 'lynx -source $url';
$text_data = 'lynx -dump $url';
```

The libwww–perl (LWP) modules from CPAN provide a more powerful way to do this. They don't require lynx, but like lynx, can still work through proxies:

```
# simplest version
use LWP::Simple;
$content = get($URL);

# or print HTML from a URL
use LWP::Simple;
getprint "http://www.linpro.no/lwp/";

# or print ASCII from HTML from a URL
# also need HTML-Tree package from CPAN
use LWP::Simple;
use HTML::Parser;
use HTML::FormatText;
my ($html, $ascii);
$html = get("http://www.perl.com/");
defined $html
    or die "Can't fetch HTML from http://www.perl.com/";
$ascii = HTML::FormatText->new->format(parse_html($html));
print $ascii;
```

How do I automate an HTML form submission?

If you're submitting values using the GET method, create a URL and encode the form using the `query_form` method:

```
use LWP::Simple;
use URI::URL;

my $url = url('http://www.perl.com/cgi-bin/cpan_mod');
$url->query_form(module => 'DB_File', readme => 1);
$content = get($url);
```

If you're using the POST method, create your own user agent and encode the content appropriately.

```
use HTTP::Request::Common qw(POST);
use LWP::UserAgent;

$ua = LWP::UserAgent->new();
my $req = POST 'http://www.perl.com/cgi-bin/cpan_mod',
               [ module => 'DB_File', readme => 1 ];
$content = $ua->request($req)->as_string;
```

How do I decode or create those %–encodings on the web?

Here's an example of decoding:

```
$string = "http://altavista.digital.com/cgi-bin/query?pg=q&what=news&fmt=.&q=%2Bc
$string =~ s/%([a-fA-F0-9]{2})/chr(hex($1))/ge;
```

Encoding is a bit harder, because you can't just blindly change all characters that are not letters, digits or underscores (`\W`) into their hex escapes. It's important that characters with special meaning like `/` and `?` *not* be translated. Probably the easiest way to get this right is to avoid reinventing the wheel and just use the URI::Escape module, available from CPAN.

How do I redirect to another page?

Instead of sending back a `Content-Type` as the headers of your reply, send back a `Location:` header. Officially this should be a `URI:` header, so the CGI.pm module (available from CPAN) sends back both:

```
Location: http://www.domain.com/newpage
URI: http://www.domain.com/newpage
```

Note that relative URLs in these headers can cause strange effects because of "optimizations" that servers do.

```
$url = "http://www.perl.com/CPAN/";
print "Location: $url\n\n";
exit;
```

To target a particular frame in a frameset, include the "Window-target:" in the header.

```
print <<EOF;
Location: http://www.domain.com/newpage
Window-target: <FrameName>

EOF
```

To be correct to the spec, each of those virtual newlines should really be physical `"\015\012"` sequences by the time your message is received by the client browser. Except for NPH scripts, though, that local newline should get translated by your server into standard form, so you shouldn't have a problem here, even if you are stuck on MacOS. Everybody else probably won't even notice.

How do I put a password on my web pages?

That depends. You'll need to read the documentation for your web server, or perhaps check some of the other FAQs referenced above.

How do I edit my .htpasswd and .htgroup files with Perl?

The HTTPD::UserAdmin and HTTPD::GroupAdmin modules provide a consistent OO interface to these files, regardless of how they're stored. Databases may be text, dbm, Berkley DB or any database with a DBI compatible driver. HTTPD::UserAdmin supports files used by the 'Basic' and 'Digest' authentication schemes. Here's an example:

```
use HTTPD::UserAdmin ();
HTTPD::UserAdmin
      ->new(DB => "/foo/.htpasswd")
      ->add($username => $password);
```

How do I make sure users can't enter values into a form that cause my CGI script to do bad things?

Read the CGI security FAQ, at http://www-genome.wi.mit.edu/WWW/faqs/www-security-faq.html , and the Perl/CGI FAQ at http://www.perl.com/CPAN/doc/FAQs/cgi/perl-cgi-faq.html .

In brief: use tainting (see *perlsec*), which makes sure that data from outside your script (eg, CGI parameters) are never used in `eval` or `system` calls. In addition to tainting, never use the single-argument form of `system()` or `exec()`. Instead, supply the command and arguments as a list, which prevents shell globbing.

How do I parse a mail header?

For a quick-and-dirty solution, try this solution derived from *split*:

```
$/ = '';
```

```
$header = <MSG>;
$header =~ s/\n\s+/ /g;merge continuation lines
%head = ( UNIX_FROM_LINE, split /^([-\w]+):\s*/m, $header );
```

That solution doesn't do well if, for example, you're trying to maintain all the Received lines. A more complete approach is to use the Mail::Header module from CPAN (part of the MailTools package).

How do I decode a CGI form?

You use a standard module, probably CGI.pm. Under no circumstances should you attempt to do so by hand!

You'll see a lot of CGI programs that blindly read from STDIN the number of bytes equal to CONTENT_LENGTH for POSTs, or grab QUERY_STRING for decoding GETs. These programs are very poorly written. They only work sometimes. They typically forget to check the return value of the `read()` system call, which is a cardinal sin. They don't handle HEAD requests. They don't handle multipart forms used for file uploads. They don't deal with GET/POST combinations where query fields are in more than one place. They don't deal with keywords in the query string.

In short, they're bad hacks. Resist them at all costs. Please do not be tempted to reinvent the wheel. Instead, use the CGI.pm or CGI_Lite.pm (available from CPAN), or if you're trapped in the module-free land of perl1 .. perl4, you might look into cgi-lib.pl (available from http://cgi-lib.stanford.edu/cgi-lib/).

Make sure you know whether to use a GET or a POST in your form. GETs should only be used for something that doesn't update the server. Otherwise you can get mangled databases and repeated feedback mail messages. The fancy word for this is ''idempotency''. This simply means that there should be no difference between making a GET request for a particular URL once or multiple times. This is because the HTTP protocol definition says that a GET request may be cached by the browser, or server, or an intervening proxy. POST requests cannot be cached, because each request is independent and matters. Typically, POST requests change or depend on state on the server (query or update a database, send mail, or purchase a computer).

How do I check a valid mail address?

You can't, at least, not in real time. Bummer, eh?

Without sending mail to the address and seeing whether there's a human on the other hand to answer you, you cannot determine whether a mail address is valid. Even if you apply the mail header standard, you can have problems, because there are deliverable addresses that aren't RFC-822 (the mail header standard) compliant, and addresses that aren't deliverable which are compliant.

Many are tempted to try to eliminate many frequently-invalid mail addresses with a simple regex, such as `/^[\w.-]+\@([\w.-]\.)+\w+$/`. It's a very bad idea. However, this also throws out many valid ones, and says nothing about potential deliverability, so is not suggested. Instead, see http://www.perl.com/CPAN/authors/Tom_Christiansen/scripts/ckaddr.gz , which actually checks against the full RFC spec (except for nested comments), looks for addresses you may not wish to accept mail to (say, Bill Clinton or your postmaster), and then makes sure that the hostname given can be looked up in the DNS MX records. It's not fast, but it works for what it tries to do.

Our best advice for verifying a person's mail address is to have them enter their address twice, just as you normally do to change a password. This usually weeds out typos. If both versions match, send mail to that address with a personal message that looks somewhat like:

```
Dear someuser@host.com,

Please confirm the mail address you gave us Wed May  6 09:38:41
MDT 1998 by replying to this message.  Include the string
"Rumpelstiltskin" in that reply, but spelled in reverse; that is,
start with "Nik...".  Once this is done, your confirmed address will
be entered into our records.
```

If you get the message back and they've followed your directions, you can be reasonably assured that it's

real.

A related strategy that's less open to forgery is to give them a PIN (personal ID number). Record the address and PIN (best that it be a random one) for later processing. In the mail you send, ask them to include the PIN in their reply. But if it bounces, or the message is included via a ''vacation'' script, it'll be there anyway. So it's best to ask them to mail back a slight alteration of the PIN, such as with the characters reversed, one added or subtracted to each digit, etc.

How do I decode a MIME/BASE64 string?

The MIME−tools package (available from CPAN) handles this and a lot more. Decoding BASE64 becomes as simple as:

```
use MIME::base64;
$decoded = decode_base64($encoded);
```

A more direct approach is to use the `unpack()` function's "u" format after minor transliterations:

```
tr#A-Za-z0-9+/##cd;                  # remove non-base64 chars
tr#A-Za-z0-9+/# -_#;                 # convert to uuencoded format
$len = pack("c", 32 + 0.75*length);  # compute length byte
print unpack("u", $len . $_);        # uudecode and print
```

How do I return the user's mail address?

On systems that support getpwuid, the `$<` variable, and the Sys::Hostname module (which is part of the standard perl distribution), you can probably try using something like this:

```
use Sys::Hostname;
$address = sprintf('%s@%s', scalar getpwuid($<), hostname);
```

Company policies on mail address can mean that this generates addresses that the company's mail system will not accept, so you should ask for users' mail addresses when this matters. Furthermore, not all systems on which Perl runs are so forthcoming with this information as is Unix.

The Mail::Util module from CPAN (part of the MailTools package) provides a `mailaddress()` function that tries to guess the mail address of the user. It makes a more intelligent guess than the code above, using information given when the module was installed, but it could still be incorrect. Again, the best way is often just to ask the user.

How do I send mail?

Use the `sendmail` program directly:

```
open(SENDMAIL, "|/usr/lib/sendmail -oi -t -odq")
                    or die "Can't fork for sendmail: $!\n";
print SENDMAIL <<"EOF";
From: User Originating Mail <me\@host>
To: Final Destination <you\@otherhost>
Subject: A relevant subject line

Body of the message goes here after the blank line
in as many lines as you like.
EOF
close(SENDMAIL)     or warn "sendmail didn't close nicely";
```

The **−oi** option prevents sendmail from interpreting a line consisting of a single dot as "end of message". The **−t** option says to use the headers to decide who to send the message to, and **−odq** says to put the message into the queue. This last option means your message won't be immediately delivered, so leave it out if you want immediate delivery.

Alternate, less convenient approaches include calling mail (sometimes called mailx) directly or simply opening up port 25 have having an intimate conversation between just you and the remote SMTP daemon, probably sendmail.

Or you might be able use the CPAN module Mail::Mailer:

```
use Mail::Mailer;

$mailer = Mail::Mailer->new();
$mailer->open({ From    => $from_address,
                To      => $to_address,
                Subject => $subject,
              })
    or die "Can't open: $!\n";
print $mailer $body;
$mailer->close();
```

The Mail::Internet module uses Net::SMTP which is less Unix-centric than Mail::Mailer, but less reliable. Avoid raw SMTP commands. There are many reasons to use a mail transport agent like sendmail. These include queueing, MX records, and security.

How do I read mail?

While you could use the Mail::Folder module from CPAN (part of the MailFolder package) or the Mail::Internet module from CPAN (also part of the MailTools package), often a module is overkill. Here's a mail sorter.

```
#!/usr/bin/perl
# bysub1 - simple sort by subject
my(@msgs, @sub);
my $msgno = -1;
$/ = '';                    # paragraph reads
while (<>) {
    if (/^From/m) {
        /^Subject:\s*(?:Re:\s*)*(.*)/mi;
        $sub[++$msgno] = lc($1) || '';
    }
    $msgs[$msgno] .= $_;
}
for my $i (sort { $sub[$a] cmp $sub[$b] || $a <=> $b } (0 .. $#msgs)) {
    print $msgs[$i];
}
```

Or more succinctly,

```
#!/usr/bin/perl -n00
# bysub2 - awkish sort-by-subject
BEGIN { $msgno = -1 }
$sub[++$msgno] = (/^Subject:\s*(?:Re:\s*)*(.*)/mi)[0] if /^From/m;
$msg[$msgno] .= $_;
END { print @msg[ sort { $sub[$a] cmp $sub[$b] || $a <=> $b } (0 .. $#msg) ] }
```

How do I find out my hostname/domainname/IP address?

The normal way to find your own hostname is to call the `hostname` program. While sometimes expedient, this has some problems, such as not knowing whether you've got the canonical name or not. It's one of those tradeoffs of convenience versus portability.

The Sys::Hostname module (part of the standard perl distribution) will give you the hostname after which you can find out the IP address (assuming you have working DNS) with a `gethostbyname()` call.

```
use Socket;
use Sys::Hostname;
my $host = hostname();
my $addr = inet_ntoa(scalar gethostbyname($host || 'localhost'));
```

Probably the simplest way to learn your DNS domain name is to grok it out of /etc/resolv.conf, at least under Unix. Of course, this assumes several things about your resolv.conf configuration, including that it exists.

(We still need a good DNS domain name−learning method for non−Unix systems.)

How do I fetch a news article or the active newsgroups?

Use the Net::NNTP or News::NNTPClient modules, both available from CPAN. This can make tasks like fetching the newsgroup list as simple as

```
perl -MNews::NNTPClient
  -e 'print News::NNTPClient->new->list("newsgroups")'
```

How do I fetch/put an FTP file?

LWP::Simple (available from CPAN) can fetch but not put. Net::FTP (also available from CPAN) is more complex but can put as well as fetch.

How can I do RPC in Perl?

A DCE::RPC module is being developed (but is not yet available) and will be released as part of the DCE−Perl package (available from CPAN). The rpcgen suite, available from CPAN/authors/id/JAKE/, is an RPC stub generator and includes an RPC::ONC module.

AUTHOR AND COPYRIGHT

NAME

perlfilter – Source Filters

DESCRIPTION

This article is about a little–known feature of Perl called *source filters*. Source filters alter the program text of a module before Perl sees it, much as a C preprocessor alters the source text of a C program before the compiler sees it. This article tells you more about what source filters are, how they work, and how to write your own.

The original purpose of source filters was to let you encrypt your program source to prevent casual piracy. This isn't all they can do, as you'll soon learn. But first, the basics.

CONCEPTS

Before the Perl interpreter can execute a Perl script, it must first read it from a file into memory for parsing and compilation. If that script itself includes other scripts with a `use` or `require` statement, then each of those scripts will have to be read from their respective files as well.

Now think of each logical connection between the Perl parser and an individual file as a *source stream*. A source stream is created when the Perl parser opens a file, it continues to exist as the source code is read into memory, and it is destroyed when Perl is finished parsing the file. If the parser encounters a `require` or `use` statement in a source stream, a new and distinct stream is created just for that file.

The diagram below represents a single source stream, with the flow of source from a Perl script file on the left into the Perl parser on the right. This is how Perl normally operates.

```
file -------> parser
```

There are two important points to remember:

1. Although there can be any number of source streams in existence at any given time, only one will be active.

2. Every source stream is associated with only one file.

A source filter is a special kind of Perl module that intercepts and modifies a source stream before it reaches the parser. A source filter changes our diagram like this:

```
file ----> filter ----> parser
```

If that doesn't make much sense, consider the analogy of a command pipeline. Say you have a shell script stored in the compressed file *trial.gz*. The simple pipeline command below runs the script without needing to create a temporary file to hold the uncompressed file.

```
gunzip -c trial.gz | sh
```

In this case, the data flow from the pipeline can be represented as follows:

```
trial.gz ----> gunzip ----> sh
```

With source filters, you can store the text of your script compressed and use a source filter to uncompress it for Perl's parser:

```
 compressed           gunzip
Perl program ---> source filter ---> parser
```

USING FILTERS

So how do you use a source filter in a Perl script? Above, I said that a source filter is just a special kind of module. Like all Perl modules, a source filter is invoked with a use statement.

Say you want to pass your Perl source through the C preprocessor before execution. You could use the existing `-P` command line option to do this, but as it happens, the source filters distribution comes with a C preprocessor filter module called Filter::cpp. Let's use that instead.

Below is an example program, `cpp_test`, which makes use of this filter. Line numbers have been added to allow specific lines to be referenced easily.

```
1: use Filter::cpp ;
2: #define TRUE 1
3: $a = TRUE ;
4: print "a = $a\n" ;
```

When you execute this script, Perl creates a source stream for the file. Before the parser processes any of the lines from the file, the source stream looks like this:

```
cpp_test ---------> parser
```

Line 1, `use Filter::cpp`, includes and installs the `cpp` filter module. All source filters work this way. The use statement is compiled and executed at compile time, before any more of the file is read, and it attaches the cpp filter to the source stream behind the scenes. Now the data flow looks like this:

```
cpp_test ----> cpp filter ----> parser
```

As the parser reads the second and subsequent lines from the source stream, it feeds those lines through the `cpp` source filter before processing them. The `cpp` filter simply passes each line through the real C preprocessor. The output from the C preprocessor is then inserted back into the source stream by the filter.

```
                .-> cpp --.
                |         |
                |         |
                |       <-'
cpp_test ----> cpp filter ----> parser
```

The parser then sees the following code:

```
use Filter::cpp ;
$a = 1 ;
print "a = $a\n" ;
```

Let's consider what happens when the filtered code includes another module with use:

```
1: use Filter::cpp ;
2: #define TRUE 1
3: use Fred ;
4: $a = TRUE ;
5: print "a = $a\n" ;
```

The `cpp` filter does not apply to the text of the Fred module, only to the text of the file that used it (`cpp_test`). Although the use statement on line 3 will pass through the cpp filter, the module that gets included (`Fred`) will not. The source streams look like this after line 3 has been parsed and before line 4 is parsed:

```
cpp_test ---> cpp filter ---> parser (INACTIVE)

Fred.pm ----> parser
```

As you can see, a new stream has been created for reading the source from `Fred.pm`. This stream will remain active until all of `Fred.pm` has been parsed. The source stream for `cpp_test` will still exist, but is inactive. Once the parser has finished reading Fred.pm, the source stream associated with it will be destroyed. The source stream for `cpp_test` then becomes active again and the parser reads line 4 and subsequent lines from `cpp_test`.

You can use more than one source filter on a single file. Similarly, you can reuse the same filter in as many files as you like.

For example, if you have a uuencoded and compressed source file, it is possible to stack a uudecode filter and an uncompression filter like this:

```
use Filter::uudecode ; use Filter::uncompress ;
M'XL(".H<US4''V9I;F%L')Q;>7/;1I;_>_I3=&E=%:F*I"T?22Q/
M6]9*<IQCO*XFT"0[PL%%'Y+IG?WN^ZYN-$'J.[.JE$,20/?K=_[>
...
```

Once the first line has been processed, the flow will look like this:

```
file ---> uudecode ---> uncompress ---> parser
           filter         filter
```

Data flows through filters in the same order they appear in the source file. The uudecode filter appeared before the uncompress filter, so the source file will be uudecoded before it's uncompressed.

WRITING A SOURCE FILTER

There are three ways to write your own source filter. You can write it in C, use an external program as a filter, or write the filter in Perl. I won't cover the first two in any great detail, so I'll get them out of the way first. Writing the filter in Perl is most convenient, so I'll devote the most space to it.

WRITING A SOURCE FILTER IN C

The first of the three available techniques is to write the filter completely in C. The external module you create interfaces directly with the source filter hooks provided by Perl.

The advantage of this technique is that you have complete control over the implementation of your filter. The big disadvantage is the increased complexity required to write the filter – not only do you need to understand the source filter hooks, but you also need a reasonable knowledge of Perl guts. One of the few times it is worth going to this trouble is when writing a source scrambler. The `decrypt` filter (which unscrambles the source before Perl parses it) included with the source filter distribution is an example of a C source filter (see Decryption Filters, below).

Decryption Filters

All decryption filters work on the principle of "security through obscurity." Regardless of how well you write a decryption filter and how strong your encryption algorithm, anyone determined enough can retrieve the original source code. The reason is quite simple – once the decryption filter has decrypted the source back to its original form, fragments of it will be stored in the computer's memory as Perl parses it. The source might only be in memory for a short period of time, but anyone possessing a debugger, skill, and lots of patience can eventually reconstruct your program.

That said, there are a number of steps that can be taken to make life difficult for the potential cracker. The most important: Write your decryption filter in C and statically link the decryption module into the Perl binary. For further tips to make life difficult for the potential cracker, see the file *decrypt.pm* in the source filters module.

CREATING A SOURCE FILTER AS A SEPARATE EXECUTABLE

An alternative to writing the filter in C is to create a separate executable in the language of your choice. The separate executable reads from standard input, does whatever processing is necessary, and writes the filtered data to standard output. `Filter:cpp` is an example of a source filter implemented as a separate executable – the executable is the C preprocessor bundled with your C compiler.

The source filter distribution includes two modules that simplify this task: `Filter::exec` and `Filter::sh`. Both allow you to run any external executable. Both use a coprocess to control the flow of data into and out of the external executable. (For details on coprocesses, see Stephens, W.R. "Advanced Programming in the UNIX Environment." Addison–Wesley, ISBN 0–210–56317–7, pages 441–445.) The difference between them is that `Filter::exec` spawns the external command directly, while `Filter::sh` spawns a shell to execute the external command. (Unix uses the Bourne shell; NT uses the cmd shell.) Spawning a shell allows you to make use of the shell metacharacters and redirection facilities.

Here is an example script that uses `Filter::sh`:

```
use Filter::sh 'tr XYZ PQR' ;
$a = 1 ;
```

```
print "XYZ a = $a\n" ;
```

The output you'll get when the script is executed:

```
PQR a = 1
```

Writing a source filter as a separate executable works fine, but a small performance penalty is incurred. For example, if you execute the small example above, a separate subprocess will be created to run the Unix `tr` command. Each use of the filter requires its own subprocess. If creating subprocesses is expensive on your system, you might want to consider one of the other options for creating source filters.

WRITING A SOURCE FILTER IN PERL

The easiest and most portable option available for creating your own source filter is to write it completely in Perl. To distinguish this from the previous two techniques, I'll call it a Perl source filter.

To help understand how to write a Perl source filter we need an example to study. Here is a complete source filter that performs rot13 decoding. (Rot13 is a very simple encryption scheme used in Usenet postings to hide the contents of offensive posts. It moves every letter forward thirteen places, so that A becomes N, B becomes O, and Z becomes M.)

```
package Rot13 ;

use Filter::Util::Call ;

sub import {
   my ($type) = @_ ;
   my ($ref) = [] ;
   filter_add(bless $ref) ;
}

sub filter {
   my ($self) = @_ ;
   my ($status) ;

   tr/n-za-mN-ZA-M/a-zA-Z/
      if ($status = filter_read()) > 0 ;
   $status ;
}

1;
```

All Perl source filters are implemented as Perl classes and have the same basic structure as the example above.

First, we include the `Filter::Util::Call` module, which exports a number of functions into your filter's namespace. The filter shown above uses two of these functions, `filter_add()` and `filter_read()`.

Next, we create the filter object and associate it with the source stream by defining the `import` function. If you know Perl well enough, you know that `import` is called automatically every time a module is included with a use statement. This makes `import` the ideal place to both create and install a filter object.

In the example filter, the object (`$ref`) is blessed just like any other Perl object. Our example uses an anonymous array, but this isn't a requirement. Because this example doesn't need to store any context information, we could have used a scalar or hash reference just as well. The next section demonstrates context data.

The association between the filter object and the source stream is made with the `filter_add()` function. This takes a filter object as a parameter (`$ref` in this case) and installs it in the source stream.

Finally, there is the code that actually does the filtering. For this type of Perl source filter, all the filtering is done in a method called `filter()`. (It is also possible to write a Perl source filter using a closure. See the `Filter::Util::Call` manual page for more details.) It's called every time the Perl parser needs

another line of source to process. The `filter()` method, in turn, reads lines from the source stream using the `filter_read()` function.

If a line was available from the source stream, `filter_read()` returns a status value greater than zero and appends the line to `$_`. A status value of zero indicates end–of–file, less than zero means an error. The filter function itself is expected to return its status in the same way, and put the filtered line it wants written to the source stream in `$_`. The use of `$_` accounts for the brevity of most Perl source filters.

In order to make use of the rot13 filter we need some way of encoding the source file in rot13 format. The script below, `mkrot13`, does just that.

```
die "usage mkrot13 filename\n" unless @ARGV ;
my $in = $ARGV[0] ;
my $out = "$in.tmp" ;
open(IN, "<$in") or die "Cannot open file $in: $!\n";
open(OUT, ">$out") or die "Cannot open file $out: $!\n";

print OUT "use Rot13;\n" ;
while (<IN>) {
   tr/a-zA-Z/n-za-mN-ZA-M/ ;
   print OUT ;
}

close IN;
close OUT;
unlink $in;
rename $out, $in;
```

If we encrypt this with `mkrot13`:

```
print " hello fred \n" ;
```

the result will be this:

```
use Rot13;
cevag "uryyb serq\a" ;
```

Running it produces this output:

```
hello fred
```

USING CONTEXT: THE DEBUG FILTER

The rot13 example was a trivial example. Here's another demonstration that shows off a few more features.

Say you wanted to include a lot of debugging code in your Perl script during development, but you didn't want it available in the released product. Source filters offer a solution. In order to keep the example simple, let's say you wanted the debugging output to be controlled by an environment variable, `DEBUG`. Debugging code is enabled if the variable exists, otherwise it is disabled.

Two special marker lines will bracket debugging code, like this:

```
## DEBUG_BEGIN
if ($year > 1999) {
   warn "Debug: millennium bug in year $year\n" ;
}
## DEBUG_END
```

When the `DEBUG` environment variable exists, the filter ensures that Perl parses only the code between the `DEBUG_BEGIN` and `DEBUG_END` markers. That means that when `DEBUG` does exist, the code above should be passed through the filter unchanged. The marker lines can also be passed through as–is, because the Perl parser will see them as comment lines. When `DEBUG` isn't set, we need a way to disable the debug code. A simple way to achieve that is to convert the lines between the two markers into comments:

```
## DEBUG_BEGIN
#if ($year > 1999) {
#     warn "Debug: millennium bug in year $year\n" ;
#}
## DEBUG_END
```

Here is the complete Debug filter:

```
package Debug;

use strict;
use warnings;
use Filter::Util::Call ;

use constant TRUE => 1 ;
use constant FALSE => 0 ;

sub import {
   my ($type) = @_ ;
   my (%context) = (
     Enabled => defined $ENV{DEBUG},
     InTraceBlock => FALSE,
     Filename => (caller)[1],
     LineNo => 0,
     LastBegin => 0,
   ) ;
   filter_add(bless \%context) ;
}

sub Die {
   my ($self) = shift ;
   my ($message) = shift ;
   my ($line_no) = shift || $self->{LastBegin} ;
   die "$message at $self->{Filename} line $line_no.\n"
}

sub filter {
   my ($self) = @_ ;
   my ($status) ;
   $status = filter_read() ;
   ++ $self->{LineNo} ;

   # deal with EOF/error first
   if ($status <= 0) {
       $self->Die("DEBUG_BEGIN has no DEBUG_END")
           if $self->{InTraceBlock} ;
       return $status ;
   }

   if ($self->{InTraceBlock}) {
      if (/^\s*##\s*DEBUG_BEGIN/ ) {
          $self->Die("Nested DEBUG_BEGIN", $self->{LineNo})
      } elsif (/^\s*##\s*DEBUG_END/) {
          $self->{InTraceBlock} = FALSE ;
      }

      # comment out the debug lines when the filter is disabled
      s/^/#/ if ! $self->{Enabled} ;
   } elsif ( /^\s*##\s*DEBUG_BEGIN/ ) {
```

```
        $self->{InTraceBlock} = TRUE ;
        $self->{LastBegin} = $self->{LineNo} ;
    } elsif ( /^\s*##\s*DEBUG_END/ ) {
        $self->Die("DEBUG_END has no DEBUG_BEGIN", $self->{LineNo});
    }
    return $status ;
}

1 ;
```

The big difference between this filter and the previous example is the use of context data in the filter object. The filter object is based on a hash reference, and is used to keep various pieces of context information between calls to the filter function. All but two of the hash fields are used for error reporting. The first of those two, Enabled, is used by the filter to determine whether the debugging code should be given to the Perl parser. The second, InTraceBlock, is true when the filter has encountered a `DEBUG_BEGIN` line, but has not yet encountered the following `DEBUG_END` line.

If you ignore all the error checking that most of the code does, the essence of the filter is as follows:

```
sub filter {
    my ($self) = @_ ;
    my ($status) ;
    $status = filter_read() ;

    # deal with EOF/error first
    return $status if $status <= 0 ;
    if ($self->{InTraceBlock}) {
        if (/^\s*##\s*DEBUG_END/) {
            $self->{InTraceBlock} = FALSE
        }

        # comment out debug lines when the filter is disabled
        s/^/#/ if ! $self->{Enabled} ;
    } elsif ( /^\s*##\s*DEBUG_BEGIN/ ) {
        $self->{InTraceBlock} = TRUE ;
    }
    return $status ;
}
```

Be warned: just as the C–preprocessor doesn't know C, the Debug filter doesn't know Perl. It can be fooled quite easily:

```
print <<EOM;
##DEBUG_BEGIN
EOM
```

Such things aside, you can see that a lot can be achieved with a modest amount of code.

CONCLUSION

You now have better understanding of what a source filter is, and you might even have a possible use for them. If you feel like playing with source filters but need a bit of inspiration, here are some extra features you could add to the Debug filter.

First, an easy one. Rather than having debugging code that is all–or–nothing, it would be much more useful to be able to control which specific blocks of debugging code get included. Try extending the syntax for debug blocks to allow each to be identified. The contents of the `DEBUG` environment variable can then be used to control which blocks get included.

Once you can identify individual blocks, try allowing them to be nested. That isn't difficult either.

Here is a interesting idea that doesn't involve the Debug filter. Currently Perl subroutines have fairly limited support for formal parameter lists. You can specify the number of parameters and their type, but you still have to manually take them out of the @_ array yourself. Write a source filter that allows you to have a named parameter list. Such a filter would turn this:

```
sub MySub ($first, $second, @rest) { ... }
```

into this:

```
sub MySub($$@) {
   my ($first) = shift ;
   my ($second) = shift ;
   my (@rest) = @_ ;
   ...
}
```

Finally, if you feel like a real challenge, have a go at writing a full–blown Perl macro preprocessor as a source filter. Borrow the useful features from the C preprocessor and any other macro processors you know. The tricky bit will be choosing how much knowledge of Perl's syntax you want your filter to have.

REQUIREMENTS

The Source Filters distribution is available on CPAN, in

```
CPAN/modules/by-module/Filter
```

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NAME

perlfork – Perl's `fork()` emulation

SYNOPSIS

Perl provides a `fork()` keyword that corresponds to the Unix system call of the same name. On most Unix-like platforms where the `fork()` system call is available, Perl's `fork()` simply calls it.

On some platforms such as Windows where the `fork()` system call is not available, Perl can be built to emulate `fork()` at the interpreter level. While the emulation is designed to be as compatible as possible with the real `fork()` at the level of the Perl program, there are certain important differences that stem from the fact that all the pseudo child "processes" created this way live in the same real process as far as the operating system is concerned.

This document provides a general overview of the capabilities and limitations of the `fork()` emulation. Note that the issues discussed here are not applicable to platforms where a real `fork()` is available and Perl has been configured to use it.

DESCRIPTION

The `fork()` emulation is implemented at the level of the Perl interpreter. What this means in general is that running `fork()` will actually clone the running interpreter and all its state, and run the cloned interpreter in a separate thread, beginning execution in the new thread just after the point where the `fork()` was called in the parent. We will refer to the thread that implements this child "process" as the pseudo-process.

To the Perl program that called `fork()`, all this is designed to be transparent. The parent returns from the `fork()` with a pseudo-process ID that can be subsequently used in any process manipulation functions; the child returns from the `fork()` with a value of to signify that it is the child pseudo-process.

Behavior of other Perl features in forked pseudo-processes

Most Perl features behave in a natural way within pseudo-processes.

`$$` or `$PROCESS_ID`

This special variable is correctly set to the pseudo-process ID. It can be used to identify pseudo-processes within a particular session. Note that this value is subject to recycling if any pseudo-processes are launched after others have been `wait()`-ed on.

%ENV Each pseudo-process maintains its own virtual environment. Modifications to %ENV affect the virtual environment, and are only visible within that pseudo-process, and in any processes (or pseudo-processes) launched from it.

`chdir()` and all other builtins that accept filenames

Each pseudo-process maintains its own virtual idea of the current directory. Modifications to the current directory using `chdir()` are only visible within that pseudo-process, and in any processes (or pseudo-processes) launched from it. All file and directory accesses from the pseudo-process will correctly map the virtual working directory to the real working directory appropriately.

`wait()` and `waitpid()`

`wait()` and `waitpid()` can be passed a pseudo-process ID returned by `fork()`. These calls will properly wait for the termination of the pseudo-process and return its status.

`kill()` `kill()` can be used to terminate a pseudo-process by passing it the ID returned by `fork()`. This should not be used except under dire circumstances, because the operating system may not guarantee integrity of the process resources when a running thread is terminated. Note that using `kill()` on a `pseudo-process()` may typically cause memory leaks, because the thread that implements the pseudo-process does not get a chance to clean up its resources.

exec() Calling exec() within a pseudo−process actually spawns the requested executable in a separate process and waits for it to complete before exiting with the same exit status as that process. This means that the process ID reported within the running executable will be different from what the earlier Perl fork() might have returned. Similarly, any process manipulation functions applied to the ID returned by fork() will affect the waiting pseudo−process that called exec(), not the real process it is waiting for after the exec().

exit() exit() always exits just the executing pseudo−process, after automatically wait()−ing for any outstanding child pseudo−processes. Note that this means that the process as a whole will not exit unless all running pseudo−processes have exited.

Open handles to files, directories and network sockets

All open handles are dup()−ed in pseudo−processes, so that closing any handles in one process does not affect the others. See below for some limitations.

Resource limits

In the eyes of the operating system, pseudo−processes created via the fork() emulation are simply threads in the same process. This means that any process−level limits imposed by the operating system apply to all pseudo−processes taken together. This includes any limits imposed by the operating system on the number of open file, directory and socket handles, limits on disk space usage, limits on memory size, limits on CPU utilization etc.

Killing the parent process

If the parent process is killed (either using Perl's kill() builtin, or using some external means) all the pseudo−processes are killed as well, and the whole process exits.

Lifetime of the parent process and pseudo−processes

During the normal course of events, the parent process and every pseudo−process started by it will wait for their respective pseudo−children to complete before they exit. This means that the parent and every pseudo−child created by it that is also a pseudo−parent will only exit after their pseudo−children have exited.

A way to mark a pseudo−processes as running detached from their parent (so that the parent would not have to wait() for them if it doesn't want to) will be provided in future.

CAVEATS AND LIMITATIONS

BEGIN blocks

The fork() emulation will not work entirely correctly when called from within a BEGIN block. The forked copy will run the contents of the BEGIN block, but will not continue parsing the source stream after the BEGIN block. For example, consider the following code:

```
BEGIN {
    fork and exit;          # fork child and exit the parent
    print "inner\n";
}
print "outer\n";
```

This will print:

```
inner
```

rather than the expected:

```
inner
outer
```

This limitation arises from fundamental technical difficulties in cloning and restarting the stacks used by the Perl parser in the middle of a parse.

Open filehandles

Any filehandles open at the time of the `fork()` will be `dup()`–ed. Thus, the files can be closed independently in the parent and child, but beware that the `dup()`–ed handles will still share the same seek pointer. Changing the seek position in the parent will change it in the child and vice–versa. One can avoid this by opening files that need distinct seek pointers separately in the child.

Forking pipe `open()` not yet implemented

The `open(FOO, "|-")` and `open(BAR, "-|")` constructs are not yet implemented. This limitation can be easily worked around in new code by creating a pipe explicitly. The following example shows how to write to a forked child:

```
# simulate open(FOO, "|-")
sub pipe_to_fork ($) {
    my $parent = shift;
    pipe my $child, $parent or die;
    my $pid = fork();
    die "fork() failed: $!" unless defined $pid;
    if ($pid) {
        close $child;
    }
    else {
        close $parent;
        open(STDIN, "<&=" . fileno($child)) or die;
    }
    $pid;
}

if (pipe_to_fork('FOO')) {
    # parent
    print FOO "pipe_to_fork\n";
    close FOO;
}
else {
    # child
    while (<STDIN>) { print; }
    close STDIN;
    exit(0);
}
```

And this one reads from the child:

```
# simulate open(FOO, "-|")
sub pipe_from_fork ($) {
    my $parent = shift;
    pipe $parent, my $child or die;
    my $pid = fork();
    die "fork() failed: $!" unless defined $pid;
    if ($pid) {
        close $child;
    }
    else {
        close $parent;
        open(STDOUT, ">&=" . fileno($child)) or die;
    }
    $pid;
```

```
}

if (pipe_from_fork('BAR')) {
    # parent
    while (<BAR>) { print; }
    close BAR;
}
else {
    # child
    print "pipe_from_fork\n";
    close STDOUT;
    exit(0);
}
```

Forking pipe `open()` constructs will be supported in future.

Global state maintained by XSUBs

External subroutines (XSUBs) that maintain their own global state may not work correctly. Such XSUBs will either need to maintain locks to protect simultaneous access to global data from different pseudo-processes, or maintain all their state on the Perl symbol table, which is copied naturally when `fork()` is called. A callback mechanism that provides extensions an opportunity to clone their state will be provided in the near future.

Interpreter embedded in larger application

The `fork()` emulation may not behave as expected when it is executed in an application which embeds a Perl interpreter and calls Perl APIs that can evaluate bits of Perl code. This stems from the fact that the emulation only has knowledge about the Perl interpreter's own data structures and knows nothing about the containing application's state. For example, any state carried on the application's own call stack is out of reach.

Thread-safety of extensions

Since the `fork()` emulation runs code in multiple threads, extensions calling into non-thread-safe libraries may not work reliably when calling `fork()`. As Perl's threading support gradually becomes more widely adopted even on platforms with a native `fork()`, such extensions are expected to be fixed for thread-safety.

BUGS

- Having pseudo-process IDs be negative integers breaks down for the integer `-1` because the `wait()` and `waitpid()` functions treat this number as being special. The tacit assumption in the current implementation is that the system never allocates a thread ID of `1` for user threads. A better representation for pseudo-process IDs will be implemented in future.
- This document may be incomplete in some respects.

AUTHOR

Support for concurrent interpreters and the `fork()` emulation was implemented by ActiveState, with funding from Microsoft Corporation.

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SEE ALSO

fork in perlfunc, *perlipc*

NAME

perlform – Perl formats

DESCRIPTION

Perl has a mechanism to help you generate simple reports and charts. To facilitate this, Perl helps you code up your output page close to how it will look when it's printed. It can keep track of things like how many lines are on a page, what page you're on, when to print page headers, etc. Keywords are borrowed from FORTRAN: `format()` to declare and `write()` to execute; see their entries in *perlfunc*. Fortunately, the layout is much more legible, more like BASIC's PRINT USING statement. Think of it as a poor man's nroff(1).

Formats, like packages and subroutines, are declared rather than executed, so they may occur at any point in your program. (Usually it's best to keep them all together though.) They have their own namespace apart from all the other "types" in Perl. This means that if you have a function named "Foo", it is not the same thing as having a format named "Foo". However, the default name for the format associated with a given filehandle is the same as the name of the filehandle. Thus, the default format for STDOUT is named "STDOUT", and the default format for filehandle TEMP is named "TEMP". They just look the same. They aren't.

Output record formats are declared as follows:

```
format NAME =
FORMLIST
.
```

If name is omitted, format "STDOUT" is defined. FORMLIST consists of a sequence of lines, each of which may be one of three types:

1. A comment, indicated by putting a '#' in the first column.
2. A "picture" line giving the format for one output line.
3. An argument line supplying values to plug into the previous picture line.

Picture lines are printed exactly as they look, except for certain fields that substitute values into the line. Each field in a picture line starts with either "@" (at) or "^" (caret). These lines do not undergo any kind of variable interpolation. The at field (not to be confused with the array marker @) is the normal kind of field; the other kind, caret fields, are used to do rudimentary multi-line text block filling. The length of the field is supplied by padding out the field with multiple "<", ">", or "|" characters to specify, respectively, left justification, right justification, or centering. If the variable would exceed the width specified, it is truncated.

As an alternate form of right justification, you may also use "#" characters (with an optional ".") to specify a numeric field. This way you can line up the decimal points. If any value supplied for these fields contains a newline, only the text up to the newline is printed. Finally, the special field "@*" can be used for printing multi-line, nontruncated values; it should appear by itself on a line.

The values are specified on the following line in the same order as the picture fields. The expressions providing the values should be separated by commas. The expressions are all evaluated in a list context before the line is processed, so a single list expression could produce multiple list elements. The expressions may be spread out to more than one line if enclosed in braces. If so, the opening brace must be the first token on the first line. If an expression evaluates to a number with a decimal part, and if the corresponding picture specifies that the decimal part should appear in the output (that is, any picture except multiple "#" characters **without** an embedded "."), the character used for the decimal point is **always** determined by the current LC_NUMERIC locale. This means that, if, for example, the run-time environment happens to specify a German locale, "," will be used instead of the default ".". See *perllocale* and *"WARNINGS"* for more information.

Picture fields that begin with ^ rather than @ are treated specially. With a # field, the field is blanked out if the value is undefined. For other field types, the caret enables a kind of fill mode. Instead of an arbitrary

expression, the value supplied must be a scalar variable name that contains a text string. Perl puts as much text as it can into the field, and then chops off the front of the string so that the next time the variable is referenced, more of the text can be printed. (Yes, this means that the variable itself is altered during execution of the `write()` call, and is not returned.) Normally you would use a sequence of fields in a vertical stack to print out a block of text. You might wish to end the final field with the text "...", which will appear in the output if the text was too long to appear in its entirety. You can change which characters are legal to break on by changing the variable `$:` (that's `$FORMAT_LINE_BREAK_CHARACTERS` if you're using the English module) to a list of the desired characters.

Using caret fields can produce variable length records. If the text to be formatted is short, you can suppress blank lines by putting a "~" (tilde) character anywhere in the line. The tilde will be translated to a space upon output. If you put a second tilde contiguous to the first, the line will be repeated until all the fields on the line are exhausted. (If you use a field of the at variety, the expression you supply had better not give the same value every time forever!)

Top−of−form processing is by default handled by a format with the same name as the current filehandle with "_TOP" concatenated to it. It's triggered at the top of each page. See *write*.

Examples:

```
# a report on the /etc/passwd file
format STDOUT_TOP =
                        Passwd File
Name                Login    Office   Uid   Gid Home
------------------------------------------------------------------
.
format STDOUT =
@<<<<<<<<<<<<<<<<<< @|||||||| @<<<<<<@>>>> @>>>> @<<<<<<<<<<<<<<<<<<
$name,              $login,  $office,$uid,$gid, $home
.

# a report from a bug report form
format STDOUT_TOP =
                        Bug Reports
@<<<<<<<<<<<<<<<<<<<<<<<     @|||         @>>>>>>>>>>>>>>>>>>>>>>>
$system,                      $%,         $date
------------------------------------------------------------------
.
format STDOUT =
Subject: @<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
         $subject
Index: @<<<<<<<<<<<<<<<<<<<<<<<<<<<< ^<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
       $index,                        $description
Priority: @<<<<<<<<<< Date: @<<<<<<< ^<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
          $priority,        $date,    $description
From: @<<<<<<<<<<<<<<<<<<<<<<<<<<<<< ^<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
      $from,                         $description
Assigned to: @<<<<<<<<<<<<<<<<<<<<<< ^<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
             $programmer,            $description
~                                    ^<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
                                     $description
~                                    ^<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
                                     $description
~                                    ^<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
                                     $description
~                                    ^<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
                                     $description
```

```
 ~                                       ^<<<<<<<<<<<<<<<<<<<<<<...
                                         $description
 .
```

It is possible to intermix `print()`s with `write()`s on the same output channel, but you'll have to handle `$-` (`$FORMAT_LINES_LEFT`) yourself.

Format Variables

The current format name is stored in the variable `$~` (`$FORMAT_NAME`), and the current top of form format name is in `$^` (`$FORMAT_TOP_NAME`). The current output page number is stored in `$%` (`$FORMAT_PAGE_NUMBER`), and the number of lines on the page is in `$=` (`$FORMAT_LINES_PER_PAGE`). Whether to autoflush output on this handle is stored in `$|` (`$OUTPUT_AUTOFLUSH`). The string output before each top of page (except the first) is stored in `$^L` (`$FORMAT_FORMFEED`). These variables are set on a per-filehandle basis, so you'll need to `select()` into a different one to affect them:

```
select((select(OUTF),
        $~ = "My_Other_Format",
        $^ = "My_Top_Format"
       )[0]);
```

Pretty ugly, eh? It's a common idiom though, so don't be too surprised when you see it. You can at least use a temporary variable to hold the previous filehandle: (this is a much better approach in general, because not only does legibility improve, you now have intermediary stage in the expression to single-step the debugger through):

```
$ofh = select(OUTF);
$~ = "My_Other_Format";
$^ = "My_Top_Format";
select($ofh);
```

If you use the English module, you can even read the variable names:

```
use English;
$ofh = select(OUTF);
$FORMAT_NAME     = "My_Other_Format";
$FORMAT_TOP_NAME = "My_Top_Format";
select($ofh);
```

But you still have those funny `select()`s. So just use the FileHandle module. Now, you can access these special variables using lowercase method names instead:

```
use FileHandle;
format_name     OUTF "My_Other_Format";
format_top_name OUTF "My_Top_Format";
```

Much better!

NOTES

Because the values line may contain arbitrary expressions (for at fields, not caret fields), you can farm out more sophisticated processing to other functions, like `sprintf()` or one of your own. For example:

```
format Ident =
    @<<<<<<<<<<<<<<<
    &commify($n)
.
```

To get a real at or caret into the field, do this:

```
format Ident =
I have an @ here.
```

```
        "@"
.
```

To center a whole line of text, do something like this:

```
format Ident =
@|||||||||||||||||||||||||||||||||||||||||||||||
        "Some text line"
.
```

There is no builtin way to say "float this to the right hand side of the page, however wide it is." You have to specify where it goes. The truly desperate can generate their own format on the fly, based on the current number of columns, and then `eval()` it:

```
$format  = "format STDOUT = \n"
         . '^' . '<' x $cols . "\n"
         . '$entry' . "\n"
         . "\t^" . "<" x ($cols-8) . "~~\n"
         . '$entry' . "\n"
         . ".\n";
print $format if $Debugging;
eval $format;
die $@ if $@;
```

Which would generate a format looking something like this:

```
format STDOUT =
^<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
$entry
        ^<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<~~
$entry
.
```

Here's a little program that's somewhat like fmt(1):

```
format =
^<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<< ~~
$_

.

$/ = '';
while (<>) {
    s/\s*\n\s*/ /g;
    write;
}
```

Footers

While `$FORMAT_TOP_NAME` contains the name of the current header format, there is no corresponding mechanism to automatically do the same thing for a footer. Not knowing how big a format is going to be until you evaluate it is one of the major problems. It's on the TODO list.

Here's one strategy: If you have a fixed-size footer, you can get footers by checking `$FORMAT_LINES_LEFT` before each `write()` and print the footer yourself if necessary.

Here's another strategy: Open a pipe to yourself, using `open(MYSELF, "|-")` (see *open()*) and always `write()` to MYSELF instead of STDOUT. Have your child process massage its STDIN to rearrange headers and footers however you like. Not very convenient, but doable.

Accessing Formatting Internals

For low–level access to the formatting mechanism. you may use `formline()` and access `$^A` (the `$ACCUMULATOR` variable) directly.

For example:

```
$str = formline <<'END', 1,2,3;
@<<<  @|||  @>>>
END

print "Wow, I just stored `$^A' in the accumulator!\n";
```

Or to make an `swrite()` subroutine, which is to `write()` what `sprintf()` is to `printf()`, do this:

```
use Carp;
sub swrite {
    croak "usage: swrite PICTURE ARGS" unless @_;
    my $format = shift;
    $^A = "";
    formline($format,@_);
    return $^A;
}

$string = swrite(<<'END', 1, 2, 3);
Check me out
@<<<  @|||  @>>>
END
print $string;
```

WARNINGS

The lone dot that ends a format can also prematurely end a mail message passing through a misconfigured Internet mailer (and based on experience, such misconfiguration is the rule, not the exception). So when sending format code through mail, you should indent it so that the format–ending dot is not on the left margin; this will prevent SMTP cutoff.

Lexical variables (declared with "my") are not visible within a format unless the format is declared within the scope of the lexical variable. (They weren't visible at all before version 5.001.)

Formats are the only part of Perl that unconditionally use information from a program's locale; if a program's environment specifies an LC_NUMERIC locale, it is always used to specify the decimal point character in formatted output. Perl ignores all other aspects of locale handling unless the `use locale` pragma is in effect. Formatted output cannot be controlled by `use locale` because the pragma is tied to the block structure of the program, and, for historical reasons, formats exist outside that block structure. See *perllocale* for further discussion of locale handling.

Inside of an expression, the whitespace characters \n, \t and \f are considered to be equivalent to a single space. Thus, you could think of this filter being applied to each value in the format:

```
$value =~ tr/\n\t\f/ /;
```

The remaining whitespace character, \r, forces the printing of a new line if allowed by the picture line.

NAME

perlfunc – Perl builtin functions

DESCRIPTION

The functions in this section can serve as terms in an expression. They fall into two major categories: list operators and named unary operators. These differ in their precedence relationship with a following comma. (See the precedence table in *perlop*.) List operators take more than one argument, while unary operators can never take more than one argument. Thus, a comma terminates the argument of a unary operator, but merely separates the arguments of a list operator. A unary operator generally provides a scalar context to its argument, while a list operator may provide either scalar or list contexts for its arguments. If it does both, the scalar arguments will be first, and the list argument will follow. (Note that there can ever be only one such list argument.) For instance, `splice()` has three scalar arguments followed by a list, whereas `gethostbyname()` has four scalar arguments.

In the syntax descriptions that follow, list operators that expect a list (and provide list context for the elements of the list) are shown with LIST as an argument. Such a list may consist of any combination of scalar arguments or list values; the list values will be included in the list as if each individual element were interpolated at that point in the list, forming a longer single–dimensional list value. Elements of the LIST should be separated by commas.

Any function in the list below may be used either with or without parentheses around its arguments. (The syntax descriptions omit the parentheses.) If you use the parentheses, the simple (but occasionally surprising) rule is this: It *looks* like a function, therefore it *is* a function, and precedence doesn't matter. Otherwise it's a list operator or unary operator, and precedence does matter. And whitespace between the function and left parenthesis doesn't count—so you need to be careful sometimes:

```
print 1+2+4;         # Prints 7.
print(1+2) + 4;      # Prints 3.
print (1+2)+4;       # Also prints 3!
print +(1+2)+4;      # Prints 7.
print ((1+2)+4);     # Prints 7.
```

If you run Perl with the **–w** switch it can warn you about this. For example, the third line above produces:

```
print (...) interpreted as function at - line 1.
Useless use of integer addition in void context at - line 1.
```

A few functions take no arguments at all, and therefore work as neither unary nor list operators. These include such functions as `time` and `endpwent`. For example, `time+86_400` always means `time() + 86_400`.

For functions that can be used in either a scalar or list context, nonabortive failure is generally indicated in a scalar context by returning the undefined value, and in a list context by returning the null list.

Remember the following important rule: There is **no rule** that relates the behavior of an expression in list context to its behavior in scalar context, or vice versa. It might do two totally different things. Each operator and function decides which sort of value it would be most appropriate to return in scalar context. Some operators return the length of the list that would have been returned in list context. Some operators return the first value in the list. Some operators return the last value in the list. Some operators return a count of successful operations. In general, they do what you want, unless you want consistency.

An named array in scalar context is quite different from what would at first glance appear to be a list in scalar context. You can't get a list like `(1,2,3)` into being in scalar context, because the compiler knows the context at compile time. It would generate the scalar comma operator there, not the list construction version of the comma. That means it was never a list to start with.

In general, functions in Perl that serve as wrappers for system calls of the same name (like chown(2), fork(2), closedir(2), etc.) all return true when they succeed and `undef` otherwise, as is usually mentioned in the descriptions below. This is different from the C interfaces, which return `-1` on failure. Exceptions to this

rule are `wait`, `waitpid`, and `syscall`. System calls also set the special `$!` variable on failure. Other functions do not, except accidentally.

Perl Functions by Category

Here are Perl's functions (including things that look like functions, like some keywords and named operators) arranged by category. Some functions appear in more than one place.

Functions for SCALARs or strings

`chomp`, `chop`, `chr`, `crypt`, `hex`, `index`, `lc`, `lcfirst`, `length`, `oct`, `ord`, `pack`, `q/STRING/`, `qq/STRING/`, `reverse`, `rindex`, `sprintf`, `substr`, `tr///`, `uc`, `ucfirst`, `y///`

Regular expressions and pattern matching

`m//`, `pos`, `quotemeta`, `s///`, `split`, `study`, `qr//`

Numeric functions

`abs`, `atan2`, `cos`, `exp`, `hex`, `int`, `log`, `oct`, `rand`, `sin`, `sqrt`, `srand`

Functions for real @ARRAYs

`pop`, `push`, `shift`, `splice`, `unshift`

Functions for list data

`grep`, `join`, `map`, `qw/STRING/`, `reverse`, `sort`, `unpack`

Functions for real %HASHes

`delete`, `each`, `exists`, `keys`, `values`

Input and output functions

`binmode`, `close`, `closedir`, `dbmclose`, `dbmopen`, `die`, `eof`, `fileno`, `flock`, `format`, `getc`, `print`, `printf`, `read`, `readdir`, `rewinddir`, `seek`, `seekdir`, `select`, `syscall`, `sysread`, `sysseek`, `syswrite`, `tell`, `telldir`, `truncate`, `warn`, `write`

Functions for fixed length data or records

`pack`, `read`, `syscall`, `sysread`, `syswrite`, `unpack`, `vec`

Functions for filehandles, files, or directories

`-X`, `chdir`, `chmod`, `chown`, `chroot`, `fcntl`, `glob`, `ioctl`, `link`, `lstat`, `mkdir`, `open`, `opendir`, `readlink`, `rename`, `rmdir`, `stat`, `symlink`, `umask`, `unlink`, `utime`

Keywords related to the control flow of your perl program

`caller`, `continue`, `die`, `do`, `dump`, `eval`, `exit`, `goto`, `last`, `next`, `redo`, `return`, `sub`, `wantarray`

Keywords related to scoping

`caller`, `import`, `local`, `my`, `our`, `package`, `use`

Miscellaneous functions

`defined`, `dump`, `eval`, `formline`, `local`, `my`, `our`, `reset`, `scalar`, `undef`, `wantarray`

Functions for processes and process groups

`alarm`, `exec`, `fork`, `getpgrp`, `getppid`, `getpriority`, `kill`, `pipe`, `qx/STRING/`, `setpgrp`, `setpriority`, `sleep`, `system`, `times`, `wait`, `waitpid`

Keywords related to perl modules

`do`, `import`, `no`, `package`, `require`, `use`

Keywords related to classes and object–orientedness

`bless`, `dbmclose`, `dbmopen`, `package`, `ref`, `tie`, `tied`, `untie`, `use`

Low–level socket functions

accept, bind, connect, getpeername, getsockname, getsockopt, listen, recv, send, setsockopt, shutdown, socket, socketpair

System V interprocess communication functions

msgctl, msgget, msgrcv, msgsnd, semctl, semget, semop, shmctl, shmget, shmread, shmwrite

Fetching user and group info

endgrent, endhostent, endnetent, endpwent, getgrent, getgrgid, getgrnam, getlogin, getpwent, getpwnam, getpwuid, setgrent, setpwent

Fetching network info

endprotoent, endservent, gethostbyaddr, gethostbyname, gethostent, getnetbyaddr, getnetbyname, getnetent, getprotobyname, getprotobynumber, getprotoent, getservbyname, getservbyport, getservent, sethostent, setnetent, setprotoent, setservent

Time–related functions

gmtime, localtime, time, times

Functions new in perl5

abs, bless, chomp, chr, exists, formline, glob, import, lc, lcfirst, map, my, no, our, prototype, qx, qw, readline, readpipe, ref, sub*, sysopen, tie, tied, uc, ucfirst, untie, use

* – sub was a keyword in perl4, but in perl5 it is an operator, which can be used in expressions.

Functions obsoleted in perl5

dbmclose, dbmopen

Portability

Perl was born in Unix and can therefore access all common Unix system calls. In non–Unix environments, the functionality of some Unix system calls may not be available, or details of the available functionality may differ slightly. The Perl functions affected by this are:

–X, binmode, chmod, chown, chroot, crypt, dbmclose, dbmopen, dump, endgrent, endhostent, endnetent, endprotoent, endpwent, endservent, exec, fcntl, flock, fork, getgrent, getgrgid, gethostent, getlogin, getnetbyaddr, getnetbyname, getnetent, getppid, getprgp, getpriority, getprotobynumber, getprotoent, getpwent, getpwnam, getpwuid, getservbyport, getservent, getsockopt, glob, ioctl, kill, link, lstat, msgctl, msgget, msgrcv, msgsnd, open, pipe, readlink, rename, select, semctl, semget, semop, setgrent, sethostent, setnetent, setpgrp, setpriority, setprotoent, setpwent, setservent, setsockopt, shmctl, shmget, shmread, shmwrite, socket, socketpair, stat, symlink, syscall, sysopen, system, times, truncate, umask, unlink, utime, wait, waitpid

For more information about the portability of these functions, see *perlport* and other available platform–specific documentation.

Alphabetical Listing of Perl Functions

–X FILEHANDLE
–X EXPR

–X A file test, where X is one of the letters listed below. This unary operator takes one argument, either a filename or a filehandle, and tests the associated file to see if something is true about it. If the argument is omitted, tests $_, except for –t, which tests STDIN. Unless otherwise documented, it returns 1 for true and '' for false, or the undefined value if the file doesn't exist.

Despite the funny names, precedence is the same as any other named unary operator, and the argument may be parenthesized like any other unary operator. The operator may be any of:
X<–rX<–wX<–xX<–oX<–RX<–WX<–XX<–OX<–eX<–zX<–sX<–fX<–dX<–lX<–p
X<–SX<–bX<–cX<–tX<–uX<–gX<–kX<–TX<–BX<–MX<–AX<–C

```
-r  File is readable by effective uid/gid.
-w  File is writable by effective uid/gid.
-x  File is executable by effective uid/gid.
-o  File is owned by effective uid.

-R  File is readable by real uid/gid.
-W  File is writable by real uid/gid.
-X  File is executable by real uid/gid.
-O  File is owned by real uid.

-e  File exists.
-z  File has zero size.
-s  File has nonzero size (returns size).

-f  File is a plain file.
-d  File is a directory.
-l  File is a symbolic link.
-p  File is a named pipe (FIFO), or Filehandle is a pipe.
-S  File is a socket.
-b  File is a block special file.
-c  File is a character special file.
-t  Filehandle is opened to a tty.

-u  File has setuid bit set.
-g  File has setgid bit set.
-k  File has sticky bit set.

-T  File is an ASCII text file.
-B  File is a "binary" file (opposite of -T).

-M  Age of file in days when script started.
-A  Same for access time.
-C  Same for inode change time.
```

Example:

```
while (<>) {
    chop;
    next unless -f $_;      # ignore specials
    #...
}
```

The interpretation of the file permission operators `-r`, `-R`, `-w`, `-W`, `-x`, and `-X` is by default based solely on the mode of the file and the uids and gids of the user. There may be other reasons you can't actually read, write, or execute the file. Such reasons may be for example network filesystem access controls, ACLs (access control lists), read–only filesystems, and unrecognized executable formats.

Also note that, for the superuser on the local filesystems, the `-r`, `-R`, `-w`, and `-W` tests always return 1, and `-x` and `-X` return 1 if any execute bit is set in the mode. Scripts run by the superuser may thus need to do a `stat()` to determine the actual mode of the file, or temporarily set their effective uid to something else.

If you are using ACLs, there is a pragma called `filetest` that may produce more accurate results than the bare `stat()` mode bits. When under the `use filetest 'access'` the

above–mentioned filetests will test whether the permission can (not) be granted using the `access()` family of system calls. Also note that the `-x` and `-X` may under this pragma return true even if there are no execute permission bits set (nor any extra execute permission ACLs). This strangeness is due to the underlying system calls' definitions. Read the documentation for the `filetest` pragma for more information.

Note that `-s/a/b/` does not do a negated substitution. Saying `-exp($foo)` still works as expected, however—only single letters following a minus are interpreted as file tests.

The `-T` and `-B` switches work as follows. The first block or so of the file is examined for odd characters such as strange control codes or characters with the high bit set. If too many strange characters (30%) are found, it's a `-B` file, otherwise it's a `-T` file. Also, any file containing null in the first block is considered a binary file. If `-T` or `-B` is used on a filehandle, the current stdio buffer is examined rather than the first block. Both `-T` and `-B` return true on a null file, or a file at EOF when testing a filehandle. Because you have to read a file to do the `-T` test, on most occasions you want to use a `-f` against the file first, as in `next unless -f $file && -T $file`.

If any of the file tests (or either the `stat` or `lstat` operators) are given the special filehandle consisting of a solitary underline, then the stat structure of the previous file test (or stat operator) is used, saving a system call. (This doesn't work with `-t`, and you need to remember that `lstat()` and `-l` will leave values in the stat structure for the symbolic link, not the real file.) Example:

```
print "Can do.\n" if -r $a || -w _ || -x _;

stat($filename);
print "Readable\n" if -r _;
print "Writable\n" if -w _;
print "Executable\n" if -x _;
print "Setuid\n" if -u _;
print "Setgid\n" if -g _;
print "Sticky\n" if -k _;
print "Text\n" if -T _;
print "Binary\n" if -B _;
```

abs VALUE

abs Returns the absolute value of its argument. If VALUE is omitted, uses `$_`.

accept NEWSOCKET,GENERICSOCKET

Accepts an incoming socket connect, just as the accept(2) system call does. Returns the packed address if it succeeded, false otherwise. See the example in *Sockets: Client/Server Communication in perlipc*.

On systems that support a close–on–exec flag on files, the flag will be set for the newly opened file descriptor, as determined by the value of `$^F`. See *$^F*.

alarm SECONDS

alarm Arranges to have a SIGALRM delivered to this process after the specified number of seconds have elapsed. If SECONDS is not specified, the value stored in `$_` is used. (On some machines, unfortunately, the elapsed time may be up to one second less than you specified because of how seconds are counted.) Only one timer may be counting at once. Each call disables the previous timer, and an argument of may be supplied to cancel the previous timer without starting a new one. The returned value is the amount of time remaining on the previous timer.

For delays of finer granularity than one second, you may use Perl's four–argument version of `select()` leaving the first three arguments undefined, or you might be able to use the `syscall` interface to access setitimer(2) if your system supports it. The Time::HiRes module from CPAN may also prove useful.

It is usually a mistake to intermix `alarm` and `sleep` calls. (`sleep` may be internally implemented in your system with `alarm`)

If you want to use `alarm` to time out a system call you need to use an `eval/die` pair. You can't rely on the alarm causing the system call to fail with `$!` set to `EINTR` because Perl sets up signal handlers to restart system calls on some systems. Using `eval/die` always works, modulo the caveats given in *Signals in perlipc*.

```
eval {
    local $SIG{ALRM} = sub { die "alarm\n" }; # NB: \n required
    alarm $timeout;
    $nread = sysread SOCKET, $buffer, $size;
    alarm 0;
};
if ($@) {
    die unless $@ eq "alarm\n";   # propagate unexpected errors
    # timed out
}
else {
    # didn't
}
```

atan2 Y,X

Returns the arctangent of Y/X in the range –PI to PI.

For the tangent operation, you may use the `Math::Trig::tan` function, or use the familiar relation:

```
sub tan { sin($_[0]) / cos($_[0])  }
```

bind SOCKET,NAME

Binds a network address to a socket, just as the bind system call does. Returns true if it succeeded, false otherwise. NAME should be a packed address of the appropriate type for the socket. See the examples in *Sockets: Client/Server Communication in perlipc*.

binmode FILEHANDLE, DISCIPLINE
binmode FILEHANDLE

Arranges for FILEHANDLE to be read or written in "binary" or "text" mode on systems where the run–time libraries distinguish between binary and text files. If FILEHANDLE is an expression, the value is taken as the name of the filehandle. DISCIPLINE can be either of `":raw"` for binary mode or `":crlf"` for "text" mode. If the DISCIPLINE is omitted, it defaults to `":raw"`.

`binmode()` should be called after `open()` but before any I/O is done on the filehandle.

On many systems `binmode()` currently has no effect, but in future, it will be extended to support user–defined input and output disciplines. On some systems `binmode()` is necessary when you're not working with a text file. For the sake of portability it is a good idea to always use it when appropriate, and to never use it when it isn't appropriate.

In other words: Regardless of platform, use `binmode()` on binary files, and do not use `binmode()` on text files.

The `open` pragma can be used to establish default disciplines. See *open*.

The operating system, device drivers, C libraries, and Perl run–time system all work together to let the programmer treat a single character (`\n`) as the line terminator, irrespective of the external representation. On many operating systems, the native text file representation matches the internal representation, but on some platforms the external representation of `\n` is made up of more than one character.

Mac OS and all variants of Unix use a single character to end each line in the external representation of text (even though that single character is not necessarily the same across these platforms). Consequently `binmode()` has no effect on these operating systems. In other systems like VMS, MS-DOS and the various flavors of MS-Windows your program sees a `\n` as a simple `\cJ`, but what's stored in text files are the two characters `\cM\cJ`. That means that, if you don't use `binmode()` on these systems, `\cM\cJ` sequences on disk will be converted to `\n` on input, and any `\n` in your program will be converted back to `\cM\cJ` on output. This is what you want for text files, but it can be disastrous for binary files.

Another consequence of using `binmode()` (on some systems) is that special end-of-file markers will be seen as part of the data stream. For systems from the Microsoft family this means that if your binary data contains `\cZ`, the I/O subsystem will regard it as the end of the file, unless you use `binmode()`.

`binmode()` is not only important for `readline()` and `print()` operations, but also when using `read()`, `seek()`, `sysread()`, `syswrite()` and `tell()` (see *perlport* for more details). See the `$/` and `$\` variables in *perlvar* for how to manually set your input and output line-termination sequences.

bless REF,CLASSNAME
bless REF

This function tells the thingy referenced by REF that it is now an object in the CLASSNAME package. If CLASSNAME is omitted, the current package is used. Because a `bless` is often the last thing in a constructor, it returns the reference for convenience. Always use the two-argument version if the function doing the blessing might be inherited by a derived class. See *perltoot* and *perlobj* for more about the blessing (and blessings) of objects.

Consider always blessing objects in CLASSNAMEs that are mixed case. Namespaces with all lowercase names are considered reserved for Perl pragmata. Builtin types have all uppercase names, so to prevent confusion, you may wish to avoid such package names as well. Make sure that CLASSNAME is a true value.

See *Perl Modules in perlmod*.

caller EXPR
caller Returns the context of the current subroutine call. In scalar context, returns the caller's package name if there is a caller, that is, if we're in a subroutine or `eval` or `require`, and the undefined value otherwise. In list context, returns

```
($package, $filename, $line) = caller;
```

With EXPR, it returns some extra information that the debugger uses to print a stack trace. The value of EXPR indicates how many call frames to go back before the current one.

```
($package, $filename, $line, $subroutine, $hasargs,
$wantarray, $evaltext, $is_require, $hints, $bitmask) = caller($i);
```

Here `$subroutine` may be `(eval)` if the frame is not a subroutine call, but an `eval`. In such a case additional elements `$evaltext` and `$is_require` are set: `$is_require` is true if the frame is created by a `require` or `use` statement, `$evaltext` contains the text of the `eval EXPR` statement. In particular, for an `eval BLOCK` statement, `$filename` is `(eval)`, but `$evaltext` is undefined. (Note also that each `use` statement creates a `require` frame inside an `eval EXPR`) frame. `$hasargs` is true if a new instance of `@_` was set up for the frame. `$hints` and `$bitmask` contain pragmatic hints that the caller was compiled with. The `$hints` and `$bitmask` values are subject to change between versions of Perl, and are not meant for external use.

Furthermore, when called from within the DB package, caller returns more detailed information: it sets the list variable `@DB::args` to be the arguments with which the subroutine was invoked.

Be aware that the optimizer might have optimized call frames away before `caller` had a chance to get the information. That means that `caller(N)` might not return information about the call frame you expect it do, for `< N 1`. In particular, `@DB::args` might have information from the previous time `caller` was called.

chdir EXPR

Changes the working directory to EXPR, if possible. If EXPR is omitted, changes to the directory specified by `$ENV{HOME}`, if set; if not, changes to the directory specified by `$ENV{LOGDIR}`. If neither is set, `chdir` does nothing. It returns true upon success, false otherwise. See the example under `die`.

chmod LIST

Changes the permissions of a list of files. The first element of the list must be the numerical mode, which should probably be an octal number, and which definitely should *not* a string of octal digits: `0644` is okay, `'0644'` is not. Returns the number of files successfully changed. See also */oct*, if all you have is a string.

```
$cnt = chmod 0755, 'foo', 'bar';
chmod 0755, @executables;
$mode = '0644'; chmod $mode, 'foo';      # !!! sets mode to
                                         # --w----r-T
$mode = '0644'; chmod oct($mode), 'foo'; # this is better
$mode = 0644;   chmod $mode, 'foo';      # this is best
```

You can also import the symbolic `S_I*` constants from the Fcntl module:

```
use Fcntl ':mode';

chmod S_IRWXU|S_IRGRP|S_IXGRP|S_IROTH|S_IXOTH, @executables;
# This is identical to the chmod 0755 of the above example.
```

chomp VARIABLE
chomp LIST
chomp

This safer version of */chop* removes any trailing string that corresponds to the current value of `$/` (also known as `$INPUT_RECORD_SEPARATOR` in the `English` module). It returns the total number of characters removed from all its arguments. It's often used to remove the newline from the end of an input record when you're worried that the final record may be missing its newline. When in paragraph mode (`$/ = ""`), it removes all trailing newlines from the string. When in slurp mode (`$/ = undef`) or fixed–length record mode (`$/` is a reference to an integer or the like, see *perlvar*) `chomp()` won't remove anything. If VARIABLE is omitted, it chomps `$_`. Example:

```
while (<>) {
    chomp;  # avoid \n on last field
    @array = split(/:/);
    # ...
}
```

If VARIABLE is a hash, it chomps the hash's values, but not its keys.

You can actually chomp anything that's an lvalue, including an assignment:

```
chomp($cwd = `pwd`);
chomp($answer = <STDIN>);
```

If you chomp a list, each element is chomped, and the total number of characters removed is returned.

chop VARIABLE
chop LIST
chop Chops off the last character of a string and returns the character chopped. It's used primarily to remove the newline from the end of an input record, but is much more efficient than `s/\n//` because it neither scans nor copies the string. If VARIABLE is omitted, chops `$_`. Example:

```
while (<>) {
    chop;   # avoid \n on last field
    @array = split(/:/);
    #...
}
```

If VARIABLE is a hash, it chops the hash's values, but not its keys.

You can actually chop anything that's an lvalue, including an assignment:

```
chop($cwd = `pwd`);
chop($answer = <STDIN>);
```

If you chop a list, each element is chopped. Only the value of the last `chop` is returned.

Note that `chop` returns the last character. To return all but the last character, use `substr($string, 0, -1)`.

chown LIST

Changes the owner (and group) of a list of files. The first two elements of the list must be the *numeric* uid and gid, in that order. A value of -1 in either position is interpreted by most systems to leave that value unchanged. Returns the number of files successfully changed.

```
$cnt = chown $uid, $gid, 'foo', 'bar';
chown $uid, $gid, @filenames;
```

Here's an example that looks up nonnumeric uids in the passwd file:

```
print "User: ";
chomp($user = <STDIN>);
print "Files: ";
chomp($pattern = <STDIN>);

($login,$pass,$uid,$gid) = getpwnam($user)
    or die "$user not in passwd file";

@ary = glob($pattern);      # expand filenames
chown $uid, $gid, @ary;
```

On most systems, you are not allowed to change the ownership of the file unless you're the superuser, although you should be able to change the group to any of your secondary groups. On insecure systems, these restrictions may be relaxed, but this is not a portable assumption. On POSIX systems, you can detect this condition this way:

```
use POSIX qw(sysconf _PC_CHOWN_RESTRICTED);
$can_chown_giveaway = not sysconf(_PC_CHOWN_RESTRICTED);
```

chr NUMBER
chr Returns the character represented by that NUMBER in the character set. For example, `chr(65)` is `"A"` in either ASCII or Unicode, and chr(0x263a) is a Unicode smiley face. Within the scope of `use utf8`, characters higher than 127 are encoded in Unicode; if you don't want this, temporarily `use bytes` or use `pack("C*",...)`

For the reverse, use */ord*. See *utf8* for more about Unicode.

If NUMBER is omitted, uses `$_`.

chroot FILENAME

chroot This function works like the system call by the same name: it makes the named directory the new root directory for all further pathnames that begin with a / by your process and all its children. (It doesn't change your current working directory, which is unaffected.) For security reasons, this call is restricted to the superuser. If FILENAME is omitted, does a `chroot` to `$_`.

close FILEHANDLE

close Closes the file or pipe associated with the file handle, returning true only if stdio successfully flushes buffers and closes the system file descriptor. Closes the currently selected filehandle if the argument is omitted.

You don't have to close FILEHANDLE if you are immediately going to do another `open` on it, because `open` will close it for you. (See `open`.) However, an explicit `close` on an input file resets the line counter (`$.`), while the implicit close done by `open` does not.

If the file handle came from a piped open `close` will additionally return false if one of the other system calls involved fails or if the program exits with non–zero status. (If the only problem was that the program exited non–zero `$!` will be set to .) Closing a pipe also waits for the process executing on the pipe to complete, in case you want to look at the output of the pipe afterwards, and implicitly puts the exit status value of that command into `$?`.

Prematurely closing the read end of a pipe (i.e. before the process writing to it at the other end has closed it) will result in a SIGPIPE being delivered to the writer. If the other end can't handle that, be sure to read all the data before closing the pipe.

Example:

```
open(OUTPUT, '|sort >foo')  # pipe to sort
    or die "Can't start sort: $!";
#...                        # print stuff to output
close OUTPUT                # wait for sort to finish
    or warn $! ? "Error closing sort pipe: $!"
               : "Exit status $? from sort";
open(INPUT, 'foo')          # get sort's results
    or die "Can't open 'foo' for input: $!";
```

FILEHANDLE may be an expression whose value can be used as an indirect filehandle, usually the real filehandle name.

closedir DIRHANDLE

Closes a directory opened by `opendir` and returns the success of that system call.

DIRHANDLE may be an expression whose value can be used as an indirect dirhandle, usually the real dirhandle name.

connect SOCKET,NAME

Attempts to connect to a remote socket, just as the connect system call does. Returns true if it succeeded, false otherwise. NAME should be a packed address of the appropriate type for the socket. See the examples in *Sockets: Client/Server Communication in perlipc*.

continue BLOCK

Actually a flow control statement rather than a function. If there is a `continue` BLOCK attached to a BLOCK (typically in a `while` or `foreach`), it is always executed just before the conditional is about to be evaluated again, just like the third part of a `for` loop in C. Thus it can be used to increment a loop variable, even when the loop has been continued via the `next` statement (which is similar to the C `continue` statement).

`last`, `next`, or `redo` may appear within a `continue` block. `last` and `redo` will behave as if they had been executed within the main block. So will `next`, but since it will execute a

`continue` block, it may be more entertaining.

```
while (EXPR) {
    ### redo always comes here
    do_something;
} continue {
    ### next always comes here
    do_something_else;
    # then back the top to re-check EXPR
}
### last always comes here
```

Omitting the `continue` section is semantically equivalent to using an empty one, logically enough. In that case, `next` goes directly back to check the condition at the top of the loop.

cos EXPR

cos

Returns the cosine of EXPR (expressed in radians). If EXPR is omitted, takes cosine of `$_`.

For the inverse cosine operation, you may use the `Math::Trig::acos()` function, or use this relation:

```
sub acos { atan2( sqrt(1 - $_[0] * $_[0]), $_[0] ) }
```

crypt PLAINTEXT,SALT

Encrypts a string exactly like the crypt(3) function in the C library (assuming that you actually have a version there that has not been extirpated as a potential munition). This can prove useful for checking the password file for lousy passwords, amongst other things. Only the guys wearing white hats should do this.

Note that `crypt` is intended to be a one-way function, much like breaking eggs to make an omelette. There is no (known) corresponding decrypt function. As a result, this function isn't all that useful for cryptography. (For that, see your nearby CPAN mirror.)

When verifying an existing encrypted string you should use the encrypted text as the salt (like `crypt($plain, $crypted) eq $crypted)`. This allows your code to work with the standard `crypt` and with more exotic implementations. When choosing a new salt create a random two character string whose characters come from the set `[./0-9A-Za-z]` (like `join '', ('.', '/', 0..9, 'A'..'Z', 'a'..'z')[rand 64, rand 64]`).

Here's an example that makes sure that whoever runs this program knows their own password:

```
$pwd = (getpwuid($<))[1];

system "stty -echo";
print "Password: ";
chomp($word = <STDIN>);
print "\n";
system "stty echo";

if (crypt($word, $pwd) ne $pwd) {
    die "Sorry...\n";
} else {
    print "ok\n";
}
```

Of course, typing in your own password to whoever asks you for it is unwise.

The *crypt* function is unsuitable for encrypting large quantities of data, not least of all because you can't get the information back. Look at the ***by-module/Crypt*** and ***by-module/PGP*** directories on your favorite CPAN mirror for a slew of potentially useful modules.

dbmclose HASH

[This function has been largely superseded by the `untie` function.]

Breaks the binding between a DBM file and a hash.

dbmopen HASH,DBNAME,MASK

[This function has been largely superseded by the `tie` function.]

This binds a dbm(3), ndbm(3), sdbm(3), gdbm(3), or Berkeley DB file to a hash. HASH is the name of the hash. (Unlike normal `open`, the first argument is *not* a filehandle, even though it looks like one). DBNAME is the name of the database (without the ***.dir*** or ***.pag*** extension if any). If the database does not exist, it is created with protection specified by MASK (as modified by the `umask`). If your system supports only the older DBM functions, you may perform only one `dbmopen` in your program. In older versions of Perl, if your system had neither DBM nor ndbm, calling `dbmopen` produced a fatal error; it now falls back to sdbm(3).

If you don't have write access to the DBM file, you can only read hash variables, not set them. If you want to test whether you can write, either use file tests or try setting a dummy hash entry inside an `eval`, which will trap the error.

Note that functions such as `keys` and `values` may return huge lists when used on large DBM files. You may prefer to use the `each` function to iterate over large DBM files. Example:

```
# print out history file offsets
dbmopen(%HIST,'/usr/lib/news/history',0666);
while (($key,$val) = each %HIST) {
    print $key, ' = ', unpack('L',$val), "\n";
}
dbmclose(%HIST);
```

See also *AnyDBM_File* for a more general description of the pros and cons of the various dbm approaches, as well as *DB_File* for a particularly rich implementation.

You can control which DBM library you use by loading that library before you call `dbmopen()`:

```
use DB_File;
dbmopen(%NS_Hist, "$ENV{HOME}/.netscape/history.db")
    or die "Can't open netscape history file: $!";
```

defined EXPR

defined Returns a Boolean value telling whether EXPR has a value other than the undefined value `undef`. If EXPR is not present, `$_` will be checked.

Many operations return `undef` to indicate failure, end of file, system error, uninitialized variable, and other exceptional conditions. This function allows you to distinguish `undef` from other values. (A simple Boolean test will not distinguish among `undef`, zero, the empty string, and `"0"`, which are all equally false.) Note that since `undef` is a valid scalar, its presence doesn't *necessarily* indicate an exceptional condition: `pop` returns `undef` when its argument is an empty array, *or* when the element to return happens to be `undef`.

You may also use `defined(&func)` to check whether subroutine `&func` has ever been defined. The return value is unaffected by any forward declarations of `&foo`.

Use of `defined` on aggregates (hashes and arrays) is deprecated. It used to report whether memory for that aggregate has ever been allocated. This behavior may disappear in future versions of Perl. You should instead use a simple test for size:

```
if (@an_array) { print "has array elements\n" }
if (%a_hash)   { print "has hash members\n"   }
```

When used on a hash element, it tells you whether the value is defined, not whether the key exists in the hash. Use */exists* for the latter purpose.

Examples:

```
print if defined $switch{'D'};
print "$val\n" while defined($val = pop(@ary));
die "Can't readlink $sym: $!"
    unless defined($value = readlink $sym);
sub foo { defined &$bar ? &$bar(@_) : die "No bar"; }
$debugging = 0 unless defined $debugging;
```

Note: Many folks tend to overuse `defined`, and then are surprised to discover that the number and `""` (the zero-length string) are, in fact, defined values. For example, if you say

```
"ab" =~ /a(.*)b/;
```

The pattern match succeeds, and `$1` is defined, despite the fact that it matched "nothing". But it didn't really match nothing—rather, it matched something that happened to be zero characters long. This is all very above-board and honest. When a function returns an undefined value, it's an admission that it couldn't give you an honest answer. So you should use `defined` only when you're questioning the integrity of what you're trying to do. At other times, a simple comparison to or `""` is what you want.

See also */undef*, */exists*, */ref*.

delete EXPR

Given an expression that specifies a hash element, array element, hash slice, or array slice, deletes the specified element(s) from the hash or array. In the case of an array, if the array elements happen to be at the end, the size of the array will shrink to the highest element that tests true for `exists()` (or 0 if no such element exists).

Returns each element so deleted or the undefined value if there was no such element. Deleting from `$ENV{}` modifies the environment. Deleting from a hash tied to a DBM file deletes the entry from the DBM file. Deleting from a `tied` hash or array may not necessarily return anything.

Deleting an array element effectively returns that position of the array to its initial, uninitialized state. Subsequently testing for the same element with `exists()` will return false. Note that deleting array elements in the middle of an array will not shift the index of the ones after them down—use `splice()` for that. See */exists*.

The following (inefficiently) deletes all the values of %HASH and @ARRAY:

```
foreach $key (keys %HASH) {
    delete $HASH{$key};
}

foreach $index (0 .. $#ARRAY) {
    delete $ARRAY[$index];
}
```

And so do these:

```
delete @HASH{keys %HASH};

delete @ARRAY[0 .. $#ARRAY];
```

But both of these are slower than just assigning the empty list or undefining %HASH or @ARRAY:

```
%HASH = ();         # completely empty %HASH
undef %HASH;        # forget %HASH ever existed
```

```
@ARRAY = ();# completely empty @ARRAY
undef @ARRAY# forget @ARRAY ever existed
```

Note that the EXPR can be arbitrarily complicated as long as the final operation is a hash element, array element, hash slice, or array slice lookup:

```
delete $ref->[$x][$y]{$key};
delete @{$ref->[$x][$y]}{$key1, $key2, @morekeys};

delete $ref->[$x][$y][$index];
delete @{$ref->[$x][$y]}[$index1, $index2, @moreindices];
```

die LIST Outside an `eval`, prints the value of LIST to `STDERR` and exits with the current value of `$!` (errno). If `$!` is , exits with the value of `<< ($? 8)` (backtick 'command' status). If `<< ($? 8)` is , exits with `255`. Inside an `eval()`, the error message is stuffed into `$@` and the `eval` is terminated with the undefined value. This makes `die` the way to raise an exception.

Equivalent examples:

```
die "Can't cd to spool: $!\n" unless chdir '/usr/spool/news';
chdir '/usr/spool/news' or die "Can't cd to spool: $!\n"
```

If the value of EXPR does not end in a newline, the current script line number and input line number (if any) are also printed, and a newline is supplied. Note that the "input line number" (also known as "chunk") is subject to whatever notion of "line" happens to be currently in effect, and is also available as the special variable `$.`. See *$/ in perlvar* and *$. in perlvar*.

Hint: sometimes appending `", stopped"` to your message will cause it to make better sense when the string `"at foo line 123"` is appended. Suppose you are running script "canasta".

```
die "/etc/games is no good";
die "/etc/games is no good, stopped";
```

produce, respectively

```
/etc/games is no good at canasta line 123.
/etc/games is no good, stopped at canasta line 123.
```

See also `exit()`, `warn()`, and the Carp module.

If LIST is empty and `$@` already contains a value (typically from a previous eval) that value is reused after appending `"\t...propagated"`. This is useful for propagating exceptions:

```
eval { ... };
die unless $@ =~ /Expected exception/;
```

If `$@` is empty then the string `"Died"` is used.

`die()` can also be called with a reference argument. If this happens to be trapped within an `eval()`, `$@` contains the reference. This behavior permits a more elaborate exception handling implementation using objects that maintain arbitrary state about the nature of the exception. Such a scheme is sometimes preferable to matching particular string values of `$@` using regular expressions. Here's an example:

```
eval { ... ; die Some::Module::Exception->new( FOO => "bar" ) };
if ($@) {
    if (ref($@) && UNIVERSAL::isa($@,"Some::Module::Exception")) {
        # handle Some::Module::Exception
    }
    else {
        # handle all other possible exceptions
```

```
    }
}
```

Because perl will stringify uncaught exception messages before displaying them, you may want to overload stringification operations on such custom exception objects. See *overload* for details about that.

You can arrange for a callback to be run just before the `die` does its deed, by setting the `$SIG{__DIE__}` hook. The associated handler will be called with the error text and can change the error message, if it sees fit, by calling `die` again. See *$SIG{expr}* for details on setting `%SIG` entries, and *"eval BLOCK"* for some examples. Although this feature was meant to be run only right before your program was to exit, this is not currently the case—the `$SIG{__DIE__}` hook is currently called even inside `eval()`ed blocks/strings! If one wants the hook to do nothing in such situations, put

```
die @_ if $^S;
```

as the first line of the handler (see *$^S*). Because this promotes strange action at a distance, this counterintuitive behavior may be fixed in a future release.

do BLOCK

Not really a function. Returns the value of the last command in the sequence of commands indicated by BLOCK. When modified by a loop modifier, executes the BLOCK once before testing the loop condition. (On other statements the loop modifiers test the conditional first.)

`do BLOCK` does *not* count as a loop, so the loop control statements `next`, `last`, or `redo` cannot be used to leave or restart the block. See *perlsyn* for alternative strategies.

do SUBROUTINE(LIST)

A deprecated form of subroutine call. See *perlsub*.

do EXPR

Uses the value of EXPR as a filename and executes the contents of the file as a Perl script. Its primary use is to include subroutines from a Perl subroutine library.

```
do 'stat.pl';
```

is just like

```
scalar eval `cat stat.pl`;
```

except that it's more efficient and concise, keeps track of the current filename for error messages, searches the @INC libraries, and updates `%INC` if the file is found. See *Predefined Names* for these variables. It also differs in that code evaluated with `do FILENAME` cannot see lexicals in the enclosing scope; `eval STRING` does. It's the same, however, in that it does reparse the file every time you call it, so you probably don't want to do this inside a loop.

If `do` cannot read the file, it returns undef and sets `$!` to the error. If `do` can read the file but cannot compile it, it returns undef and sets an error message in `$@`. If the file is successfully compiled, `do` returns the value of the last expression evaluated.

Note that inclusion of library modules is better done with the `use` and `require` operators, which also do automatic error checking and raise an exception if there's a problem.

You might like to use `do` to read in a program configuration file. Manual error checking can be done this way:

```
# read in config files: system first, then user
for $file ("/share/prog/defaults.rc",
           "$ENV{HOME}/.someprogrc")
{
    unless ($return = do $file) {
        warn "couldn't parse $file: $@" if $@;
```

```
            warn "couldn't do $file: $!"    unless defined $return;
            warn "couldn't run $file"       unless $return;
        }
    }
```

dump LABEL

dump This function causes an immediate core dump. See also the **–u** command–line switch in *perlrun*, which does the same thing. Primarily this is so that you can use the **undump** program (not supplied) to turn your core dump into an executable binary after having initialized all your variables at the beginning of the program. When the new binary is executed it will begin by executing a `goto LABEL` (with all the restrictions that `goto` suffers). Think of it as a goto with an intervening core dump and reincarnation. If `LABEL` is omitted, restarts the program from the top.

WARNING: Any files opened at the time of the dump will *not* be open any more when the program is reincarnated, with possible resulting confusion on the part of Perl.

This function is now largely obsolete, partly because it's very hard to convert a core file into an executable, and because the real compiler backends for generating portable bytecode and compilable C code have superseded it.

If you're looking to use *dump* to speed up your program, consider generating bytecode or native C code as described in *perlcc*. If you're just trying to accelerate a CGI script, consider using the `mod_perl` extension to **Apache**, or the CPAN module, Fast::CGI. You might also consider autoloading or selfloading, which at least make your program *appear* to run faster.

each HASH

When called in list context, returns a 2–element list consisting of the key and value for the next element of a hash, so that you can iterate over it. When called in scalar context, returns only the key for the next element in the hash.

Entries are returned in an apparently random order. The actual random order is subject to change in future versions of perl, but it is guaranteed to be in the same order as either the `keys` or `values` function would produce on the same (unmodified) hash.

When the hash is entirely read, a null array is returned in list context (which when assigned produces a false () value), and `undef` in scalar context. The next call to `each` after that will start iterating again. There is a single iterator for each hash, shared by all `each`, `keys`, and `values` function calls in the program; it can be reset by reading all the elements from the hash, or by evaluating `keys HASH` or `values HASH`. If you add or delete elements of a hash while you're iterating over it, you may get entries skipped or duplicated, so don't. Exception: It is always safe to delete the item most recently returned by `each()`, which means that the following code will work:

```
while (($key, $value) = each %hash) {
  print $key, "\n";
  delete $hash{$key};   # This is safe
}
```

The following prints out your environment like the printenv(1) program, only in a different order:

```
while (($key,$value) = each %ENV) {
    print "$key=$value\n";
}
```

See also `keys`, `values` and `sort`.

eof FILEHANDLE
eof ()
eof

Returns 1 if the next read on FILEHANDLE will return end of file, or if FILEHANDLE is not open. FILEHANDLE may be an expression whose value gives the real filehandle. (Note that this function actually reads a character and then ungetcs it, so isn't very useful in an interactive context.) Do not read from a terminal file (or call eof(FILEHANDLE) on it) after end-of-file is reached. File types such as terminals may lose the end-of-file condition if you do.

An eof without an argument uses the last file read. Using eof() with empty parentheses is very different. It refers to the pseudo file formed from the files listed on the command line and accessed via the < > operator. Since < > isn't explicitly opened, as a normal filehandle is, an eof() before < > has been used will cause @ARGV to be examined to determine if input is available.

In a < while (<>) loop, eof or eof(ARGV) can be used to detect the end of each file, eof() will only detect the end of the last file. Examples:

```
# reset line numbering on each input file
while (<>) {
    next if /^\s*#/;        # skip comments
    print "$.\t$_";
} continue {
    close ARGV  if eof;     # Not eof()!
}

# insert dashes just before last line of last file
while (<>) {
    if (eof()) {            # check for end of current file
        print "--------------\n";
        close(ARGV);        # close or last; is needed if we
                            # are reading from the terminal
    }
    print;
}
```

Practical hint: you almost never need to use eof in Perl, because the input operators typically return undef when they run out of data, or if there was an error.

eval EXPR
eval BLOCK

In the first form, the return value of EXPR is parsed and executed as if it were a little Perl program. The value of the expression (which is itself determined within scalar context) is first parsed, and if there weren't any errors, executed in the lexical context of the current Perl program, so that any variable settings or subroutine and format definitions remain afterwards. Note that the value is parsed every time the eval executes. If EXPR is omitted, evaluates $_. This form is typically used to delay parsing and subsequent execution of the text of EXPR until run time.

In the second form, the code within the BLOCK is parsed only once—at the same time the code surrounding the eval itself was parsed—and executed within the context of the current Perl program. This form is typically used to trap exceptions more efficiently than the first (see below), while also providing the benefit of checking the code within BLOCK at compile time.

The final semicolon, if any, may be omitted from the value of EXPR or within the BLOCK.

In both forms, the value returned is the value of the last expression evaluated inside the mini-program; a return statement may be also used, just as with subroutines. The expression providing the return value is evaluated in void, scalar, or list context, depending on the context of

the eval itself. See */wantarray* for more on how the evaluation context can be determined.

If there is a syntax error or runtime error, or a `die` statement is executed, an undefined value is returned by `eval`, and `$@` is set to the error message. If there was no error, `$@` is guaranteed to be a null string. Beware that using `eval` neither silences perl from printing warnings to STDERR, nor does it stuff the text of warning messages into `$@`. To do either of those, you have to use the `$SIG{__WARN__}` facility. See */warn* and *perlvar*.

Note that, because `eval` traps otherwise–fatal errors, it is useful for determining whether a particular feature (such as `socket` or `symlink`) is implemented. It is also Perl's exception trapping mechanism, where the die operator is used to raise exceptions.

If the code to be executed doesn't vary, you may use the eval–BLOCK form to trap run–time errors without incurring the penalty of recompiling each time. The error, if any, is still returned in `$@`. Examples:

```
# make divide-by-zero nonfatal
eval { $answer = $a / $b; }; warn $@ if $@;

# same thing, but less efficient
eval '$answer = $a / $b'; warn $@ if $@;

# a compile-time error
eval { $answer = };                 # WRONG

# a run-time error
eval '$answer =';   # sets $@
```

Due to the current arguably broken state of `__DIE__` hooks, when using the `eval{}` form as an exception trap in libraries, you may wish not to trigger any `__DIE__` hooks that user code may have installed. You can use the `local $SIG{__DIE__}` construct for this purpose, as shown in this example:

```
# a very private exception trap for divide-by-zero
eval { local $SIG{'__DIE__'}; $answer = $a / $b; };
warn $@ if $@;
```

This is especially significant, given that `__DIE__` hooks can call `die` again, which has the effect of changing their error messages:

```
# __DIE__ hooks may modify error messages
{
   local $SIG{'__DIE__'} =
          sub { (my $x = $_[0]) =~ s/foo/bar/g; die $x };
   eval { die "foo lives here" };
   print $@ if $@;                # prints "bar lives here"
}
```

Because this promotes action at a distance, this counterintuitive behavior may be fixed in a future release.

With an `eval`, you should be especially careful to remember what's being looked at when:

```
eval $x;            # CASE 1
eval "$x";          # CASE 2

eval '$x';          # CASE 3
eval { $x };        # CASE 4

eval "\$$x++";      # CASE 5
$$x++;              # CASE 6
```

Cases 1 and 2 above behave identically: they run the code contained in the variable `$x`. (Although case 2 has misleading double quotes making the reader wonder what else might be happening (nothing is).) Cases 3 and 4 likewise behave in the same way: they run the code `'$x'`, which does nothing but return the value of `$x`. (Case 4 is preferred for purely visual reasons, but it also has the advantage of compiling at compile–time instead of at run–time.) Case 5 is a place where normally you *would* like to use double quotes, except that in this particular situation, you can just use symbolic references instead, as in case 6.

`eval BLOCK` does *not* count as a loop, so the loop control statements `next`, `last`, or `redo` cannot be used to leave or restart the block.

exec LIST
exec PROGRAM LIST

The `exec` function executes a system command *and never returns*— use `system` instead of `exec` if you want it to return. It fails and returns false only if the command does not exist *and* it is executed directly instead of via your system's command shell (see below).

Since it's a common mistake to use `exec` instead of `system`, Perl warns you if there is a following statement which isn't `die`, `warn`, or `exit` (if `-w` is set - but you always do that). If you *really* want to follow an `exec` with some other statement, you can use one of these styles to avoid the warning:

```
exec ('foo')   or print STDERR "couldn't exec foo: $!";
{ exec ('foo') }; print STDERR "couldn't exec foo: $!";
```

If there is more than one argument in LIST, or if LIST is an array with more than one value, calls execvp(3) with the arguments in LIST. If there is only one scalar argument or an array with one element in it, the argument is checked for shell metacharacters, and if there are any, the entire argument is passed to the system's command shell for parsing (this is `/bin/sh -c` on Unix platforms, but varies on other platforms). If there are no shell metacharacters in the argument, it is split into words and passed directly to `execvp`, which is more efficient. Examples:

```
exec '/bin/echo', 'Your arguments are: ', @ARGV;
exec "sort $outfile | uniq";
```

If you don't really want to execute the first argument, but want to lie to the program you are executing about its own name, you can specify the program you actually want to run as an "indirect object" (without a comma) in front of the LIST. (This always forces interpretation of the LIST as a multivalued list, even if there is only a single scalar in the list.) Example:

```
$shell = '/bin/csh';
exec $shell '-sh';          # pretend it's a login shell
```

or, more directly,

```
exec {'/bin/csh'} '-sh';    # pretend it's a login shell
```

When the arguments get executed via the system shell, results will be subject to its quirks and capabilities. See *'STRING' in perlop* for details.

Using an indirect object with `exec` or `system` is also more secure. This usage (which also works fine with `system()`) forces interpretation of the arguments as a multivalued list, even if the list had just one argument. That way you're safe from the shell expanding wildcards or splitting up words with whitespace in them.

```
@args = ( "echo surprise" );

exec @args;               # subject to shell escapes
                            # if @args == 1
exec { $args[0] } @args;  # safe even with one-arg list
```

The first version, the one without the indirect object, ran the *echo* program, passing it `"surprise"` an argument. The second version didn't—it tried to run a program literally called *"echo surprise"*, didn't find it, and set `$?` to a non–zero value indicating failure.

Beginning with v5.6.0, Perl will attempt to flush all files opened for output before the exec, but this may not be supported on some platforms (see *perlport*). To be safe, you may need to set `$|` (`$AUTOFLUSH` in English) or call the `autoflush()` method of `IO::Handle` on any open handles in order to avoid lost output.

Note that `exec` will not call your `END` blocks, nor will it call any `DESTROY` methods in your objects.

exists EXPR

Given an expression that specifies a hash element or array element, returns true if the specified element in the hash or array has ever been initialized, even if the corresponding value is undefined. The element is not autovivified if it doesn't exist.

```
print "Exists\n"    if exists $hash{$key};
print "Defined\n"   if defined $hash{$key};
print "True\n"      if $hash{$key};

print "Exists\n"    if exists $array[$index];
print "Defined\n"   if defined $array[$index];
print "True\n"      if $array[$index];
```

A hash or array element can be true only if it's defined, and defined if it exists, but the reverse doesn't necessarily hold true.

Given an expression that specifies the name of a subroutine, returns true if the specified subroutine has ever been declared, even if it is undefined. Mentioning a subroutine name for exists or defined does not count as declaring it.

```
print "Exists\n"    if exists &subroutine;
print "Defined\n"   if defined &subroutine;
```

Note that the EXPR can be arbitrarily complicated as long as the final operation is a hash or array key lookup or subroutine name:

```
if (exists $ref->{A}->{B}->{$key})  { }
if (exists $hash{A}{B}{$key})       { }

if (exists $ref->{A}->{B}->[$ix])   { }
if (exists $hash{A}{B}[$ix])        { }

if (exists &{$ref->{A}{B}{$key}})   { }
```

Although the deepest nested array or hash will not spring into existence just because its existence was tested, any intervening ones will. Thus `< $ref->{"A"} >` and `< $ref->{"A"}->{"B"} >` will spring into existence due to the existence test for the `$key` element above. This happens anywhere the arrow operator is used, including even:

```
undef $ref;
if (exists $ref->{"Some key"})      { }
print $ref;             # prints HASH(0x80d3d5c)
```

This surprising autovivification in what does not at first—or even second—glance appear to be an lvalue context may be fixed in a future release.

See *Pseudo–hashes: Using an array as a hash in perlref* for specifics on how `exists()` acts when used on a pseudo–hash.

Use of a subroutine call, rather than a subroutine name, as an argument to `exists()` is an error.

```
exists &sub;# OK
exists &sub(#;Error
```

exit EXPR

Evaluates EXPR and exits immediately with that value. Example:

```
$ans = <STDIN>;
exit 0 if $ans =~ /^[Xx]/;
```

See also `die`. If EXPR is omitted, exits with status. The only universally recognized values for EXPR are for success and `1` for error; other values are subject to interpretation depending on the environment in which the Perl program is running. For example, exiting 69 (EX_UNAVAILABLE) from a *sendmail* incoming−mail filter will cause the mailer to return the item undelivered, but that's not true everywhere.

Don't use `exit` to abort a subroutine if there's any chance that someone might want to trap whatever error happened. Use `die` instead, which can be trapped by an `eval`.

The `exit()` function does not always exit immediately. It calls any defined `END` routines first, but these `END` routines may not themselves abort the exit. Likewise any object destructors that need to be called are called before the real exit. If this is a problem, you can call `POSIX::_exit($status)` to avoid END and destructor processing. See *perlmod* for details.

exp EXPR

exp Returns *e* (the natural logarithm base) to the power of EXPR. If EXPR is omitted, gives `exp($_)`.

fcntl FILEHANDLE,FUNCTION,SCALAR

Implements the fcntl(2) function. You'll probably have to say

```
use Fcntl;
```

first to get the correct constant definitions. Argument processing and value return works just like `ioctl` below. For example:

```
use Fcntl;
fcntl($filehandle, F_GETFL, $packed_return_buffer)
    or die "can't fcntl F_GETFL: $!";
```

You don't have to check for `defined` on the return from `fnctl`. Like `ioctl`, it maps a return from the system call into `"0 but true"` in Perl. This string is true in boolean context and in numeric context. It is also exempt from the normal **−w** warnings on improper numeric conversions.

Note that `fcntl` will produce a fatal error if used on a machine that doesn't implement fcntl(2). See the Fcntl module or your fcntl(2) manpage to learn what functions are available on your system.

fileno FILEHANDLE

Returns the file descriptor for a filehandle, or undefined if the filehandle is not open. This is mainly useful for constructing bitmaps for `select` and low−level POSIX tty−handling operations. If FILEHANDLE is an expression, the value is taken as an indirect filehandle, generally its name.

You can use this to find out whether two handles refer to the same underlying descriptor:

```
if (fileno(THIS) == fileno(THAT)) {
    print "THIS and THAT are dups\n";
}
```

flock FILEHANDLE,OPERATION

Calls flock(2), or an emulation of it, on FILEHANDLE. Returns true for success, false on failure. Produces a fatal error if used on a machine that doesn't implement flock(2), fcntl(2) locking, or lockf(3). `flock` is Perl's portable file locking interface, although it locks only entire files, not records.

Two potentially non–obvious but traditional `flock` semantics are that it waits indefinitely until the lock is granted, and that its locks **merely advisory**. Such discretionary locks are more flexible, but offer fewer guarantees. This means that files locked with `flock` may be modified by programs that do not also use `flock`. See *perlport*, your port's specific documentation, or your system–specific local manpages for details. It's best to assume traditional behavior if you're writing portable programs. (But if you're not, you should as always feel perfectly free to write for your own system's idiosyncrasies (sometimes called "features"). Slavish adherence to portability concerns shouldn't get in the way of your getting your job done.)

OPERATION is one of LOCK_SH, LOCK_EX, or LOCK_UN, possibly combined with LOCK_NB. These constants are traditionally valued 1, 2, 8 and 4, but you can use the symbolic names if you import them from the Fcntl module, either individually, or as a group using the ':flock' tag. LOCK_SH requests a shared lock, LOCK_EX requests an exclusive lock, and LOCK_UN releases a previously requested lock. If LOCK_NB is bitwise–or'ed with LOCK_SH or LOCK_EX then `flock` will return immediately rather than blocking waiting for the lock (check the return status to see if you got it).

To avoid the possibility of miscoordination, Perl now flushes FILEHANDLE before locking or unlocking it.

Note that the emulation built with lockf(3) doesn't provide shared locks, and it requires that FILEHANDLE be open with write intent. These are the semantics that lockf(3) implements. Most if not all systems implement lockf(3) in terms of fcntl(2) locking, though, so the differing semantics shouldn't bite too many people.

Note also that some versions of `flock` cannot lock things over the network; you would need to use the more system–specific `fcntl` for that. If you like you can force Perl to ignore your system's flock(2) function, and so provide its own fcntl(2)–based emulation, by passing the switch `-Ud_flock` to the ***Configure*** program when you configure perl.

Here's a mailbox appender for BSD systems.

```
use Fcntl ':flock'; # import LOCK_* constants

sub lock {
    flock(MBOX,LOCK_EX);
    # and, in case someone appended
    # while we were waiting...
    seek(MBOX, 0, 2);
}

sub unlock {
    flock(MBOX,LOCK_UN);
}

open(MBOX, ">>/usr/spool/mail/$ENV{'USER'}")
        or die "Can't open mailbox: $!";

lock();
print MBOX $msg,"\n\n";
unlock();
```

On systems that support a real `flock()`, locks are inherited across `fork()` calls, whereas those that must resort to the more capricious `fcntl()` function lose the locks, making it harder

to write servers.

See also *DB_File* for other `flock()` examples.

fork

Does a fork(2) system call to create a new process running the same program at the same point. It returns the child pid to the parent process, to the child process, or `undef` if the fork is unsuccessful. File descriptors (and sometimes locks on those descriptors) are shared, while everything else is copied. On most systems supporting `fork()`, great care has gone into making it extremely efficient (for example, using copy–on–write technology on data pages), making it the dominant paradigm for multitasking over the last few decades.

Beginning with v5.6.0, Perl will attempt to flush all files opened for output before forking the child process, but this may not be supported on some platforms (see *perlport*). To be safe, you may need to set `$|` (`$AUTOFLUSH` in English) or call the `autoflush()` method of `IO::Handle` on any open handles in order to avoid duplicate output.

If you `fork` without ever waiting on your children, you will accumulate zombies. On some systems, you can avoid this by setting `$SIG{CHLD}` to `"IGNORE"`. See also *perlipc* for more examples of forking and reaping moribund children.

Note that if your forked child inherits system file descriptors like STDIN and STDOUT that are actually connected by a pipe or socket, even if you exit, then the remote server (such as, say, a CGI script or a backgrounded job launched from a remote shell) won't think you're done. You should reopen those to ***/dev/null*** if it's any issue.

format

Declare a picture format for use by the `write` function. For example:

```
format Something =
    Test: @<<<<<<<< @||||| @>>>>>
          $str,     $%,    '$' . int($num)
.

$str = "widget";
$num = $cost/$quantity;
$~ = 'Something';
write;
```

See *perlform* for many details and examples.

formline PICTURE,LIST

This is an internal function used by `formats`, though you may call it, too. It formats (see *perlform*) a list of values according to the contents of PICTURE, placing the output into the format output accumulator, `$^A` (or `$ACCUMULATOR` in English). Eventually, when a `write` is done, the contents of `$^A` are written to some filehandle, but you could also read `$^A` yourself and then set `$^A` back to `""`. Note that a format typically does one `formline` per line of form, but the `formline` function itself doesn't care how many newlines are embedded in the PICTURE. This means that the ~ and ~~ tokens will treat the entire PICTURE as a single line. You may therefore need to use multiple formlines to implement a single record format, just like the format compiler.

Be careful if you put double quotes around the picture, because an `@` character may be taken to mean the beginning of an array name. `formline` always returns true. See *perlform* for other examples.

getc FILEHANDLE

getc

Returns the next character from the input file attached to FILEHANDLE, or the undefined value at end of file, or if there was an error. If FILEHANDLE is omitted, reads from STDIN. This is not particularly efficient. However, it cannot be used by itself to fetch single characters without waiting for the user to hit enter. For that, try something more like:

```
if ($BSD_STYLE) {
    system "stty cbreak </dev/tty >/dev/tty 2>&1";
}
else {
    system "stty", '-icanon', 'eol', "\001";
}

$key = getc(STDIN);

if ($BSD_STYLE) {
    system "stty -cbreak </dev/tty >/dev/tty 2>&1";
}
else {
    system "stty", 'icanon', 'eol', '^@'; # ASCII null
}
print "\n";
```

Determination of whether `$BSD_STYLE` should be set is left as an exercise to the reader.

The `POSIX::getattr` function can do this more portably on systems purporting POSIX compliance. See also the `Term::ReadKey` module from your nearest CPAN site; details on CPAN can be found on *CPAN*.

getlogin Implements the C library function of the same name, which on most systems returns the current login from ***/etc/utmp***, if any. If null, use `getpwuid`.

```
$login = getlogin || getpwuid($<) || "Kilroy";
```

Do not consider `getlogin` for authentication: it is not as secure as `getpwuid`.

getpeername SOCKET

Returns the packed sockaddr address of other end of the SOCKET connection.

```
use Socket;
$hersockaddr    = getpeername(SOCK);
($port, $iaddr) = sockaddr_in($hersockaddr);
$herhostname    = gethostbyaddr($iaddr, AF_INET);
$herstraddr     = inet_ntoa($iaddr);
```

getpgrp PID

Returns the current process group for the specified PID. Use a PID of to get the current process group for the current process. Will raise an exception if used on a machine that doesn't implement getpgrp(2). If PID is omitted, returns process group of current process. Note that the POSIX version of `getpgrp` does not accept a PID argument, so only `PID==0` is truly portable.

getppid Returns the process id of the parent process.

getpriority WHICH,WHO

Returns the current priority for a process, a process group, or a user. (See *getpriority(2)*.) Will raise a fatal exception if used on a machine that doesn't implement getpriority(2).

getpwnam NAME
getgrnam NAME
gethostbyname NAME
getnetbyname NAME
getprotobyname NAME
getpwuid UID
getgrgid GID
getservbyname NAME,PROTO

gethostbyaddr ADDR,ADDRTYPE
getnetbyaddr ADDR,ADDRTYPE
getprotobynumber NUMBER
getservbyport PORT,PROTO
getpwent
getgrent
gethostent
getnetent
getprotoent
getservent
setpwent
setgrent
sethostent STAYOPEN
setnetent STAYOPEN
setprotoent STAYOPEN
setservent STAYOPEN
endpwent
endgrent
endhostent
endnetent
endprotoent
endservent

These routines perform the same functions as their counterparts in the system library. In list context, the return values from the various get routines are as follows:

```
($name,$passwd,$uid,$gid,
   $quota,$comment,$gcos,$dir,$shell,$expire) = getpw*
($name,$passwd,$gid,$members) = getgr*
($name,$aliases,$addrtype,$length,@addrs) = gethost*
($name,$aliases,$addrtype,$net) = getnet*
($name,$aliases,$proto) = getproto*
($name,$aliases,$port,$proto) = getserv*
```

(If the entry doesn't exist you get a null list.)

The exact meaning of the `$gcos` field varies but it usually contains the real name of the user (as opposed to the login name) and other information pertaining to the user. Beware, however, that in many system users are able to change this information and therefore it cannot be trusted and therefore the `$gcos` is tainted (see *perlsec*). The `$passwd` and `$shell`, user's encrypted password and login shell, are also tainted, because of the same reason.

In scalar context, you get the name, unless the function was a lookup by name, in which case you get the other thing, whatever it is. (If the entry doesn't exist you get the undefined value.) For example:

```
$uid   = getpwnam($name);
$name  = getpwuid($num);
$name  = getpwent();
$gid   = getgrnam($name);
$name  = getgrgid($num;
$name  = getgrent();
#etc.
```

In *getpw*()* the fields `$quota`, `$comment`, and `$expire` are special cases in the sense that in many systems they are unsupported. If the `$quota` is unsupported, it is an empty scalar. If it is supported, it usually encodes the disk quota. If the `$comment` field is unsupported, it is an empty scalar. If it is supported it usually encodes some administrative comment about the

user. In some systems the $quota field may be $change or $age, fields that have to do with password aging. In some systems the $comment field may be $class. The $expire field, if present, encodes the expiration period of the account or the password. For the availability and the exact meaning of these fields in your system, please consult your getpwnam(3) documentation and your ***pwd.h*** file. You can also find out from within Perl what your $quota and $comment fields mean and whether you have the $expire field by using the Config module and the values d_pwquota, d_pwage, d_pwchange, d_pwcomment, and d_pwexpire. Shadow password files are only supported if your vendor has implemented them in the intuitive fashion that calling the regular C library routines gets the shadow versions if you're running under privilege or if there exists the shadow(3) functions as found in System V (this includes Solaris and Linux.) Those systems which implement a proprietary shadow password facility are unlikely to be supported.

The $members value returned by *getgr*()* is a space separated list of the login names of the members of the group.

For the *gethost*()* functions, if the h_errno variable is supported in C, it will be returned to you via $? if the function call fails. The @addrs value returned by a successful call is a list of the raw addresses returned by the corresponding system library call. In the Internet domain, each address is four bytes long and you can unpack it by saying something like:

```
($a,$b,$c,$d) = unpack('C4',$addr[0]);
```

The Socket library makes this slightly easier:

```
use Socket;
$iaddr = inet_aton("127.1"); # or whatever address
$name  = gethostbyaddr($iaddr, AF_INET);

# or going the other way
$straddr = inet_ntoa($iaddr);
```

If you get tired of remembering which element of the return list contains which return value, by-name interfaces are provided in standard modules: File::stat, Net::hostent, Net::netent, Net::protoent, Net::servent, Time::gmtime, Time::localtime, and User::grent. These override the normal built-ins, supplying versions that return objects with the appropriate names for each field. For example:

```
use File::stat;
use User::pwent;
$is_his = (stat($filename)->uid == pwent($whoever)->uid);
```

Even though it looks like they're the same method calls (uid), they aren't, because a File::stat object is different from a User::pwent object.

getsockname SOCKET

Returns the packed sockaddr address of this end of the SOCKET connection, in case you don't know the address because you have several different IPs that the connection might have come in on.

```
use Socket;
$mysockaddr = getsockname(SOCK);
($port, $myaddr) = sockaddr_in($mysockaddr);
printf "Connect to %s [%s]\n",
   scalar gethostbyaddr($myaddr, AF_INET),
   inet_ntoa($myaddr);
```

getsockopt SOCKET,LEVEL,OPTNAME

Returns the socket option requested, or undef if there is an error.

glob EXPR
glob

Returns the value of EXPR with filename expansions such as the standard Unix shell */bin/csh* would do. This is the internal function implementing the `< <*.c` operator, but you can use it directly. If EXPR is omitted, `$_` is used. The `< <*.c` operator is discussed in more detail in *I/O Operators in perlop*.

Beginning with v5.6.0, this operator is implemented using the standard `File::Glob` extension. See *File::Glob* for details.

gmtime EXPR

Converts a time as returned by the time function to a 8–element list with the time localized for the standard Greenwich time zone. Typically used as follows:

```
#  0    1    2     3     4    5     6     7
($sec,$min,$hour,$mday,$mon,$year,$wday,$yday) =
                                        gmtime(time);
```

All list elements are numeric, and come straight out of the C 'struct tm'. `$sec`, `$min`, and `$hour` are the seconds, minutes, and hours of the specified time. `$mday` is the day of the month, and `$mon` is the month itself, in the range `0..11` with 0 indicating January and 11 indicating December. `$year` is the number of years since 1900. That is, `$year` is `123` in year 2023. `$wday` is the day of the week, with 0 indicating Sunday and 3 indicating Wednesday. `$yday` is the day of the year, in the range `0..364` (or `0..365` in leap years.)

Note that the `$year` element is *not* simply the last two digits of the year. If you assume it is, then you create non–Y2K–compliant programs—and you wouldn't want to do that, would you?

The proper way to get a complete 4–digit year is simply:

```
$year += 1900;
```

And to get the last two digits of the year (e.g., '01' in 2001) do:

```
$year = sprintf("%02d", $year % 100);
```

If EXPR is omitted, `gmtime()` uses the current time (`gmtime(time)`).

In scalar context, `gmtime()` returns the ctime(3) value:

```
$now_string = gmtime;  # e.g., "Thu Oct 13 04:54:34 1994"
```

Also see the `timegm` function provided by the `Time::Local` module, and the strftime(3) function available via the POSIX module.

This scalar value is **not** locale dependent (see *perllocale*), but is instead a Perl builtin. Also see the `Time::Local` module, and the strftime(3) and mktime(3) functions available via the POSIX module. To get somewhat similar but locale dependent date strings, set up your locale environment variables appropriately (please see *perllocale*) and try for example:

```
use POSIX qw(strftime);
$now_string = strftime "%a %b %e %H:%M:%S %Y", gmtime;
```

Note that the `%a` and `%b` escapes, which represent the short forms of the day of the week and the month of the year, may not necessarily be three characters wide in all locales.

goto LABEL
goto EXPR
goto `&NAME`

The `goto-LABEL` form finds the statement labeled with LABEL and resumes execution there. It may not be used to go into any construct that requires initialization, such as a subroutine or a `foreach` loop. It also can't be used to go into a construct that is optimized away, or to get out of a block or subroutine given to `sort`. It can be used to go almost anywhere else within the

dynamic scope, including out of subroutines, but it's usually better to use some other construct such as `last` or `die`. The author of Perl has never felt the need to use this form of `goto` (in Perl, that is—C is another matter).

The `goto-EXPR` form expects a label name, whose scope will be resolved dynamically. This allows for computed `goto`s per FORTRAN, but isn't necessarily recommended if you're optimizing for maintainability:

```
goto ("FOO", "BAR", "GLARCH")[$i];
```

The `goto-&NAME` form is quite different from the other forms of `goto`. In fact, it isn't a goto in the normal sense at all, and doesn't have the stigma associated with other gotos. Instead, it substitutes a call to the named subroutine for the currently running subroutine. This is used by `AUTOLOAD` subroutines that wish to load another subroutine and then pretend that the other subroutine had been called in the first place (except that any modifications to `@_` in the current subroutine are propagated to the other subroutine.) After the `goto`, not even `caller` will be able to tell that this routine was called first.

NAME needn't be the name of a subroutine; it can be a scalar variable containing a code reference, or a block which evaluates to a code reference.

grep BLOCK LIST
grep EXPR,LIST

This is similar in spirit to, but not the same as, grep(1) and its relatives. In particular, it is not limited to using regular expressions.

Evaluates the BLOCK or EXPR for each element of LIST (locally setting `$_` to each element) and returns the list value consisting of those elements for which the expression evaluated to true. In scalar context, returns the number of times the expression was true.

```
@foo = grep(!/^#/, @bar);     # weed out comments
```

or equivalently,

```
@foo = grep {!/^#/} @bar;     # weed out comments
```

Note that `$_` is an alias to the list value, so it can be used to modify the elements of the LIST. While this is useful and supported, it can cause bizarre results if the elements of LIST are not variables. Similarly, grep returns aliases into the original list, much as a for loop's index variable aliases the list elements. That is, modifying an element of a list returned by grep (for example, in a `foreach`, `map` or another `grep`) actually modifies the element in the original list. This is usually something to be avoided when writing clear code.

See also */map* for a list composed of the results of the BLOCK or EXPR.

hex EXPR
hex Interprets EXPR as a hex string and returns the corresponding value. (To convert strings that might start with either 0, 0x, or 0b, see */oct*.) If EXPR is omitted, uses `$_`.

```
print hex '0xAf'; # prints '175'
print hex 'aF';   # same
```

Hex strings may only represent integers. Strings that would cause integer overflow trigger a warning.

import There is no builtin `import` function. It is just an ordinary method (subroutine) defined (or inherited) by modules that wish to export names to another module. The `use` function calls the `import` method for the package used. See also */use()*, *perlmod*, and *Exporter*.

index STR,SUBSTR,POSITION
index STR,SUBSTR

The index function searches for one string within another, but without the wildcard–like

behavior of a full regular−expression pattern match. It returns the position of the first occurrence of SUBSTR in STR at or after POSITION. If POSITION is omitted, starts searching from the beginning of the string. The return value is based at (or whatever you've set the `$[` variable to—but don't do that). If the substring is not found, returns one less than the base, ordinarily `-1`.

int EXPR

int

Returns the integer portion of EXPR. If EXPR is omitted, uses `$_`. You should not use this function for rounding: one because it truncates towards , and two because machine representations of floating point numbers can sometimes produce counterintuitive results. For example, `int(-6.725/0.025)` produces −268 rather than the correct −269; that's because it's really more like −268.99999999999994315658 instead. Usually, the `sprintf`, `printf`, or the `POSIX::floor` and `POSIX::ceil` functions will serve you better than will `int()`.

ioctl FILEHANDLE,FUNCTION,SCALAR

Implements the ioctl(2) function. You'll probably first have to say

```
require "ioctl.ph"; # probably in /usr/local/lib/perl/ioctl.ph
```

to get the correct function definitions. If ***ioctl.ph*** doesn't exist or doesn't have the correct definitions you'll have to roll your own, based on your C header files such as **< <sys/ioctl.h** . (There is a Perl script called **h2ph** that comes with the Perl kit that may help you in this, but it's nontrivial.) SCALAR will be read and/or written depending on the FUNCTION—a pointer to the string value of SCALAR will be passed as the third argument of the actual `ioctl` call. (If SCALAR has no string value but does have a numeric value, that value will be passed rather than a pointer to the string value. To guarantee this to be true, add a to the scalar before using it.) The `pack` and `unpack` functions may be needed to manipulate the values of structures used by `ioctl`.

The return value of `ioctl` (and `fcntl`) is as follows:

```
if OS returns:          then Perl returns:
    -1                    undefined value
     0                  string "0 but true"
anything else               that number
```

Thus Perl returns true on success and false on failure, yet you can still easily determine the actual value returned by the operating system:

```
$retval = ioctl(...) || -1;
printf "System returned %d\n", $retval;
```

The special string " but true" is exempt from **−w** complaints about improper numeric conversions.

Here's an example of setting a filehandle named `REMOTE` to be non−blocking at the system level. You'll have to negotiate `$|` on your own, though.

```
use Fcntl qw(F_GETFL F_SETFL O_NONBLOCK);

$flags = fcntl(REMOTE, F_GETFL, 0)
            or die "Can't get flags for the socket: $!\n";

$flags = fcntl(REMOTE, F_SETFL, $flags | O_NONBLOCK)
            or die "Can't set flags for the socket: $!\n";
```

join EXPR,LIST

Joins the separate strings of LIST into a single string with fields separated by the value of EXPR, and returns that new string. Example:

```
$rec = join(':', $login,$passwd,$uid,$gid,$gcos,$home,$shell);
```

Beware that unlike `split`, `join` doesn't take a pattern as its first argument. Compare */split*.

keys HASH

Returns a list consisting of all the keys of the named hash. (In scalar context, returns the number of keys.) The keys are returned in an apparently random order. The actual random order is subject to change in future versions of perl, but it is guaranteed to be the same order as either the `values` or `each` function produces (given that the hash has not been modified). As a side effect, it resets HASH's iterator.

Here is yet another way to print your environment:

```
@keys = keys %ENV;
@values = values %ENV;
while (@keys) {
    print pop(@keys), '=', pop(@values), "\n";
}
```

or how about sorted by key:

```
foreach $key (sort(keys %ENV)) {
    print $key, '=', $ENV{$key}, "\n";
}
```

The returned values are copies of the original keys in the hash, so modifying them will not affect the original hash. Compare */values*.

To sort a hash by value, you'll need to use a `sort` function. Here's a descending numeric sort of a hash by its values:

```
foreach $key (sort { $hash{$b} <=> $hash{$a} } keys %hash) {
    printf "%4d %s\n", $hash{$key}, $key;
}
```

As an lvalue `keys` allows you to increase the number of hash buckets allocated for the given hash. This can gain you a measure of efficiency if you know the hash is going to get big. (This is similar to pre-extending an array by assigning a larger number to `$#array`.) If you say

```
keys %hash = 200;
```

then `%hash` will have at least 200 buckets allocated for it—256 of them, in fact, since it rounds up to the next power of two. These buckets will be retained even if you do `%hash = ()`, use `undef %hash` if you want to free the storage while `%hash` is still in scope. You can't shrink the number of buckets allocated for the hash using `keys` in this way (but you needn't worry about doing this by accident, as trying has no effect).

See also `each`, `values` and `sort`.

kill SIGNAL, LIST

Sends a signal to a list of processes. Returns the number of processes successfully signaled (which is not necessarily the same as the number actually killed).

```
$cnt = kill 1, $child1, $child2;
kill 9, @goners;
```

If SIGNAL is zero, no signal is sent to the process. This is a useful way to check that the process is alive and hasn't changed its UID. See *perlport* for notes on the portability of this construct.

Unlike in the shell, if SIGNAL is negative, it kills process groups instead of processes. (On System V, a negative *PROCESS* number will also kill process groups, but that's not portable.) That means you usually want to use positive not negative signals. You may also use a signal name in quotes. See *Signals in perlipc* for details.

last LABEL

last The `last` command is like the `break` statement in C (as used in loops); it immediately exits the loop in question. If the LABEL is omitted, the command refers to the innermost enclosing loop. The `continue` block, if any, is not executed:

```
LINE: while (<STDIN>) {
    last LINE if /^$/;      # exit when done with header
    #...
}
```

`last` cannot be used to exit a block which returns a value such as `eval {}`, `sub {}` or `do {}`, and should not be used to exit a `grep()` or `map()` operation.

Note that a block by itself is semantically identical to a loop that executes once. Thus `last` can be used to effect an early exit out of such a block.

See also */continue* for an illustration of how `last`, `next`, and `redo` work.

lc EXPR

lc Returns an lowercased version of EXPR. This is the internal function implementing the `\L` escape in double−quoted strings. Respects current LC_CTYPE locale if `use locale` in force. See *perllocale* and *utf8*.

If EXPR is omitted, uses `$_`.

lcfirst EXPR

lcfirst Returns the value of EXPR with the first character lowercased. This is the internal function implementing the `\l` escape in double−quoted strings. Respects current LC_CTYPE locale if `use locale` in force. See *perllocale*.

If EXPR is omitted, uses `$_`.

length EXPR

length Returns the length in characters of the value of EXPR. If EXPR is omitted, returns length of `$_`. Note that this cannot be used on an entire array or hash to find out how many elements these have. For that, use `scalar @array` and `scalar keys %hash` respectively.

link OLDFILE,NEWFILE

Creates a new filename linked to the old filename. Returns true for success, false otherwise.

listen SOCKET,QUEUESIZE

Does the same thing that the listen system call does. Returns true if it succeeded, false otherwise. See the example in *Sockets: Client/Server Communication in perlipc*.

local EXPR

You really probably want to be using `my` instead, because `local` isn't what most people think of as "local". See *"Private Variables via `my()`"* for details.

A local modifies the listed variables to be local to the enclosing block, file, or eval. If more than one value is listed, the list must be placed in parentheses. See *"Temporary Values via `local()`"* for details, including issues with tied arrays and hashes.

localtime EXPR

Converts a time as returned by the time function to a 9−element list with the time analyzed for the local time zone. Typically used as follows:

```
#  0    1    2     3     4    5     6     7     8
($sec,$min,$hour,$mday,$mon,$year,$wday,$yday,$isdst) =
                                            localtime(time);
```

All list elements are numeric, and come straight out of the C 'struct tm'. `$sec`, `$min`, and

`$hour` are the seconds, minutes, and hours of the specified time. `$mday` is the day of the month, and `$mon` is the month itself, in the range `0..11` with 0 indicating January and 11 indicating December. `$year` is the number of years since 1900. That is, `$year` is `123` in year 2023. `$wday` is the day of the week, with 0 indicating Sunday and 3 indicating Wednesday. `$yday` is the day of the year, in the range `0..364` (or `0..365` in leap years.) `$isdst` is true if the specified time occurs during daylight savings time, false otherwise.

Note that the `$year` element is *not* simply the last two digits of the year. If you assume it is, then you create non-Y2K-compliant programs—and you wouldn't want to do that, would you?

The proper way to get a complete 4-digit year is simply:

```
$year += 1900;
```

And to get the last two digits of the year (e.g., '01' in 2001) do:

```
$year = sprintf("%02d", $year % 100);
```

If EXPR is omitted, `localtime()` uses the current time (`localtime(time)`).

In scalar context, `localtime()` returns the ctime(3) value:

```
$now_string = localtime;  # e.g., "Thu Oct 13 04:54:34 1994"
```

This scalar value is **not** locale dependent, see *perllocale*, but instead a Perl builtin. Also see the `Time::Local` module (to convert the second, minutes, hours, ... back to seconds since the stroke of midnight the 1st of January 1970, the value returned by `time()`), and the strftime(3) and mktime(3) functions available via the POSIX module. To get somewhat similar but locale dependent date strings, set up your locale environment variables appropriately (please see *perllocale*) and try for example:

```
use POSIX qw(strftime);
$now_string = strftime "%a %b %e %H:%M:%S %Y", localtime;
```

Note that the `%a` and `%b`, the short forms of the day of the week and the month of the year, may not necessarily be three characters wide.

lock

```
lock I<THING>
```

This function places an advisory lock on a variable, subroutine, or referenced object contained in *THING* until the lock goes out of scope. This is a built-in function only if your version of Perl was built with threading enabled, and if you've said `use Threads`. Otherwise a user-defined function by this name will be called. See *Thread*.

log EXPR

log

Returns the natural logarithm (base *e*) of EXPR. If EXPR is omitted, returns log of `$_`. To get the log of another base, use basic algebra: The base-N log of a number is equal to the natural log of that number divided by the natural log of N. For example:

```
sub log10 {
    my $n = shift;
    return log($n)/log(10);
}
```

See also */exp* for the inverse operation.

lstat EXPR

lstat

Does the same thing as the `stat` function (including setting the special _ filehandle) but stats a symbolic link instead of the file the symbolic link points to. If symbolic links are unimplemented on your system, a normal `stat` is done.

If EXPR is omitted, stats `$_`.

m// The match operator. See *perlop*.

map BLOCK LIST
map EXPR,LIST

Evaluates the BLOCK or EXPR for each element of LIST (locally setting $_ to each element) and returns the list value composed of the results of each such evaluation. In scalar context, returns the total number of elements so generated. Evaluates BLOCK or EXPR in list context, so each element of LIST may produce zero, one, or more elements in the returned value.

```
@chars = map(chr, @nums);
```

translates a list of numbers to the corresponding characters. And

```
%hash = map { getkey($_) => $_ } @array;
```

is just a funny way to write

```
%hash = ();
foreach $_ (@array) {
    $hash{getkey($_)} = $_;
}
```

Note that $_ is an alias to the list value, so it can be used to modify the elements of the LIST. While this is useful and supported, it can cause bizarre results if the elements of LIST are not variables. Using a regular `foreach` loop for this purpose would be clearer in most cases. See also */grep* for an array composed of those items of the original list for which the BLOCK or EXPR evaluates to true.

mkdir FILENAME,MASK
mkdir FILENAME

Creates the directory specified by FILENAME, with permissions specified by MASK (as modified by `umask`). If it succeeds it returns true, otherwise it returns false and sets `$!` (errno). If omitted, MASK defaults to 0777.

In general, it is better to create directories with permissive MASK, and let the user modify that with their `umask`, than it is to supply a restrictive MASK and give the user no way to be more permissive. The exceptions to this rule are when the file or directory should be kept private (mail files, for instance). The perlfunc(1) entry on `umask` discusses the choice of MASK in more detail.

msgctl ID,CMD,ARG

Calls the System V IPC function msgctl(2). You'll probably have to say

```
use IPC::SysV;
```

first to get the correct constant definitions. If CMD is `IPC_STAT`, then ARG must be a variable which will hold the returned `msqid_ds` structure. Returns like `ioctl`: the undefined value for error, `"0 but true"` for zero, or the actual return value otherwise. See also *SysV IPC in perlipc*, `IPC::SysV`, and `IPC::Semaphore` documentation.

msgget KEY,FLAGS

Calls the System V IPC function msgget(2). Returns the message queue id, or the undefined value if there is an error. See also *SysV IPC in perlipc* and `IPC::SysV` and `IPC::Msg` documentation.

msgrcv ID,VAR,SIZE,TYPE,FLAGS

Calls the System V IPC function msgrcv to receive a message from message queue ID into variable VAR with a maximum message size of SIZE. Note that when a message is received, the message type as a native long integer will be the first thing in VAR, followed by the actual message. This packing may be opened with `unpack("l! a*")`. Taints the variable. Returns

true if successful, or false if there is an error. See also *SysV IPC in perlipc*, `IPC::SysV`, and `IPC::SysV::Msg` documentation.

msgsnd ID,MSG,FLAGS

Calls the System V IPC function msgsnd to send the message MSG to the message queue ID. MSG must begin with the native long integer message type, and be followed by the length of the actual message, and finally the message itself. This kind of packing can be achieved with `pack("l! a*", $type, $message)`. Returns true if successful, or false if there is an error. See also `IPC::SysV` and `IPC::SysV::Msg` documentation.

my EXPR
my EXPR : ATTRIBUTES

A `my` declares the listed variables to be local (lexically) to the enclosing block, file, or `eval`. If more than one value is listed, the list must be placed in parentheses. See *"Private Variables via my()"* for details.

next LABEL
next

The `next` command is like the `continue` statement in C; it starts the next iteration of the loop:

```
LINE: while (<STDIN>) {
    next LINE if /^#/;      # discard comments
    #...
}
```

Note that if there were a `continue` block on the above, it would get executed even on discarded lines. If the LABEL is omitted, the command refers to the innermost enclosing loop.

`next` cannot be used to exit a block which returns a value such as `eval {}`, `sub {}` or `do {}`, and should not be used to exit a `grep()` or `map()` operation.

Note that a block by itself is semantically identical to a loop that executes once. Thus `next` will exit such a block early.

See also */continue* for an illustration of how `last`, `next`, and `redo` work.

no Module LIST

See the */use* function, which `no` is the opposite of.

oct EXPR
oct

Interprets EXPR as an octal string and returns the corresponding value. (If EXPR happens to start off with `0x`, interprets it as a hex string. If EXPR starts off with `0b`, it is interpreted as a binary string.) The following will handle decimal, binary, octal, and hex in the standard Perl or C notation:

```
$val = oct($val) if $val =~ /^0/;
```

If EXPR is omitted, uses `$_`. To go the other way (produce a number in octal), use `sprintf()` or `printf()`:

```
$perms = (stat("filename"))[2] & 07777;
$oct_perms = sprintf "%lo", $perms;
```

The `oct()` function is commonly used when a string such as `644` needs to be converted into a file mode, for example. (Although perl will automatically convert strings into numbers as needed, this automatic conversion assumes base 10.)

open FILEHANDLE,MODE,LIST
open FILEHANDLE,EXPR
open FILEHANDLE

Opens the file whose filename is given by EXPR, and associates it with FILEHANDLE. If

FILEHANDLE is an expression, its value is used as the name of the real filehandle wanted. (This is considered a symbolic reference, so `use strict 'refs'` should *not* be in effect.)

If EXPR is omitted, the scalar variable of the same name as the FILEHANDLE contains the filename. (Note that lexical variables—those declared with `my`—will not work for this purpose; so if you're using `my`, specify EXPR in your call to open.) See *perlopentut* for a kinder, gentler explanation of opening files.

If MODE is `< '<'` or nothing, the file is opened for input. If MODE is `< ''`, the file is truncated and opened for output, being created if necessary. If MODE is `<< ''`, the file is opened for appending, again being created if necessary. You can put a `'+'` in front of the `< ''` or `< '<'` to indicate that you want both read and write access to the file; thus `< '+<'` is almost always preferred for read/write updates—the `< '+'` mode would clobber the file first. You can't usually use either read-write mode for updating textfiles, since they have variable length records. See the **-i** switch in *perlrun* for a better approach. The file is created with permissions of `0666` modified by the process' `umask` value.

These various prefixes correspond to the fopen(3) modes of `'r'`, `'r+'`, `'w'`, `'w+'`, `'a'`, and `'a+'`.

In the 2-arguments (and 1-argument) form of the call the mode and filename should be concatenated (in this order), possibly separated by spaces. It is possible to omit the mode if the mode is `< '<'`.

If the filename begins with `'|'`, the filename is interpreted as a command to which output is to be piped, and if the filename ends with a `'|'`, the filename is interpreted as a command which pipes output to us. See *"Using `open()` for IPC"* for more examples of this. (You are not allowed to `open` to a command that pipes both in *and* out, but see *IPC::Open2*, *IPC::Open3*, and *Bidirectional Communication with Another Process in perlipc* for alternatives.)

If MODE is `'|-'`, the filename is interpreted as a command to which output is to be piped, and if MODE is `'-|'`, the filename is interpreted as a command which pipes output to us. In the 2-arguments (and 1-argument) form one should replace dash (`'-'`) with the command. See *"Using `open()` for IPC"* for more examples of this. (You are not allowed to `open` to a command that pipes both in *and* out, but see *IPC::Open2*, *IPC::Open3*, and *Bidirectional Communication in perlipc* for alternatives.)

In the 2-arguments (and 1-argument) form opening `'-'` opens STDIN and opening `< '-'` opens STDOUT.

Open returns nonzero upon success, the undefined value otherwise. If the `open` involved a pipe, the return value happens to be the pid of the subprocess.

If you're unfortunate enough to be running Perl on a system that distinguishes between text files and binary files (modern operating systems don't care), then you should check out */binmode* for tips for dealing with this. The key distinction between systems that need `binmode` and those that don't is their text file formats. Systems like Unix, MacOS, and Plan9, which delimit lines with a single character, and which encode that character in C as `"\n"`, do not need `binmode`. The rest need it.

When opening a file, it's usually a bad idea to continue normal execution if the request failed, so `open` is frequently used in connection with `die`. Even if `die` won't do what you want (say, in a CGI script, where you want to make a nicely formatted error message (but there are modules that can help with that problem)) you should always check the return value from opening a file. The infrequent exception is when working with an unopened filehandle is actually what you want to do.

Examples:

```
$ARTICLE = 100;
```

```
open ARTICLE or die "Can't find article $ARTICLE: $!\n";
while (<ARTICLE>) {...

open(LOG, '>>/usr/spool/news/twitlog');     # (log is reserved)
# if the open fails, output is discarded

open(DBASE, '+<', 'dbase.mine')             # open for update
    or die "Can't open 'dbase.mine' for update: $!";

open(DBASE, '+<dbase.mine')                 # ditto
    or die "Can't open 'dbase.mine' for update: $!";

open(ARTICLE, '-|', "caesar <$article")     # decrypt article
    or die "Can't start caesar: $!";

open(ARTICLE, "caesar <$article |")         # ditto
    or die "Can't start caesar: $!";

open(EXTRACT, "|sort >/tmp/Tmp$$")          # $$ is our process id
    or die "Can't start sort: $!";

# process argument list of files along with any includes

foreach $file (@ARGV) {
    process($file, 'fh00');
}

sub process {
    my($filename, $input) = @_;
    $input++;               # this is a string increment
    unless (open($input, $filename)) {
        print STDERR "Can't open $filename: $!\n";
        return;
    }

    local $_;
    while (<$input>) {              # note use of indirection
        if (/^#include "(.*)"/) {
            process($1, $input);
            next;
        }
        #...                # whatever
    }
}
```

You may also, in the Bourne shell tradition, specify an EXPR beginning with `< '&'`, in which case the rest of the string is interpreted as the name of a filehandle (or file descriptor, if numeric) to be duped and opened. You may use `&` after `<`, `<<`, `<<`, `<+`, `<<+`, and `<+<`. The mode you specify should match the mode of the original filehandle. (Duping a filehandle does not take into account any existing contents of stdio buffers.) Duping file handles is not yet supported for 3–argument `open()`.

Here is a script that saves, redirects, and restores STDOUT and STDERR:

```
#!/usr/bin/perl
open(OLDOUT, ">&STDOUT");
open(OLDERR, ">&STDERR");

open(STDOUT, '>', "foo.out") || die "Can't redirect stdout";
open(STDERR, ">&STDOUT")     || die "Can't dup stdout";
```

```
select(STDERR); $| =#1¶make unbuffered
select(STDOUT); $| =#1¶make unbuffered

print STDOUT "stdout 1\n";  # this works for
print STDERR "stderr 1\n";  # subprocesses too

close(STDOUT);
close(STDERR);

open(STDOUT, ">&OLDOUT");
open(STDERR, ">&OLDERR");

print STDOUT "stdout 2\n";
print STDERR "stderr 2\n";
```

If you specify `< '<&=N'` , where `N` is a number, then Perl will do an equivalent of C's `fdopen` of that file descriptor; this is more parsimonious of file descriptors. For example:

```
open(FILEHANDLE, "<&=$fd")
```

Note that this feature depends on the `fdopen()` C library function. On many UNIX systems, `fdopen()` is known to fail when file descriptors exceed a certain value, typically 255. If you need more file descriptors than that, consider rebuilding Perl to use the `sfio` library.

If you open a pipe on the command `'-'`, i.e., either `'|-'` or `'-|'` with 2–arguments (or 1–argument) form of `open()`, then there is an implicit fork done, and the return value of open is the pid of the child within the parent process, and within the child process. (Use `defined($pid)` to determine whether the open was successful.) The filehandle behaves normally for the parent, but i/o to that filehandle is piped from/to the STDOUT/STDIN of the child process. In the child process the filehandle isn't opened—i/o happens from/to the new STDOUT or STDIN. Typically this is used like the normal piped open when you want to exercise more control over just how the pipe command gets executed, such as when you are running setuid, and don't want to have to scan shell commands for metacharacters. The following triples are more or less equivalent:

```
open(FOO, "|tr '[a-z]' '[A-Z]'");
open(FOO, '|-', "tr '[a-z]' '[A-Z]'");
open(FOO, '|-') || exec 'tr', '[a-z]', '[A-Z]';

open(FOO, "cat -n '$file'|");
open(FOO, '-|', "cat -n '$file'");
open(FOO, '-|') || exec 'cat', '-n', $file;
```

See *Safe Pipe Opens in perlipc* for more examples of this.

Beginning with v5.6.0, Perl will attempt to flush all files opened for output before any operation that may do a fork, but this may not be supported on some platforms (see *perlport*). To be safe, you may need to set `$|` (`$AUTOFLUSH` in English) or call the `autoflush()` method of `IO::Handle` on any open handles.

On systems that support a close–on–exec flag on files, the flag will be set for the newly opened file descriptor as determined by the value of `$^F`. See *$^F*.

Closing any piped filehandle causes the parent process to wait for the child to finish, and returns the status value in `$?`.

The filename passed to 2–argument (or 1–argument) form of `open()` will have leading and trailing whitespace deleted, and the normal redirection characters honored. This property, known as "magic open", can often be used to good effect. A user could specify a filename of ***"rsh cat file |"***, or you could change certain filenames as needed:

```
$filename =~ s/(.*\.gz)\s*$/gzip -dc < $1|/;
```

```
open(FH, $filename) or die "Can't open $filename: $!";
```

Use 3-argument form to open a file with arbitrary weird characters in it,

```
open(FOO, '<', $file);
```

otherwise it's necessary to protect any leading and trailing whitespace:

```
$file =~ s#^(\s)#./$1#;
open(FOO, "< $file\0");
```

(this may not work on some bizarre filesystems). One should conscientiously choose between the *magic* and 3-arguments form of `open()`:

```
open IN, $ARGV[0];
```

will allow the user to specify an argument of the form `"rsh cat file |"`, but will not work on a filename which happens to have a trailing space, while

```
open IN, '<', $ARGV[0];
```

will have exactly the opposite restrictions.

If you want a "real" C `open` (see *open(2)* on your system), then you should use the `sysopen` function, which involves no such magic (but may use subtly different filemodes than Perl `open()`, which is mapped to C `fopen()`). This is another way to protect your filenames from interpretation. For example:

```
use IO::Handle;
sysopen(HANDLE, $path, O_RDWR|O_CREAT|O_EXCL)
    or die "sysopen $path: $!";
$oldfh = select(HANDLE); $| = 1; select($oldfh);
print HANDLE "stuff $$\n");
seek(HANDLE, 0, 0);
print "File contains: ", <HANDLE>;
```

Using the constructor from the `IO::Handle` package (or one of its subclasses, such as `IO::File` or `IO::Socket`), you can generate anonymous filehandles that have the scope of whatever variables hold references to them, and automatically close whenever and however you leave that scope:

```
use IO::File;
#...
sub read_myfile_munged {
    my $ALL = shift;
    my $handle = new IO::File;
    open($handle, "myfile") or die "myfile: $!";
    $first = <$handle>
        or return ();     # Automatically closed here.
    mung $first or die "mung failed";       # Or here.
    return $first, <$handle> if $ALL;       # Or here.
    $first;                                 # Or here.
}
```

See */seek* for some details about mixing reading and writing.

opendir DIRHANDLE,EXPR

Opens a directory named EXPR for processing by `readdir`, `telldir`, `seekdir`, `rewinddir`, and `closedir`. Returns true if successful. DIRHANDLEs have their own namespace separate from FILEHANDLEs.

ord EXPR

ord Returns the numeric (ASCII or Unicode) value of the first character of EXPR. If EXPR is omitted, uses `$_`. For the reverse, see */chr*. See *utf8* for more about Unicode.

our EXPR

An `our` declares the listed variables to be valid globals within the enclosing block, file, or `eval`. That is, it has the same scoping rules as a "my" declaration, but does not create a local variable. If more than one value is listed, the list must be placed in parentheses. The `our` declaration has no semantic effect unless "use strict vars" is in effect, in which case it lets you use the declared global variable without qualifying it with a package name. (But only within the lexical scope of the `our` declaration. In this it differs from "use vars", which is package scoped.)

An `our` declaration declares a global variable that will be visible across its entire lexical scope, even across package boundaries. The package in which the variable is entered is determined at the point of the declaration, not at the point of use. This means the following behavior holds:

```
package Foo;
our $bar;           # declares $Foo::bar for rest of lexical scope
$bar = 20;

package Bar;
print $bar;         # prints 20
```

Multiple `our` declarations in the same lexical scope are allowed if they are in different packages. If they happened to be in the same package, Perl will emit warnings if you have asked for them.

```
use warnings;
package Foo;
our $bar;           # declares $Foo::bar for rest of lexical scope
$bar = 20;

package Bar;
our $bar = 30;      # declares $Bar::bar for rest of lexical scope
print $bar;         # prints 30

our $bar;           # emits warning
```

pack TEMPLATE,LIST

Takes a LIST of values and converts it into a string using the rules given by the TEMPLATE. The resulting string is the concatenation of the converted values. Typically, each converted value looks like its machine−level representation. For example, on 32−bit machines a converted integer may be represented by a sequence of 4 bytes.

The TEMPLATE is a sequence of characters that give the order and type of values, as follows:

```
a   A string with arbitrary binary data, will be null padded.
A   An ASCII string, will be space padded.
Z   A null terminated (asciz) string, will be null padded.

b   A bit string (ascending bit order inside each byte, like vec()).
B   A bit string (descending bit order inside each byte).
h   A hex string (low nybble first).
H   A hex string (high nybble first).

c   A signed char value.
C   An unsigned char value.  Only does bytes.  See U for Unicode.

s   A signed short value.
S   An unsigned short value.
      (This 'short' is _exactly_ 16 bits, which may differ from
```

```
       what a local C compiler calls 'short'.  If you want
       native-length shorts, use the '!' suffix.)

   i   A signed integer value.
   I   An unsigned integer value.
         (This 'integer' is _at_least_ 32 bits wide.  Its exact
       size depends on what a local C compiler calls 'int',
       and may even be larger than the 'long' described in
       the next item.)

   l   A signed long value.
   L   An unsigned long value.
         (This 'long' is _exactly_ 32 bits, which may differ from
       what a local C compiler calls 'long'.  If you want
       native-length longs, use the '!' suffix.)

   n   An unsigned short in "network" (big-endian) order.
   N   An unsigned long in "network" (big-endian) order.
   v   An unsigned short in "VAX" (little-endian) order.
   V   An unsigned long in "VAX" (little-endian) order.
         (These 'shorts' and 'longs' are _exactly_ 16 bits and
       _exactly_ 32 bits, respectively.)

   q   A signed quad (64-bit) value.
   Q   An unsigned quad value.
         (Quads are available only if your system supports 64-bit
       integer values _and_ if Perl has been compiled to support those.
       Causes a fatal error otherwise.)

   f   A single-precision float in the native format.
   d   A double-precision float in the native format.

   p   A pointer to a null-terminated string.
   P   A pointer to a structure (fixed-length string).

   u   A uuencoded string.
   U   A Unicode character number.  Encodes to UTF-8 internally.
       Works even if C<use utf8> is not in effect.

   w   A BER compressed integer.  Its bytes represent an unsigned
       integer in base 128, most significant digit first, with as
       few digits as possible.  Bit eight (the high bit) is set
       on each byte except the last.

   x   A null byte.
   X   Back up a byte.
   @   Null fill to absolute position.
```

The following rules apply:

- Each letter may optionally be followed by a number giving a repeat count. With all types except `a`, `A`, `Z`, `b`, `B`, `h`, `H`, and `P` the pack function will gobble up that many values from the LIST. A `*` for the repeat count means to use however many items are left, except for `@`, `x`, `X`, where it is equivalent to , and `u`, where it is equivalent to 1 (or 45, what is the same).

  When used with `Z`, `*` results in the addition of a trailing null byte (so the packed result will be one longer than the byte `length` of the item).

  The repeat count for `u` is interpreted as the maximal number of bytes to encode per line of output, with 0 and 1 replaced by 45.

- The a, A, and Z types gobble just one value, but pack it as a string of length count, padding with nulls or spaces as necessary. When unpacking, A strips trailing spaces and nulls, Z strips everything after the first null, and a returns data verbatim. When packing, a, and Z are equivalent.

  If the value−to−pack is too long, it is truncated. If too long and an explicit count is provided, Z packs only $count−1 bytes, followed by a null byte. Thus Z always packs a trailing null byte under all circumstances.

- Likewise, the b and B fields pack a string that many bits long. Each byte of the input field of pack() generates 1 bit of the result. Each result bit is based on the least−significant bit of the corresponding input byte, i.e., on ord($byte)%2. In particular, bytes "0" and "1" generate bits 0 and 1, as do bytes "\0" and "\1".

  Starting from the beginning of the input string of pack(), each 8−tuple of bytes is converted to 1 byte of output. With format b the first byte of the 8−tuple determines the least−significant bit of a byte, and with format B it determines the most−significant bit of a byte.

  If the length of the input string is not exactly divisible by 8, the remainder is packed as if the input string were padded by null bytes at the end. Similarly, during unpack()ing the "extra" bits are ignored.

  If the input string of pack() is longer than needed, extra bytes are ignored. A * for the repeat count of pack() means to use all the bytes of the input field. On unpack()ing the bits are converted to a string of "0"s and "1"s.

- The h and H fields pack a string that many nybbles (4−bit groups, representable as hexadecimal digits, 0−9a−f) long.

  Each byte of the input field of pack() generates 4 bits of the result. For non−alphabetical bytes the result is based on the 4 least−significant bits of the input byte, i.e., on ord($byte)%16. In particular, bytes "0" and "1" generate nybbles 0 and 1, as do bytes "\0" and "\1". For bytes "a".."f" and "A".."F" the result is compatible with the usual hexadecimal digits, so that "a" and "A" both generate the nybble 0xa==10. The result for bytes "g".."z" and "G".."Z" is not well−defined.

  Starting from the beginning of the input string of pack(), each pair of bytes is converted to 1 byte of output. With format h the first byte of the pair determines the least−significant nybble of the output byte, and with format H it determines the most−significant nybble.

  If the length of the input string is not even, it behaves as if padded by a null byte at the end. Similarly, during unpack()ing the "extra" nybbles are ignored.

  If the input string of pack() is longer than needed, extra bytes are ignored. A * for the repeat count of pack() means to use all the bytes of the input field. On unpack()ing the bits are converted to a string of hexadecimal digits.

- The p type packs a pointer to a null−terminated string. You are responsible for ensuring the string is not a temporary value (which can potentially get deallocated before you get around to using the packed result). The P type packs a pointer to a structure of the size indicated by the length. A NULL pointer is created if the corresponding value for p or P is undef, similarly for unpack().

- The / template character allows packing and unpacking of strings where the packed structure contains a byte count followed by the string itself. You write *length−item/string−item*.

The *length−item* can be any `pack` template letter, and describes how the length value is packed. The ones likely to be of most use are integer−packing ones like `n` (for Java strings), `w` (for ASN.1 or SNMP) and `N` (for Sun XDR).

The *string−item* must, at present, be `"A*"`, `"a*"` or `"Z*"`. For `unpack` the length of the string is obtained from the *length−item*, but if you put in the '*' it will be ignored.

```
unpack 'C/a', "\04Gurusamy";         gives 'Guru'
unpack 'a3/A* A*', '007 Bond  J ';   gives (' Bond','J')
pack 'n/a* w/a*','hello,','world';   gives "\000\006hello,\005worl
```

The *length−item* is not returned explicitly from `unpack`.

Adding a count to the *length−item* letter is unlikely to do anything useful, unless that letter is `A`, `a` or `Z`. Packing with a *length−item* of `a` or `Z` may introduce `"\000"` characters, which Perl does not regard as legal in numeric strings.

- The integer types `s`, `S`, `l`, and `L` may be immediately followed by a `!` suffix to signify native shorts or longs—as you can see from above for example a bare `l` does mean exactly 32 bits, the native `long` (as seen by the local C compiler) may be larger. This is an issue mainly in 64−bit platforms. You can see whether using `!` makes any difference by

```
print length(pack("s")), " ", length(pack("s!")), "\n";
print length(pack("l")), " ", length(pack("l!")), "\n";
```

`i!` and `I!` also work but only because of completeness; they are identical to `i` and `I`.

The actual sizes (in bytes) of native shorts, ints, longs, and long longs on the platform where Perl was built are also available via *Config*:

```
use Config;
print $Config{shortsize},    "\n";
print $Config{intsize},      "\n";
print $Config{longsize},     "\n";
print $Config{longlongsize}, "\n";
```

(The `$Config{longlongsize}` will be undefine if your system does not support long longs.)

- The integer formats `s`, `S`, `i`, `I`, `l`, and `L` are inherently non−portable between processors and operating systems because they obey the native byteorder and endianness. For example a 4−byte integer 0x12345678 (305419896 decimal) be ordered natively (arranged in and handled by the CPU registers) into bytes as

```
0x12 0x34 0x56 0x78     # big-endian
0x78 0x56 0x34 0x12     # little-endian
```

Basically, the Intel and VAX CPUs are little−endian, while everybody else, for example Motorola m68k/88k, PPC, Sparc, HP PA, Power, and Cray are big−endian. Alpha and MIPS can be either: Digital/Compaq used/uses them in little−endian mode; SGI/Cray uses them in big−endian mode.

The names 'big−endian' and 'little−endian' are comic references to the classic "Gulliver's Travels" (via the paper "On Holy Wars and a Plea for Peace" by Danny Cohen, USC/ISI IEN 137, April 1, 1980) and the egg−eating habits of the Lilliputians.

Some systems may have even weirder byte orders such as

```
0x56 0x78 0x12 0x34
0x34 0x12 0x78 0x56
```

You can see your system's preference with

```
print join(" ", map { sprintf "%#02x", $_ }
                    unpack("C*",pack("L",0x12345678))), "\n";
```

The byteorder on the platform where Perl was built is also available via *Config*:

```
use Config;
print $Config{byteorder}, "\n";
```

Byteorders `'1234'` and `'12345678'` are little–endian, `'4321'` and `'87654321'` are big–endian.

If you want portable packed integers use the formats `n`, `N`, `v`, and `V`, their byte endianness and size is known. See also *perlport*.

- Real numbers (floats and doubles) are in the native machine format only; due to the multiplicity of floating formats around, and the lack of a standard "network" representation, no facility for interchange has been made. This means that packed floating point data written on one machine may not be readable on another – even if both use IEEE floating point arithmetic (as the endian–ness of the memory representation is not part of the IEEE spec). See also *perlport*.

  Note that Perl uses doubles internally for all numeric calculation, and converting from double into float and thence back to double again will lose precision (i.e., `unpack("f", pack("f", $foo))` will not in general equal `$foo`).

- If the pattern begins with a `U`, the resulting string will be treated as Unicode–encoded. You can force UTF8 encoding on in a string with an initial `U0`, and the bytes that follow will be interpreted as Unicode characters. If you don't want this to happen, you can begin your pattern with `C0` (or anything else) to force Perl not to UTF8 encode your string, and then follow this with a `U*` somewhere in your pattern.

- You must yourself do any alignment or padding by inserting for example enough `'x'`es while packing. There is no way to `pack()` and `unpack()` could know where the bytes are going to or coming from. Therefore `pack` (and `unpack`) handle their output and input as flat sequences of bytes.

- A comment in a TEMPLATE starts with # and goes to the end of line.

- If TEMPLATE requires more arguments to `pack()` than actually given, `pack()` assumes additional `""` arguments. If TEMPLATE requires less arguments to `pack()` than actually given, extra arguments are ignored.

Examples:

```
$foo = pack("CCCC",65,66,67,68);
# foo eq "ABCD"
$foo = pack("C4",65,66,67,68);
# same thing
$foo = pack("U4",0x24b6,0x24b7,0x24b8,0x24b9);
# same thing with Unicode circled letters

$foo = pack("ccxxcc",65,66,67,68);
# foo eq "AB\0\0CD"

# note: the above examples featuring "C" and "c" are true
# only on ASCII and ASCII-derived systems such as ISO Latin 1
```

```
# and UTF-8.  In EBCDIC the first example would be
# $foo = pack("CCCC",193,194,195,196);

$foo = pack("s2",1,2);
# "\1\0\2\0" on little-endian
# "\0\1\0\2" on big-endian

$foo = pack("a4","abcd","x","y","z");
# "abcd"

$foo = pack("aaaa","abcd","x","y","z");
# "axyz"

$foo = pack("a14","abcdefg");
# "abcdefg\0\0\0\0\0\0\0"

$foo = pack("i9pl", gmtime);
# a real struct tm (on my system anyway)

$utmp_template = "Z8 Z8 Z16 L";
$utmp = pack($utmp_template, @utmp1);
# a struct utmp (BSDish)

@utmp2 = unpack($utmp_template, $utmp);
# "@utmp1" eq "@utmp2"

sub bintodec {
    unpack("N", pack("B32", substr("0" x 32 . shift, -32)));
}

$foo = pack('sx2l', 12, 34);
# short 12, two zero bytes padding, long 34
$bar = pack('s@4l', 12, 34);
# short 12, zero fill to position 4, long 34
# $foo eq $bar
```

The same template may generally also be used in `unpack()`.

package NAMESPACE

package Declares the compilation unit as being in the given namespace. The scope of the package declaration is from the declaration itself through the end of the enclosing block, file, or eval (the same as the `my` operator). All further unqualified dynamic identifiers will be in this namespace. A package statement affects only dynamic variables—including those you've used `local` on—but *not* lexical variables, which are created with `my`. Typically it would be the first declaration in a file to be included by the `require` or `use` operator. You can switch into a package in more than one place; it merely influences which symbol table is used by the compiler for the rest of that block. You can refer to variables and filehandles in other packages by prefixing the identifier with the package name and a double colon: `$Package::Variable`. If the package name is null, the `main` package as assumed. That is, `$::sail` is equivalent to `$main::sail` (as well as to `$main'sail`, still seen in older code).

If NAMESPACE is omitted, then there is no current package, and all identifiers must be fully qualified or lexicals. This is stricter than `use strict`, since it also extends to function names.

See *Packages in perlmod* for more information about packages, modules, and classes. See *perlsub* for other scoping issues.

pipe READHANDLE,WRITEHANDLE

Opens a pair of connected pipes like the corresponding system call. Note that if you set up a loop of piped processes, deadlock can occur unless you are very careful. In addition, note that Perl's

pipes use stdio buffering, so you may need to set `$|` to flush your WRITEHANDLE after each command, depending on the application.

See *IPC::Open2*, *IPC::Open3*, and *Bidirectional Communication in perlipc* for examples of such things.

On systems that support a close-on-exec flag on files, the flag will be set for the newly opened file descriptors as determined by the value of `$^F`. See *$^F*.

pop ARRAY

pop Pops and returns the last value of the array, shortening the array by one element. Has an effect similar to

```
$ARRAY[$#ARRAY--]
```

If there are no elements in the array, returns the undefined value (although this may happen at other times as well). If ARRAY is omitted, pops the `@ARGV` array in the main program, and the `@_` array in subroutines, just like `shift`.

pos SCALAR

pos Returns the offset of where the last `m//g` search left off for the variable in question (`$_` is used when the variable is not specified). May be modified to change that offset. Such modification will also influence the `\G` zero-width assertion in regular expressions. See *perlre* and *perlop*.

print FILEHANDLE LIST

print LIST

print Prints a string or a list of strings. Returns true if successful. FILEHANDLE may be a scalar variable name, in which case the variable contains the name of or a reference to the filehandle, thus introducing one level of indirection. (NOTE: If FILEHANDLE is a variable and the next token is a term, it may be misinterpreted as an operator unless you interpose a `+` or put parentheses around the arguments.) If FILEHANDLE is omitted, prints by default to standard output (or to the last selected output channel—see */select*). If LIST is also omitted, prints `$_` to the currently selected output channel. To set the default output channel to something other than STDOUT use the select operation. The current value of `$,` (if any) is printed between each LIST item. The current value of `$\` (if any) is printed after the entire LIST has been printed. Because print takes a LIST, anything in the LIST is evaluated in list context, and any subroutine that you call will have one or more of its expressions evaluated in list context. Also be careful not to follow the print keyword with a left parenthesis unless you want the corresponding right parenthesis to terminate the arguments to the print—interpose a `+` or put parentheses around all the arguments.

Note that if you're storing FILEHANDLES in an array or other expression, you will have to use a block returning its value instead:

```
print { $files[$i] } "stuff\n";
print { $OK ? STDOUT : STDERR } "stuff\n";
```

printf FILEHANDLE FORMAT, LIST

printf FORMAT, LIST

Equivalent to `print FILEHANDLE sprintf(FORMAT, LIST)`, except that `$\` (the output record separator) is not appended. The first argument of the list will be interpreted as the `printf` format. If `use locale` is in effect, the character used for the decimal point in formatted real numbers is affected by the LC_NUMERIC locale. See *perllocale*.

Don't fall into the trap of using a `printf` when a simple `print` would do. The `print` is more efficient and less error prone.

prototype FUNCTION

Returns the prototype of a function as a string (or `undef` if the function has no prototype). FUNCTION is a reference to, or the name of, the function whose prototype you want to retrieve.

If FUNCTION is a string starting with `CORE::`, the rest is taken as a name for Perl builtin. If the builtin is not *overridable* (such as `qw//`) or its arguments cannot be expressed by a prototype (such as `system`) returns `undef` because the builtin does not really behave like a Perl function. Otherwise, the string describing the equivalent prototype is returned.

push ARRAY,LIST

Treats ARRAY as a stack, and pushes the values of LIST onto the end of ARRAY. The length of ARRAY increases by the length of LIST. Has the same effect as

```
for $value (LIST) {
    $ARRAY[++$#ARRAY] = $value;
}
```

but is more efficient. Returns the new number of elements in the array.

q/STRING/
qq/STRING/
qr/STRING/
qx/STRING/
qw/STRING/

Generalized quotes. See *Regexp Quote-Like Operators in perlop*.

quotemeta EXPR
quotemeta

Returns the value of EXPR with all non-"word" characters backslashed. (That is, all characters not matching `/[A-Za-z_0-9]/` will be preceded by a backslash in the returned string, regardless of any locale settings.) This is the internal function implementing the `\Q` escape in double-quoted strings.

If EXPR is omitted, uses `$_`.

rand EXPR
rand

Returns a random fractional number greater than or equal to and less than the value of EXPR. (EXPR should be positive.) If EXPR is omitted, the value `1` is used. Automatically calls `srand` unless `srand` has already been called. See also `srand`.

(Note: If your rand function consistently returns numbers that are too large or too small, then your version of Perl was probably compiled with the wrong number of RANDBITS.)

read FILEHANDLE,SCALAR,LENGTH,OFFSET
read FILEHANDLE,SCALAR,LENGTH

Attempts to read LENGTH bytes of data into variable SCALAR from the specified FILEHANDLE. Returns the number of bytes actually read, at end of file, or undef if there was an error. SCALAR will be grown or shrunk to the length actually read. An OFFSET may be specified to place the read data at some other place than the beginning of the string. This call is actually implemented in terms of stdio's fread(3) call. To get a true read(2) system call, see `sysread`.

readdir DIRHANDLE

Returns the next directory entry for a directory opened by `opendir`. If used in list context, returns all the rest of the entries in the directory. If there are no more entries, returns an undefined value in scalar context or a null list in list context.

If you're planning to filetest the return values out of a `readdir`, you'd better prepend the directory in question. Otherwise, because we didn't `chdir` there, it would have been testing the wrong file.

```
opendir(DIR, $some_dir) || die "can't opendir $some_dir: $!";
@dots = grep { /^\./ && -f "$some_dir/$_" } readdir(DIR);
closedir DIR;
```

readline EXPR

Reads from the filehandle whose typeglob is contained in EXPR. In scalar context, each call reads and returns the next line, until end–of–file is reached, whereupon the subsequent call returns undef. In list context, reads until end–of–file is reached and returns a list of lines. Note that the notion of "line" used here is however you may have defined it with `$/` or `$INPUT_RECORD_SEPARATOR)`. See *$/ in perlvar*.

When `$/` is set to `undef`, when `readline()` is in scalar context (i.e. file slurp mode), and when an empty file is read, it returns `''` the first time, followed by `undef` subsequently.

This is the internal function implementing the `< <EXPR` operator, but you can use it directly. The `< <EXPR` operator is discussed in more detail in *I/O Operators in perlop*.

```
$line = <STDIN>;
$line = readline(*STDIN);           # same thing
```

readlink EXPR

readlink Returns the value of a symbolic link, if symbolic links are implemented. If not, gives a fatal error. If there is some system error, returns the undefined value and sets `$!` (errno). If EXPR is omitted, uses `$_`.

readpipe EXPR

EXPR is executed as a system command. The collected standard output of the command is returned. In scalar context, it comes back as a single (potentially multi–line) string. In list context, returns a list of lines (however you've defined lines with `$/` or `$INPUT_RECORD_SEPARATOR)`. This is the internal function implementing the `qx/EXPR/` operator, but you can use it directly. The `qx/EXPR/` operator is discussed in more detail in *I/O Operators in perlop*.

recv SOCKET,SCALAR,LENGTH,FLAGS

Receives a message on a socket. Attempts to receive LENGTH bytes of data into variable SCALAR from the specified SOCKET filehandle. SCALAR will be grown or shrunk to the length actually read. Takes the same flags as the system call of the same name. Returns the address of the sender if SOCKET's protocol supports this; returns an empty string otherwise. If there's an error, returns the undefined value. This call is actually implemented in terms of recvfrom(2) system call. See *UDP: Message Passing in perlipc* for examples.

redo LABEL

redo The `redo` command restarts the loop block without evaluating the conditional again. The `continue` block, if any, is not executed. If the LABEL is omitted, the command refers to the innermost enclosing loop. This command is normally used by programs that want to lie to themselves about what was just input:

```
# a simpleminded Pascal comment stripper
# (warning: assumes no { or } in strings)
LINE: while (<STDIN>) {
    while (s|({.*}.*){.*}|$1 |) {}
    s|{.*}| |;
    if (s|{.*| |) {
        $front = $_;
        while (<STDIN>) {
            if (/}/) {      # end of comment?
                s|^|$front\{|;
                redo LINE;
            }
        }
    }
```

```
        print;
    }
```

`redo` cannot be used to retry a block which returns a value such as `eval {}`, `sub {}` or `do {}`, and should not be used to exit a `grep()` or `map()` operation.

Note that a block by itself is semantically identical to a loop that executes once. Thus `redo` inside such a block will effectively turn it into a looping construct.

See also */continue* for an illustration of how `last`, `next`, and `redo` work.

ref EXPR

ref Returns a true value if EXPR is a reference, false otherwise. If EXPR is not specified, `$_` will be used. The value returned depends on the type of thing the reference is a reference to. Builtin types include:

```
SCALAR
ARRAY
HASH
CODE
REF
GLOB
LVALUE
```

If the referenced object has been blessed into a package, then that package name is returned instead. You can think of `ref` as a `typeof` operator.

```
if (ref($r) eq "HASH") {
    print "r is a reference to a hash.\n";
}
unless (ref($r)) {
    print "r is not a reference at all.\n";
}
if (UNIVERSAL::isa($r, "HASH")) {  # for subclassing
    print "r is a reference to something that isa hash.\n";
}
```

See also *perlref*.

rename OLDNAME,NEWNAME

Changes the name of a file; an existing file NEWNAME will be clobbered. Returns true for success, false otherwise.

Behavior of this function varies wildly depending on your system implementation. For example, it will usually not work across file system boundaries, even though the system *mv* command sometimes compensates for this. Other restrictions include whether it works on directories, open files, or pre–existing files. Check *perlport* and either the rename(2) manpage or equivalent system documentation for details.

require VERSION

require EXPR

require Demands some semantics specified by EXPR, or by `$_` if EXPR is not supplied.

If a VERSION is specified as a literal of the form v5.6.1, demands that the current version of Perl (`$^V` or `$PERL_VERSION`) be at least as recent as that version, at run time. (For compatibility with older versions of Perl, a numeric argument will also be interpreted as VERSION.) Compare with */use*, which can do a similar check at compile time.

```
require v5.6.1;     # run time version check
require 5.6.1;      # ditto
require 5.005_03;   # float version allowed for compatibility
```

Otherwise, demands that a library file be included if it hasn't already been included. The file is included via the do-FILE mechanism, which is essentially just a variety of `eval`. Has semantics similar to the following subroutine:

```
sub require {
    my($filename) = @_;
    return 1 if $INC{$filename};
    my($realfilename,$result);
    ITER: {
        foreach $prefix (@INC) {
            $realfilename = "$prefix/$filename";
            if (-f $realfilename) {
                $INC{$filename} = $realfilename;
                $result = do $realfilename;
                last ITER;
            }
        }
        die "Can't find $filename in \@INC";
    }
    delete $INC{$filename} if $@ || !$result;
    die $@ if $@;
    die "$filename did not return true value" unless $result;
    return $result;
}
```

Note that the file will not be included twice under the same specified name. The file must return true as the last statement to indicate successful execution of any initialization code, so it's customary to end such a file with `1;` unless you're sure it'll return true otherwise. But it's better just to put the `1;`, in case you add more statements.

If EXPR is a bareword, the require assumes a "***.pm***" extension and replaces "***::***" with "**/**" in the filename for you, to make it easy to load standard modules. This form of loading of modules does not risk altering your namespace.

In other words, if you try this:

```
require Foo::Bar;    # a splendid bareword
```

The require function will actually look for the "***Foo/Bar.pm***" file in the directories specified in the `@INC` array.

But if you try this:

```
$class = 'Foo::Bar';
require $class;      # $class is not a bareword
#or
require "Foo::Bar";  # not a bareword because of the ""
```

The require function will look for the "***Foo::Bar***" file in the @INC array and will complain about not finding "***Foo::Bar***" there. In this case you can do:

```
eval "require $class";
```

For a yet-more-powerful import facility, see */use* and *perlmod*.

reset EXPR

reset Generally used in a `continue` block at the end of a loop to clear variables and reset `??` searches so that they work again. The expression is interpreted as a list of single characters (hyphens allowed for ranges). All variables and arrays beginning with one of those letters are reset to their pristine state. If the expression is omitted, one-match searches (`?pattern?`) are

reset to match again. Resets only variables or searches in the current package. Always returns 1. Examples:

```
reset 'X';          # reset all X variables
reset 'a-z';        # reset lower case variables
reset;              # just reset ?one-time? searches
```

Resetting "A-Z" is not recommended because you'll wipe out your @ARGV and @INC arrays and your %ENV hash. Resets only package variables—lexical variables are unaffected, but they clean themselves up on scope exit anyway, so you'll probably want to use them instead. See */my*.

return EXPR

return Returns from a subroutine, eval, or do FILE with the value given in EXPR. Evaluation of EXPR may be in list, scalar, or void context, depending on how the return value will be used, and the context may vary from one execution to the next (see wantarray). If no EXPR is given, returns an empty list in list context, the undefined value in scalar context, and (of course) nothing at all in a void context.

(Note that in the absence of a explicit return, a subroutine, eval, or do FILE will automatically return the value of the last expression evaluated.)

reverse LIST

In list context, returns a list value consisting of the elements of LIST in the opposite order. In scalar context, concatenates the elements of LIST and returns a string value with all characters in the opposite order.

```
print reverse <>;           # line tac, last line first

undef $/;                   # for efficiency of <>
print scalar reverse <>;    # character tac, last line tsrif
```

This operator is also handy for inverting a hash, although there are some caveats. If a value is duplicated in the original hash, only one of those can be represented as a key in the inverted hash. Also, this has to unwind one hash and build a whole new one, which may take some time on a large hash, such as from a DBM file.

```
%by_name = reverse %by_address;     # Invert the hash
```

rewinddir DIRHANDLE

Sets the current position to the beginning of the directory for the readdir routine on DIRHANDLE.

rindex STR,SUBSTR,POSITION
rindex STR,SUBSTR

Works just like index() except that it returns the position of the LAST occurrence of SUBSTR in STR. If POSITION is specified, returns the last occurrence at or before that position.

rmdir FILENAME

rmdir Deletes the directory specified by FILENAME if that directory is empty. If it succeeds it returns true, otherwise it returns false and sets $! (errno). If FILENAME is omitted, uses $_.

s/// The substitution operator. See *perlop*.

scalar EXPR

Forces EXPR to be interpreted in scalar context and returns the value of EXPR.

```
@counts = ( scalar @a, scalar @b, scalar @c );
```

There is no equivalent operator to force an expression to be interpolated in list context because in practice, this is never needed. If you really wanted to do so, however, you could use the

construction `@{ [ (some expression) ] }`, but usually a simple `(some expression)` suffices.

Because `scalar` is unary operator, if you accidentally use for EXPR a parenthesized list, this behaves as a scalar comma expression, evaluating all but the last element in void context and returning the final element evaluated in scalar context. This is seldom what you want.

The following single statement:

```
print uc(scalar(&foo,$bar)),$baz;
```

is the moral equivalent of these two:

```
&foo;
print(uc($bar),$baz);
```

See *perlop* for more details on unary operators and the comma operator.

seek FILEHANDLE,POSITION,WHENCE

Sets FILEHANDLE's position, just like the `fseek` call of `stdio`. FILEHANDLE may be an expression whose value gives the name of the filehandle. The values for WHENCE are to set the new position to POSITION, `1` to set it to the current position plus POSITION, and `2` to set it to EOF plus POSITION (typically negative). For WHENCE you may use the constants `SEEK_SET`, `SEEK_CUR`, and `SEEK_END` (start of the file, current position, end of the file) from the Fcntl module. Returns `1` upon success, otherwise.

If you want to position file for `sysread` or `syswrite`, don't use `seek`—buffering makes its effect on the file's system position unpredictable and non–portable. Use `sysseek` instead.

Due to the rules and rigors of ANSI C, on some systems you have to do a seek whenever you switch between reading and writing. Amongst other things, this may have the effect of calling stdio's clearerr(3). A WHENCE of `1` (`SEEK_CUR`) is useful for not moving the file position:

```
seek(TEST,0,1);
```

This is also useful for applications emulating `tail -f`. Once you hit EOF on your read, and then sleep for a while, you might have to stick in a `seek()` to reset things. The `seek` doesn't change the current position, but it *does* clear the end–of–file condition on the handle, so that the next `< <FILE` makes Perl try again to read something. We hope.

If that doesn't work (some stdios are particularly cantankerous), then you may need something more like this:

```
for (;;) {
    for ($curpos = tell(FILE); $_ = <FILE>;
         $curpos = tell(FILE)) {
        # search for some stuff and put it into files
    }
    sleep($for_a_while);
    seek(FILE, $curpos, 0);
}
```

seekdir DIRHANDLE,POS

Sets the current position for the `readdir` routine on DIRHANDLE. POS must be a value returned by `telldir`. Has the same caveats about possible directory compaction as the corresponding system library routine.

select FILEHANDLE

select

Returns the currently selected filehandle. Sets the current default filehandle for output, if FILEHANDLE is supplied. This has two effects: first, a `write` or a `print` without a filehandle will default to this FILEHANDLE. Second, references to variables related to output will refer to this output channel. For example, if you have to set the top of form format for more

than one output channel, you might do the following:

```
select(REPORT1);
$^ = 'report1_top';
select(REPORT2);
$^ = 'report2_top';
```

FILEHANDLE may be an expression whose value gives the name of the actual filehandle. Thus:

```
$oldfh = select(STDERR); $| = 1; select($oldfh);
```

Some programmers may prefer to think of filehandles as objects with methods, preferring to write the last example as:

```
use IO::Handle;
STDERR->autoflush(1);
```

select RBITS,WBITS,EBITS,TIMEOUT

This calls the select(2) system call with the bit masks specified, which can be constructed using `fileno` and `vec`, along these lines:

```
$rin = $win = $ein = '';
vec($rin,fileno(STDIN),1) = 1;
vec($win,fileno(STDOUT),1) = 1;
$ein = $rin | $win;
```

If you want to select on many filehandles you might wish to write a subroutine:

```
sub fhbits {
    my(@fhlist) = split(' ',$_[0]);
    my($bits);
    for (@fhlist) {
        vec($bits,fileno($_),1) = 1;
    }
    $bits;
}
$rin = fhbits('STDIN TTY SOCK');
```

The usual idiom is:

```
($nfound,$timeleft) =
  select($rout=$rin, $wout=$win, $eout=$ein, $timeout);
```

or to block until something becomes ready just do this

```
$nfound = select($rout=$rin, $wout=$win, $eout=$ein, undef);
```

Most systems do not bother to return anything useful in `$timeleft`, so calling `select()` in scalar context just returns `$nfound`.

Any of the bit masks can also be undef. The timeout, if specified, is in seconds, which may be fractional. Note: not all implementations are capable of returning the`$timeleft`. If not, they always return `$timeleft` equal to the supplied `$timeout`.

You can effect a sleep of 250 milliseconds this way:

```
select(undef, undef, undef, 0.25);
```

WARNING: One should not attempt to mix buffered I/O (like `read` or <FH) with `select`, except as permitted by POSIX, and even then only on POSIX systems. You have to use `sysread` instead.

semctl ID,SEMNUM,CMD,ARG

Calls the System V IPC function `semctl`. You'll probably have to say

```
use IPC::SysV;
```

first to get the correct constant definitions. If CMD is IPC_STAT or GETALL, then ARG must be a variable which will hold the returned semid_ds structure or semaphore value array. Returns like `ioctl`: the undefined value for error, "`0 but true`" for zero, or the actual return value otherwise. The ARG must consist of a vector of native short integers, which may be created with `pack("s!",(0)x$nsem)`. See also *SysV IPC in perlipc*, `IPC::SysV`, `IPC::Semaphore` documentation.

semget KEY,NSEMS,FLAGS

Calls the System V IPC function semget. Returns the semaphore id, or the undefined value if there is an error. See also *SysV IPC in perlipc*, `IPC::SysV`, `IPC::SysV::Semaphore` documentation.

semop KEY,OPSTRING

Calls the System V IPC function semop to perform semaphore operations such as signaling and waiting. OPSTRING must be a packed array of semop structures. Each semop structure can be generated with `pack("sss", $semnum, $semop, $semflag)`. The number of semaphore operations is implied by the length of OPSTRING. Returns true if successful, or false if there is an error. As an example, the following code waits on semaphore `$semnum` of semaphore id `$semid`:

```
$semop = pack("sss", $semnum, -1, 0);
die "Semaphore trouble: $!\n" unless semop($semid, $semop);
```

To signal the semaphore, replace `-1` with `1`. See also *SysV IPC in perlipc*, `IPC::SysV`, and `IPC::SysV::Semaphore` documentation.

send SOCKET,MSG,FLAGS,TO
send SOCKET,MSG,FLAGS

Sends a message on a socket. Takes the same flags as the system call of the same name. On unconnected sockets you must specify a destination to send TO, in which case it does a C `sendto`. Returns the number of characters sent, or the undefined value if there is an error. The C system call sendmsg(2) is currently unimplemented. See *UDP: Message Passing in perlipc* for examples.

setpgrp PID,PGRP

Sets the current process group for the specified PID, for the current process. Will produce a fatal error if used on a machine that doesn't implement POSIX setpgid(2) or BSD setpgrp(2). If the arguments are omitted, it defaults to `0,0`. Note that the BSD 4.2 version of `setpgrp` does not accept any arguments, so only `setpgrp(0,0)` is portable. See also `POSIX::setsid()`.

setpriority WHICH,WHO,PRIORITY

Sets the current priority for a process, a process group, or a user. (See setpriority(2).) Will produce a fatal error if used on a machine that doesn't implement setpriority(2).

setsockopt SOCKET,LEVEL,OPTNAME,OPTVAL

Sets the socket option requested. Returns undefined if there is an error. OPTVAL may be specified as `undef` if you don't want to pass an argument.

shift ARRAY
shift

Shifts the first value of the array off and returns it, shortening the array by 1 and moving everything down. If there are no elements in the array, returns the undefined value. If ARRAY is omitted, shifts the `@_` array within the lexical scope of subroutines and formats, and the

@ARGV array at file scopes or within the lexical scopes established by the `eval ''`, `BEGIN {}`, `INIT {}`, `CHECK {}`, and `END {}` constructs.

See also `unshift`, `push`, and `pop`. `shift` and `unshift` do the same thing to the left end of an array that `pop` and `push` do to the right end.

shmctl ID,CMD,ARG

Calls the System V IPC function shmctl. You'll probably have to say

```
use IPC::SysV;
```

first to get the correct constant definitions. If CMD is `IPC_STAT`, then ARG must be a variable which will hold the returned `shmid_ds` structure. Returns like ioctl: the undefined value for error, " but true" for zero, or the actual return value otherwise. See also *SysV IPC in perlipc* and `IPC::SysV` documentation.

shmget KEY,SIZE,FLAGS

Calls the System V IPC function shmget. Returns the shared memory segment id, or the undefined value if there is an error. See also *SysV IPC in perlipc* and `IPC::SysV` documentation.

shmread ID,VAR,POS,SIZE
shmwrite ID,STRING,POS,SIZE

Reads or writes the System V shared memory segment ID starting at position POS for size SIZE by attaching to it, copying in/out, and detaching from it. When reading, VAR must be a variable that will hold the data read. When writing, if STRING is too long, only SIZE bytes are used; if STRING is too short, nulls are written to fill out SIZE bytes. Return true if successful, or false if there is an error. `shmread()` taints the variable. See also *SysV IPC in perlipc*, `IPC::SysV` documentation, and the `IPC::Shareable` module from CPAN.

shutdown SOCKET,HOW

Shuts down a socket connection in the manner indicated by HOW, which has the same interpretation as in the system call of the same name.

```
shutdown(SOCKET, 0);    # I/we have stopped reading data
shutdown(SOCKET, 1);    # I/we have stopped writing data
shutdown(SOCKET, 2);    # I/we have stopped using this socket
```

This is useful with sockets when you want to tell the other side you're done writing but not done reading, or vice versa. It's also a more insistent form of close because it also disables the file descriptor in any forked copies in other processes.

sin EXPR
sin

Returns the sine of EXPR (expressed in radians). If EXPR is omitted, returns sine of `$_`.

For the inverse sine operation, you may use the `Math::Trig::asin` function, or use this relation:

```
sub asin { atan2($_[0], sqrt(1 - $_[0] * $_[0])) }
```

sleep EXPR
sleep

Causes the script to sleep for EXPR seconds, or forever if no EXPR. May be interrupted if the process receives a signal such as `SIGALRM`. Returns the number of seconds actually slept. You probably cannot mix `alarm` and `sleep` calls, because `sleep` is often implemented using `alarm`.

On some older systems, it may sleep up to a full second less than what you requested, depending on how it counts seconds. Most modern systems always sleep the full amount. They may appear to sleep longer than that, however, because your process might not be scheduled right away in a busy multitasking system.

For delays of finer granularity than one second, you may use Perl's `syscall` interface to access setitimer(2) if your system supports it, or else see */select* above. The Time::HiRes module from CPAN may also help.

See also the POSIX module's `pause` function.

socket SOCKET,DOMAIN,TYPE,PROTOCOL

Opens a socket of the specified kind and attaches it to filehandle SOCKET. DOMAIN, TYPE, and PROTOCOL are specified the same as for the system call of the same name. You should `use Socket` first to get the proper definitions imported. See the examples in *Sockets: Client/Server Communication in perlipc*.

On systems that support a close−on−exec flag on files, the flag will be set for the newly opened file descriptor, as determined by the value of `$^F`. See *$^F*.

socketpair SOCKET1,SOCKET2,DOMAIN,TYPE,PROTOCOL

Creates an unnamed pair of sockets in the specified domain, of the specified type. DOMAIN, TYPE, and PROTOCOL are specified the same as for the system call of the same name. If unimplemented, yields a fatal error. Returns true if successful.

On systems that support a close−on−exec flag on files, the flag will be set for the newly opened file descriptors, as determined by the value of `$^F`. See *$^F*.

Some systems defined `pipe` in terms of `socketpair`, in which a call to `pipe(Rdr, Wtr)` is essentially:

```
use Socket;
socketpair(Rdr, Wtr, AF_UNIX, SOCK_STREAM, PF_UNSPEC);
shutdown(Rdr, 1);        # no more writing for reader
shutdown(Wtr, 0);        # no more reading for writer
```

See *perlipc* for an example of socketpair use.

sort SUBNAME LIST
sort BLOCK LIST
sort LIST Sorts the LIST and returns the sorted list value. If SUBNAME or BLOCK is omitted, `sort`s in standard string comparison order. If SUBNAME is specified, it gives the name of a subroutine that returns an integer less than, equal to, or greater than , depending on how the elements of the list are to be ordered. (The `<` `<=` and `cmp` operators are extremely useful in such routines.) SUBNAME may be a scalar variable name (unsubscripted), in which case the value provides the name of (or a reference to) the actual subroutine to use. In place of a SUBNAME, you can provide a BLOCK as an anonymous, in−line sort subroutine.

If the subroutine's prototype is `($$)`, the elements to be compared are passed by reference in `@_`, as for a normal subroutine. This is slower than unprototyped subroutines, where the elements to be compared are passed into the subroutine as the package global variables `$a` and `$b` (see example below). Note that in the latter case, it is usually counter−productive to declare `$a` and `$b` as lexicals.

In either case, the subroutine may not be recursive. The values to be compared are always passed by reference, so don't modify them.

You also cannot exit out of the sort block or subroutine using any of the loop control operators described in *perlsyn* or with `goto`.

When `use locale` is in effect, `sort LIST` sorts LIST according to the current collation locale. See *perllocale*.

Examples:

```
# sort lexically
@articles = sort @files;
```

```
# same thing, but with explicit sort routine
@articles = sort {$a cmp $b} @files;

# now case-insensitively
@articles = sort {uc($a) cmp uc($b)} @files;

# same thing in reversed order
@articles = sort {$b cmp $a} @files;

# sort numerically ascending
@articles = sort {$a <=> $b} @files;

# sort numerically descending
@articles = sort {$b <=> $a} @files;

# this sorts the %age hash by value instead of key
# using an in-line function
@eldest = sort { $age{$b} <=> $age{$a} } keys %age;

# sort using explicit subroutine name
sub byage {
    $age{$a} <=> $age{$b};  # presuming numeric
}
@sortedclass = sort byage @class;

sub backwards { $b cmp $a }
@harry  = qw(dog cat x Cain Abel);
@george = qw(gone chased yz Punished Axed);
print sort @harry;
        # prints AbelCaincatdogx
print sort backwards @harry;
        # prints xdogcatCainAbel
print sort @george, 'to', @harry;
        # prints AbelAxedCainPunishedcatchaseddoggonetoxyz

# inefficiently sort by descending numeric compare using
# the first integer after the first = sign, or the
# whole record case-insensitively otherwise

@new = sort {
    ($b =~ /=(\d+)/)[0] <=> ($a =~ /=(\d+)/)[0]
                        ||
                uc($a)  cmp  uc($b)
} @old;

# same thing, but much more efficiently;
# we'll build auxiliary indices instead
# for speed
@nums = @caps = ();
for (@old) {
    push @nums, /=(\d+)/;
    push @caps, uc($_);
}

@new = @old[ sort {
                    $nums[$b] <=> $nums[$a]
                              ||
                    $caps[$a] cmp $caps[$b]
                   } 0..$#old
           ];
```

```
# same thing, but without any temps
@new = map { $_->[0] }
       sort { $b->[1] <=> $a->[1]
                          ||
              $a->[2] cmp $b->[2]
       } map { [$_, /=(\d+)/, uc($_)] } @old;

# using a prototype allows you to use any comparison subroutine
# as a sort subroutine (including other package's subroutines)
package other;
sub backwards ($$) { $_[1] cmp $_[0]; }     # $a and $b are not set here

package main;
@new = sort other::backwards @old;
```

If you're using strict, you *must not* declare `$a` and `$b` as lexicals. They are package globals. That means if you're in the `main` package and type

```
@articles = sort {$b <=> $a} @files;
```

then `$a` and `$b` are `$main::a` and `$main::b` (or `$::a` and `$::b`), but if you're in the `FooPack` package, it's the same as typing

```
@articles = sort {$FooPack::b <=> $FooPack::a} @files;
```

The comparison function is required to behave. If it returns inconsistent results (sometimes saying `$x[1]` is less than `$x[2]` and sometimes saying the opposite, for example) the results are not well–defined.

splice ARRAY,OFFSET,LENGTH,LIST
splice ARRAY,OFFSET,LENGTH
splice ARRAY,OFFSET
splice ARRAY

Removes the elements designated by OFFSET and LENGTH from an array, and replaces them with the elements of LIST, if any. In list context, returns the elements removed from the array. In scalar context, returns the last element removed, or `undef` if no elements are removed. The array grows or shrinks as necessary. If OFFSET is negative then it starts that far from the end of the array. If LENGTH is omitted, removes everything from OFFSET onward. If LENGTH is negative, leaves that many elements off the end of the array. If both OFFSET and LENGTH are omitted, removes everything.

The following equivalences hold (assuming `$[ == 0`):

```
push(@a,$x,$y)      splice(@a,@a,0,$x,$y)
pop(@a)             splice(@a,-1)
shift(@a)           splice(@a,0,1)
unshift(@a,$x,$y)   splice(@a,0,0,$x,$y)
$a[$x] = $y         splice(@a,$x,1,$y)
```

Example, assuming array lengths are passed before arrays:

```
sub aeq {   # compare two list values
    my(@a) = splice(@_,0,shift);
    my(@b) = splice(@_,0,shift);
    return 0 unless @a == @b;       # same len?
    while (@a) {
        return 0 if pop(@a) ne pop(@b);
    }
    return 1;
}
```

```
    if (&aeq($len,@foo[1..$len],0+@bar,@bar)) { ... }
```

split /PATTERN/,EXPR,LIMIT
split /PATTERN/,EXPR
split /PATTERN/
split Splits a string into a list of strings and returns that list. By default, empty leading fields are preserved, and empty trailing ones are deleted.

In scalar context, returns the number of fields found and splits into the `@_` array. Use of split in scalar context is deprecated, however, because it clobbers your subroutine arguments.

If EXPR is omitted, splits the `$_` string. If PATTERN is also omitted, splits on whitespace (after skipping any leading whitespace). Anything matching PATTERN is taken to be a delimiter separating the fields. (Note that the delimiter may be longer than one character.)

If LIMIT is specified and positive, splits into no more than that many fields (though it may split into fewer). If LIMIT is unspecified or zero, trailing null fields are stripped (which potential users of `pop` would do well to remember). If LIMIT is negative, it is treated as if an arbitrarily large LIMIT had been specified.

A pattern matching the null string (not to be confused with a null pattern `//`, which is just one member of the set of patterns matching a null string) will split the value of EXPR into separate characters at each point it matches that way. For example:

```
print join(':', split(/ */, 'hi there'));
```

produces the output 'h:i:t:h:e:r:e'.

The LIMIT parameter can be used to split a line partially

```
($login, $passwd, $remainder) = split(/:/, $_, 3);
```

When assigning to a list, if LIMIT is omitted, Perl supplies a LIMIT one larger than the number of variables in the list, to avoid unnecessary work. For the list above LIMIT would have been 4 by default. In time critical applications it behooves you not to split into more fields than you really need.

If the PATTERN contains parentheses, additional list elements are created from each matching substring in the delimiter.

```
split(/([,-])/, "1-10,20", 3);
```

produces the list value

```
(1, '-', 10, ',', 20)
```

If you had the entire header of a normal Unix email message in `$header`, you could split it up into fields and their values this way:

```
$header =~ s/\n\s+/ /g;  # fix continuation lines
%hdrs   =  (UNIX_FROM => split /^(\S*?):\s*/m, $header);
```

The pattern `/PATTERN/` may be replaced with an expression to specify patterns that vary at runtime. (To do runtime compilation only once, use `/$variable/o`.)

As a special case, specifying a PATTERN of space (`' '`) will split on white space just as `split` with no arguments does. Thus, `split(' ')` can be used to emulate **awk**'s default behavior, whereas `split(/ /)` will give you as many null initial fields as there are leading spaces. A `split` on `/\s+/` is like a `split(' ')` except that any leading whitespace produces a null first field. A `split` with no arguments really does a `split(' ', $_)` internally.

A PATTERN of `/^/` is treated as if it were `/^/m`, since it isn't much use otherwise.

Example:

```
open(PASSWD, '/etc/passwd');
while (<PASSWD>) {
    ($login, $passwd, $uid, $gid,
     $gcos, $home, $shell) = split(/:/);
    #...
}
```

(Note that `$shell` above will still have a newline on it. See */chop*, */chomp*, and */join*.)

sprintf FORMAT, LIST

Returns a string formatted by the usual `printf` conventions of the C library function `sprintf`. See below for more details and see *sprintf(3)* or *printf(3)* on your system for an explanation of the general principles.

For example:

```
# Format number with up to 8 leading zeroes
$result = sprintf("%08d", $number);

# Round number to 3 digits after decimal point
$rounded = sprintf("%.3f", $number);
```

Perl does its own `sprintf` formatting—it emulates the C function `sprintf`, but it doesn't use it (except for floating–point numbers, and even then only the standard modifiers are allowed). As a result, any non–standard extensions in your local `sprintf` are not available from Perl.

Unlike `printf`, `sprintf` does not do what you probably mean when you pass it an array as your first argument. The array is given scalar context, and instead of using the 0th element of the array as the format, Perl will use the count of elements in the array as the format, which is almost never useful.

Perl's `sprintf` permits the following universally–known conversions:

```
%%   a percent sign
%c   a character with the given number
%s   a string
%d   a signed integer, in decimal
%u   an unsigned integer, in decimal
%o   an unsigned integer, in octal
%x   an unsigned integer, in hexadecimal
%e   a floating-point number, in scientific notation
%f   a floating-point number, in fixed decimal notation
%g   a floating-point number, in %e or %f notation
```

In addition, Perl permits the following widely–supported conversions:

```
%X   like %x, but using upper-case letters
%E   like %e, but using an upper-case "E"
%G   like %g, but with an upper-case "E" (if applicable)
%b   an unsigned integer, in binary
%p   a pointer (outputs the Perl value's address in hexadecimal)
%n   special: *stores* the number of characters output so far
     into the next variable in the parameter list
```

Finally, for backward (and we do mean "backward") compatibility, Perl permits these unnecessary but widely–supported conversions:

```
%i   a synonym for %d
%D   a synonym for %ld
```

```
%U   a synonym for %lu
%O   a synonym for %lo
%F   a synonym for %f
```

Note that the number of exponent digits in the scientific notation by `%e`, `%E`, `%g` and `%G` for numbers with the modulus of the exponent less than 100 is system−dependent: it may be three or less (zero−padded as necessary). In other words, 1.23 times ten to the 99th may be either "1.23e99" or "1.23e099".

Perl permits the following universally−known flags between the `%` and the conversion letter:

```
space   prefix positive number with a space
+       prefix positive number with a plus sign
-       left-justify within the field
0       use zeros, not spaces, to right-justify
#       prefix non-zero octal with "0", non-zero hex with "0x"
number  minimum field width
.number "precision": digits after decimal point for
        floating-point, max length for string, minimum length
        for integer
l       interpret integer as C type "long" or "unsigned long"
h       interpret integer as C type "short" or "unsigned short"
        If no flags, interpret integer as C type "int" or "unsigned"
```

Perl supports parameter ordering, in other words, fetching the parameters in some explicitly specified "random" ordering as opposed to the default implicit sequential ordering. The syntax is, instead of the `%` and `*`, to use `%`*digits*`$` and `*`*digits*`$`, where the *digits* is the wanted index, from one upwards. For example:

```
printf "%2\$d %1\$d\n", 12, 34;             # will print "34 12\n"
printf "%*2\$d\n",      12, 3;              # will print " 12\n"
```

Note that using the reordering syntax does not interfere with the usual implicit sequential fetching of the parameters:

```
printf "%2\$d %d\n",    12, 34;             # will print "34 12\n"
printf "%2\$d %d %d\n", 12, 34;             # will print "34 12 34\n"
printf "%3\$d %d %d\n", 12, 34, 56;         # will print "56 12 34\n"
printf "%2\$*3\$d %d\n", 12, 34, 3;         # will print " 34 12\n"
printf "%*3\$2\$d %d\n", 12, 34, 3;         # will print " 34 12\n"
```

There are also two Perl−specific flags:

```
V       interpret integer as Perl's standard integer type
v       interpret string as a vector of integers, output as
        numbers separated either by dots, or by an arbitrary
        string received from the argument list when the flag
        is preceded by C<*>
```

Where a number would appear in the flags, an asterisk (`*`) may be used instead, in which case Perl uses the next item in the parameter list as the given number (that is, as the field width or precision). If a field width obtained through `*` is negative, it has the same effect as the `-` flag: left−justification.

The `v` flag is useful for displaying ordinal values of characters in arbitrary strings:

```
printf "version is v%vd\n", $^V;            # Perl's version
printf "address is %*vX\n", ":", $addr;     # IPv6 address
printf "bits are %*vb\n", " ", $bits;       # random bitstring
```

If `use locale` is in effect, the character used for the decimal point in formatted real numbers is affected by the LC_NUMERIC locale. See *perllocale*.

If Perl understands "quads" (64–bit integers) (this requires either that the platform natively support quads or that Perl be specifically compiled to support quads), the characters

```
d u o x X b i D U O
```

print quads, and they may optionally be preceded by

```
ll L q
```

For example

```
%lld %16LX %qo
```

You can find out whether your Perl supports quads via *Config*:

```
use Config;
($Config{use64bitint} eq 'define' || $Config{longsize} == 8) &&
        print "quads\n";
```

If Perl understands "long doubles" (this requires that the platform support long doubles), the flags

```
e f g E F G
```

may optionally be preceded by

```
ll L
```

For example

```
%llf %Lg
```

You can find out whether your Perl supports long doubles via *Config*:

```
use Config;
$Config{d_longdbl} eq 'define' && print "long doubles\n";
```

sqrt EXPR

sqrt Return the square root of EXPR. If EXPR is omitted, returns square root of `$_`. Only works on non–negative operands, unless you've loaded the standard Math::Complex module.

```
use Math::Complex;
print sqrt(-2);    # prints 1.4142135623731i
```

srand EXPR

srand Sets the random number seed for the `rand` operator. If EXPR is omitted, uses a semi–random value supplied by the kernel (if it supports the ***/dev/urandom*** device) or based on the current time and process ID, among other things. In versions of Perl prior to 5.004 the default seed was just the current `time`. This isn't a particularly good seed, so many old programs supply their own seed value (often `time ^ $$` or `time ^ ($$ + ($$ << 15))`), but that isn't necessary any more.

In fact, it's usually not necessary to call `srand` at all, because if it is not called explicitly, it is called implicitly at the first use of the `rand` operator. However, this was not the case in version of Perl before 5.004, so if your script will run under older Perl versions, it should call `srand`.

Note that you need something much more random than the default seed for cryptographic purposes. Checksumming the compressed output of one or more rapidly changing operating system status programs is the usual method. For example:

```
srand (time ^ $$ ^ unpack "%L*", `ps axww | gzip`);
```

If you're particularly concerned with this, see the `Math::TrulyRandom` module in CPAN.

Do *not* call `srand` multiple times in your program unless you know exactly what you're doing and why you're doing it. The point of the function is to "seed" the `rand` function so that `rand` can produce a different sequence each time you run your program. Just do it once at the top of your program, or you *won't* get random numbers out of `rand`!

Frequently called programs (like CGI scripts) that simply use

```
time ^ $$
```

for a seed can fall prey to the mathematical property that

```
a^b == (a+1)^(b+1)
```

one−third of the time. So don't do that.

stat FILEHANDLE
stat EXPR
stat Returns a 13−element list giving the status info for a file, either the file opened via FILEHANDLE, or named by EXPR. If EXPR is omitted, it stats `$_`. Returns a null list if the stat fails. Typically used as follows:

```
($dev,$ino,$mode,$nlink,$uid,$gid,$rdev,$size,
   $atime,$mtime,$ctime,$blksize,$blocks)
       = stat($filename);
```

Not all fields are supported on all filesystem types. Here are the meaning of the fields:

```
 0 dev      device number of filesystem
 1 ino      inode number
 2 mode     file mode  (type and permissions)
 3 nlink    number of (hard) links to the file
 4 uid      numeric user ID of file's owner
 5 gid      numeric group ID of file's owner
 6 rdev     the device identifier (special files only)
 7 size     total size of file, in bytes
 8 atime    last access time in seconds since the epoch
 9 mtime    last modify time in seconds since the epoch
10 ctime    inode change time (NOT creation time!) in seconds since the epoc
11 blksize  preferred block size for file system I/O
12 blocks   actual number of blocks allocated
```

(The epoch was at 00:00 January 1, 1970 GMT.)

If stat is passed the special filehandle consisting of an underline, no stat is done, but the current contents of the stat structure from the last stat or filetest are returned. Example:

```
if (-x $file && (($d) = stat(_)) && $d < 0) {
    print "$file is executable NFS file\n";
}
```

(This works on machines only for which the device number is negative under NFS.)

Because the mode contains both the file type and its permissions, you should mask off the file type portion and (s)printf using a `"%o"` if you want to see the real permissions.

```
$mode = (stat($filename))[2];
printf "Permissions are %04o\n", $mode & 07777;
```

In scalar context, `stat` returns a boolean value indicating success or failure, and, if successful, sets the information associated with the special filehandle `_`.

The File::stat module provides a convenient, by−name access mechanism:

```
use File::stat;
$sb = stat($filename);
printf "File is %s, size is %s, perm %04o, mtime %s\n",
    $filename, $sb->size, $sb->mode & 07777,
    scalar localtime $sb->mtime;
```

You can import symbolic mode constants (S_IF*) and functions (S_IS*) from the Fcntl module:

```
use Fcntl ':mode';

$mode = (stat($filename))[2];

$user_rwx      = ($mode & S_IRWXU) >> 6;
$group_read    = ($mode & S_IRGRP) >> 3;
$other_execute =  $mode & S_IXOTH;

printf "Permissions are %04o\n", S_ISMODE($mode), "\n";

$is_setuid     =  $mode & S_ISUID;
$is_setgid     =  S_ISDIR($mode);
```

You could write the last two using the −u and −d operators. The commonly available S_IF* constants are

```
# Permissions: read, write, execute, for user, group, others.

S_IRWXU S_IRUSR S_IWUSR S_IXUSR
S_IRWXG S_IRGRP S_IWGRP S_IXGRP
S_IRWXO S_IROTH S_IWOTH S_IXOTH

# Setuid/Setgid/Stickiness.

S_ISUID S_ISGID S_ISVTX S_ISTXT

# File types.  Not necessarily all are available on your system.

S_IFREG S_IFDIR S_IFLNK S_IFBLK S_ISCHR S_IFIFO S_IFSOCK S_IFWHT S_ENFMT

# The following are compatibility aliases for S_IRUSR, S_IWUSR, S_IXUSR.

S_IREAD S_IWRITE S_IEXEC
```

and the S_IF* functions are

```
S_IFMODE($mode)     the part of $mode containing the permission bits
                    and the setuid/setgid/sticky bits

S_IFMT($mode)       the part of $mode containing the file type
                    which can be bit-anded with e.g. S_IFREG
                    or with the following functions

# The operators -f, -d, -l, -b, -c, -p, and -s.

S_ISREG($mode) S_ISDIR($mode) S_ISLNK($mode)
S_ISBLK($mode) S_ISCHR($mode) S_ISFIFO($mode) S_ISSOCK($mode)

# No direct -X operator counterpart, but for the first one
# the -g operator is often equivalent.  The ENFMT stands for
# record flocking enforcement, a platform-dependent feature.

S_ISENFMT($mode) S_ISWHT($mode)
```

See your native chmod(2) and stat(2) documentation for more details about the S_* constants.

study SCALAR
study Takes extra time to study SCALAR ($_ if unspecified) in anticipation of doing many pattern matches on the string before it is next modified. This may or may not save time, depending on the nature and number of patterns you are searching on, and on the distribution of character frequencies in the string to be searched—you probably want to compare run times with and without it to see which runs faster. Those loops which scan for many short constant strings (including the constant parts of more complex patterns) will benefit most. You may have only one `study` active at a time—if you study a different scalar the first is "unstudied". (The way `study` works is this: a linked list of every character in the string to be searched is made, so we know, for example, where all the `'k'` characters are. From each search string, the rarest character is selected, based on some static frequency tables constructed from some C programs and English text. Only those places that contain this "rarest" character are examined.)

For example, here is a loop that inserts index producing entries before any line containing a certain pattern:

```
while (<>) {
    study;
    print ".IX foo\n"       if /\bfoo\b/;
    print ".IX bar\n"       if /\bbar\b/;
    print ".IX blurfl\n"    if /\bblurfl\b/;
    # ...
    print;
}
```

In searching for `/\bfoo\b/`, only those locations in `$_` that contain `f` will be looked at, because `f` is rarer than `o`. In general, this is a big win except in pathological cases. The only question is whether it saves you more time than it took to build the linked list in the first place.

Note that if you have to look for strings that you don't know till runtime, you can build an entire loop as a string and `eval` that to avoid recompiling all your patterns all the time. Together with undefining `$/` to input entire files as one record, this can be very fast, often faster than specialized programs like fgrep(1). The following scans a list of files (`@files`) for a list of words (`@words`), and prints out the names of those files that contain a match:

```
$search = 'while (<>) { study;';
foreach $word (@words) {
    $search .= "++\$seen{\$ARGV} if /\\b$word\\b/;\n";
}
$search .= "}";
@ARGV = @files;
undef $/;
eval $search;               # this screams
$/ = "\n";          # put back to normal input delimiter
foreach $file (sort keys(%seen)) {
    print $file, "\n";
}
```

sub BLOCK
sub NAME
sub NAME BLOCK

This is subroutine definition, not a real function *per se*. With just a NAME (and possibly prototypes or attributes), it's just a forward declaration. Without a NAME, it's an anonymous function declaration, and does actually return a value: the CODE ref of the closure you just created. See *perlsub* and *perlref* for details.

substr EXPR,OFFSET,LENGTH,REPLACEMENT
substr EXPR,OFFSET,LENGTH
substr EXPR,OFFSET

Extracts a substring out of EXPR and returns it. First character is at offset , or whatever you've set `$[` to (but don't do that). If OFFSET is negative (or more precisely, less than `$[`), starts that far from the end of the string. If LENGTH is omitted, returns everything to the end of the string. If LENGTH is negative, leaves that many characters off the end of the string.

You can use the `substr()` function as an lvalue, in which case EXPR must itself be an lvalue. If you assign something shorter than LENGTH, the string will shrink, and if you assign something longer than LENGTH, the string will grow to accommodate it. To keep the string the same length you may need to pad or chop your value using `sprintf`.

If OFFSET and LENGTH specify a substring that is partly outside the string, only the part within the string is returned. If the substring is beyond either end of the string, `substr()` returns the undefined value and produces a warning. When used as an lvalue, specifying a substring that is entirely outside the string is a fatal error. Here's an example showing the behavior for boundary cases:

```
my $name = 'fred';
substr($name, 4) = 'dy';            # $name is now 'freddy'
my $null = substr $name, 6, 2;      # returns '' (no warning)
my $oops = substr $name, 7;         # returns undef, with warning
substr($name, 7) = 'gap';           # fatal error
```

An alternative to using `substr()` as an lvalue is to specify the replacement string as the 4th argument. This allows you to replace parts of the EXPR and return what was there before in one operation, just as you can with `splice()`.

symlink OLDFILE,NEWFILE

Creates a new filename symbolically linked to the old filename. Returns `1` for success, otherwise. On systems that don't support symbolic links, produces a fatal error at run time. To check for that, use eval:

```
$symlink_exists = eval { symlink("","",); 1 };
```

syscall LIST

Calls the system call specified as the first element of the list, passing the remaining elements as arguments to the system call. If unimplemented, produces a fatal error. The arguments are interpreted as follows: if a given argument is numeric, the argument is passed as an int. If not, the pointer to the string value is passed. You are responsible to make sure a string is pre-extended long enough to receive any result that might be written into a string. You can't use a string literal (or other read-only string) as an argument to `syscall` because Perl has to assume that any string pointer might be written through. If your integer arguments are not literals and have never been interpreted in a numeric context, you may need to add to them to force them to look like numbers. This emulates the `syswrite` function (or vice versa):

```
require 'syscall.ph';               # may need to run h2ph
$s = "hi there\n";
syscall(&SYS_write, fileno(STDOUT), $s, length $s);
```

Note that Perl supports passing of up to only 14 arguments to your system call, which in practice should usually suffice.

Syscall returns whatever value returned by the system call it calls. If the system call fails, `syscall` returns `-1` and sets `$!` (errno). Note that some system calls can legitimately return `-1`. The proper way to handle such calls is to assign `$!=0;` before the call and check the value of `$!` if syscall returns `-1`.

There's a problem with `syscall(&SYS_pipe)`: it returns the file number of the read end of the pipe it creates. There is no way to retrieve the file number of the other end. You can avoid this problem by using `pipe` instead.

sysopen FILEHANDLE,FILENAME,MODE
sysopen FILEHANDLE,FILENAME,MODE,PERMS

Opens the file whose filename is given by FILENAME, and associates it with FILEHANDLE. If FILEHANDLE is an expression, its value is used as the name of the real filehandle wanted. This function calls the underlying operating system's `open` function with the parameters FILENAME, MODE, PERMS.

The possible values and flag bits of the MODE parameter are system-dependent; they are available via the standard module `Fcntl`. See the documentation of your operating system's `open` to see which values and flag bits are available. You may combine several flags using the `|`-operator.

Some of the most common values are `O_RDONLY` for opening the file in read-only mode, `O_WRONLY` for opening the file in write-only mode, and `O_RDWR` for opening the file in read-write mode, and.

For historical reasons, some values work on almost every system supported by perl: zero means read-only, one means write-only, and two means read/write. We know that these values do *not* work under OS/390 & VM/ESA Unix and on the Macintosh; you probably don't want to use them in new code.

If the file named by FILENAME does not exist and the `open` call creates it (typically because MODE includes the `O_CREAT` flag), then the value of PERMS specifies the permissions of the newly created file. If you omit the PERMS argument to `sysopen`, Perl uses the octal value `0666`. These permission values need to be in octal, and are modified by your process's current `umask`.

In many systems the `O_EXCL` flag is available for opening files in exclusive mode. This is **not** locking: exclusiveness means here that if the file already exists, `sysopen()` fails. The `O_EXCL` wins `O_TRUNC`.

Sometimes you may want to truncate an already-existing file: `O_TRUNC`.

You should seldom if ever use `0644` as argument to `sysopen`, because that takes away the user's option to have a more permissive umask. Better to omit it. See the perlfunc(1) entry on `umask` for more on this.

Note that `sysopen` depends on the `fdopen()` C library function. On many UNIX systems, `fdopen()` is known to fail when file descriptors exceed a certain value, typically 255. If you need more file descriptors than that, consider rebuilding Perl to use the `sfio` library, or perhaps using the `POSIX::open()` function.

See *perlopentut* for a kinder, gentler explanation of opening files.

sysread FILEHANDLE,SCALAR,LENGTH,OFFSET
sysread FILEHANDLE,SCALAR,LENGTH

Attempts to read LENGTH bytes of data into variable SCALAR from the specified FILEHANDLE, using the system call read(2). It bypasses stdio, so mixing this with other kinds of reads, `print`, `write`, `seek`, `tell`, or `eof` can cause confusion because stdio usually buffers data. Returns the number of bytes actually read, at end of file, or undef if there was an error. SCALAR will be grown or shrunk so that the last byte actually read is the last byte of the scalar after the read.

An OFFSET may be specified to place the read data at some place in the string other than the beginning. A negative OFFSET specifies placement at that many bytes counting backwards from the end of the string. A positive OFFSET greater than the length of SCALAR results in the

string being padded to the required size with "\0" bytes before the result of the read is appended.

There is no syseof() function, which is ok, since eof() doesn't work very well on device files (like ttys) anyway. Use sysread() and check for a return value for 0 to decide whether you're done.

sysseek FILEHANDLE,POSITION,WHENCE

Sets FILEHANDLE's system position using the system call lseek(2). It bypasses stdio, so mixing this with reads (other than sysread), print, write, seek, tell, or eof may cause confusion. FILEHANDLE may be an expression whose value gives the name of the filehandle. The values for WHENCE are to set the new position to POSITION, 1 to set the it to the current position plus POSITION, and 2 to set it to EOF plus POSITION (typically negative). For WHENCE, you may also use the constants SEEK_SET, SEEK_CUR, and SEEK_END (start of the file, current position, end of the file) from the Fcntl module.

Returns the new position, or the undefined value on failure. A position of zero is returned as the string "0 but true"; thus sysseek returns true on success and false on failure, yet you can still easily determine the new position.

system LIST
system PROGRAM LIST

Does exactly the same thing as exec LIST, except that a fork is done first, and the parent process waits for the child process to complete. Note that argument processing varies depending on the number of arguments. If there is more than one argument in LIST, or if LIST is an array with more than one value, starts the program given by the first element of the list with arguments given by the rest of the list. If there is only one scalar argument, the argument is checked for shell metacharacters, and if there are any, the entire argument is passed to the system's command shell for parsing (this is /bin/sh -c on Unix platforms, but varies on other platforms). If there are no shell metacharacters in the argument, it is split into words and passed directly to execvp, which is more efficient.

Beginning with v5.6.0, Perl will attempt to flush all files opened for output before any operation that may do a fork, but this may not be supported on some platforms (see *perlport*). To be safe, you may need to set $| ($AUTOFLUSH in English) or call the autoflush() method of IO::Handle on any open handles.

The return value is the exit status of the program as returned by the wait call. To get the actual exit value divide by 256. See also */exec*. This is *not* what you want to use to capture the output from a command, for that you should use merely backticks or qx//, as described in *'STRING' in perlop*. Return value of −1 indicates a failure to start the program (inspect $! for the reason).

Like exec, system allows you to lie to a program about its name if you use the system PROGRAM LIST syntax. Again, see */exec*.

Because system and backticks block SIGINT and SIGQUIT, killing the program they're running doesn't actually interrupt your program.

```
@args = ("command", "arg1", "arg2");
system(@args) == 0
     or die "system @args failed: $?"
```

You can check all the failure possibilities by inspecting $? like this:

```
$exit_value  = $? >> 8;
$signal_num  = $? & 127;
$dumped_core = $? & 128;
```

When the arguments get executed via the system shell, results and return codes will be subject to

its quirks and capabilities. See *'STRING' in perlop* and */exec* for details.

syswrite FILEHANDLE,SCALAR,LENGTH,OFFSET
syswrite FILEHANDLE,SCALAR,LENGTH
syswrite FILEHANDLE,SCALAR

Attempts to write LENGTH bytes of data from variable SCALAR to the specified FILEHANDLE, using the system call write(2). If LENGTH is not specified, writes whole SCALAR. It bypasses stdio, so mixing this with reads (other than `sysread()`), `print`, `write`, `seek`, `tell`, or `eof` may cause confusion because stdio usually buffers data. Returns the number of bytes actually written, or `undef` if there was an error. If the LENGTH is greater than the available data in the SCALAR after the OFFSET, only as much data as is available will be written.

An OFFSET may be specified to write the data from some part of the string other than the beginning. A negative OFFSET specifies writing that many bytes counting backwards from the end of the string. In the case the SCALAR is empty you can use OFFSET but only zero offset.

tell FILEHANDLE
tell

Returns the current position for FILEHANDLE, or −1 on error. FILEHANDLE may be an expression whose value gives the name of the actual filehandle. If FILEHANDLE is omitted, assumes the file last read.

The return value of `tell()` for the standard streams like the STDIN depends on the operating system: it may return −1 or something else. `tell()` on pipes, fifos, and sockets usually returns −1.

There is no `systell` function. Use `sysseek(FH, 0, 1)` for that.

telldir DIRHANDLE

Returns the current position of the `readdir` routines on DIRHANDLE. Value may be given to `seekdir` to access a particular location in a directory. Has the same caveats about possible directory compaction as the corresponding system library routine.

tie VARIABLE,CLASSNAME,LIST

This function binds a variable to a package class that will provide the implementation for the variable. VARIABLE is the name of the variable to be enchanted. CLASSNAME is the name of a class implementing objects of correct type. Any additional arguments are passed to the `new` method of the class (meaning `TIESCALAR`, `TIEHANDLE`, `TIEARRAY`, or `TIEHASH`). Typically these are arguments such as might be passed to the `dbm_open()` function of C. The object returned by the `new` method is also returned by the `tie` function, which would be useful if you want to access other methods in CLASSNAME.

Note that functions such as `keys` and `values` may return huge lists when used on large objects, like DBM files. You may prefer to use the `each` function to iterate over such. Example:

```
# print out history file offsets
use NDBM_File;
tie(%HIST, 'NDBM_File', '/usr/lib/news/history', 1, 0);
while (($key,$val) = each %HIST) {
    print $key, ' = ', unpack('L',$val), "\n";
}
untie(%HIST);
```

A class implementing a hash should have the following methods:

```
TIEHASH classname, LIST
FETCH this, key
STORE this, key, value
```

```
DELETE this, key
CLEAR this
EXISTS this, key
FIRSTKEY this
NEXTKEY this, lastkey
DESTROY this
UNTIE this
```

A class implementing an ordinary array should have the following methods:

```
TIEARRAY classname, LIST
FETCH this, key
STORE this, key, value
FETCHSIZE this
STORESIZE this, count
CLEAR this
PUSH this, LIST
POP this
SHIFT this
UNSHIFT this, LIST
SPLICE this, offset, length, LIST
EXTEND this, count
DESTROY this
UNTIE this
```

A class implementing a file handle should have the following methods:

```
TIEHANDLE classname, LIST
READ this, scalar, length, offset
READLINE this
GETC this
WRITE this, scalar, length, offset
PRINT this, LIST
PRINTF this, format, LIST
BINMODE this
EOF this
FILENO this
SEEK this, position, whence
TELL this
OPEN this, mode, LIST
CLOSE this
DESTROY this
UNTIE this
```

A class implementing a scalar should have the following methods:

```
TIESCALAR classname, LIST
FETCH this,
STORE this, value
DESTROY this
UNTIE this
```

Not all methods indicated above need be implemented. See *perltie*, *Tie::Hash*, *Tie::Array*, *Tie::Scalar*, and *Tie::Handle*.

Unlike `dbmopen`, the `tie` function will not use or require a module for you—you need to do that explicitly yourself. See *DB_File* or the ***Config*** module for interesting `tie` implementations.

For further details see *perltie*, *"tied VARIABLE"*.

tied VARIABLE

Returns a reference to the object underlying VARIABLE (the same value that was originally returned by the `tie` call that bound the variable to a package.) Returns the undefined value if VARIABLE isn't tied to a package.

time Returns the number of non-leap seconds since whatever time the system considers to be the epoch (that's 00:00:00, January 1, 1904 for MacOS, and 00:00:00 UTC, January 1, 1970 for most other systems). Suitable for feeding to `gmtime` and `localtime`.

For measuring time in better granularity than one second, you may use either the Time::HiRes module from CPAN, or if you have gettimeofday(2), you may be able to use the `syscall` interface of Perl, see *perlfaq8* for details.

times Returns a four-element list giving the user and system times, in seconds, for this process and the children of this process.

```
($user,$system,$cuser,$csystem) = times;
```

tr/// The transliteration operator. Same as `y///`. See *perlop*.

truncate FILEHANDLE,LENGTH
truncate EXPR,LENGTH

Truncates the file opened on FILEHANDLE, or named by EXPR, to the specified length. Produces a fatal error if truncate isn't implemented on your system. Returns true if successful, the undefined value otherwise.

uc EXPR
uc Returns an uppercased version of EXPR. This is the internal function implementing the `\U` escape in double-quoted strings. Respects current LC_CTYPE locale if `use locale` in force. See *perllocale*. Under Unicode (`use utf8`) it uses the standard Unicode uppercase mappings. (It does not attempt to do titlecase mapping on initial letters. See `ucfirst` for that.)

If EXPR is omitted, uses `$_`.

ucfirst EXPR
ucfirst Returns the value of EXPR with the first character in uppercase (titlecase in Unicode). This is the internal function implementing the `\u` escape in double-quoted strings. Respects current LC_CTYPE locale if `use locale` in force. See *perllocale* and *utf8*.

If EXPR is omitted, uses `$_`.

umask EXPR
umask Sets the umask for the process to EXPR and returns the previous value. If EXPR is omitted, merely returns the current umask.

The Unix permission `rwxr-x--` is represented as three sets of three bits, or three octal digits: `0750` (the leading 0 indicates octal and isn't one of the digits). The `umask` value is such a number representing disabled permissions bits. The permission (or "mode") values you pass `mkdir` or `sysopen` are modified by your umask, so even if you tell `sysopen` to create a file with permissions `0777`, if your umask is `0022` then the file will actually be created with permissions `0755`. If your `umask` were `0027` (group can't write; others can't read, write, or execute), then passing `sysopen 0666` would create a file with mode `0640` (`0666 &~ 027` is `0640`).

Here's some advice: supply a creation mode of `0666` for regular files (in `sysopen`) and one of `0777` for directories (in `mkdir`) and executable files. This gives users the freedom of choice: if they want protected files, they might choose process umasks of `022`, `027`, or even the particularly antisocial mask of `077`. Programs should rarely if ever make policy decisions better left to the user. The exception to this is when writing files that should be kept private: mail files,

web browser cookies, *.rhosts* files, and so on.

If umask(2) is not implemented on your system and you are trying to restrict access for *yourself* (i.e., (EXPR & 0700) 0), produces a fatal error at run time. If umask(2) is not implemented and you are not trying to restrict access for yourself, returns `undef`.

Remember that a umask is a number, usually given in octal; it is *not* a string of octal digits. See also */oct*, if all you have is a string.

undef EXPR

undef Undefines the value of EXPR, which must be an lvalue. Use only on a scalar value, an array (using `@`), a hash (using `%`), a subroutine (using `&`) , or a typeglob (using <*). (Saying `undef $hash{$key}` will probably not do what you expect on most predefined variables or DBM list values, so don't do that; see *delete*.) Always returns the undefined value. You can omit the EXPR, in which case nothing is undefined, but you still get an undefined value that you could, for instance, return from a subroutine, assign to a variable or pass as a parameter. Examples:

```
undef $foo;
undef $bar{'blurfl'};      # Compare to: delete $bar{'blurfl'};
undef @ary;
undef %hash;
undef &mysub;
undef *xyz;       # destroys $xyz, @xyz, %xyz, &xyz, etc.
return (wantarray ? (undef, $errmsg) : undef) if $they_blew_it;
select undef, undef, undef, 0.25;
($a, $b, undef, $c) = &foo;       # Ignore third value returned
```

Note that this is a unary operator, not a list operator.

unlink LIST

unlink Deletes a list of files. Returns the number of files successfully deleted.

```
$cnt = unlink 'a', 'b', 'c';
unlink @goners;
unlink <*.bak>;
```

Note: `unlink` will not delete directories unless you are superuser and the **-U** flag is supplied to Perl. Even if these conditions are met, be warned that unlinking a directory can inflict damage on your filesystem. Use `rmdir` instead.

If LIST is omitted, uses `$_`.

unpack TEMPLATE,EXPR

`unpack` does the reverse of `pack`: it takes a string and expands it out into a list of values. (In scalar context, it returns merely the first value produced.)

The string is broken into chunks described by the TEMPLATE. Each chunk is converted separately to a value. Typically, either the string is a result of `pack`, or the bytes of the string represent a C structure of some kind.

The TEMPLATE has the same format as in the `pack` function. Here's a subroutine that does substring:

```
sub substr {
    my($what,$where,$howmuch) = @_;
    unpack("x$where a$howmuch", $what);
}
```

and then there's

```
sub ordinal { unpack("c",$_[0]); } # same as ord()
```

In addition to fields allowed in `pack()`, you may prefix a field with a %<number to indicate that you want a <number−bit checksum of the items instead of the items themselves. Default is a 16−bit checksum. Checksum is calculated by summing numeric values of expanded values (for string fields the sum of `ord($char)` is taken, for bit fields the sum of zeroes and ones).

For example, the following computes the same number as the System V sum program:

```
$checksum = do {
    local $/;  # slurp!
    unpack("%32C*",<>) % 65535;
};
```

The following efficiently counts the number of set bits in a bit vector:

```
$setbits = unpack("%32b*", $selectmask);
```

The `p` and `P` formats should be used with care. Since Perl has no way of checking whether the value passed to `unpack()` corresponds to a valid memory location, passing a pointer value that's not known to be valid is likely to have disastrous consequences.

If the repeat count of a field is larger than what the remainder of the input string allows, repeat count is decreased. If the input string is longer than one described by the TEMPLATE, the rest is ignored.

See */pack* for more examples and notes.

untie VARIABLE

Breaks the binding between a variable and a package. (See `tie`.)

unshift ARRAY,LIST

Does the opposite of a `shift`. Or the opposite of a `push`, depending on how you look at it. Prepends list to the front of the array, and returns the new number of elements in the array.

```
unshift(ARGV, '-e') unless $ARGV[0] =~ /^-/;
```

Note the LIST is prepended whole, not one element at a time, so the prepended elements stay in the same order. Use `reverse` to do the reverse.

use Module VERSION LIST
use Module VERSION
use Module LIST
use Module
use VERSION

Imports some semantics into the current package from the named module, generally by aliasing certain subroutine or variable names into your package. It is exactly equivalent to

```
BEGIN { require Module; import Module LIST; }
```

except that Module *must* be a bareword.

VERSION, which can be specified as a literal of the form v5.6.1, demands that the current version of Perl (`$^V` or `$PERL_VERSION`) be at least as recent as that version. (For compatibility with older versions of Perl, a numeric literal will also be interpreted as VERSION.) If the version of the running Perl interpreter is less than VERSION, then an error message is printed and Perl exits immediately without attempting to parse the rest of the file. Compare with */require*, which can do a similar check at run time.

```
use v5.6.1;         # compile time version check
use 5.6.1;          # ditto
use 5.005_03;       # float version allowed for compatibility
```

This is often useful if you need to check the current Perl version before `use`ing library modules

that have changed in incompatible ways from older versions of Perl. (We try not to do this more than we have to.)

The BEGIN forces the require and import to happen at compile time. The require makes sure the module is loaded into memory if it hasn't been yet. The import is not a builtin—it's just an ordinary static method call into the Module package to tell the module to import the list of features back into the current package. The module can implement its import method any way it likes, though most modules just choose to derive their import method via inheritance from the Exporter class that is defined in the Exporter module. See *Exporter*. If no import method can be found then the call is skipped.

If you do not want to call the package's import method (for instance, to stop your namespace from being altered), explicitly supply the empty list:

```
use Module ();
```

That is exactly equivalent to

```
BEGIN { require Module }
```

If the VERSION argument is present between Module and LIST, then the use will call the VERSION method in class Module with the given version as an argument. The default VERSION method, inherited from the UNIVERSAL class, croaks if the given version is larger than the value of the variable $Module::VERSION.

Again, there is a distinction between omitting LIST (import called with no arguments) and an explicit empty LIST () (import not called). Note that there is no comma after VERSION!

Because this is a wide−open interface, pragmas (compiler directives) are also implemented this way. Currently implemented pragmas are:

```
use constant;
use diagnostics;
use integer;
use sigtrap  qw(SEGV BUS);
use strict   qw(subs vars refs);
use subs     qw(afunc blurfl);
use warnings qw(all);
```

Some of these pseudo−modules import semantics into the current block scope (like strict or integer, unlike ordinary modules, which import symbols into the current package (which are effective through the end of the file).

There's a corresponding no command that unimports meanings imported by use, i.e., it calls unimport Module LIST instead of import.

```
no integer;
no strict 'refs';
no warnings;
```

If no unimport method can be found the call fails with a fatal error.

See *perlmod* for a list of standard modules and pragmas. See *perlrun* for the −M and −m command−line options to perl that give use functionality from the command−line.

utime LIST

Changes the access and modification times on each file of a list of files. The first two elements of the list must be the NUMERICAL access and modification times, in that order. Returns the number of files successfully changed. The inode change time of each file is set to the current time. This code has the same effect as the touch command if the files already exist:

```
#!/usr/bin/perl
```

```
$now = time;
utime $now, $now, @ARGV;
```

values HASH

Returns a list consisting of all the values of the named hash. (In a scalar context, returns the number of values.) The values are returned in an apparently random order. The actual random order is subject to change in future versions of perl, but it is guaranteed to be the same order as either the `keys` or `each` function would produce on the same (unmodified) hash.

Note that the values are not copied, which means modifying them will modify the contents of the hash:

```
for (values %hash)      { s/foo/bar/g }   # modifies %hash values
for (@hash{keys %hash}) { s/foo/bar/g }   # same
```

As a side effect, calling `values()` resets the HASH's internal iterator. See also `keys`, `each`, and `sort`.

vec EXPR,OFFSET,BITS

Treats the string in EXPR as a bit vector made up of elements of width BITS, and returns the value of the element specified by OFFSET as an unsigned integer. BITS therefore specifies the number of bits that are reserved for each element in the bit vector. This must be a power of two from 1 to 32 (or 64, if your platform supports that).

If BITS is 8, "elements" coincide with bytes of the input string.

If BITS is 16 or more, bytes of the input string are grouped into chunks of size BITS/8, and each group is converted to a number as with `pack()/unpack()` with big–endian formats `n`/`N` (and analogously for BITS==64). See *"pack"* for details.

If bits is 4 or less, the string is broken into bytes, then the bits of each byte are broken into 8/BITS groups. Bits of a byte are numbered in a little–endian–ish way, as in `0x01`, `0x02`, `0x04`, `0x08`, `0x10`, `0x20`, `0x40`, `0x80`. For example, breaking the single input byte `chr(0x36)` into two groups gives a list `(0x6, 0x3)`; breaking it into 4 groups gives `(0x2, 0x1, 0x3, 0x0)`.

`vec` may also be assigned to, in which case parentheses are needed to give the expression the correct precedence as in

```
vec($image, $max_x * $x + $y, 8) = 3;
```

If the selected element is outside the string, the value 0 is returned. If an element off the end of the string is written to, Perl will first extend the string with sufficiently many zero bytes. It is an error to try to write off the beginning of the string (i.e. negative OFFSET).

The string should not contain any character with the value 255 (which can only happen if you're using UTF8 encoding). If it does, it will be treated as something which is not UTF8 encoded. When the `vec` was assigned to, other parts of your program will also no longer consider the string to be UTF8 encoded. In other words, if you do have such characters in your string, `vec()` will operate on the actual byte string, and not the conceptual character string.

Strings created with `vec` can also be manipulated with the logical operators `|`, `&`, `^`, and `~`. These operators will assume a bit vector operation is desired when both operands are strings. See *Bitwise String Operators in perlop*.

The following code will build up an ASCII string saying `'PerlPerlPerl'`. The comments show the string after each step. Note that this code works in the same way on big–endian or little–endian machines.

```
my $foo = '';
vec($foo,  0, 32) = 0x5065726C;     # 'Perl'
```

```
# $foo eq "Perl" eq "\x50\x65\x72\x6C", 32 bits
print vec($foo, 0, 8);      # prints 80 == 0x50 == ord('P')

vec($foo,  2, 16) = 0x5065;         # 'PerlPe'
vec($foo,  3, 16) = 0x726C;         # 'PerlPerl'
vec($foo,  8,  8) = 0x50;           # 'PerlPerlP'
vec($foo,  9,  8) = 0x65;           # 'PerlPerlPe'
vec($foo, 20,  4) = 2;              # 'PerlPerlPe'   . "\x02"
vec($foo, 21,  4) = 7;              # 'PerlPerlPer'
                                    # 'r' is "\x72"
vec($foo, 45,  2) = 3;              # 'PerlPerlPer'  . "\x0c"
vec($foo, 93,  1) = 1;              # 'PerlPerlPer'  . "\x2c"
vec($foo, 94,  1) = 1;              # 'PerlPerlPerl'
                                    # 'l' is "\x6c"
```

To transform a bit vector into a string or list of 0's and 1's, use these:

```
$bits = unpack("b*", $vector);
@bits = split(//, unpack("b*", $vector));
```

If you know the exact length in bits, it can be used in place of the `*`.

Here is an example to illustrate how the bits actually fall in place:

```
#!/usr/bin/perl -wl

print <<'EOT';
                                  0         1         2         3
                    unpack("V",$_) 01234567890123456789012345678901
------------------------------------------------------------------
EOT

for $w (0..3) {
    $width = 2**$w;
    for ($shift=0; $shift < $width; ++$shift) {
        for ($off=0; $off < 32/$width; ++$off) {
            $str = pack("B*", "0"x32);
            $bits = (1<<$shift);
            vec($str, $off, $width) = $bits;
            $res = unpack("b*",$str);
            $val = unpack("V", $str);
            write;
        }
    }
}

format STDOUT =
vec($_,@#,@#) = @<< == @######### @>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
$off, $width, $bits, $val, $res
.
__END__
```

Regardless of the machine architecture on which it is run, the above example should print the following table:

```
                                  0         1         2         3
                    unpack("V",$_) 01234567890123456789012345678901
------------------------------------------------------------------
vec($_, 0, 1) = 1   ==          1 10000000000000000000000000000000
vec($_, 1, 1) = 1   ==          2 01000000000000000000000000000000
```

```
vec($_, 2, 1) = 1   ==          4 00100000000000000000000000000000
vec($_, 3, 1) = 1   ==          8 00010000000000000000000000000000
vec($_, 4, 1) = 1   ==         16 00001000000000000000000000000000
vec($_, 5, 1) = 1   ==         32 00000100000000000000000000000000
vec($_, 6, 1) = 1   ==         64 00000010000000000000000000000000
vec($_, 7, 1) = 1   ==        128 00000001000000000000000000000000
vec($_, 8, 1) = 1   ==        256 00000000100000000000000000000000
vec($_, 9, 1) = 1   ==        512 00000000010000000000000000000000
vec($_,10, 1) = 1   ==       1024 00000000001000000000000000000000
vec($_,11, 1) = 1   ==       2048 00000000000100000000000000000000
vec($_,12, 1) = 1   ==       4096 00000000000010000000000000000000
vec($_,13, 1) = 1   ==       8192 00000000000001000000000000000000
vec($_,14, 1) = 1   ==      16384 00000000000000100000000000000000
vec($_,15, 1) = 1   ==      32768 00000000000000010000000000000000
vec($_,16, 1) = 1   ==      65536 00000000000000001000000000000000
vec($_,17, 1) = 1   ==     131072 00000000000000000100000000000000
vec($_,18, 1) = 1   ==     262144 00000000000000000010000000000000
vec($_,19, 1) = 1   ==     524288 00000000000000000001000000000000
vec($_,20, 1) = 1   ==    1048576 00000000000000000000100000000000
vec($_,21, 1) = 1   ==    2097152 00000000000000000000010000000000
vec($_,22, 1) = 1   ==    4194304 00000000000000000000001000000000
vec($_,23, 1) = 1   ==    8388608 00000000000000000000000100000000
vec($_,24, 1) = 1   ==   16777216 00000000000000000000000010000000
vec($_,25, 1) = 1   ==   33554432 00000000000000000000000001000000
vec($_,26, 1) = 1   ==   67108864 00000000000000000000000000100000
vec($_,27, 1) = 1   ==  134217728 00000000000000000000000000010000
vec($_,28, 1) = 1   ==  268435456 00000000000000000000000000001000
vec($_,29, 1) = 1   ==  536870912 00000000000000000000000000000100
vec($_,30, 1) = 1   == 1073741824 00000000000000000000000000000010
vec($_,31, 1) = 1   == 2147483648 00000000000000000000000000000001
vec($_, 0, 2) = 1   ==          1 10000000000000000000000000000000
vec($_, 1, 2) = 1   ==          4 00100000000000000000000000000000
vec($_, 2, 2) = 1   ==         16 00001000000000000000000000000000
vec($_, 3, 2) = 1   ==         64 00000010000000000000000000000000
vec($_, 4, 2) = 1   ==        256 00000000100000000000000000000000
vec($_, 5, 2) = 1   ==       1024 00000000001000000000000000000000
vec($_, 6, 2) = 1   ==       4096 00000000000010000000000000000000
vec($_, 7, 2) = 1   ==      16384 00000000000000100000000000000000
vec($_, 8, 2) = 1   ==      65536 00000000000000001000000000000000
vec($_, 9, 2) = 1   ==     262144 00000000000000000010000000000000
vec($_,10, 2) = 1   ==    1048576 00000000000000000000100000000000
vec($_,11, 2) = 1   ==    4194304 00000000000000000000001000000000
vec($_,12, 2) = 1   ==   16777216 00000000000000000000000010000000
vec($_,13, 2) = 1   ==   67108864 00000000000000000000000000100000
vec($_,14, 2) = 1   ==  268435456 00000000000000000000000000001000
vec($_,15, 2) = 1   == 1073741824 00000000000000000000000000000010
vec($_, 0, 2) = 2   ==          2 01000000000000000000000000000000
vec($_, 1, 2) = 2   ==          8 00010000000000000000000000000000
vec($_, 2, 2) = 2   ==         32 00000100000000000000000000000000
vec($_, 3, 2) = 2   ==        128 00000001000000000000000000000000
vec($_, 4, 2) = 2   ==        512 00000000010000000000000000000000
vec($_, 5, 2) = 2   ==       2048 00000000000100000000000000000000
vec($_, 6, 2) = 2   ==       8192 00000000000001000000000000000000
vec($_, 7, 2) = 2   ==      32768 00000000000000010000000000000000
```

```
vec($_, 8, 2) = 2   ==     131072 00000000000000000100000000000000
vec($_, 9, 2) = 2   ==     524288 00000000000000000001000000000000
vec($_,10, 2) = 2   ==    2097152 00000000000000000000010000000000
vec($_,11, 2) = 2   ==    8388608 00000000000000000000000100000000
vec($_,12, 2) = 2   ==   33554432 00000000000000000000000001000000
vec($_,13, 2) = 2   ==  134217728 00000000000000000000000000010000
vec($_,14, 2) = 2   ==  536870912 00000000000000000000000000000100
vec($_,15, 2) = 2   == 2147483648 00000000000000000000000000000001
vec($_, 0, 4) = 1   ==          1 10000000000000000000000000000000
vec($_, 1, 4) = 1   ==         16 00001000000000000000000000000000
vec($_, 2, 4) = 1   ==        256 00000000100000000000000000000000
vec($_, 3, 4) = 1   ==       4096 00000000000010000000000000000000
vec($_, 4, 4) = 1   ==      65536 00000000000000001000000000000000
vec($_, 5, 4) = 1   ==    1048576 00000000000000000000100000000000
vec($_, 6, 4) = 1   ==   16777216 00000000000000000000000010000000
vec($_, 7, 4) = 1   ==  268435456 00000000000000000000000000001000
vec($_, 0, 4) = 2   ==          2 01000000000000000000000000000000
vec($_, 1, 4) = 2   ==         32 00000100000000000000000000000000
vec($_, 2, 4) = 2   ==        512 00000000010000000000000000000000
vec($_, 3, 4) = 2   ==       8192 00000000000001000000000000000000
vec($_, 4, 4) = 2   ==     131072 00000000000000010000000000000000
vec($_, 5, 4) = 2   ==    2097152 00000000000000000000010000000000
vec($_, 6, 4) = 2   ==   33554432 00000000000000000000000001000000
vec($_, 7, 4) = 2   ==  536870912 00000000000000000000000000000100
vec($_, 0, 4) = 4   ==          4 00100000000000000000000000000000
vec($_, 1, 4) = 4   ==         64 00000100000000000000000000000000
vec($_, 2, 4) = 4   ==       1024 00000000001000000000000000000000
vec($_, 3, 4) = 4   ==      16384 00000000000001000000000000000000
vec($_, 4, 4) = 4   ==     262144 00000000000000010000000000000000
vec($_, 5, 4) = 4   ==    4194304 00000000000000000000010000000000
vec($_, 6, 4) = 4   ==   67108864 00000000000000000000000100000000
vec($_, 7, 4) = 4   == 1073741824 00000000000000000000000000000010
vec($_, 0, 4) = 8   ==          8 00010000000000000000000000000000
vec($_, 1, 4) = 8   ==        128 00000001000000000000000000000000
vec($_, 2, 4) = 8   ==       2048 00000000000100000000000000000000
vec($_, 3, 4) = 8   ==      32768 00000000000000010000000000000000
vec($_, 4, 4) = 8   ==     524288 00000000000000000001000000000000
vec($_, 5, 4) = 8   ==    8388608 00000000000000000000000100000000
vec($_, 6, 4) = 8   ==  134217728 00000000000000000000000000010000
vec($_, 7, 4) = 8   == 2147483648 00000000000000000000000000000001
vec($_, 0, 8) = 1   ==          1 10000000000000000000000000000000
vec($_, 1, 8) = 1   ==        256 00000000100000000000000000000000
vec($_, 2, 8) = 1   ==      65536 00000000000000001000000000000000
vec($_, 3, 8) = 1   ==   16777216 00000000000000000000000010000000
vec($_, 0, 8) = 2   ==          2 01000000000000000000000000000000
vec($_, 1, 8) = 2   ==        512 00000000010000000000000000000000
vec($_, 2, 8) = 2   ==     131072 00000000000000010000000000000000
vec($_, 3, 8) = 2   ==   33554432 00000000000000000000000001000000
vec($_, 0, 8) = 4   ==          4 00100000000000000000000000000000
vec($_, 1, 8) = 4   ==       1024 00000000001000000000000000000000
vec($_, 2, 8) = 4   ==     262144 00000000000000010000000000000000
vec($_, 3, 8) = 4   ==   67108864 00000000000000000000000100000000
vec($_, 0, 8) = 8   ==          8 00010000000000000000000000000000
vec($_, 1, 8) = 8   ==       2048 00000000000100000000000000000000
```

```
vec($_, 2, 8) = 8   ==     524288 00000000000000000001000000000000
vec($_, 3, 8) = 8   ==  134217728 00000000000000000000000000010000
vec($_, 0, 8) = 16  ==         16 00001000000000000000000000000000
vec($_, 1, 8) = 16  ==       4096 00000000000010000000000000000000
vec($_, 2, 8) = 16  ==    1048576 00000000000000000001000000000000
vec($_, 3, 8) = 16  ==  268435456 00000000000000000000000000001000
vec($_, 0, 8) = 32  ==         32 00001000000000000000000000000000
vec($_, 1, 8) = 32  ==       8192 00000000000010000000000000000000
vec($_, 2, 8) = 32  ==    2097152 00000000000000000001000000000000
vec($_, 3, 8) = 32  ==  536870912 00000000000000000000000000000100
vec($_, 0, 8) = 64  ==         64 00000010000000000000000000000000
vec($_, 1, 8) = 64  ==      16384 00000000000001000000000000000000
vec($_, 2, 8) = 64  ==    4194304 00000000000000000001000000000000
vec($_, 3, 8) = 64  == 1073741824 00000000000000000000000000000010
vec($_, 0, 8) = 128 ==        128 00000001000000000000000000000000
vec($_, 1, 8) = 128 ==      32768 00000000000000010000000000000000
vec($_, 2, 8) = 128 ==    8388608 00000000000000000000000100000000
vec($_, 3, 8) = 128 == 2147483648 00000000000000000000000000000001
```

wait Behaves like the wait(2) system call on your system: it waits for a child process to terminate and returns the pid of the deceased process, or `-1` if there are no child processes. The status is returned in `$?`. Note that a return value of `-1` could mean that child processes are being automatically reaped, as described in *perlipc*.

waitpid PID,FLAGS

Waits for a particular child process to terminate and returns the pid of the deceased process, or `-1` if there is no such child process. On some systems, a value of 0 indicates that there are processes still running. The status is returned in `$?`. If you say

```
use POSIX ":sys_wait_h";
#...
do {
    $kid = waitpid(-1,&WNOHANG);
} until $kid == -1;
```

then you can do a non–blocking wait for all pending zombie processes. Non–blocking wait is available on machines supporting either the waitpid(2) or wait4(2) system calls. However, waiting for a particular pid with FLAGS of is implemented everywhere. (Perl emulates the system call by remembering the status values of processes that have exited but have not been harvested by the Perl script yet.)

Note that on some systems, a return value of `-1` could mean that child processes are being automatically reaped. See *perlipc* for details, and for other examples.

wantarray

Returns true if the context of the currently executing subroutine is looking for a list value. Returns false if the context is looking for a scalar. Returns the undefined value if the context is looking for no value (void context).

```
return unless defined wantarray;    # don't bother doing more
my @a = complex_calculation();
return wantarray ? @a : "@a";
```

This function should have been named `wantlist()` instead.

warn LIST

Produces a message on STDERR just like `die`, but doesn't exit or throw an exception.

If LIST is empty and `$@` already contains a value (typically from a previous eval) that value is used after appending `"\t...caught"` to `$@`. This is useful for staying almost, but not entirely similar to `die`.

If `$@` is empty then the string `"Warning: Something's wrong"` is used.

No message is printed if there is a `$SIG{__WARN__}` handler installed. It is the handler's responsibility to deal with the message as it sees fit (like, for instance, converting it into a `die`). Most handlers must therefore make arrangements to actually display the warnings that they are not prepared to deal with, by calling `warn` again in the handler. Note that this is quite safe and will not produce an endless loop, since `__WARN__` hooks are not called from inside one.

You will find this behavior is slightly different from that of `$SIG{__DIE__}` handlers (which don't suppress the error text, but can instead call `die` again to change it).

Using a `__WARN__` handler provides a powerful way to silence all warnings (even the so-called mandatory ones). An example:

```
# wipe out *all* compile-time warnings
BEGIN { $SIG{'__WARN__'} = sub { warn $_[0] if $DOWARN } }
my $foo = 10;
my $foo = 20;          # no warning about duplicate my $foo,
                       # but hey, you asked for it!
# no compile-time or run-time warnings before here
$DOWARN = 1;

# run-time warnings enabled after here
warn "\$foo is alive and $foo!";     # does show up
```

See *perlvar* for details on setting `%SIG` entries, and for more examples. See the Carp module for other kinds of warnings using its `carp()` and `cluck()` functions.

write FILEHANDLE
write EXPR
write

Writes a formatted record (possibly multi-line) to the specified FILEHANDLE, using the format associated with that file. By default the format for a file is the one having the same name as the filehandle, but the format for the current output channel (see the `select` function) may be set explicitly by assigning the name of the format to the `$~` variable.

Top of form processing is handled automatically: if there is insufficient room on the current page for the formatted record, the page is advanced by writing a form feed, a special top-of-page format is used to format the new page header, and then the record is written. By default the top-of-page format is the name of the filehandle with "_TOP" appended, but it may be dynamically set to the format of your choice by assigning the name to the `$^` variable while the filehandle is selected. The number of lines remaining on the current page is in variable `$-`, which can be set to to force a new page.

If FILEHANDLE is unspecified, output goes to the current default output channel, which starts out as STDOUT but may be changed by the `select` operator. If the FILEHANDLE is an EXPR, then the expression is evaluated and the resulting string is used to look up the name of the FILEHANDLE at run time. For more on formats, see *perlform*.

Note that write is *not* the opposite of `read`. Unfortunately.

y///

The transliteration operator. Same as `tr///`. See *perlop*.

NAME

perlguts – Introduction to the Perl API

DESCRIPTION

This document attempts to describe how to use the Perl API, as well as containing some info on the basic workings of the Perl core. It is far from complete and probably contains many errors. Please refer any questions or comments to the author below.

Variables

Datatypes

Perl has three typedefs that handle Perl's three main data types:

```
SV  Scalar Value
AV  Array Value
HV  Hash Value
```

Each typedef has specific routines that manipulate the various data types.

What is an "IV"?

Perl uses a special typedef IV which is a simple signed integer type that is guaranteed to be large enough to hold a pointer (as well as an integer). Additionally, there is the UV, which is simply an unsigned IV.

Perl also uses two special typedefs, I32 and I16, which will always be at least 32–bits and 16–bits long, respectively. (Again, there are U32 and U16, as well.)

Working with SVs

An SV can be created and loaded with one command. There are four types of values that can be loaded: an integer value (IV), a double (NV), a string (PV), and another scalar (SV).

The six routines are:

```
SV*  newSViv(IV);
SV*  newSVnv(double);
SV*  newSVpv(const char*, int);
SV*  newSVpvn(const char*, int);
SV*  newSVpvf(const char*, ...);
SV*  newSVsv(SV*);
```

To change the value of an *already–existing* SV, there are seven routines:

```
void  sv_setiv(SV*, IV);
void  sv_setuv(SV*, UV);
void  sv_setnv(SV*, double);
void  sv_setpv(SV*, const char*);
void  sv_setpvn(SV*, const char*, int)
void  sv_setpvf(SV*, const char*, ...);
void  sv_setpvfn(SV*, const char*, STRLEN, va_list *, SV **, I32, bool);
void  sv_setsv(SV*, SV*);
```

Notice that you can choose to specify the length of the string to be assigned by using `sv_setpvn`, `newSVpvn`, or `newSVpv`, or you may allow Perl to calculate the length by using `sv_setpv` or by specifying 0 as the second argument to `newSVpv`. Be warned, though, that Perl will determine the string's length by using `strlen`, which depends on the string terminating with a NUL character.

The arguments of `sv_setpvf` are processed like `sprintf`, and the formatted output becomes the value.

`sv_setpvfn` is an analogue of `vsprintf`, but it allows you to specify either a pointer to a variable argument list or the address and length of an array of SVs. The last argument points to a boolean; on return, if that boolean is true, then locale–specific information has been used to format the string, and the string's contents are therefore untrustworthy (see *perlsec*). This pointer may be NULL if that information is not

important. Note that this function requires you to specify the length of the format.

The `sv_set*()` functions are not generic enough to operate on values that have "magic". See *Magic Virtual Tables* later in this document.

All SVs that contain strings should be terminated with a NUL character. If it is not NUL-terminated there is a risk of core dumps and corruptions from code which passes the string to C functions or system calls which expect a NUL-terminated string. Perl's own functions typically add a trailing NUL for this reason. Nevertheless, you should be very careful when you pass a string stored in an SV to a C function or system call.

To access the actual value that an SV points to, you can use the macros:

```
SvIV(SV*)
SvUV(SV*)
SvNV(SV*)
SvPV(SV*, STRLEN len)
SvPV_nolen(SV*)
```

which will automatically coerce the actual scalar type into an IV, UV, double, or string.

In the `SvPV` macro, the length of the string returned is placed into the variable `len` (this is a macro, so you do *not* use `&len`). If you do not care what the length of the data is, use the `SvPV_nolen` macro. Historically the `SvPV` macro with the global variable `PL_na` has been used in this case. But that can be quite inefficient because `PL_na` must be accessed in thread-local storage in threaded Perl. In any case, remember that Perl allows arbitrary strings of data that may both contain NULs and might not be terminated by a NUL.

Also remember that C doesn't allow you to safely say `foo(SvPV(s, len), len);`. It might work with your compiler, but it won't work for everyone. Break this sort of statement up into separate assignments:

```
SV *s;
STRLEN len;
char * ptr;
ptr = SvPV(s, len);
foo(ptr, len);
```

If you want to know if the scalar value is TRUE, you can use:

```
SvTRUE(SV*)
```

Although Perl will automatically grow strings for you, if you need to force Perl to allocate more memory for your SV, you can use the macro

```
SvGROW(SV*, STRLEN newlen)
```

which will determine if more memory needs to be allocated. If so, it will call the function `sv_grow`. Note that `SvGROW` can only increase, not decrease, the allocated memory of an SV and that it does not automatically add a byte for the a trailing NUL (perl's own string functions typically do `SvGROW(sv, len + 1)`).

If you have an SV and want to know what kind of data Perl thinks is stored in it, you can use the following macros to check the type of SV you have.

```
SvIOK(SV*)
SvNOK(SV*)
SvPOK(SV*)
```

You can get and set the current length of the string stored in an SV with the following macros:

```
SvCUR(SV*)
SvCUR_set(SV*, I32 val)
```

You can also get a pointer to the end of the string stored in the SV with the macro:

```
SvEND(SV*)
```

But note that these last three macros are valid only if `SvPOK()` is true.

If you want to append something to the end of string stored in an `SV*`, you can use the following functions:

```
void  sv_catpv(SV*, const char*);
void  sv_catpvn(SV*, const char*, STRLEN);
void  sv_catpvf(SV*, const char*, ...);
void  sv_catpvfn(SV*, const char*, STRLEN, va_list *, SV **, I32, bool);
void  sv_catsv(SV*, SV*);
```

The first function calculates the length of the string to be appended by using `strlen`. In the second, you specify the length of the string yourself. The third function processes its arguments like `sprintf` and appends the formatted output. The fourth function works like `vsprintf`. You can specify the address and length of an array of SVs instead of the va_list argument. The fifth function extends the string stored in the first SV with the string stored in the second SV. It also forces the second SV to be interpreted as a string.

The `sv_cat*()` functions are not generic enough to operate on values that have "magic". See *Magic Virtual Tables* later in this document.

If you know the name of a scalar variable, you can get a pointer to its SV by using the following:

```
SV*  get_sv("package::varname", FALSE);
```

This returns NULL if the variable does not exist.

If you want to know if this variable (or any other SV) is actually `defined`, you can call:

```
SvOK(SV*)
```

The scalar `undef` value is stored in an SV instance called `PL_sv_undef`. Its address can be used whenever an `SV*` is needed.

There are also the two values `PL_sv_yes` and `PL_sv_no`, which contain Boolean TRUE and FALSE values, respectively. Like `PL_sv_undef`, their addresses can be used whenever an `SV*` is needed.

Do not be fooled into thinking that `(SV *) 0` is the same as `&PL_sv_undef`. Take this code:

```
SV* sv = (SV*) 0;
if (I-am-to-return-a-real-value) {
        sv = sv_2mortal(newSViv(42));
}
sv_setsv(ST(0), sv);
```

This code tries to return a new SV (which contains the value 42) if it should return a real value, or undef otherwise. Instead it has returned a NULL pointer which, somewhere down the line, will cause a segmentation violation, bus error, or just weird results. Change the zero to `&PL_sv_undef` in the first line and all will be well.

To free an SV that you've created, call `SvREFCNT_dec(SV*)`. Normally this call is not necessary (see *Reference Counts and Mortality*).

Offsets

Perl provides the function `sv_chop` to efficiently remove characters from the beginning of a string; you give it an SV and a pointer to somewhere inside the the PV, and it discards everything before the pointer. The efficiency comes by means of a little hack: instead of actually removing the characters, `sv_chop` sets the flag `OOK` (offset OK) to signal to other functions that the offset hack is in effect, and it puts the number of bytes chopped off into the IV field of the SV. It then moves the PV pointer (called `SvPVX`) forward that many bytes, and adjusts `SvCUR` and `SvLEN`.

Hence, at this point, the start of the buffer that we allocated lives at `SvPVX(sv) - SvIV(sv)` in memory and the PV pointer is pointing into the middle of this allocated storage.

This is best demonstrated by example:

```
% ./perl -Ilib -MDevel::Peek -le '$a="12345"; $a=~s/.//; Dump($a)'
SV = PVIV(0x8128450) at 0x81340f0
  REFCNT = 1
  FLAGS = (POK,OOK,pPOK)
  IV = 1  (OFFSET)
  PV = 0x8135781 ( "1" . ) "2345"\0
  CUR = 4
  LEN = 5
```

Here the number of bytes chopped off (1) is put into IV, and `Devel::Peek::Dump` helpfully reminds us that this is an offset. The portion of the string between the "real" and the "fake" beginnings is shown in parentheses, and the values of `SvCUR` and `SvLEN` reflect the fake beginning, not the real one.

What's Really Stored in an SV?

Recall that the usual method of determining the type of scalar you have is to use `Sv*OK` macros. Because a scalar can be both a number and a string, usually these macros will always return TRUE and calling the `Sv*V` macros will do the appropriate conversion of string to integer/double or integer/double to string.

If you *really* need to know if you have an integer, double, or string pointer in an SV, you can use the following three macros instead:

```
SvIOKp(SV*)
SvNOKp(SV*)
SvPOKp(SV*)
```

These will tell you if you truly have an integer, double, or string pointer stored in your SV. The "p" stands for private.

In general, though, it's best to use the `Sv*V` macros.

Working with AVs

There are two ways to create and load an AV. The first method creates an empty AV:

```
AV*  newAV();
```

The second method both creates the AV and initially populates it with SVs:

```
AV*  av_make(I32 num, SV **ptr);
```

The second argument points to an array containing `num` `SV*`'s. Once the AV has been created, the SVs can be destroyed, if so desired.

Once the AV has been created, the following operations are possible on AVs:

```
void  av_push(AV*, SV*);
SV*   av_pop(AV*);
SV*   av_shift(AV*);
void  av_unshift(AV*, I32 num);
```

These should be familiar operations, with the exception of `av_unshift`. This routine adds `num` elements at the front of the array with the `undef` value. You must then use `av_store` (described below) to assign values to these new elements.

Here are some other functions:

```
I32   av_len(AV*);
SV**  av_fetch(AV*, I32 key, I32 lval);
SV**  av_store(AV*, I32 key, SV* val);
```

The av_len function returns the highest index value in array (just like $#array in Perl). If the array is empty, -1 is returned. The av_fetch function returns the value at index key, but if lval is non-zero, then av_fetch will store an undef value at that index. The av_store function stores the value val at index key, and does not increment the reference count of val. Thus the caller is responsible for taking care of that, and if av_store returns NULL, the caller will have to decrement the reference count to avoid a memory leak. Note that av_fetch and av_store both return SV**'s, not SV*'s as their return value.

```
void  av_clear(AV*);
void  av_undef(AV*);
void  av_extend(AV*, I32 key);
```

The av_clear function deletes all the elements in the AV* array, but does not actually delete the array itself. The av_undef function will delete all the elements in the array plus the array itself. The av_extend function extends the array so that it contains at least key+1 elements. If key+1 is less than the currently allocated length of the array, then nothing is done.

If you know the name of an array variable, you can get a pointer to its AV by using the following:

```
AV*  get_av("package::varname", FALSE);
```

This returns NULL if the variable does not exist.

See *Understanding the Magic of Tied Hashes and Arrays* for more information on how to use the array access functions on tied arrays.

Working with HVs

To create an HV, you use the following routine:

```
HV*  newHV();
```

Once the HV has been created, the following operations are possible on HVs:

```
SV**  hv_store(HV*, const char* key, U32 klen, SV* val, U32 hash);
SV**  hv_fetch(HV*, const char* key, U32 klen, I32 lval);
```

The klen parameter is the length of the key being passed in (Note that you cannot pass 0 in as a value of klen to tell Perl to measure the length of the key). The val argument contains the SV pointer to the scalar being stored, and hash is the precomputed hash value (zero if you want hv_store to calculate it for you). The lval parameter indicates whether this fetch is actually a part of a store operation, in which case a new undefined value will be added to the HV with the supplied key and hv_fetch will return as if the value had already existed.

Remember that hv_store and hv_fetch return SV**'s and not just SV*. To access the scalar value, you must first dereference the return value. However, you should check to make sure that the return value is not NULL before dereferencing it.

These two functions check if a hash table entry exists, and deletes it.

```
bool  hv_exists(HV*, const char* key, U32 klen);
SV*   hv_delete(HV*, const char* key, U32 klen, I32 flags);
```

If flags does not include the G_DISCARD flag then hv_delete will create and return a mortal copy of the deleted value.

And more miscellaneous functions:

```
void   hv_clear(HV*);
void   hv_undef(HV*);
```

Like their AV counterparts, hv_clear deletes all the entries in the hash table but does not actually delete the hash table. The hv_undef deletes both the entries and the hash table itself.

Perl keeps the actual data in linked list of structures with a typedef of HE. These contain the actual key and value pointers (plus extra administrative overhead). The key is a string pointer; the value is an SV*.

However, once you have an HE*, to get the actual key and value, use the routines specified below.

```
I32     hv_iterinit(HV*);
         /* Prepares starting point to traverse hash table */
HE*     hv_iternext(HV*);
         /* Get the next entry, and return a pointer to a
            structure that has both the key and value */
char*   hv_iterkey(HE* entry, I32* retlen);
         /* Get the key from an HE structure and also return
            the length of the key string */
SV*     hv_iterval(HV*, HE* entry);
         /* Return a SV pointer to the value of the HE
            structure */
SV*     hv_iternextsv(HV*, char** key, I32* retlen);
         /* This convenience routine combines hv_iternext,
            hv_iterkey, and hv_iterval.  The key and retlen
            arguments are return values for the key and its
            length.  The value is returned in the SV* argument */
```

If you know the name of a hash variable, you can get a pointer to its HV by using the following:

```
HV*  get_hv("package::varname", FALSE);
```

This returns NULL if the variable does not exist.

The hash algorithm is defined in the PERL_HASH(hash, key, klen) macro:

```
hash = 0;
while (klen--)
    hash = (hash * 33) + *key++;
hash = hash + (hash >> 5);                  /* after 5.6 */
```

The last step was added in version 5.6 to improve distribution of lower bits in the resulting hash value.

See *Understanding the Magic of Tied Hashes and Arrays* for more information on how to use the hash access functions on tied hashes.

Hash API Extensions

Beginning with version 5.004, the following functions are also supported:

```
HE*     hv_fetch_ent  (HV* tb, SV* key, I32 lval, U32 hash);
HE*     hv_store_ent  (HV* tb, SV* key, SV* val, U32 hash);

bool    hv_exists_ent (HV* tb, SV* key, U32 hash);
SV*     hv_delete_ent (HV* tb, SV* key, I32 flags, U32 hash);

SV*     hv_iterkeysv  (HE* entry);
```

Note that these functions take SV* keys, which simplifies writing of extension code that deals with hash structures. These functions also allow passing of SV* keys to tie functions without forcing you to stringify the keys (unlike the previous set of functions).

They also return and accept whole hash entries (HE*), making their use more efficient (since the hash number for a particular string doesn't have to be recomputed every time). See *perlapi* for detailed descriptions.

The following macros must always be used to access the contents of hash entries. Note that the arguments to these macros must be simple variables, since they may get evaluated more than once. See *perlapi* for detailed descriptions of these macros.

```
HePV(HE* he, STRLEN len)
HeVAL(HE* he)
```

```
HeHASH(HE* he)
HeSVKEY(HE* he)
HeSVKEY_force(HE* he)
HeSVKEY_set(HE* he, SV* sv)
```

These two lower level macros are defined, but must only be used when dealing with keys that are not SV*s:

```
HeKEY(HE* he)
HeKLEN(HE* he)
```

Note that both hv_store and hv_store_ent do not increment the reference count of the stored val, which is the caller's responsibility. If these functions return a NULL value, the caller will usually have to decrement the reference count of val to avoid a memory leak.

References

References are a special type of scalar that point to other data types (including references).

To create a reference, use either of the following functions:

```
SV* newRV_inc((SV*) thing);
SV* newRV_noinc((SV*) thing);
```

The thing argument can be any of an SV*, AV*, or HV*. The functions are identical except that newRV_inc increments the reference count of the thing, while newRV_noinc does not. For historical reasons, newRV is a synonym for newRV_inc.

Once you have a reference, you can use the following macro to dereference the reference:

```
SvRV(SV*)
```

then call the appropriate routines, casting the returned SV* to either an AV* or HV*, if required.

To determine if an SV is a reference, you can use the following macro:

```
SvROK(SV*)
```

To discover what type of value the reference refers to, use the following macro and then check the return value.

```
SvTYPE(SvRV(SV*))
```

The most useful types that will be returned are:

```
SVt_IV    Scalar
SVt_NV    Scalar
SVt_PV    Scalar
SVt_RV    Scalar
SVt_PVAV  Array
SVt_PVHV  Hash
SVt_PVCV  Code
SVt_PVGV  Glob (possible a file handle)
SVt_PVMG  Blessed or Magical Scalar

See the sv.h header file for more details.
```

Blessed References and Class Objects

References are also used to support object−oriented programming. In the OO lexicon, an object is simply a reference that has been blessed into a package (or class). Once blessed, the programmer may now use the reference to access the various methods in the class.

A reference can be blessed into a package with the following function:

```
SV* sv_bless(SV* sv, HV* stash);
```

The sv argument must be a reference. The stash argument specifies which class the reference will belong to. See *Stashes and Globs* for information on converting class names into stashes.

/* Still under construction */

Upgrades rv to reference if not already one. Creates new SV for rv to point to. If classname is non–null, the SV is blessed into the specified class. SV is returned.

```
SV* newSVrv(SV* rv, const char* classname);
```

Copies integer or double into an SV whose reference is rv. SV is blessed if classname is non–null.

```
SV* sv_setref_iv(SV* rv, const char* classname, IV iv);
SV* sv_setref_nv(SV* rv, const char* classname, NV iv);
```

Copies the pointer value (*the address, not the string!*) into an SV whose reference is rv. SV is blessed if classname is non–null.

```
SV* sv_setref_pv(SV* rv, const char* classname, PV iv);
```

Copies string into an SV whose reference is rv. Set length to 0 to let Perl calculate the string length. SV is blessed if classname is non–null.

```
SV* sv_setref_pvn(SV* rv, const char* classname, PV iv, STRLEN length);
```

Tests whether the SV is blessed into the specified class. It does not check inheritance relationships.

```
int  sv_isa(SV* sv, const char* name);
```

Tests whether the SV is a reference to a blessed object.

```
int  sv_isobject(SV* sv);
```

Tests whether the SV is derived from the specified class. SV can be either a reference to a blessed object or a string containing a class name. This is the function implementing the UNIVERSAL::isa functionality.

```
bool sv_derived_from(SV* sv, const char* name);
```

To check if you've got an object derived from a specific class you have to write:

```
if (sv_isobject(sv) && sv_derived_from(sv, class)) { ... }
```

Creating New Variables

To create a new Perl variable with an undef value which can be accessed from your Perl script, use the following routines, depending on the variable type.

```
SV*  get_sv("package::varname", TRUE);
AV*  get_av("package::varname", TRUE);
HV*  get_hv("package::varname", TRUE);
```

Notice the use of TRUE as the second parameter. The new variable can now be set, using the routines appropriate to the data type.

There are additional macros whose values may be bitwise OR'ed with the TRUE argument to enable certain extra features. Those bits are:

```
GV_ADDMULTI Marks the variable as multiply defined, thus preventing the
            "Name <varname> used only once: possible typo" warning.
GV_ADDWARN  Issues the warning "Had to create <varname> unexpectedly" if
            the variable did not exist before the function was called.
```

If you do not specify a package name, the variable is created in the current package.

Reference Counts and Mortality

Perl uses an reference count–driven garbage collection mechanism. SVs, AVs, or HVs (xV for short in the following) start their life with a reference count of 1. If the reference count of an xV ever drops to 0, then it

will be destroyed and its memory made available for reuse.

This normally doesn't happen at the Perl level unless a variable is undef'ed or the last variable holding a reference to it is changed or overwritten. At the internal level, however, reference counts can be manipulated with the following macros:

```
int SvREFCNT(SV* sv);
SV* SvREFCNT_inc(SV* sv);
void SvREFCNT_dec(SV* sv);
```

However, there is one other function which manipulates the reference count of its argument. The newRV_inc function, you will recall, creates a reference to the specified argument. As a side effect, it increments the argument's reference count. If this is not what you want, use newRV_noinc instead.

For example, imagine you want to return a reference from an XSUB function. Inside the XSUB routine, you create an SV which initially has a reference count of one. Then you call newRV_inc, passing it the just–created SV. This returns the reference as a new SV, but the reference count of the SV you passed to newRV_inc has been incremented to two. Now you return the reference from the XSUB routine and forget about the SV. But Perl hasn't! Whenever the returned reference is destroyed, the reference count of the original SV is decreased to one and nothing happens. The SV will hang around without any way to access it until Perl itself terminates. This is a memory leak.

The correct procedure, then, is to use newRV_noinc instead of newRV_inc. Then, if and when the last reference is destroyed, the reference count of the SV will go to zero and it will be destroyed, stopping any memory leak.

There are some convenience functions available that can help with the destruction of xVs. These functions introduce the concept of "mortality". An xV that is mortal has had its reference count marked to be decremented, but not actually decremented, until "a short time later". Generally the term "short time later" means a single Perl statement, such as a call to an XSUB function. The actual determinant for when mortal xVs have their reference count decremented depends on two macros, SAVETMPS and FREETMPS. See *perlcall* and *perlxs* for more details on these macros.

"Mortalization" then is at its simplest a deferred SvREFCNT_dec. However, if you mortalize a variable twice, the reference count will later be decremented twice.

You should be careful about creating mortal variables. Strange things can happen if you make the same value mortal within multiple contexts, or if you make a variable mortal multiple times.

To create a mortal variable, use the functions:

```
SV*  sv_newmortal()
SV*  sv_2mortal(SV*)
SV*  sv_mortalcopy(SV*)
```

The first call creates a mortal SV, the second converts an existing SV to a mortal SV (and thus defers a call to SvREFCNT_dec), and the third creates a mortal copy of an existing SV.

The mortal routines are not just for SVs — AVs and HVs can be made mortal by passing their address (type–casted to SV*) to the sv_2mortal or sv_mortalcopy routines.

Stashes and Globs

A "stash" is a hash that contains all of the different objects that are contained within a package. Each key of the stash is a symbol name (shared by all the different types of objects that have the same name), and each value in the hash table is a GV (Glob Value). This GV in turn contains references to the various objects of that name, including (but not limited to) the following:

```
Scalar Value
Array Value
Hash Value
I/O Handle
```

```
Format
Subroutine
```

There is a single stash called "PL_defstash" that holds the items that exist in the "main" package. To get at the items in other packages, append the string "::" to the package name. The items in the "Foo" package are in the stash "Foo::" in PL_defstash. The items in the "Bar::Baz" package are in the stash "Baz::" in "Bar::"'s stash.

To get the stash pointer for a particular package, use the function:

```
HV*  gv_stashpv(const char* name, I32 create)
HV*  gv_stashsv(SV*, I32 create)
```

The first function takes a literal string, the second uses the string stored in the SV. Remember that a stash is just a hash table, so you get back an `HV*`. The `create` flag will create a new package if it is set.

The name that `gv_stash*v` wants is the name of the package whose symbol table you want. The default package is called `main`. If you have multiply nested packages, pass their names to `gv_stash*v`, separated by `::` as in the Perl language itself.

Alternately, if you have an SV that is a blessed reference, you can find out the stash pointer by using:

```
HV*  SvSTASH(SvRV(SV*));
```

then use the following to get the package name itself:

```
char*  HvNAME(HV* stash);
```

If you need to bless or re–bless an object you can use the following function:

```
SV*  sv_bless(SV*, HV* stash)
```

where the first argument, an `SV*`, must be a reference, and the second argument is a stash. The returned `SV*` can now be used in the same way as any other SV.

For more information on references and blessings, consult *perlref*.

Double–Typed SVs

Scalar variables normally contain only one type of value, an integer, double, pointer, or reference. Perl will automatically convert the actual scalar data from the stored type into the requested type.

Some scalar variables contain more than one type of scalar data. For example, the variable `$!` contains either the numeric value of `errno` or its string equivalent from either `strerror` or `sys_errlist[]`.

To force multiple data values into an SV, you must do two things: use the `sv_set*v` routines to add the additional scalar type, then set a flag so that Perl will believe it contains more than one type of data. The four macros to set the flags are:

```
SvIOK_on
SvNOK_on
SvPOK_on
SvROK_on
```

The particular macro you must use depends on which `sv_set*v` routine you called first. This is because every `sv_set*v` routine turns on only the bit for the particular type of data being set, and turns off all the rest.

For example, to create a new Perl variable called "dberror" that contains both the numeric and descriptive string error values, you could use the following code:

```
extern int  dberror;
extern char *dberror_list;

SV* sv = get_sv("dberror", TRUE);
sv_setiv(sv, (IV) dberror);
```

```
sv_setpv(sv, dberror_list[dberror]);
SvIOK_on(sv);
```

If the order of sv_setiv and sv_setpv had been reversed, then the macro SvPOK_on would need to be called instead of SvIOK_on.

Magic Variables

[This section still under construction. Ignore everything here. Post no bills. Everything not permitted is forbidden.]

Any SV may be magical, that is, it has special features that a normal SV does not have. These features are stored in the SV structure in a linked list of struct magic's, typedef'ed to MAGIC.

```
struct magic {
    MAGIC*      mg_moremagic;
    MGVTBL*     mg_virtual;
    U16         mg_private;
    char        mg_type;
    U8          mg_flags;
    SV*         mg_obj;
    char*       mg_ptr;
    I32         mg_len;
};
```

Note this is current as of patchlevel 0, and could change at any time.

Assigning Magic

Perl adds magic to an SV using the sv_magic function:

```
void sv_magic(SV* sv, SV* obj, int how, const char* name, I32 namlen);
```

The sv argument is a pointer to the SV that is to acquire a new magical feature.

If sv is not already magical, Perl uses the SvUPGRADE macro to set the SVt_PVMG flag for the sv. Perl then continues by adding it to the beginning of the linked list of magical features. Any prior entry of the same type of magic is deleted. Note that this can be overridden, and multiple instances of the same type of magic can be associated with an SV.

The name and namlen arguments are used to associate a string with the magic, typically the name of a variable. namlen is stored in the mg_len field and if name is non–null and namlen = 0 a malloc'd copy of the name is stored in mg_ptr field.

The sv_magic function uses how to determine which, if any, predefined "Magic Virtual Table" should be assigned to the mg_virtual field. See the "Magic Virtual Table" section below. The how argument is also stored in the mg_type field.

The obj argument is stored in the mg_obj field of the MAGIC structure. If it is not the same as the sv argument, the reference count of the obj object is incremented. If it is the same, or if the how argument is "#", or if it is a NULL pointer, then obj is merely stored, without the reference count being incremented.

There is also a function to add magic to an HV:

```
void hv_magic(HV *hv, GV *gv, int how);
```

This simply calls sv_magic and coerces the gv argument into an SV.

To remove the magic from an SV, call the function sv_unmagic:

```
void sv_unmagic(SV *sv, int type);
```

The type argument should be equal to the how value when the SV was initially made magical.

Magic Virtual Tables

The mg_virtual field in the MAGIC structure is a pointer to a MGVTBL, which is a structure of function pointers and stands for "Magic Virtual Table" to handle the various operations that might be applied to that variable.

The MGVTBL has five pointers to the following routine types:

```
int  (*svt_get)(SV* sv, MAGIC* mg);
int  (*svt_set)(SV* sv, MAGIC* mg);
U32  (*svt_len)(SV* sv, MAGIC* mg);
int  (*svt_clear)(SV* sv, MAGIC* mg);
int  (*svt_free)(SV* sv, MAGIC* mg);
```

This MGVTBL structure is set at compile−time in perl.h and there are currently 19 types (or 21 with overloading turned on). These different structures contain pointers to various routines that perform additional actions depending on which function is being called.

```
Function pointer    Action taken
----------------    ------------
svt_get             Do something after the value of the SV is retrieved.
svt_set             Do something after the SV is assigned a value.
svt_len             Report on the SV's length.
svt_clear           Clear something the SV represents.
svt_free            Free any extra storage associated with the SV.
```

For instance, the MGVTBL structure called vtbl_sv (which corresponds to an mg_type of '\0') contains:

```
{ magic_get, magic_set, magic_len, 0, 0 }
```

Thus, when an SV is determined to be magical and of type '\0', if a get operation is being performed, the routine magic_get is called. All the various routines for the various magical types begin with magic_. NOTE: the magic routines are not considered part of the Perl API, and may not be exported by the Perl library.

The current kinds of Magic Virtual Tables are:

```
mg_type  MGVTBL              Type of magic
-------  ------              ----------------------------
\0       vtbl_sv             Special scalar variable
A        vtbl_amagic         %OVERLOAD hash
a        vtbl_amagicelem     %OVERLOAD hash element
c        (none)              Holds overload table (AMT) on stash
B        vtbl_bm             Boyer-Moore (fast string search)
D        vtbl_regdata        Regex match position data (@+ and @- vars)
d        vtbl_regdatum       Regex match position data element
E        vtbl_env            %ENV hash
e        vtbl_envelem        %ENV hash element
f        vtbl_fm             Formline ('compiled' format)
g        vtbl_mglob          m//g target / study()ed string
I        vtbl_isa            @ISA array
i        vtbl_isaelem        @ISA array element
k        vtbl_nkeys          scalar(keys()) lvalue
L        (none)              Debugger %_<filename
l        vtbl_dbline         Debugger %_<filename element
o        vtbl_collxfrm       Locale transformation
P        vtbl_pack           Tied array or hash
p        vtbl_packelem       Tied array or hash element
```

```
q        vtbl_packelem       Tied scalar or handle
S        vtbl_sig            %SIG hash
s        vtbl_sigelem        %SIG hash element
t        vtbl_taint          Taintedness
U        vtbl_uvar           Available for use by extensions
v        vtbl_vec            vec() lvalue
x        vtbl_substr         substr() lvalue
y        vtbl_defelem        Shadow "foreach" iterator variable /
                              smart parameter vivification
*        vtbl_glob           GV (typeglob)
#        vtbl_arylen         Array length ($#ary)
.        vtbl_pos            pos() lvalue
~        (none)              Available for use by extensions
```

When an uppercase and lowercase letter both exist in the table, then the uppercase letter is used to represent some kind of composite type (a list or a hash), and the lowercase letter is used to represent an element of that composite type.

The '~' and 'U' magic types are defined specifically for use by extensions and will not be used by perl itself. Extensions can use '~' magic to 'attach' private information to variables (typically objects). This is especially useful because there is no way for normal perl code to corrupt this private information (unlike using extra elements of a hash object).

Similarly, 'U' magic can be used much like `tie()` to call a C function any time a scalar's value is used or changed. The `MAGIC`'s `mg_ptr` field points to a `ufuncs` structure:

```
struct ufuncs {
    I32 (*uf_val)(IV, SV*);
    I32 (*uf_set)(IV, SV*);
    IV uf_index;
};
```

When the SV is read from or written to, the `uf_val` or `uf_set` function will be called with `uf_index` as the first arg and a pointer to the SV as the second. A simple example of how to add 'U' magic is shown below. Note that the ufuncs structure is copied by sv_magic, so you can safely allocate it on the stack.

```
void
Umagic(sv)
    SV *sv;
PREINIT:
    struct ufuncs uf;
CODE:
    uf.uf_val   = &my_get_fn;
    uf.uf_set   = &my_set_fn;
    uf.uf_index = 0;
    sv_magic(sv, 0, 'U', (char*)&uf, sizeof(uf));
```

Note that because multiple extensions may be using '~' or 'U' magic, it is important for extensions to take extra care to avoid conflict. Typically only using the magic on objects blessed into the same class as the extension is sufficient. For '~' magic, it may also be appropriate to add an I32 'signature' at the top of the private data area and check that.

Also note that the `sv_set*()` and `sv_cat*()` functions described earlier do **not** invoke 'set' magic on their targets. This must be done by the user either by calling the `SvSETMAGIC()` macro after calling these functions, or by using one of the `sv_set*_mg()` or `sv_cat*_mg()` functions. Similarly, generic C code must call the `SvGETMAGIC()` macro to invoke any 'get' magic if they use an SV obtained from external sources in functions that don't handle magic. See *perlapi* for a description of these functions. For example, calls to the `sv_cat*()` functions typically need to be followed by `SvSETMAGIC()`, but they

don't need a prior SvGETMAGIC() since their implementation handles 'get' magic.

Finding Magic

```
MAGIC* mg_find(SV*, int type); /* Finds the magic pointer of that type */
```

This routine returns a pointer to the MAGIC structure stored in the SV. If the SV does not have that magical feature, NULL is returned. Also, if the SV is not of type SVt_PVMG, Perl may core dump.

```
int mg_copy(SV* sv, SV* nsv, const char* key, STRLEN klen);
```

This routine checks to see what types of magic sv has. If the mg_type field is an uppercase letter, then the mg_obj is copied to nsv, but the mg_type field is changed to be the lowercase letter.

Understanding the Magic of Tied Hashes and Arrays

Tied hashes and arrays are magical beasts of the 'P' magic type.

WARNING: As of the 5.004 release, proper usage of the array and hash access functions requires understanding a few caveats. Some of these caveats are actually considered bugs in the API, to be fixed in later releases, and are bracketed with [MAYCHANGE] below. If you find yourself actually applying such information in this section, be aware that the behavior may change in the future, umm, without warning.

The perl tie function associates a variable with an object that implements the various GET, SET etc methods. To perform the equivalent of the perl tie function from an XSUB, you must mimic this behaviour. The code below carries out the necessary steps – firstly it creates a new hash, and then creates a second hash which it blesses into the class which will implement the tie methods. Lastly it ties the two hashes together, and returns a reference to the new tied hash. Note that the code below does NOT call the TIEHASH method in the MyTie class – see *Calling Perl Routines from within C Programs* for details on how to do this.

```
SV*
mytie()
PREINIT:
    HV *hash;
    HV *stash;
    SV *tie;
CODE:
    hash = newHV();
    tie = newRV_noinc((SV*)newHV());
    stash = gv_stashpv("MyTie", TRUE);
    sv_bless(tie, stash);
    hv_magic(hash, tie, 'P');
    RETVAL = newRV_noinc(hash);
OUTPUT:
    RETVAL
```

The av_store function, when given a tied array argument, merely copies the magic of the array onto the value to be "stored", using mg_copy. It may also return NULL, indicating that the value did not actually need to be stored in the array. [MAYCHANGE] After a call to av_store on a tied array, the caller will usually need to call mg_set(val) to actually invoke the perl level "STORE" method on the TIEARRAY object. If av_store did return NULL, a call to SvREFCNT_dec(val) will also be usually necessary to avoid a memory leak. [/MAYCHANGE]

The previous paragraph is applicable verbatim to tied hash access using the hv_store and hv_store_ent functions as well.

av_fetch and the corresponding hash functions hv_fetch and hv_fetch_ent actually return an undefined mortal value whose magic has been initialized using mg_copy. Note the value so returned does not need to be deallocated, as it is already mortal. [MAYCHANGE] But you will need to call mg_get() on the returned value in order to actually invoke the perl level "FETCH" method on the underlying TIE object. Similarly, you may also call mg_set() on the return value after possibly assigning a suitable value to it using sv_setsv, which will invoke the "STORE" method on the TIE object. [/MAYCHANGE]

[MAYCHANGE] In other words, the array or hash fetch/store functions don't really fetch and store actual values in the case of tied arrays and hashes. They merely call `mg_copy` to attach magic to the values that were meant to be "stored" or "fetched". Later calls to `mg_get` and `mg_set` actually do the job of invoking the TIE methods on the underlying objects. Thus the magic mechanism currently implements a kind of lazy access to arrays and hashes.

Currently (as of perl version 5.004), use of the hash and array access functions requires the user to be aware of whether they are operating on "normal" hashes and arrays, or on their tied variants. The API may be changed to provide more transparent access to both tied and normal data types in future versions. [/MAYCHANGE]

You would do well to understand that the TIEARRAY and TIEHASH interfaces are mere sugar to invoke some perl method calls while using the uniform hash and array syntax. The use of this sugar imposes some overhead (typically about two to four extra opcodes per FETCH/STORE operation, in addition to the creation of all the mortal variables required to invoke the methods). This overhead will be comparatively small if the TIE methods are themselves substantial, but if they are only a few statements long, the overhead will not be insignificant.

Localizing changes

Perl has a very handy construction

```
{
  local $var = 2;
  ...
}
```

This construction is *approximately* equivalent to

```
{
  my $oldvar = $var;
  $var = 2;
  ...
  $var = $oldvar;
}
```

The biggest difference is that the first construction would reinstate the initial value of `$var`, irrespective of how control exits the block: `goto`, `return`, `die/eval` etc. It is a little bit more efficient as well.

There is a way to achieve a similar task from C via Perl API: create a *pseudo–block*, and arrange for some changes to be automatically undone at the end of it, either explicit, or via a non–local exit (via `die()`). A *block*–like construct is created by a pair of `ENTER/LEAVE` macros (see *Returning a Scalar in perlcall*). Such a construct may be created specially for some important localized task, or an existing one (like boundaries of enclosing Perl subroutine/block, or an existing pair for freeing TMPs) may be used. (In the second case the overhead of additional localization must be almost negligible.) Note that any XSUB is automatically enclosed in an `ENTER/LEAVE` pair.

Inside such a *pseudo–block* the following service is available:

`SAVEINT(int i)`
`SAVEIV(IV i)`
`SAVEI32(I32 i)`
`SAVELONG(long i)`

These macros arrange things to restore the value of integer variable `i` at the end of enclosing *pseudo–block*.

`SAVESPTR(s)`
`SAVEPPTR(p)`

These macros arrange things to restore the value of pointers `s` and `p`. `s` must be a pointer of a type which survives conversion to `SV*` and back, `p` should be able to survive conversion to `char*` and

back.

`SAVEFREESV(SV *sv)`

The refcount of `sv` would be decremented at the end of *pseudo−block*. This is similar to `sv_2mortal`, which should (?) be used instead.

`SAVEFREEOP(OP *op)`

The `OP *` is `op_free()`ed at the end of *pseudo−block*.

`SAVEFREEPV(p)`

The chunk of memory which is pointed to by `p` is `Safefree()`ed at the end of *pseudo−block*.

`SAVECLEARSV(SV *sv)`

Clears a slot in the current scratchpad which corresponds to `sv` at the end of *pseudo−block*.

`SAVEDELETE(HV *hv, char *key, I32 length)`

The key `key` of `hv` is deleted at the end of *pseudo−block*. The string pointed to by `key` is `Safefree()`ed. If one has a *key* in short−lived storage, the corresponding string may be reallocated like this:

```
SAVEDELETE(PL_defstash, savepv(tmpbuf), strlen(tmpbuf));
```

`SAVEDESTRUCTOR(DESTRUCTORFUNC_NOCONTEXT_t f, void *p)`

At the end of *pseudo−block* the function `f` is called with the only argument `p`.

`SAVEDESTRUCTOR_X(DESTRUCTORFUNC_t f, void *p)`

At the end of *pseudo−block* the function `f` is called with the implicit context argument (if any), and `p`.

`SAVESTACK_POS()`

The current offset on the Perl internal stack (cf. `SP`) is restored at the end of *pseudo−block*.

The following API list contains functions, thus one needs to provide pointers to the modifiable data explicitly (either C pointers, or Perlish `GV *`s). Where the above macros take `int`, a similar function takes `int *`.

`SV* save_scalar(GV *gv)`

Equivalent to Perl code `local $gv`.

`AV* save_ary(GV *gv)`
`HV* save_hash(GV *gv)`

Similar to `save_scalar`, but localize `@gv` and `%gv`.

`void save_item(SV *item)`

Duplicates the current value of `SV`, on the exit from the current `ENTER/LEAVE` *pseudo−block* will restore the value of `SV` using the stored value.

`void save_list(SV **sarg, I32 maxsarg)`

A variant of `save_item` which takes multiple arguments via an array `sarg` of `SV*` of length `maxsarg`.

`SV* save_svref(SV **sptr)`

Similar to `save_scalar`, but will reinstate a `SV *`.

`void save_aptr(AV **aptr)`
`void save_hptr(HV **hptr)`

Similar to `save_svref`, but localize `AV *` and `HV *`.

The `Alias` module implements localization of the basic types within the *caller's scope*. People who are interested in how to localize things in the containing scope should take a look there too.

Subroutines

XSUBs and the Argument Stack

The XSUB mechanism is a simple way for Perl programs to access C subroutines. An XSUB routine will have a stack that contains the arguments from the Perl program, and a way to map from the Perl data structures to a C equivalent.

The stack arguments are accessible through the `ST(n)` macro, which returns the `n`'th stack argument. Argument 0 is the first argument passed in the Perl subroutine call. These arguments are `SV*`, and can be used anywhere an `SV*` is used.

Most of the time, output from the C routine can be handled through use of the RETVAL and OUTPUT directives. However, there are some cases where the argument stack is not already long enough to handle all the return values. An example is the POSIX `tzname()` call, which takes no arguments, but returns two, the local time zone's standard and summer time abbreviations.

To handle this situation, the PPCODE directive is used and the stack is extended using the macro:

```
EXTEND(SP, num);
```

where `SP` is the macro that represents the local copy of the stack pointer, and `num` is the number of elements the stack should be extended by.

Now that there is room on the stack, values can be pushed on it using the macros to push IVs, doubles, strings, and SV pointers respectively:

```
PUSHi(IV)
PUSHn(double)
PUSHp(char*, I32)
PUSHs(SV*)
```

And now the Perl program calling `tzname`, the two values will be assigned as in:

```
($standard_abbrev, $summer_abbrev) = POSIX::tzname;
```

An alternate (and possibly simpler) method to pushing values on the stack is to use the macros:

```
XPUSHi(IV)
XPUSHn(double)
XPUSHp(char*, I32)
XPUSHs(SV*)
```

These macros automatically adjust the stack for you, if needed. Thus, you do not need to call `EXTEND` to extend the stack.

For more information, consult *perlxs* and *perlxstut*.

Calling Perl Routines from within C Programs

There are four routines that can be used to call a Perl subroutine from within a C program. These four are:

```
I32  call_sv(SV*, I32);
I32  call_pv(const char*, I32);
I32  call_method(const char*, I32);
I32  call_argv(const char*, I32, register char**);
```

The routine most often used is `call_sv`. The `SV*` argument contains either the name of the Perl subroutine to be called, or a reference to the subroutine. The second argument consists of flags that control the context in which the subroutine is called, whether or not the subroutine is being passed arguments, how errors should be trapped, and how to treat return values.

All four routines return the number of arguments that the subroutine returned on the Perl stack.

These routines used to be called `perl_call_sv` etc., before Perl v5.6.0, but those names are now

deprecated; macros of the same name are provided for compatibility.

When using any of these routines (except `call_argv`), the programmer must manipulate the Perl stack. These include the following macros and functions:

```
dSP
SP
PUSHMARK()
PUTBACK
SPAGAIN
ENTER
SAVETMPS
FREETMPS
LEAVE
XPUSH*()
POP*()
```

For a detailed description of calling conventions from C to Perl, consult *perlcall*.

Memory Allocation

All memory meant to be used with the Perl API functions should be manipulated using the macros described in this section. The macros provide the necessary transparency between differences in the actual malloc implementation that is used within perl.

It is suggested that you enable the version of malloc that is distributed with Perl. It keeps pools of various sizes of unallocated memory in order to satisfy allocation requests more quickly. However, on some platforms, it may cause spurious malloc or free errors.

```
New(x, pointer, number, type);
Newc(x, pointer, number, type, cast);
Newz(x, pointer, number, type);
```

These three macros are used to initially allocate memory.

The first argument `x` was a "magic cookie" that was used to keep track of who called the macro, to help when debugging memory problems. However, the current code makes no use of this feature (most Perl developers now use run–time memory checkers), so this argument can be any number.

The second argument `pointer` should be the name of a variable that will point to the newly allocated memory.

The third and fourth arguments `number` and `type` specify how many of the specified type of data structure should be allocated. The argument `type` is passed to `sizeof`. The final argument to `Newc`, `cast`, should be used if the `pointer` argument is different from the `type` argument.

Unlike the `New` and `Newc` macros, the `Newz` macro calls `memzero` to zero out all the newly allocated memory.

```
Renew(pointer, number, type);
Renewc(pointer, number, type, cast);
Safefree(pointer)
```

These three macros are used to change a memory buffer size or to free a piece of memory no longer needed. The arguments to `Renew` and `Renewc` match those of `New` and `Newc` with the exception of not needing the "magic cookie" argument.

```
Move(source, dest, number, type);
Copy(source, dest, number, type);
Zero(dest, number, type);
```

These three macros are used to move, copy, or zero out previously allocated memory. The `source` and `dest` arguments point to the source and destination starting points. Perl will move, copy, or zero out

`number` instances of the size of the `type` data structure (using the `sizeof` function).

Here is a handy table of equivalents between ordinary C and Perl's memory abstraction layer:

```
Instead Of:                Use:

malloc                     New
calloc                     Newz
realloc                    Renew
memcopy                    Copy
memmove                    Move
free                       Safefree
strdup                     savepv
strndup                    savepvn (Hey, strndup doesn't exist!)
memcpy/*(struct foo *)    StructCopy
```

PerlIO

The most recent development releases of Perl has been experimenting with removing Perl's dependency on the "normal" standard I/O suite and allowing other stdio implementations to be used. This involves creating a new abstraction layer that then calls whichever implementation of stdio Perl was compiled with. All XSUBs should now use the functions in the PerlIO abstraction layer and not make any assumptions about what kind of stdio is being used.

For a complete description of the PerlIO abstraction, consult *perlapio*.

Putting a C value on Perl stack

A lot of opcodes (this is an elementary operation in the internal perl stack machine) put an SV* on the stack. However, as an optimization the corresponding SV is (usually) not recreated each time. The opcodes reuse specially assigned SVs (*target*s) which are (as a corollary) not constantly freed/created.

Each of the targets is created only once (but see *Scratchpads and recursion* below), and when an opcode needs to put an integer, a double, or a string on stack, it just sets the corresponding parts of its *target* and puts the *target* on stack.

The macro to put this target on stack is `PUSHTARG`, and it is directly used in some opcodes, as well as indirectly in zillions of others, which use it via `(X)PUSH[pni]`.

Scratchpads

The question remains on when the SVs which are *target*s for opcodes are created. The answer is that they are created when the current unit — a subroutine or a file (for opcodes for statements outside of subroutines) — is compiled. During this time a special anonymous Perl array is created, which is called a scratchpad for the current unit.

A scratchpad keeps SVs which are lexicals for the current unit and are targets for opcodes. One can deduce that an SV lives on a scratchpad by looking on its flags: lexicals have `SVs_PADMY` set, and *target*s have `SVs_PADTMP` set.

The correspondence between OPs and *target*s is not 1–to–1. Different OPs in the compile tree of the unit can use the same target, if this would not conflict with the expected life of the temporary.

Scratchpads and recursion

In fact it is not 100% true that a compiled unit contains a pointer to the scratchpad AV. In fact it contains a pointer to an AV of (initially) one element, and this element is the scratchpad AV. Why do we need an extra level of indirection?

The answer is **recursion**, and maybe (sometime soon) **threads**. Both these can create several execution pointers going into the same subroutine. For the subroutine–child not write over the temporaries for the subroutine–parent (lifespan of which covers the call to the child), the parent and the child should have different scratchpads. (*And* the lexicals should be separate anyway!)

So each subroutine is born with an array of scratchpads (of length 1). On each entry to the subroutine it is checked that the current depth of the recursion is not more than the length of this array, and if it is, new scratchpad is created and pushed into the array.

The *target*s on this scratchpad are `undef`s, but they are already marked with correct flags.

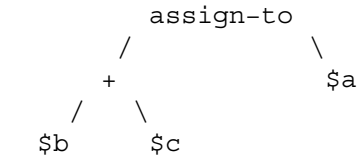
Compiled code

Code tree

Here we describe the internal form your code is converted to by Perl. Start with a simple example:

```
$a = $b + $c;
```

This is converted to a tree similar to this one:



(but slightly more complicated). This tree reflects the way Perl parsed your code, but has nothing to do with the execution order. There is an additional "thread" going through the nodes of the tree which shows the order of execution of the nodes. In our simplified example above it looks like:

```
$b ---> $c ---> + ---> $a ---> assign-to
```

But with the actual compile tree for `$a = $b + $c` it is different: some nodes *optimized away*. As a corollary, though the actual tree contains more nodes than our simplified example, the execution order is the same as in our example.

Examining the tree

If you have your perl compiled for debugging (usually done with `-D optimize=-g` on `Configure` command line), you may examine the compiled tree by specifying `-Dx` on the Perl command line. The output takes several lines per node, and for `$b+$c` it looks like this:

```
5           TYPE = add  ===> 6
            TARG = 1
            FLAGS = (SCALAR,KIDS)
            {
                TYPE = null  ===> (4)
                  (was rv2sv)
                FLAGS = (SCALAR,KIDS)
                {
3                   TYPE = gvsv  ===> 4
                    FLAGS = (SCALAR)
                    GV = main::b
                }
            }
            {
                TYPE = null  ===> (5)
                  (was rv2sv)
                FLAGS = (SCALAR,KIDS)
                {
4                   TYPE = gvsv  ===> 5
                    FLAGS = (SCALAR)
                    GV = main::c
                }
            }
```

This tree has 5 nodes (one per `TYPE` specifier), only 3 of them are not optimized away (one per number in the left column). The immediate children of the given node correspond to { } pairs on the same level of indentation, thus this listing corresponds to the tree:

```
    add
   /   \
null   null
 |      |
gvsv   gvsv
```

The execution order is indicated by `===>` marks, thus it is `3 4 5 6` (node `6` is not included into above listing), i.e., `gvsv gvsv add whatever`.

Compile pass 1: check routines

The tree is created by the compiler while *yacc* code feeds it the constructions it recognizes. Since *yacc* works bottom-up, so does the first pass of perl compilation.

What makes this pass interesting for perl developers is that some optimization may be performed on this pass. This is optimization by so-called "check routines". The correspondence between node names and corresponding check routines is described in ***opcode.pl*** (do not forget to run `make regen_headers` if you modify this file).

A check routine is called when the node is fully constructed except for the execution-order thread. Since at this time there are no back-links to the currently constructed node, one can do most any operation to the top-level node, including freeing it and/or creating new nodes above/below it.

The check routine returns the node which should be inserted into the tree (if the top-level node was not modified, check routine returns its argument).

By convention, check routines have names `ck_*`. They are usually called from `new*OP` subroutines (or `convert`) (which in turn are called from ***perly.y***).

Compile pass 1a: constant folding

Immediately after the check routine is called the returned node is checked for being compile-time executable. If it is (the value is judged to be constant) it is immediately executed, and a *constant* node with the "return value" of the corresponding subtree is substituted instead. The subtree is deleted.

If constant folding was not performed, the execution-order thread is created.

Compile pass 2: context propagation

When a context for a part of compile tree is known, it is propagated down through the tree. At this time the context can have 5 values (instead of 2 for runtime context): void, boolean, scalar, list, and lvalue. In contrast with the pass 1 this pass is processed from top to bottom: a node's context determines the context for its children.

Additional context-dependent optimizations are performed at this time. Since at this moment the compile tree contains back-references (via "thread" pointers), nodes cannot be `free()`d now. To allow optimized-away nodes at this stage, such nodes are `null()`ified instead of `free()`ing (i.e. their type is changed to OP_NULL).

Compile pass 3: peephole optimization

After the compile tree for a subroutine (or for an `eval` or a file) is created, an additional pass over the code is performed. This pass is neither top-down or bottom-up, but in the execution order (with additional complications for conditionals). These optimizations are done in the subroutine `peep()`. Optimizations performed at this stage are subject to the same restrictions as in the pass 2.

How multiple interpreters and concurrency are supported

Background and PERL_IMPLICIT_CONTEXT

The Perl interpreter can be regarded as a closed box: it has an API for feeding it code or otherwise making it do things, but it also has functions for its own use. This smells a lot like an object, and there are ways for

you to build Perl so that you can have multiple interpreters, with one interpreter represented either as a C++ object, a C structure, or inside a thread. The thread, the C structure, or the C++ object will contain all the context, the state of that interpreter.

Three macros control the major Perl build flavors: MULTIPLICITY, USE_THREADS and PERL_OBJECT. The MULTIPLICITY build has a C structure that packages all the interpreter state, there is a similar thread−specific data structure under USE_THREADS, and the PERL_OBJECT build has a C++ class to maintain interpreter state. In all three cases, PERL_IMPLICIT_CONTEXT is also normally defined, and enables the support for passing in a "hidden" first argument that represents all three data structures.

All this obviously requires a way for the Perl internal functions to be C++ methods, subroutines taking some kind of structure as the first argument, or subroutines taking nothing as the first argument. To enable these three very different ways of building the interpreter, the Perl source (as it does in so many other situations) makes heavy use of macros and subroutine naming conventions.

First problem: deciding which functions will be public API functions and which will be private. All functions whose names begin `S_` are private (think "S" for "secret" or "static"). All other functions begin with "Perl_", but just because a function begins with "Perl_" does not mean it is part of the API. (See */Internal Functions*.) The easiest way to be **sure** a function is part of the API is to find its entry in *perlapi*. If it exists in *perlapi*, it's part of the API. If it doesn't, and you think it should be (i.e., you need it for your extension), send mail via *perlbug* explaining why you think it should be.

Second problem: there must be a syntax so that the same subroutine declarations and calls can pass a structure as their first argument, or pass nothing. To solve this, the subroutines are named and declared in a particular way. Here's a typical start of a static function used within the Perl guts:

```
STATIC void
S_incline(pTHX_ char *s)
```

STATIC becomes "static" in C, and is #define'd to nothing in C++.

A public function (i.e. part of the internal API, but not necessarily sanctioned for use in extensions) begins like this:

```
void
Perl_sv_setsv(pTHX_ SV* dsv, SV* ssv)
```

`pTHX_` is one of a number of macros (in perl.h) that hide the details of the interpreter's context. THX stands for "thread", "this", or "thingy", as the case may be. (And no, George Lucas is not involved. :−) The first character could be 'p' for a **p**rototype, 'a' for **a**rgument, or 'd' for **d**eclaration.

When Perl is built without PERL_IMPLICIT_CONTEXT, there is no first argument containing the interpreter's context. The trailing underscore in the pTHX_ macro indicates that the macro expansion needs a comma after the context argument because other arguments follow it. If PERL_IMPLICIT_CONTEXT is not defined, pTHX_ will be ignored, and the subroutine is not prototyped to take the extra argument. The form of the macro without the trailing underscore is used when there are no additional explicit arguments.

When a core function calls another, it must pass the context. This is normally hidden via macros. Consider `sv_setsv`. It expands something like this:

```
ifdef PERL_IMPLICIT_CONTEXT
  define sv_setsv(a,b)      Perl_sv_setsv(aTHX_ a, b)
  /* can't do this for vararg functions, see below */
else
  define sv_setsv           Perl_sv_setsv
endif
```

This works well, and means that XS authors can gleefully write:

```
sv_setsv(foo, bar);
```

and still have it work under all the modes Perl could have been compiled with.

Under PERL_OBJECT in the core, that will translate to either:

```
    CPerlObj::Perl_sv_setsv(foo,bar);  # in CPerlObj functions,
                                       # C++ takes care of 'this'
  or
    pPerl->Perl_sv_setsv(foo,bar);     # in truly static functions,
                                       # see objXSUB.h
```

Under PERL_OBJECT in extensions (aka PERL_CAPI), or under MULTIPLICITY/USE_THREADS w/ PERL_IMPLICIT_CONTEXT in both core and extensions, it will be:

```
    Perl_sv_setsv(aTHX_ foo, bar);     # the canonical Perl "API"
                                       # for all build flavors
```

This doesn't work so cleanly for varargs functions, though, as macros imply that the number of arguments is known in advance. Instead we either need to spell them out fully, passing `aTHX_` as the first argument (the Perl core tends to do this with functions like Perl_warner), or use a context−free version.

The context−free version of Perl_warner is called Perl_warner_nocontext, and does not take the extra argument. Instead it does dTHX; to get the context from thread−local storage. We `#define warner Perl_warner_nocontext` so that extensions get source compatibility at the expense of performance. (Passing an arg is cheaper than grabbing it from thread−local storage.)

You can ignore [pad]THX[xo] when browsing the Perl headers/sources. Those are strictly for use within the core. Extensions and embedders need only be aware of [pad]THX.

How do I use all this in extensions?

When Perl is built with PERL_IMPLICIT_CONTEXT, extensions that call any functions in the Perl API will need to pass the initial context argument somehow. The kicker is that you will need to write it in such a way that the extension still compiles when Perl hasn't been built with PERL_IMPLICIT_CONTEXT enabled.

There are three ways to do this. First, the easy but inefficient way, which is also the default, in order to maintain source compatibility with extensions: whenever XSUB.h is #included, it redefines the aTHX and aTHX_ macros to call a function that will return the context. Thus, something like:

```
        sv_setsv(asv, bsv);
```

in your extension will translate to this when PERL_IMPLICIT_CONTEXT is in effect:

```
        Perl_sv_setsv(Perl_get_context(), asv, bsv);
```

or to this otherwise:

```
        Perl_sv_setsv(asv, bsv);
```

You have to do nothing new in your extension to get this; since the Perl library provides `Perl_get_context()`, it will all just work.

The second, more efficient way is to use the following template for your Foo.xs:

```
        #define PERL_NO_GET_CONTEXT     /* we want efficiency */
        #include "EXTERN.h"
        #include "perl.h"
        #include "XSUB.h"

        static my_private_function(int arg1, int arg2);

        static SV *
        my_private_function(int arg1, int arg2)
        {
```

```
    dTHX;/* fetch context */
    ... call many Perl API functions ...
}

[... etc ...]

MODULE = Foo            PACKAGE = Foo

/* typical XSUB */

void
my_xsub(arg)
        int arg
    CODE:
        my_private_function(arg, 10);
```

Note that the only two changes from the normal way of writing an extension is the addition of a `#define PERL_NO_GET_CONTEXT` before including the Perl headers, followed by a `dTHX;` declaration at the start of every function that will call the Perl API. (You'll know which functions need this, because the C compiler will complain that there's an undeclared identifier in those functions.) No changes are needed for the XSUBs themselves, because the `XS()` macro is correctly defined to pass in the implicit context if needed.

The third, even more efficient way is to ape how it is done within the Perl guts:

```
#define PERL_NO_GET_CONTEXT     /* we want efficiency */
#include "EXTERN.h"
#include "perl.h"
#include "XSUB.h"

/* pTHX_ only needed for functions that call Perl API */
static my_private_function(pTHX_ int arg1, int arg2);

static SV *
my_private_function(pTHX_ int arg1, int arg2)
{
    /* dTHX; not needed here, because THX is an argument */
    ... call Perl API functions ...
}

[... etc ...]

MODULE = Foo            PACKAGE = Foo

/* typical XSUB */

void
my_xsub(arg)
        int arg
    CODE:
        my_private_function(aTHX_ arg, 10);
```

This implementation never has to fetch the context using a function call, since it is always passed as an extra argument. Depending on your needs for simplicity or efficiency, you may mix the previous two approaches freely.

Never add a comma after `pTHX` yourself—always use the form of the macro with the underscore for functions that take explicit arguments, or the form without the argument for functions with no explicit arguments.

Future Plans and PERL_IMPLICIT_SYS

Just as PERL_IMPLICIT_CONTEXT provides a way to bundle up everything that the interpreter knows about itself and pass it around, so too are there plans to allow the interpreter to bundle up everything it knows about the environment it's running on. This is enabled with the PERL_IMPLICIT_SYS macro. Currently it only works with PERL_OBJECT, but is mostly there for MULTIPLICITY and USE_THREADS (see inside iperlsys.h).

This allows the ability to provide an extra pointer (called the "host" environment) for all the system calls. This makes it possible for all the system stuff to maintain their own state, broken down into seven C structures. These are thin wrappers around the usual system calls (see win32/perllib.c) for the default perl executable, but for a more ambitious host (like the one that would do `fork()` emulation) all the extra work needed to pretend that different interpreters are actually different "processes", would be done here.

The Perl engine/interpreter and the host are orthogonal entities. There could be one or more interpreters in a process, and one or more "hosts", with free association between them.

Internal Functions

All of Perl's internal functions which will be exposed to the outside world are be prefixed by `Perl_` so that they will not conflict with XS functions or functions used in a program in which Perl is embedded. Similarly, all global variables begin with `PL_`. (By convention, static functions start with `S_`)

Inside the Perl core, you can get at the functions either with or without the `Perl_` prefix, thanks to a bunch of defines that live in ***embed.h***. This header file is generated automatically from ***embed.pl***. ***embed.pl*** also creates the prototyping header files for the internal functions, generates the documentation and a lot of other bits and pieces. It's important that when you add a new function to the core or change an existing one, you change the data in the table at the end of ***embed.pl*** as well. Here's a sample entry from that table:

```
Apd |SV**   |av_fetch   |AV* ar|I32 key|I32 lval
```

The second column is the return type, the third column the name. Columns after that are the arguments. The first column is a set of flags:

A This function is a part of the public API.

p This function has a `Perl_` prefix; ie, it is defined as `Perl_av_fetch`

d This function has documentation using the `apidoc` feature which we'll look at in a second.

Other available flags are:

s This is a static function and is defined as `S_whatever`.

n This does not use `aTHX_` and `pTHX` to pass interpreter context. (See *Background and PERL_IMPLICIT_CONTEXT*.)

r This function never returns; `croak`, `exit` and friends.

f This function takes a variable number of arguments, `printf` style. The argument list should end with `...`, like this:

```
Afprd   |void   |croak           |const char* pat|...
```

m This function is part of the experimental development API, and may change or disappear without notice.

o This function should not have a compatibility macro to define, say, `Perl_parse` to `parse`. It must be called as `Perl_parse`.

j This function is not a member of `CPerlObj`. If you don't know what this means, don't use it.

x This function isn't exported out of the Perl core.

If you edit ***embed.pl***, you will need to run `make regen_headers` to force a rebuild of ***embed.h*** and other auto−generated files.

Formatted Printing of IVs, UVs, and NVs

If you are printing IVs, UVs, or NVS instead of the stdio(3) style formatting codes like `%d`, `%ld`, `%f`, you should use the following macros for portability

```
IVdf            IV in decimal
UVuf            UV in decimal
UVof            UV in octal
UVxf            UV in hexadecimal
NVef            NV %e-like
NVff            NV %f-like
NVgf            NV %g-like
```

These will take care of 64–bit integers and long doubles. For example:

```
printf("IV is %"IVdf"\n", iv);
```

The IVdf will expand to whatever is the correct format for the IVs.

If you are printing addresses of pointers, use UVxf combined with `PTR2UV()`, do not use %lx or %p.

Pointer–To–Integer and Integer–To–Pointer

Because pointer size does not necessarily equal integer size, use the follow macros to do it right.

```
PTR2UV(pointer)
PTR2IV(pointer)
PTR2NV(pointer)
INT2PTR(pointertotype, integer)
```

For example:

```
IV  iv = ...;
SV *sv = INT2PTR(SV*, iv);
```

and

```
AV *av = ...;
UV  uv = PTR2UV(av);
```

Source Documentation

There's an effort going on to document the internal functions and automatically produce reference manuals from them – *perlapi* is one such manual which details all the functions which are available to XS writers. *perlintern* is the autogenerated manual for the functions which are not part of the API and are supposedly for internal use only.

Source documentation is created by putting POD comments into the C source, like this:

```
/*
=for apidoc sv_setiv

Copies an integer into the given SV.  Does not handle 'set' magic.  See
C<sv_setiv_mg>.

=cut
*/
```

Please try and supply some documentation if you add functions to the Perl core.

Unicode Support

Perl 5.6.0 introduced Unicode support. It's important for porters and XS writers to understand this support and make sure that the code they write does not corrupt Unicode data.

What is Unicode, anyway?

In the olden, less enlightened times, we all used to use ASCII. Most of us did, anyway. The big problem with ASCII is that it's American. Well, no, that's not actually the problem; the problem is that it's not particularly useful for people who don't use the Roman alphabet. What used to happen was that particular languages would stick their own alphabet in the upper range of the sequence, between 128 and 255. Of course, we then ended up with plenty of variants that weren't quite ASCII, and the whole point of it being a standard was lost.

Worse still, if you've got a language like Chinese or Japanese that has hundreds or thousands of characters, then you really can't fit them into a mere 256, so they had to forget about ASCII altogether, and build their own systems using pairs of numbers to refer to one character.

To fix this, some people formed Unicode, Inc. and produced a new character set containing all the characters you can possibly think of and more. There are several ways of representing these characters, and the one Perl uses is called UTF8. UTF8 uses a variable number of bytes to represent a character, instead of just one. You can learn more about Unicode at http://www.unicode.org/

How can I recognise a UTF8 string?

You can't. This is because UTF8 data is stored in bytes just like non–UTF8 data. The Unicode character 200, (`0xC8` for you hex types) capital E with a grave accent, is represented by the two bytes `v196.172`. Unfortunately, the non–Unicode string `chr(196).chr(172)` has that byte sequence as well. So you can't tell just by looking – this is what makes Unicode input an interesting problem.

The API function `is_utf8_string` can help; it'll tell you if a string contains only valid UTF8 characters. However, it can't do the work for you. On a character–by–character basis, `is_utf8_char` will tell you whether the current character in a string is valid UTF8.

How does UTF8 represent Unicode characters?

As mentioned above, UTF8 uses a variable number of bytes to store a character. Characters with values 1...128 are stored in one byte, just like good ol' ASCII. Character 129 is stored as `v194.129`; this continues up to character 191, which is `v194.191`. Now we've run out of bits (191 is binary `10111111`) so we move on; 192 is `v195.128`. And so it goes on, moving to three bytes at character 2048.

Assuming you know you're dealing with a UTF8 string, you can find out how long the first character in it is with the `UTF8SKIP` macro:

```
char *utf = "\305\233\340\240\201";
I32 len;

len = UTF8SKIP(utf); /* len is 2 here */
utf += len;
len = UTF8SKIP(utf); /* len is 3 here */
```

Another way to skip over characters in a UTF8 string is to use `utf8_hop`, which takes a string and a number of characters to skip over. You're on your own about bounds checking, though, so don't use it lightly.

All bytes in a multi–byte UTF8 character will have the high bit set, so you can test if you need to do something special with this character like this:

```
UV uv;

if (utf & 0x80)
    /* Must treat this as UTF8 */
    uv = utf8_to_uv(utf);
else
    /* OK to treat this character as a byte */
    uv = *utf;
```

You can also see in that example that we use `utf8_to_uv` to get the value of the character; the inverse function `uv_to_utf8` is available for putting a UV into UTF8:

```
if (uv > 0x80)
    /* Must treat this as UTF8 */
    utf8 = uv_to_utf8(utf8, uv);
else
    /* OK to treat this character as a byte */
    *utf8++ = uv;
```

You **must** convert characters to UVs using the above functions if you're ever in a situation where you have to match UTF8 and non-UTF8 characters. You may not skip over UTF8 characters in this case. If you do this, you'll lose the ability to match hi-bit non-UTF8 characters; for instance, if your UTF8 string contains `v196.172`, and you skip that character, you can never match a `chr(200)` in a non-UTF8 string. So don't do that!

How does Perl store UTF8 strings?

Currently, Perl deals with Unicode strings and non-Unicode strings slightly differently. If a string has been identified as being UTF-8 encoded, Perl will set a flag in the SV, `SVf_UTF8`. You can check and manipulate this flag with the following macros:

```
SvUTF8(sv)
SvUTF8_on(sv)
SvUTF8_off(sv)
```

This flag has an important effect on Perl's treatment of the string: if Unicode data is not properly distinguished, regular expressions, `length`, `substr` and other string handling operations will have undesirable results.

The problem comes when you have, for instance, a string that isn't flagged is UTF8, and contains a byte sequence that could be UTF8 – especially when combining non-UTF8 and UTF8 strings.

Never forget that the `SVf_UTF8` flag is separate to the PV value; you need be sure you don't accidentally knock it off while you're manipulating SVs. More specifically, you cannot expect to do this:

```
SV *sv;
SV *nsv;
STRLEN len;
char *p;

p = SvPV(sv, len);
frobnicate(p);
nsv = newSVpvn(p, len);
```

The `char*` string does not tell you the whole story, and you can't copy or reconstruct an SV just by copying the string value. Check if the old SV has the UTF8 flag set, and act accordingly:

```
p = SvPV(sv, len);
frobnicate(p);
nsv = newSVpvn(p, len);
if (SvUTF8(sv))
    SvUTF8_on(nsv);
```

In fact, your `frobnicate` function should be made aware of whether or not it's dealing with UTF8 data, so that it can handle the string appropriately.

How do I convert a string to UTF8?

If you're mixing UTF8 and non-UTF8 strings, you might find it necessary to upgrade one of the strings to UTF8. If you've got an SV, the easiest way to do this is:

```
sv_utf8_upgrade(sv);
```

However, you must not do this, for example:

```
if (!SvUTF8(left))
    sv_utf8_upgrade(left);
```

If you do this in a binary operator, you will actually change one of the strings that came into the operator, and, while it shouldn't be noticeable by the end user, it can cause problems.

Instead, `bytes_to_utf8` will give you a UTF8-encoded **copy** of its string argument. This is useful for having the data available for comparisons and so on, without harming the original SV. There's also `utf8_to_bytes` to go the other way, but naturally, this will fail if the string contains any characters above 255 that can't be represented in a single byte.

Is there anything else I need to know?

Not really. Just remember these things:

- There's no way to tell if a string is UTF8 or not. You can tell if an SV is UTF8 by looking at is `SvUTF8` flag. Don't forget to set the flag if something should be UTF8. Treat the flag as part of the PV, even though it's not – if you pass on the PV to somewhere, pass on the flag too.
- If a string is UTF8, **always** use `utf8_to_uv` to get at the value, unless `!(*s & 0x80)` in which case you can use `*s`.
- When writing to a UTF8 string, **always** use `uv_to_utf8`, unless `uv < 0x80` in which case you can use `*s = uv`.
- Mixing UTF8 and non-UTF8 strings is tricky. Use `bytes_to_utf8` to get a new string which is UTF8 encoded. There are tricks you can use to delay deciding whether you need to use a UTF8 string until you get to a high character – `HALF_UPGRADE` is one of those.

AUTHORS

Until May 1997, this document was maintained by Jeff Okamoto <okamoto@corp.hp.com. It is now maintained as part of Perl itself by the Perl 5 Porters <perl5-porters@perl.org.

With lots of help and suggestions from Dean Roehrich, Malcolm Beattie, Andreas Koenig, Paul Hudson, Ilya Zakharevich, Paul Marquess, Neil Bowers, Matthew Green, Tim Bunce, Spider Boardman, Ulrich Pfeifer, Stephen McCamant, and Gurusamy Sarathy.

API Listing originally by Dean Roehrich <roehrich@cray.com.

Modifications to autogenerate the API listing (*perlapi*) by Benjamin Stuhl.

SEE ALSO

perlapi(1), perlintern(1), perlxs(1), perlembed(1)

NAME

perlhack – How to hack at the Perl internals

DESCRIPTION

This document attempts to explain how Perl development takes place, and ends with some suggestions for people wanting to become bona fide porters.

The perl5–porters mailing list is where the Perl standard distribution is maintained and developed. The list can get anywhere from 10 to 150 messages a day, depending on the heatedness of the debate. Most days there are two or three patches, extensions, features, or bugs being discussed at a time.

A searchable archive of the list is at:

```
http://www.xray.mpe.mpg.de/mailing-lists/perl5-porters/
```

The list is also archived under the usenet group name `perl.porters-gw` at:

```
http://www.deja.com/
```

List subscribers (the porters themselves) come in several flavours. Some are quiet curious lurkers, who rarely pitch in and instead watch the ongoing development to ensure they're forewarned of new changes or features in Perl. Some are representatives of vendors, who are there to make sure that Perl continues to compile and work on their platforms. Some patch any reported bug that they know how to fix, some are actively patching their pet area (threads, Win32, the regexp engine), while others seem to do nothing but complain. In other words, it's your usual mix of technical people.

Over this group of porters presides Larry Wall. He has the final word in what does and does not change in the Perl language. Various releases of Perl are shepherded by a ''pumpking'', a porter responsible for gathering patches, deciding on a patch–by–patch feature–by–feature basis what will and will not go into the release. For instance, Gurusamy Sarathy is the pumpking for the 5.6 release of Perl.

In addition, various people are pumpkings for different things. For instance, Andy Dougherty and Jarkko Hietaniemi share the *Configure* pumpkin, and Tom Christiansen is the documentation pumpking.

Larry sees Perl development along the lines of the US government: there's the Legislature (the porters), the Executive branch (the pumpkings), and the Supreme Court (Larry). The legislature can discuss and submit patches to the executive branch all they like, but the executive branch is free to veto them. Rarely, the Supreme Court will side with the executive branch over the legislature, or the legislature over the executive branch. Mostly, however, the legislature and the executive branch are supposed to get along and work out their differences without impeachment or court cases.

You might sometimes see reference to Rule 1 and Rule 2. Larry's power as Supreme Court is expressed in The Rules:

1 Larry is always by definition right about how Perl should behave. This means he has final veto power on the core functionality.

2 Larry is allowed to change his mind about any matter at a later date, regardless of whether he previously invoked Rule 1.

Got that? Larry is always right, even when he was wrong. It's rare to see either Rule exercised, but they are often alluded to.

New features and extensions to the language are contentious, because the criteria used by the pumpkings, Larry, and other porters to decide which features should be implemented and incorporated are not codified in a few small design goals as with some other languages. Instead, the heuristics are flexible and often difficult to fathom. Here is one person's list, roughly in decreasing order of importance, of heuristics that new features have to be weighed against:

Does concept match the general goals of Perl?

These haven't been written anywhere in stone, but one approximation is:

```
1. Keep it fast, simple, and useful.
2. Keep features/concepts as orthogonal as possible.
3. No arbitrary limits (platforms, data sizes, cultures).
4. Keep it open and exciting to use/patch/advocate Perl everywhere.
5. Either assimilate new technologies, or build bridges to them.
```

Where is the implementation?

All the talk in the world is useless without an implementation. In almost every case, the person or people who argue for a new feature will be expected to be the ones who implement it. Porters capable of coding new features have their own agendas, and are not available to implement your (possibly good) idea.

Backwards compatibility

It's a cardinal sin to break existing Perl programs. New warnings are contentious—some say that a program that emits warnings is not broken, while others say it is. Adding keywords has the potential to break programs, changing the meaning of existing token sequences or functions might break programs.

Could it be a module instead?

Perl 5 has extension mechanisms, modules and XS, specifically to avoid the need to keep changing the Perl interpreter. You can write modules that export functions, you can give those functions prototypes so they can be called like built–in functions, you can even write XS code to mess with the runtime data structures of the Perl interpreter if you want to implement really complicated things. If it can be done in a module instead of in the core, it's highly unlikely to be added.

Is the feature generic enough?

Is this something that only the submitter wants added to the language, or would it be broadly useful? Sometimes, instead of adding a feature with a tight focus, the porters might decide to wait until someone implements the more generalized feature. For instance, instead of implementing a ''delayed evaluation'' feature, the porters are waiting for a macro system that would permit delayed evaluation and much more.

Does it potentially introduce new bugs?

Radical rewrites of large chunks of the Perl interpreter have the potential to introduce new bugs. The smaller and more localized the change, the better.

Does it preclude other desirable features?

A patch is likely to be rejected if it closes off future avenues of development. For instance, a patch that placed a true and final interpretation on prototypes is likely to be rejected because there are still options for the future of prototypes that haven't been addressed.

Is the implementation robust?

Good patches (tight code, complete, correct) stand more chance of going in. Sloppy or incorrect patches might be placed on the back burner until the pumpking has time to fix, or might be discarded altogether without further notice.

Is the implementation generic enough to be portable?

The worst patches make use of a system–specific features. It's highly unlikely that nonportable additions to the Perl language will be accepted.

Is there enough documentation?

Patches without documentation are probably ill–thought out or incomplete. Nothing can be added without documentation, so submitting a patch for the appropriate manpages as well as the source code is always a good idea. If appropriate, patches should add to the test suite as well.

Is there another way to do it?

Larry said ''Although the Perl Slogan is *There's More Than One Way to Do It*, I hesitate to make 10 ways to do something''. This is a tricky heuristic to navigate, though—one man's essential addition is another man's pointless cruft.

Does it create too much work?

Work for the pumpking, work for Perl programmers, work for module authors, ... Perl is supposed to be easy.

Patches speak louder than words

Working code is always preferred to pie−in−the−sky ideas. A patch to add a feature stands a much higher chance of making it to the language than does a random feature request, no matter how fervently argued the request might be. This ties into ''Will it be useful?'', as the fact that someone took the time to make the patch demonstrates a strong desire for the feature.

If you're on the list, you might hear the word ''core'' bandied around. It refers to the standard distribution. ''Hacking on the core'' means you're changing the C source code to the Perl interpreter. ''A core module'' is one that ships with Perl.

Keeping in sync

The source code to the Perl interpreter, in its different versions, is kept in a repository managed by a revision control system (which is currently the Perforce program, see http://perforce.com/). The pumpkings and a few others have access to the repository to check in changes. Periodically the pumpking for the development version of Perl will release a new version, so the rest of the porters can see what's changed. The current state of the main trunk of repository, and patches that describe the individual changes that have happened since the last public release are available at this location:

```
ftp://ftp.linux.activestate.com/pub/staff/gsar/APC/
```

If you are a member of the perl5−porters mailing list, it is a good thing to keep in touch with the most recent changes. If not only to verify if what you would have posted as a bug report isn't already solved in the most recent available perl development branch, also known as perl−current, bleading edge perl, bleedperl or bleadperl.

Needless to say, the source code in perl−current is usually in a perpetual state of evolution. You should expect it to be very buggy. Do **not** use it for any purpose other than testing and development.

Keeping in sync with the most recent branch can be done in several ways, but the most convenient and reliable way is using **rsync**, available at ftp://rsync.samba.org/pub/rsync/ . (You can also get the most recent branch by FTP.)

If you choose to keep in sync using rsync, there are two approaches to doing so:

rsync'ing the source tree

Presuming you are in the directory where your perl source resides and you have rsync installed and available, you can 'upgrade' to the bleadperl using:

```
# rsync -avz rsync://ftp.linux.activestate.com/perl-current/ .
```

This takes care of updating every single item in the source tree to the latest applied patch level, creating files that are new (to your distribution) and setting date/time stamps of existing files to reflect the bleadperl status.

You can than check what patch was the latest that was applied by looking in the file **.patch**, which will show the number of the latest patch.

If you have more than one machine to keep in sync, and not all of them have access to the WAN (so you are not able to rsync all the source trees to the real source), there are some ways to get around this problem.

Using rsync over the LAN

Set up a local rsync server which makes the rsynced source tree available to the LAN and sync the other machines against this directory.

From http://rsync.samba.org/README.html:

```
"Rsync uses rsh or ssh for communication. It does not need to be
 setuid and requires no special privileges for installation.  It
 does not require a inetd entry or a deamon.  You must, however,
 have a working rsh or ssh system.  Using ssh is recommended for
 its security features."
```

Using pushing over the NFS

Having the other systems mounted over the NFS, you can take an active pushing approach by checking the just updated tree against the other not-yet synced trees. An example would be

```
#!/usr/bin/perl -w

use strict;
use File::Copy;

my %MF = map {
    m/(\S+)/;
    $1 => [ (stat $1)[2, 7, 9] ];     # mode, size, mtime
    } `cat MANIFEST`;

my %remote = map { $_ => "/$_/pro/3gl/CPAN/perl-5.7.1" } qw(host1 host2);

foreach my $host (keys %remote) {
    unless (-d $remote{$host}) {
        print STDERR "Cannot Xsync for host $host\n";
        next;
        }
    foreach my $file (keys %MF) {
        my $rfile = "$remote{$host}/$file";
        my ($mode, $size, $mtime) = (stat $rfile)[2, 7, 9];
        defined $size or ($mode, $size, $mtime) = (0, 0, 0);
        $size == $MF{$file}[1] && $mtime == $MF{$file}[2] and next;
        printf "%4s %-34s %8d %9d  %8d %9d\n",
            $host, $file, $MF{$file}[1], $MF{$file}[2], $size, $mtime;
        unlink $rfile;
        copy ($file, $rfile);
        utime time, $MF{$file}[2], $rfile;
        chmod $MF{$file}[0], $rfile;
        }
    }
```

though this is not perfect. It could be improved with checking file checksums before updating. Not all NFS systems support reliable utime support (when used over the NFS).

rsync'ing the patches

The source tree is maintained by the pumpking who applies patches to the files in the tree. These patches are either created by the pumpking himself using `diff -c` after updating the file manually or by applying patches sent in by posters on the perl5-porters list. These patches are also saved and rsync'able, so you can apply them yourself to the source files.

Presuming you are in a directory where your patches reside, you can get them in sync with

```
# rsync -avz rsync://ftp.linux.activestate.com/perl-current-diffs/ .
```

This makes sure the latest available patch is downloaded to your patch directory.

It‘s then up to you to apply these patches, using something like

```
# last=‘ls -rt1 *.gz | tail -1‘
# rsync -avz rsync://ftp.linux.activestate.com/perl-current-diffs/ .
# find . -name ’*.gz’ -newer $last -exec gzcat {} \; >blead.patch
# cd ../perl-current
# patch -p1 -N <../perl-current-diffs/blead.patch
```

or, since this is only a hint towards how it works, use CPAN-patchaperl from Andreas König to have better control over the patching process.

Why rsync the source tree

It‘s easier

Since you don‘t have to apply the patches yourself, you are sure all files in the source tree are in the right state.

It‘s more recent

According to Gurusamy Sarathy:

> "... The rsync mirror is automatic and syncs with the repository every five minutes.
>
> "Updating the patch area still requires manual intervention (with all the goofiness that implies, which you’ve noted) and is typically on a daily cycle. Making this process automatic is on my tuit list, but don’t ask me when."

It‘s more reliable

Well, since the patches are updated by hand, I don‘t have to say any more ... (see Sarathy‘s remark).

Why rsync the patches

It‘s easier

If you have more than one machine that you want to keep in track with bleadperl, it‘s easier to rsync the patches only once and then apply them to all the source trees on the different machines.

In case you try to keep in pace on 5 different machines, for which only one of them has access to the WAN, rsync‘ing all the source trees should than be done 5 times over the NFS. Having rsync‘ed the patches only once, I can apply them to all the source trees automatically. Need you say more ;-)

It‘s a good reference

If you do not only like to have the most recent development branch, but also like to **fix** bugs, or extend features, you want to dive into the sources. If you are a seasoned perl core diver, you don‘t need no manuals, tips, roadmaps, perlguts.pod or other aids to find your way around. But if you are a starter, the patches may help you in finding where you should start and how to change the bits that bug you.

The file **Changes** is updated on occasions the pumpking sees as his own little sync points. On those occasions, he releases a tar-ball of the current source tree (i.e. perl@7582.tar.gz), which will be an excellent point to start with when choosing to use the ‘rsync the patches’ scheme. Starting with perl@7582, which means a set of source files on which the latest applied patch is number 7582, you apply all succeeding patches available from than on (7583, 7584, ...).

You can use the patches later as a kind of search archive.

Finding a start point

If you want to fix/change the behaviour of function/feature Foo, just scan the patches for patches that mention Foo either in the subject, the comments, or the body of the fix. A good chance the patch shows you the files that are affected by that patch which are very likely to be the starting

point of your journey into the guts of perl.

Finding how to fix a bug

If you've found *where* the function/feature Foo misbehaves, but you don't know how to fix it (but you do know the change you want to make), you can, again, peruse the patches for similar changes and look how others apply the fix.

Finding the source of misbehaviour

When you keep in sync with bleadperl, the pumpking would love to *see* that the community efforts realy work. So after each of his sync points, you are to 'make test' to check if everything is still in working order. If it is, you do 'make ok', which will send an OK report to perlbug@perl.org. (If you do not have access to a mailer from the system you just finished successfully 'make test', you can do 'make okfile', which creates the file `perl.ok`, which you can than take to your favourite mailer and mail yourself).

But of course, as always, things will not allways lead to a success path, and one or more test do not pass the 'make test'. Before sending in a bug report (using 'make nok' or 'make nokfile'), check the mailing list if someone else has reported the bug already and if so, confirm it by replying to that message. If not, you might want to trace the source of that misbehaviour **before** sending in the bug, which will help all the other porters in finding the solution.

Here the saved patches come in very handy. You can check the list of patches to see which patch changed what file and what change caused the misbehaviour. If you note that in the bug report, it saves the one trying to solve it, looking for that point.

If searching the patches is too bothersome, you might consider using perl's bugtron to find more information about discussions and ramblings on posted bugs.

If you want to get the best of both worlds, rsync both the source tree for convenience, reliability and ease and rsync the patches for reference.

Submitting patches

Always submit patches to *perl5-porters@perl.org*. This lets other porters review your patch, which catches a surprising number of errors in patches. Either use the diff program (available in source code form from *ftp://ftp.gnu.org/pub/gnu/*), or use Johan Vromans' *makepatch* (available from *CPAN/authors/id/JV/*). Unified diffs are preferred, but context diffs are accepted. Do not send RCS-style diffs or diffs without context lines. More information is given in the *Porting/patching.pod* file in the Perl source distribution. Please patch against the latest **development** version (e.g., if you're fixing a bug in the 5.005 track, patch against the latest 5.005_5x version). Only patches that survive the heat of the development branch get applied to maintenance versions.

Your patch should update the documentation and test suite.

To report a bug in Perl, use the program *perlbug* which comes with Perl (if you can't get Perl to work, send mail to the address *perlbug@perl.com* or *perlbug@perl.org*). Reporting bugs through *perlbug* feeds into the automated bug-tracking system, access to which is provided through the web at *http://bugs.perl.org/*. It often pays to check the archives of the perl5-porters mailing list to see whether the bug you're reporting has been reported before, and if so whether it was considered a bug. See above for the location of the searchable archives.

The CPAN testers (*http://testers.cpan.org/*) are a group of volunteers who test CPAN modules on a variety of platforms. Perl Labs (*http://labs.perl.org/*) automatically tests Perl source releases on platforms and gives feedback to the CPAN testers mailing list. Both efforts welcome volunteers.

It's a good idea to read and lurk for a while before chipping in. That way you'll get to see the dynamic of the conversations, learn the personalities of the players, and hopefully be better prepared to make a useful contribution when do you speak up.

If after all this you still think you want to join the perl5-porters mailing list, send mail to *perl5-porters-subscribe@perl.org*. To unsubscribe, send mail to *perl5-porters-unsubscribe@perl.org*.

To hack on the Perl guts, you'll need to read the following things:

perlguts

This is of paramount importance, since it's the documentation of what goes where in the Perl source. Read it over a couple of times and it might start to make sense − don't worry if it doesn't yet, because the best way to study it is to read it in conjunction with poking at Perl source, and we'll do that later on.

You might also want to look at Gisle Aas's illustrated perlguts − there's no guarantee that this will be absolutely up−to−date with the latest documentation in the Perl core, but the fundamentals will be right. (http://gisle.aas.no/perl/illguts/)

perlxstut and *perlxs*

A working knowledge of XSUB programming is incredibly useful for core hacking; XSUBs use techniques drawn from the PP code, the portion of the guts that actually executes a Perl program. It's a lot gentler to learn those techniques from simple examples and explanation than from the core itself.

perlapi

The documentation for the Perl API explains what some of the internal functions do, as well as the many macros used in the source.

Porting/pumpkin.pod

This is a collection of words of wisdom for a Perl porter; some of it is only useful to the pumpkin holder, but most of it applies to anyone wanting to go about Perl development.

The perl5−porters FAQ

This is posted to perl5−porters at the beginning on every month, and should be available from http://perlhacker.org/p5p−faq; alternatively, you can get the FAQ emailed to you by sending mail to `perl5-porters-faq@perl.org`. It contains hints on reading perl5−porters, information on how perl5−porters works and how Perl development in general works.

Finding Your Way Around

Perl maintenance can be split into a number of areas, and certain people (pumpkins) will have responsibility for each area. These areas sometimes correspond to files or directories in the source kit. Among the areas are:

Core modules

Modules shipped as part of the Perl core live in the ***lib/*** and ***ext/*** subdirectories: ***lib/*** is for the pure−Perl modules, and ***ext/*** contains the core XS modules.

Documentation

Documentation maintenance includes looking after everything in the ***pod/*** directory, (as well as contributing new documentation) and the documentation to the modules in core.

Configure

The configure process is the way we make Perl portable across the myriad of operating systems it supports. Responsibility for the configure, build and installation process, as well as the overall portability of the core code rests with the configure pumpkin − others help out with individual operating systems.

The files involved are the operating system directories, (***win32/***, ***os2/***, ***vms/*** and so on) the shell scripts which generate ***config.h*** and ***Makefile***, as well as the metaconfig files which generate ***Configure***. (metaconfig isn't included in the core distribution.)

Interpreter

And of course, there's the core of the Perl interpreter itself. Let's have a look at that in a little more detail.

Before we leave looking at the layout, though, don't forget that ***MANIFEST*** contains not only the file names in the Perl distribution, but short descriptions of what's in them, too. For an overview of the important files,

try this:

```
perl -lne 'print if /^[^\/]+\.[ch]\s+/' MANIFEST
```

Elements of the interpreter

The work of the interpreter has two main stages: compiling the code into the internal representation, or bytecode, and then executing it. *Compiled code* explains exactly how the compilation stage happens.

Here is a short breakdown of perl's operation:

Startup

The action begins in ***perlmain.c***. (or ***miniperlmain.c*** for miniperl) This is very high–level code, enough to fit on a single screen, and it resembles the code found in *perlembed*; most of the real action takes place in ***perl.c***

First, ***perlmain.c*** allocates some memory and constructs a Perl interpreter:

```
1 PERL_SYS_INIT3(&argc,&argv,&env);
2
3 if (!PL_do_undump) {
4     my_perl = perl_alloc();
5     if (!my_perl)
6         exit(1);
7     perl_construct(my_perl);
8     PL_perl_destruct_level = 0;
9 }
```

Line 1 is a macro, and its definition is dependent on your operating system. Line 3 references `PL_do_undump`, a global variable – all global variables in Perl start with `PL_`. This tells you whether the current running program was created with the `-u` flag to perl and then ***undump***, which means it's going to be false in any sane context.

Line 4 calls a function in ***perl.c*** to allocate memory for a Perl interpreter. It's quite a simple function, and the guts of it looks like this:

```
my_perl = (PerlInterpreter*)PerlMem_malloc(sizeof(PerlInterpreter));
```

Here you see an example of Perl's system abstraction, which we'll see later: `PerlMem_malloc` is either your system's `malloc`, or Perl's own `malloc` as defined in ***malloc.c*** if you selected that option at configure time.

Next, in line 7, we construct the interpreter; this sets up all the special variables that Perl needs, the stacks, and so on.

Now we pass Perl the command line options, and tell it to go:

```
exitstatus = perl_parse(my_perl, xs_init, argc, argv, (char **)NULL);
if (!exitstatus) {
    exitstatus = perl_run(my_perl);
}
```

`perl_parse` is actually a wrapper around `S_parse_body`, as defined in ***perl.c***, which processes the command line options, sets up any statically linked XS modules, opens the program and calls `yyparse` to parse it.

Parsing

The aim of this stage is to take the Perl source, and turn it into an op tree. We'll see what one of those looks like later. Strictly speaking, there's three things going on here.

`yyparse`, the parser, lives in ***perly.c***, although you're better off reading the original YACC input in ***perly.y***. (Yes, Virginia, there **is** a YACC grammar for Perl!) The job of the parser is to take your code and 'understand' it, splitting it into sentences, deciding which operands go with which operators and so

on.

The parser is nobly assisted by the lexer, which chunks up your input into tokens, and decides what type of thing each token is: a variable name, an operator, a bareword, a subroutine, a core function, and so on. The main point of entry to the lexer is `yylex`, and that and its associated routines can be found in ***toke.c***. Perl isn't much like other computer languages; it's highly context sensitive at times, it can be tricky to work out what sort of token something is, or where a token ends. As such, there's a lot of interplay between the tokeniser and the parser, which can get pretty frightening if you're not used to it.

As the parser understands a Perl program, it builds up a tree of operations for the interpreter to perform during execution. The routines which construct and link together the various operations are to be found in ***op.c***, and will be examined later.

Optimization

Now the parsing stage is complete, and the finished tree represents the operations that the Perl interpreter needs to perform to execute our program. Next, Perl does a dry run over the tree looking for optimisations: constant expressions such as `3 + 4` will be computed now, and the optimizer will also see if any multiple operations can be replaced with a single one. For instance, to fetch the variable `$foo`, instead of grabbing the glob `*foo` and looking at the scalar component, the optimizer fiddles the op tree to use a function which directly looks up the scalar in question. The main optimizer is `peep` in ***op.c***, and many ops have their own optimizing functions.

Running

Now we're finally ready to go: we have compiled Perl byte code, and all that's left to do is run it. The actual execution is done by the `runops_standard` function in ***run.c***; more specifically, it's done by these three innocent looking lines:

```
while ((PL_op = CALL_FPTR(PL_op->op_ppaddr)(aTHX))) {
    PERL_ASYNC_CHECK();
}
```

You may be more comfortable with the Perl version of that:

```
PERL_ASYNC_CHECK() while $Perl::op = &{$Perl::op->{function}};
```

Well, maybe not. Anyway, each op contains a function pointer, which stipulates the function which will actually carry out the operation. This function will return the next op in the sequence – this allows for things like `if` which choose the next op dynamically at run time. The `PERL_ASYNC_CHECK` makes sure that things like signals interrupt execution if required.

The actual functions called are known as PP code, and they're spread between four files: ***pp_hot.c*** contains the 'hot' code, which is most often used and highly optimized, ***pp_sys.c*** contains all the system–specific functions, ***pp_ctl.c*** contains the functions which implement control structures (`if`, `while` and the like) and ***pp.c*** contains everything else. These are, if you like, the C code for Perl's built–in functions and operators.

Internal Variable Types

You should by now have had a look at *perlguts*, which tells you about Perl's internal variable types: SVs, HVs, AVs and the rest. If not, do that now.

These variables are used not only to represent Perl–space variables, but also any constants in the code, as well as some structures completely internal to Perl. The symbol table, for instance, is an ordinary Perl hash. Your code is represented by an SV as it's read into the parser; any program files you call are opened via ordinary Perl filehandles, and so on.

The core *Devel::Peek|Devel::Peek* module lets us examine SVs from a Perl program. Let's see, for instance, how Perl treats the constant `"hello"`.

```
  % perl -MDevel::Peek -e 'Dump("hello")'
1 SV = PV(0xa041450) at 0xa04ecbc
```

```
2   REFCNT = 1
3   FLAGS = (POK,READONLY,pPOK)
4   PV = 0xa0484e0 "hello"\0
5   CUR = 5
6   LEN = 6
```

Reading `Devel::Peek` output takes a bit of practise, so let's go through it line by line.

Line 1 tells us we're looking at an SV which lives at `0xa04ecbc` in memory. SVs themselves are very simple structures, but they contain a pointer to a more complex structure. In this case, it's a PV, a structure which holds a string value, at location `0xa041450`. Line 2 is the reference count; there are no other references to this data, so it's 1.

Line 3 are the flags for this SV – it's OK to use it as a PV, it's a read–only SV (because it's a constant) and the data is a PV internally. Next we've got the contents of the string, starting at location `0xa0484e0`.

Line 5 gives us the current length of the string – note that this does **not** include the null terminator. Line 6 is not the length of the string, but the length of the currently allocated buffer; as the string grows, Perl automatically extends the available storage via a routine called `SvGROW`.

You can get at any of these quantities from C very easily; just add `Sv` to the name of the field shown in the snippet, and you've got a macro which will return the value: `SvCUR(sv)` returns the current length of the string, `SvREFCOUNT(sv)` returns the reference count, `SvPV(sv, len)` returns the string itself with its length, and so on. More macros to manipulate these properties can be found in *perlguts*.

Let's take an example of manipulating a PV, from `sv_catpvn`, in ***sv.c***

```
 1  void
 2  Perl_sv_catpvn(pTHX_ register SV *sv, register const char *ptr, register STRL
 3  {
 4      STRLEN tlen;
 5      char *junk;

 6      junk = SvPV_force(sv, tlen);
 7      SvGROW(sv, tlen + len + 1);
 8      if (ptr == junk)
 9          ptr = SvPVX(sv);
10      Move(ptr,SvPVX(sv)+tlen,len,char);
11      SvCUR(sv) += len;
12      *SvEND(sv) = '\0';
13      (void)SvPOK_only_UTF8(sv);          /* validate pointer */
14      SvTAINT(sv);
15  }
```

This is a function which adds a string, `ptr`, of length `len` onto the end of the PV stored in `sv`. The first thing we do in line 6 is make sure that the SV **has** a valid PV, by calling the `SvPV_force` macro to force a PV. As a side effect, `tlen` gets set to the current value of the PV, and the PV itself is returned to `junk`.

In line 7, we make sure that the SV will have enough room to accommodate the old string, the new string and the null terminator. If `LEN` isn't big enough, `SvGROW` will reallocate space for us.

Now, if `junk` is the same as the string we're trying to add, we can grab the string directly from the SV; `SvPVX` is the address of the PV in the SV.

Line 10 does the actual catenation: the `Move` macro moves a chunk of memory around: we move the string `ptr` to the end of the PV – that's the start of the PV plus its current length. We're moving `len` bytes of type `char`. After doing so, we need to tell Perl we've extended the string, by altering `CUR` to reflect the new length. `SvEND` is a macro which gives us the end of the string, so that needs to be a `"\0"`.

Line 13 manipulates the flags; since we've changed the PV, any IV or NV values will no longer be valid: if we have `$a=10; $a."6";` we don't want to use the old IV of 10. `SvPOK_only_utf8` is a special

UTF8–aware version of SvPOK_only, a macro which turns off the IOK and NOK flags and turns on POK. The final SvTAINT is a macro which launders tainted data if taint mode is turned on.

AVs and HVs are more complicated, but SVs are by far the most common variable type being thrown around. Having seen something of how we manipulate these, let's go on and look at how the op tree is constructed.

Op Trees

First, what is the op tree, anyway? The op tree is the parsed representation of your program, as we saw in our section on parsing, and it's the sequence of operations that Perl goes through to execute your program, as we saw in */Running*.

An op is a fundamental operation that Perl can perform: all the built–in functions and operators are ops, and there are a series of ops which deal with concepts the interpreter needs internally – entering and leaving a block, ending a statement, fetching a variable, and so on.

The op tree is connected in two ways: you can imagine that there are two "routes" through it, two orders in which you can traverse the tree. First, parse order reflects how the parser understood the code, and secondly, execution order tells perl what order to perform the operations in.

The easiest way to examine the op tree is to stop Perl after it has finished parsing, and get it to dump out the tree. This is exactly what the compiler backends *B::Terse|B::Terse* and *B::Debug|B::Debug* do.

Let's have a look at how Perl sees `$a = $b + $c`:

```
% perl -MO=Terse -e '$a=$b+$c'
1  LISTOP (0x8179888) leave
2      OP (0x81798b0) enter
3      COP (0x8179850) nextstate
4      BINOP (0x8179828) sassign
5          BINOP (0x8179800) add [1]
6              UNOP (0x81796e0) null [15]
7                  SVOP (0x80fafe0) gvsv  GV (0x80fa4cc) *b
8              UNOP (0x81797e0) null [15]
9                  SVOP (0x8179700) gvsv  GV (0x80efeb0) *c
10         UNOP (0x816b4f0) null [15]
11             SVOP (0x816dcf0) gvsv  GV (0x80fa460) *a
```

Let's start in the middle, at line 4. This is a BINOP, a binary operator, which is at location `0x8179828`. The specific operator in question is `sassign` – scalar assignment – and you can find the code which implements it in the function `pp_sassign` in ***pp_hot.c***. As a binary operator, it has two children: the add operator, providing the result of `$b+$c`, is uppermost on line 5, and the left hand side is on line 10.

Line 10 is the null op: this does exactly nothing. What is that doing there? If you see the null op, it's a sign that something has been optimized away after parsing. As we mentioned in */Optimization*, the optimization stage sometimes converts two operations into one, for example when fetching a scalar variable. When this happens, instead of rewriting the op tree and cleaning up the dangling pointers, it's easier just to replace the redundant operation with the null op. Originally, the tree would have looked like this:

```
10         SVOP (0x816b4f0) rv2sv [15]
11             SVOP (0x816dcf0) gv  GV (0x80fa460) *a
```

That is, fetch the `a` entry from the main symbol table, and then look at the scalar component of it: `gvsv` (`pp_gvsv` into ***pp_hot.c***) happens to do both these things.

The right hand side, starting at line 5 is similar to what we've just seen: we have the `add` op (`pp_add` also in ***pp_hot.c***) add together two `gvsv`s.

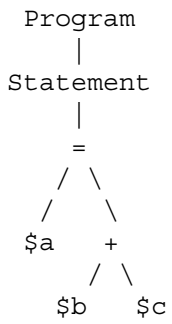
Now, what's this about?

```
1  LISTOP (0x8179888) leave
```

```
2       OP (0x81798b0) enter
3       COP (0x8179850) nextstate
```

`enter` and `leave` are scoping ops, and their job is to perform any housekeeping every time you enter and leave a block: lexical variables are tidied up, unreferenced variables are destroyed, and so on. Every program will have those first three lines: `leave` is a list, and its children are all the statements in the block. Statements are delimited by `nextstate`, so a block is a collection of `nextstate` ops, with the ops to be performed for each statement being the children of `nextstate`. `enter` is a single op which functions as a marker.

That's how Perl parsed the program, from top to bottom:



However, it's impossible to **perform** the operations in this order: you have to find the values of `$b` and `$c` before you add them together, for instance. So, the other thread that runs through the op tree is the execution order: each op has a field `op_next` which points to the next op to be run, so following these pointers tells us how perl executes the code. We can traverse the tree in this order using the `exec` option to `B::Terse`:

```
% perl -MO=Terse,exec -e '$a=$b+$c'
1  OP (0x8179928) enter
2  COP (0x81798c8) nextstate
3  SVOP (0x81796c8) gvsv  GV (0x80fa4d4) *b
4  SVOP (0x8179798) gvsv  GV (0x80efeb0) *c
5  BINOP (0x8179878) add [1]
6  SVOP (0x816dd38) gvsv  GV (0x80fa468) *a
7  BINOP (0x81798a0) sassign
8  LISTOP (0x8179900) leave
```

This probably makes more sense for a human: enter a block, start a statement. Get the values of `$b` and `$c`, and add them together. Find `$a`, and assign one to the other. Then leave.

The way Perl builds up these op trees in the parsing process can be unravelled by examining ***perly.y***, the YACC grammar. Let's take the piece we need to construct the tree for `$a = $b + $c`

```
1 term    :   term ASSIGNOP term
2                 { $$ = newASSIGNOP(OPf_STACKED, $1, $2, $3); }
3         |   term ADDOP term
4                 { $$ = newBINOP($2, 0, scalar($1), scalar($3)); }
```

If you're not used to reading BNF grammars, this is how it works: You're fed certain things by the tokeniser, which generally end up in upper case. Here, `ADDOP`, is provided when the tokeniser sees `+` in your code. `ASSIGNOP` is provided when `=` is used for assigning. These are 'terminal symbols', because you can't get any simpler than them.

The grammar, lines one and three of the snippet above, tells you how to build up more complex forms. These complex forms, 'non–terminal symbols' are generally placed in lower case. `term` here is a non–terminal symbol, representing a single expression.

The grammar gives you the following rule: you can make the thing on the left of the colon if you see all the things on the right in sequence. This is called a "reduction", and the aim of parsing is to completely reduce

the input. There are several different ways you can perform a reduction, separated by vertical bars: so, `term` followed by `=` followed by `term` makes a `term`, and `term` followed by `+` followed by `term` can also make a `term`.

So, if you see two terms with an `=` or `+`, between them, you can turn them into a single expression. When you do this, you execute the code in the block on the next line: if you see `=`, you'll do the code in line 2. If you see `+`, you'll do the code in line 4. It's this code which contributes to the op tree.

```
|   term ADDOP term
{ $$ = newBINOP($2, 0, scalar($1), scalar($3)); }
```

What this does is creates a new binary op, and feeds it a number of variables. The variables refer to the tokens: `$1` is the first token in the input, `$2` the second, and so on – think regular expression backreferences. `$$` is the op returned from this reduction. So, we call `newBINOP` to create a new binary operator. The first parameter to `newBINOP`, a function in ***op.c***, is the op type. It's an addition operator, so we want the type to be `ADDOP`. We could specify this directly, but it's right there as the second token in the input, so we use `$2`. The second parameter is the op's flags: 0 means 'nothing special'. Then the things to add: the left and right hand side of our expression, in scalar context.

Stacks

When perl executes something like `addop`, how does it pass on its results to the next op? The answer is, through the use of stacks. Perl has a number of stacks to store things it's currently working on, and we'll look at the three most important ones here.

Argument stack

Arguments are passed to PP code and returned from PP code using the argument stack, `ST`. The typical way to handle arguments is to pop them off the stack, deal with them how you wish, and then push the result back onto the stack. This is how, for instance, the cosine operator works:

```
NV value;
value = POPn;
value = Perl_cos(value);
XPUSHn(value);
```

We'll see a more tricky example of this when we consider Perl's macros below. `POPn` gives you the NV (floating point value) of the top SV on the stack: the `$x` in `cos($x)`. Then we compute the cosine, and push the result back as an NV. The `X` in `XPUSHn` means that the stack should be extended if necessary – it can't be necessary here, because we know there's room for one more item on the stack, since we've just removed one! The `XPUSH*` macros at least guarantee safety.

Alternatively, you can fiddle with the stack directly: `SP` gives you the first element in your portion of the stack, and `TOP*` gives you the top SV/IV/NV/etc. on the stack. So, for instance, to do unary negation of an integer:

```
SETi(-TOPi);
```

Just set the integer value of the top stack entry to its negation.

Argument stack manipulation in the core is exactly the same as it is in XSUBs – see *perlxstut*, *perlxs* and *perlguts* for a longer description of the macros used in stack manipulation.

Mark stack

I say 'your portion of the stack' above because PP code doesn't necessarily get the whole stack to itself: if your function calls another function, you'll only want to expose the arguments aimed for the called function, and not (necessarily) let it get at your own data. The way we do this is to have a 'virtual' bottom–of–stack, exposed to each function. The mark stack keeps bookmarks to locations in the argument stack usable by each function. For instance, when dealing with a tied variable, (internally, something with 'P' magic) Perl has to call methods for accesses to the tied variables. However, we need to separate the arguments exposed to the method to the argument exposed to the original function – the store or fetch or whatever it may be. Here's how the tied `push` is implemented; see `av_push` in ***av.c***:

```
1   PUSHMARK(SP);
2   EXTEND(SP,2);
3   PUSHs(SvTIED_obj((SV*)av, mg));
4   PUSHs(val);
5   PUTBACK;
6   ENTER;
7   call_method("PUSH", G_SCALAR|G_DISCARD);
8   LEAVE;
9   POPSTACK;
```

The lines which concern the mark stack are the first, fifth and last lines: they save away, restore and remove the current position of the argument stack.

Let's examine the whole implementation, for practice:

```
1   PUSHMARK(SP);
```

Push the current state of the stack pointer onto the mark stack. This is so that when we've finished adding items to the argument stack, Perl knows how many things we've added recently.

```
2   EXTEND(SP,2);
3   PUSHs(SvTIED_obj((SV*)av, mg));
4   PUSHs(val);
```

We're going to add two more items onto the argument stack: when you have a tied array, the `PUSH` subroutine receives the object and the value to be pushed, and that's exactly what we have here – the tied object, retrieved with `SvTIED_obj`, and the value, the SV `val`.

```
5   PUTBACK;
```

Next we tell Perl to make the change to the global stack pointer: `dSP` only gave us a local copy, not a reference to the global.

```
6   ENTER;
7   call_method("PUSH", G_SCALAR|G_DISCARD);
8   LEAVE;
```

`ENTER` and `LEAVE` localise a block of code – they make sure that all variables are tidied up, everything that has been localised gets its previous value returned, and so on. Think of them as the { and } of a Perl block.

To actually do the magic method call, we have to call a subroutine in Perl space: `call_method` takes care of that, and it's described in *perlcall*. We call the `PUSH` method in scalar context, and we're going to discard its return value.

```
9   POPSTACK;
```

Finally, we remove the value we placed on the mark stack, since we don't need it any more.

Save stack

C doesn't have a concept of local scope, so perl provides one. We've seen that `ENTER` and `LEAVE` are used as scoping braces; the save stack implements the C equivalent of, for example:

```
{
    local $foo = 42;
    ...
}
```

See *Localising Changes* for how to use the save stack.

Millions of Macros

One thing you'll notice about the Perl source is that it's full of macros. Some have called the pervasive use of macros the hardest thing to understand, others find it adds to clarity. Let's take an example, the code which implements the addition operator:

```
1  PP(pp_add)
2  {
3      djSP; dATARGET; tryAMAGICbin(add,opASSIGN);
4      {
5        dPOPTOPnnrl_ul;
6        SETn( left + right );
7        RETURN;
8      }
9  }
```

Every line here (apart from the braces, of course) contains a macro. The first line sets up the function declaration as Perl expects for PP code; line 3 sets up variable declarations for the argument stack and the target, the return value of the operation. Finally, it tries to see if the addition operation is overloaded; if so, the appropriate subroutine is called.

Line 5 is another variable declaration – all variable declarations start with `d` – which pops from the top of the argument stack two NVs (hence `nn`) and puts them into the variables `right` and `left`, hence the `rl`. These are the two operands to the addition operator. Next, we call `SETn` to set the NV of the return value to the result of adding the two values. This done, we return – the `RETURN` macro makes sure that our return value is properly handled, and we pass the next operator to run back to the main run loop.

Most of these macros are explained in *perlapi*, and some of the more important ones are explained in *perlxs* as well. Pay special attention to *Background and PERL_IMPLICIT_CONTEXT* for information on the `[pad]THX_?` macros.

Poking at Perl

To really poke around with Perl, you'll probably want to build Perl for debugging, like this:

```
./Configure -d -D optimize=-g
make
```

`-g` is a flag to the C compiler to have it produce debugging information which will allow us to step through a running program. ***Configure*** will also turn on the `DEBUGGING` compilation symbol which enables all the internal debugging code in Perl. There are a whole bunch of things you can debug with this: *perlrun* lists them all, and the best way to find out about them is to play about with them. The most useful options are probably

```
l  Context (loop) stack processing
t  Trace execution
o  Method and overloading resolution
c  String/numeric conversions
```

Some of the functionality of the debugging code can be achieved using XS modules.

```
-Dr => use re 'debug'
-Dx => use O 'Debug'
```

Using a source–level debugger

If the debugging output of `-D` doesn't help you, it's time to step through perl's execution with a source–level debugger.

- We'll use `gdb` for our examples here; the principles will apply to any debugger, but check the manual of the one you're using.

To fire up the debugger, type

```
gdb ./perl
```

You'll want to do that in your Perl source tree so the debugger can read the source code. You should see the copyright message, followed by the prompt.

```
(gdb)
```

`help` will get you into the documentation, but here are the most useful commands:

run [args]

Run the program with the given arguments.

break function_name
break source.c:xxx

Tells the debugger that we'll want to pause execution when we reach either the named function (but see */Function names*!) or the given line in the named source file.

step

Steps through the program a line at a time.

next

Steps through the program a line at a time, without descending into functions.

continue

Run until the next breakpoint.

finish

Run until the end of the current function, then stop again.

'enter'

Just pressing Enter will do the most recent operation again – it's a blessing when stepping through miles of source code.

print

Execute the given C code and print its results. **WARNING**: Perl makes heavy use of macros, and ***gdb*** is not aware of macros. You'll have to substitute them yourself. So, for instance, you can't say

```
print SvPV_nolen(sv)
```

but you have to say

```
print Perl_sv_2pv_nolen(sv)
```

You may find it helpful to have a "macro dictionary", which you can produce by saying `cpp -dM perl.c | sort`. Even then, ***cpp*** won't recursively apply the macros for you.

Dumping Perl Data Structures

One way to get around this macro hell is to use the dumping functions in ***dump.c***; these work a little like an internal *Devel::Peek|Devel::Peek*, but they also cover OPs and other structures that you can't get at from Perl. Let's take an example. We'll use the `$a = $b + $c` we used before, but give it a bit of context: `$b = "6XXXX"; $c = 2.3;`. Where's a good place to stop and poke around?

What about `pp_add`, the function we examined earlier to implement the + operator:

```
(gdb) break Perl_pp_add
Breakpoint 1 at 0x46249f: file pp_hot.c, line 309.
```

Notice we use `Perl_pp_add` and not `pp_add` – see *Function Names*. With the breakpoint in place, we can run our program:

```
(gdb) run -e '$b = "6XXXX"; $c = 2.3; $a = $b + $c'
```

Lots of junk will go past as gdb reads in the relevant source files and libraries, and then:

```
Breakpoint 1, Perl_pp_add () at pp_hot.c:309
309         djSP; dATARGET; tryAMAGICbin(add,opASSIGN);
(gdb) step
311           dPOPTOPnnrl_ul;
(gdb)
```

We looked at this bit of code before, and we said that `dPOPTOPnnrl_ul` arranges for two `NV`s to be placed into `left` and `right` – let's slightly expand it:

```
#define dPOPTOPnnrl_ul  NV right = POPn; \
                        SV *leftsv = TOPs; \
                        NV left = USE_LEFT(leftsv) ? SvNV(leftsv) : 0.0
```

`POPn` takes the SV from the top of the stack and obtains its NV either directly (if `SvNOK` is set) or by calling the `sv_2nv` function. `TOPs` takes the next SV from the top of the stack – yes, `POPn` uses `TOPs` – but doesn't remove it. We then use `SvNV` to get the NV from `leftsv` in the same way as before – yes, `POPn` uses `SvNV`.

Since we don't have an NV for `$b`, we'll have to use `sv_2nv` to convert it. If we step again, we'll find ourselves there:

```
Perl_sv_2nv (sv=0xa0675d0) at sv.c:1669
1669        if (!sv)
(gdb)
```

We can now use `Perl_sv_dump` to investigate the SV:

```
SV = PV(0xa057cc0) at 0xa0675d0
REFCNT = 1
FLAGS = (POK,pPOK)
PV = 0xa06a510 "6XXXX"\0
CUR = 5
LEN = 6
$1 = void
```

We know we're going to get `6` from this, so let's finish the subroutine:

```
(gdb) finish
Run till exit from #0  Perl_sv_2nv (sv=0xa0675d0) at sv.c:1671
0x462669 in Perl_pp_add () at pp_hot.c:311
311           dPOPTOPnnrl_ul;
```

We can also dump out this op: the current op is always stored in `PL_op`, and we can dump it with `Perl_op_dump`. This'll give us similar output to *B::Debug*|*B::Debug*.

```
{
13  TYPE = add  ===> 14
    TARG = 1
    FLAGS = (SCALAR,KIDS)
    {
        TYPE = null  ===> (12)
          (was rv2sv)
        FLAGS = (SCALAR,KIDS)
        {
11          TYPE = gvsv  ===> 12
            FLAGS = (SCALAR)
            GV = main::b
        }
```

```
        }
```

< finish this later

Patching

All right, we've now had a look at how to navigate the Perl sources and some things you'll need to know when fiddling with them. Let's now get on and create a simple patch. Here's something Larry suggested: if a `U` is the first active format during a `pack`, (for example, `pack "U3C8", @stuff`) then the resulting string should be treated as UTF8 encoded.

How do we prepare to fix this up? First we locate the code in question – the `pack` happens at runtime, so it's going to be in one of the ***pp*** files. Sure enough, `pp_pack` is in ***pp.c***. Since we're going to be altering this file, let's copy it to ***pp.c~***.

Now let's look over `pp_pack`: we take a pattern into `pat`, and then loop over the pattern, taking each format character in turn into `datum_type`. Then for each possible format character, we swallow up the other arguments in the pattern (a field width, an asterisk, and so on) and convert the next chunk input into the specified format, adding it onto the output SV `cat`.

How do we know if the `U` is the first format in the `pat`? Well, if we have a pointer to the start of `pat` then, if we see a `U` we can test whether we're still at the start of the string. So, here's where `pat` is set up:

```
    STRLEN fromlen;
    register char *pat = SvPVx(*++MARK, fromlen);
    register char *patend = pat + fromlen;
    register I32 len;
    I32 datumtype;
    SV *fromstr;
```

We'll have another string pointer in there:

```
    STRLEN fromlen;
    register char *pat = SvPVx(*++MARK, fromlen);
    register char *patend = pat + fromlen;
+   char *patcopy;
    register I32 len;
    I32 datumtype;
    SV *fromstr;
```

And just before we start the loop, we'll set `patcopy` to be the start of `pat`:

```
    items = SP - MARK;
    MARK++;
    sv_setpvn(cat, "", 0);
+   patcopy = pat;
    while (pat < patend) {
```

Now if we see a `U` which was at the start of the string, we turn on the UTF8 flag for the output SV, `cat`:

```
+   if (datumtype == 'U' && pat==patcopy+1)
+       SvUTF8_on(cat);
    if (datumtype == '#') {
        while (pat < patend && *pat != '\n')
            pat++;
```

Remember that it has to be `patcopy+1` because the first character of the string is the `U` which has been swallowed into `datumtype!`

Oops, we forgot one thing: what if there are spaces at the start of the pattern? `pack("  U*", @stuff)` will have `U` as the first active character, even though it's not the first thing in the pattern. In this case, we have to advance `patcopy` along with `pat` when we see spaces:

```
    if (isSPACE(datumtype))
        continue;
```

needs to become

```
    if (isSPACE(datumtype)) {
        patcopy++;
        continue;
    }
```

OK. That's the C part done. Now we must do two additional things before this patch is ready to go: we've changed the behaviour of Perl, and so we must document that change. We must also provide some more regression tests to make sure our patch works and doesn't create a bug somewhere else along the line.

The regression tests for each operator live in ***t/op/***, and so we make a copy of ***t/op/pack.t*** to ***t/op/pack.t~***. Now we can add our tests to the end. First, we'll test that the `U` does indeed create Unicode strings:

```
print 'not ' unless "1.20.300.4000" eq sprintf "%vd", pack("U*",1,20,300,4000);
print "ok $test\n"; $test++;
```

Now we'll test that we got that space-at-the-beginning business right:

```
print 'not ' unless "1.20.300.4000" eq
                     sprintf "%vd", pack("  U*",1,20,300,4000);
print "ok $test\n"; $test++;
```

And finally we'll test that we don't make Unicode strings if `U` is **not** the first active format:

```
print 'not ' unless v1.20.300.4000 ne
                     sprintf "%vd", pack("C0U*",1,20,300,4000);
print "ok $test\n"; $test++;
```

Mustn't forget to change the number of tests which appears at the top, or else the automated tester will get confused:

```
-print "1..156\n";
+print "1..159\n";
```

We now compile up Perl, and run it through the test suite. Our new tests pass, hooray!

Finally, the documentation. The job is never done until the paperwork is over, so let's describe the change we've just made. The relevant place is ***pod/perlfunc.pod***; again, we make a copy, and then we'll insert this text in the description of `pack`:

```
=item *

If the pattern begins with a C<U>, the resulting string will be treated
as Unicode-encoded. You can force UTF8 encoding on in a string with an
initial C<U0>, and the bytes that follow will be interpreted as Unicode
characters. If you don't want this to happen, you can begin your pattern
with C<C0> (or anything else) to force Perl not to UTF8 encode your
string, and then follow this with a C<U*> somewhere in your pattern.
```

All done. Now let's create the patch. ***Porting/patching.pod*** tells us that if we're making major changes, we should copy the entire directory to somewhere safe before we begin fiddling, and then do

```
    diff -ruN old new > patch
```

However, we know which files we've changed, and we can simply do this:

```
    diff -u pp.c~             pp.c             >  patch
    diff -u t/op/pack.t~      t/op/pack.t      >> patch
    diff -u pod/perlfunc.pod~ pod/perlfunc.pod >> patch
```

We end up with a patch looking a little like this:

```
--- pp.c~       Fri Jun 02 04:34:10 2000
+++ pp.c        Fri Jun 16 11:37:25 2000
@@ -4375,6 +4375,7 @@
     register I32 items;
     STRLEN fromlen;
     register char *pat = SvPVx(*++MARK, fromlen);
+    char *patcopy;
     register char *patend = pat + fromlen;
     register I32 len;
     I32 datumtype;
@@ -4405,6 +4406,7 @@
...
```

And finally, we submit it, with our rationale, to perl5–porters. Job done!

EXTERNAL TOOLS FOR DEBUGGING PERL

Sometimes it helps to use external tools while debugging and testing Perl. This section tries to guide you through using some common testing and debugging tools with Perl. This is meant as a guide to interfacing these tools with Perl, not as any kind of guide to the use of the tools themselves.

Rational Software's Purify

Purify is a commercial tool that is helpful in identifying memory overruns, wild pointers, memory leaks and other such badness. Perl must be compiled in a specific way for optimal testing with Purify. Purify is available under Windows NT, Solaris, HP–UX, SGI, and Siemens Unix.

The only currently known leaks happen when there are compile–time errors within eval or require. (Fixing these is non–trivial, unfortunately, but they must be fixed eventually.)

Purify on Unix

On Unix, Purify creates a new Perl binary. To get the most benefit out of Purify, you should create the perl to Purify using:

```
sh Configure -Accflags=-DPURIFY -Doptimize='-g' \
 -Uusemymalloc -Dusemultiplicity
```

where these arguments mean:

–Accflags=–DPURIFY

Disables Perl's arena memory allocation functions, as well as forcing use of memory allocation functions derived from the system malloc.

–Doptimize='–g'

Adds debugging information so that you see the exact source statements where the problem occurs. Without this flag, all you will see is the source filename of where the error occurred.

–Uusemymalloc

Disable Perl's malloc so that Purify can more closely monitor allocations and leaks. Using Perl's malloc will make Purify report most leaks in the "potential" leaks category.

–Dusemultiplicity

Enabling the multiplicity option allows perl to clean up thoroughly when the interpreter shuts down, which reduces the number of bogus leak reports from Purify.

Once you've compiled a perl suitable for Purify'ing, then you can just:

```
make pureperl
```

which creates a binary named 'pureperl' that has been Purify'ed. This binary is used in place of the standard 'perl' binary when you want to debug Perl memory problems.

As an example, to show any memory leaks produced during the standard Perl testset you would create and run the Purify'ed perl as:

```
make pureperl
cd t
../pureperl -I../lib harness
```

which would run Perl on test.pl and report any memory problems.

Purify outputs messages in "Viewer" windows by default. If you don't have a windowing environment or if you simply want the Purify output to unobtrusively go to a log file instead of to the interactive window, use these following options to output to the log file "perl.log":

```
setenv PURIFYOPTIONS "-chain-length=25 -windows=no \
 -log-file=perl.log -append-logfile=yes"
```

If you plan to use the "Viewer" windows, then you only need this option:

```
setenv PURIFYOPTIONS "-chain-length=25"
```

Purify on NT

Purify on Windows NT instruments the Perl binary 'perl.exe' on the fly. There are several options in the makefile you should change to get the most use out of Purify:

DEFINES

You should add -DPURIFY to the DEFINES line so the DEFINES line looks something like:

```
DEFINES = -DWIN32 -D_CONSOLE -DNO_STRICT $(CRYPT_FLAG) -DPURIFY=1
```

to disable Perl's arena memory allocation functions, as well as to force use of memory allocation functions derived from the system malloc.

USE_MULTI = define

Enabling the multiplicity option allows perl to clean up thoroughly when the interpreter shuts down, which reduces the number of bogus leak reports from Purify.

#PERL_MALLOC = define

Disable Perl's malloc so that Purify can more closely monitor allocations and leaks. Using Perl's malloc will make Purify report most leaks in the "potential" leaks category.

CFG = Debug

Adds debugging information so that you see the exact source statements where the problem occurs. Without this flag, all you will see is the source filename of where the error occurred.

As an example, to show any memory leaks produced during the standard Perl testset you would create and run Purify as:

```
cd win32
make
cd ../t
purify ../perl -I../lib harness
```

which would instrument Perl in memory, run Perl on test.pl, then finally report any memory problems.

CONCLUSION

We've had a brief look around the Perl source, an overview of the stages ***perl*** goes through when it's running your code, and how to use a debugger to poke at the Perl guts. We took a very simple problem and demonstrated how to solve it fully – with documentation, regression tests, and finally a patch for submission to p5p. Finally, we talked about how to use external tools to debug and test Perl.

I'd now suggest you read over those references again, and then, as soon as possible, get your hands dirty. The best way to learn is by doing, so:

- Subscribe to perl5−porters, follow the patches and try and understand them; don't be afraid to ask if there's a portion you're not clear on − who knows, you may unearth a bug in the patch...
- Keep up to date with the bleeding edge Perl distributions and get familiar with the changes. Try and get an idea of what areas people are working on and the changes they're making.
- Do read the README associated with your operating system, e.g. README.aix on the IBM AIX OS. Don't hesitate to supply patches to that README if you find anything missing or changed over a new OS release.
- Find an area of Perl that seems interesting to you, and see if you can work out how it works. Scan through the source, and step over it in the debugger. Play, poke, investigate, fiddle! You'll probably get to understand not just your chosen area but a much wider range of ***perl***'s activity as well, and probably sooner than you'd think.

The Road goes ever on and on, down from the door where it began.

If you can do these things, you've started on the long road to Perl porting. Thanks for wanting to help make Perl better − and happy hacking!

AUTHOR

This document was written by Nathan Torkington, and is maintained by the perl5−porters mailing list.

NAME

perlhist − the Perl history records

=for RCS

=begin RCS

$Id: perlhist.pod,v 1.2 2000/01/24 11:44:47 jhi Exp $

=end RCS

DESCRIPTION

This document aims to record the Perl source code releases.

INTRODUCTION

Perl history in brief, by Larry Wall:

```
Perl 0 introduced Perl to my officemates.
Perl 1 introduced Perl to the world, and changed /\(...\|...\)/ to
    /(...|...)/.  \(Dan Faigin still hasn't forgiven me. :-\)
Perl 2 introduced Henry Spencer's regular expression package.
Perl 3 introduced the ability to handle binary data (embedded nulls).
Perl 4 introduced the first Camel book.  Really.  We mostly just
    switched version numbers so the book could refer to 4.000.
Perl 5 introduced everything else, including the ability to
    introduce everything else.
```

THE KEEPERS OF THE PUMPKIN

Larry Wall, Andy Dougherty, Tom Christiansen, Charles Bailey, Nick Ing−Simmons, Chip Salzenberg, Tim Bunce, Malcolm Beattie, Gurusamy Sarathy, Graham Barr, Jarkko Hietaniemi.

PUMPKIN?

[from Porting/pumpkin.pod in the Perl source code distribution]

Chip Salzenberg gets credit for that, with a nod to his cow orker, David Croy. We had passed around various names (baton, token, hot potato) but none caught on. Then, Chip asked:

[begin quote]

```
Who has the patch pumpkin?
```

To explain: David Croy once told me once that at a previous job, there was one tape drive and multiple systems that used it for backups. But instead of some high−tech exclusion software, they used a low−tech method to prevent multiple simultaneous backups: a stuffed pumpkin. No one was allowed to make backups unless they had the "backup pumpkin".

[end quote]

The name has stuck. The holder of the pumpkin is sometimes called the pumpking (keeping the source afloat?) or the pumpkineer (pulling the strings?).

THE RECORDS

```
Pump-  Release         Date            Notes
king                                   (by no means
                                        comprehensive,
                                        see Changes*
                                        for details)
=========================================================================

Larry   0              Classified.     Don't ask.
```

```
Larry   1.000           1987-Dec-18

         1.001..10      1988-Jan-30
         1.011..14      1988-Feb-02

Larry   2.000           1988-Jun-05

         2.001          1988-Jun-28

Larry   3.000           1989-Oct-18

         3.001          1989-Oct-26
         3.002..4       1989-Nov-11
         3.005          1989-Nov-18
         3.006..8       1989-Dec-22
         3.009..13      1990-Mar-02
         3.014          1990-Mar-13
         3.015          1990-Mar-14
         3.016..18      1990-Mar-28
         3.019..27      1990-Aug-10     User subs.
         3.028          1990-Aug-14
         3.029..36      1990-Oct-17
         3.037          1990-Oct-20
         3.040          1990-Nov-10
         3.041          1990-Nov-13
         3.042..43      1990-Jan-??
         3.044          1991-Jan-12

Larry   4.000           1991-Mar-21

         4.001..3       1991-Apr-12
         4.004..9       1991-Jun-07
         4.010          1991-Jun-10
         4.011..18      1991-Nov-05
         4.019          1991-Nov-11     Stable.
         4.020..33      1992-Jun-08
         4.034          1992-Jun-11
         4.035          1992-Jun-23
Larry    4.036          1993-Feb-05     Very stable.

         5.000alpha1    1993-Jul-31
         5.000alpha2    1993-Aug-16
         5.000alpha3    1993-Oct-10
         5.000alpha4    1993-???-??
         5.000alpha5    1993-???-??
         5.000alpha6    1994-Mar-18
         5.000alpha7    1994-Mar-25
Andy     5.000alpha8    1994-Apr-04
Larry    5.000alpha9    1994-May-05     ext appears.
         5.000alpha10   1994-Jun-11
         5.000alpha11   1994-Jul-01
Andy     5.000a11a      1994-Jul-07     To fit 14.
         5.000a11b      1994-Jul-14
         5.000a11c      1994-Jul-19
         5.000a11d      1994-Jul-22
Larry    5.000alpha12   1994-Aug-04
Andy     5.000a12a      1994-Aug-08
         5.000a12b      1994-Aug-15
```

```
          5.000a12c     1994-Aug-22
          5.000a12d     1994-Aug-22
          5.000a12e     1994-Aug-22
          5.000a12f     1994-Aug-24
          5.000a12g     1994-Aug-24
          5.000a12h     1994-Aug-24
Larry     5.000beta1    1994-Aug-30
Andy      5.000b1a      1994-Sep-06
Larry     5.000beta2    1994-Sep-14     Core slushified.
Andy      5.000b2a      1994-Sep-14
          5.000b2b      1994-Sep-17
          5.000b2c      1994-Sep-17
Larry     5.000beta3    1994-Sep-??
Andy      5.000b3a      1994-Sep-18
          5.000b3b      1994-Sep-22
          5.000b3c      1994-Sep-23
          5.000b3d      1994-Sep-27
          5.000b3e      1994-Sep-28
          5.000b3f      1994-Sep-30
          5.000b3g      1994-Oct-04
Andy      5.000b3h      1994-Oct-07
Larry?    5.000gamma    1994-Oct-13?

Larry    5.000          1994-Oct-17

Andy      5.000a        1994-Dec-19
          5.000b        1995-Jan-18
          5.000c        1995-Jan-18
          5.000d        1995-Jan-18
          5.000e        1995-Jan-18
          5.000f        1995-Jan-18
          5.000g        1995-Jan-18
          5.000h        1995-Jan-18
          5.000i        1995-Jan-26
          5.000j        1995-Feb-07
          5.000k        1995-Feb-11
          5.000l        1995-Feb-21
          5.000m        1995-Feb-28
          5.000n        1995-Mar-07
          5.000o        1995-Mar-13?

Larry    5.001          1995-Mar-13

Andy      5.001a        1995-Mar-15
          5.001b        1995-Mar-31
          5.001c        1995-Apr-07
          5.001d        1995-Apr-14
          5.001e        1995-Apr-18     Stable.
          5.001f        1995-May-31
          5.001g        1995-May-25
          5.001h        1995-May-25
          5.001i        1995-May-30
          5.001j        1995-Jun-05
          5.001k        1995-Jun-06
          5.001l        1995-Jun-06     Stable.
          5.001m        1995-Jul-02     Very stable.
```

	5.001n	1995-Oct-31	Very unstable.
	5.002beta1	1995-Nov-21	
	5.002b1a	1995-Dec-04	
	5.002b1b	1995-Dec-04	
	5.002b1c	1995-Dec-04	
	5.002b1d	1995-Dec-04	
	5.002b1e	1995-Dec-08	
	5.002b1f	1995-Dec-08	
Tom	5.002b1g	1995-Dec-21	Doc release.
Andy	5.002b1h	1996-Jan-05	
	5.002b2	1996-Jan-14	
Larry	5.002b3	1996-Feb-02	
Andy	5.002gamma	1996-Feb-11	
Larry	5.002delta	1996-Feb-27	
Larry	5.002	1996-Feb-29	Prototypes.
Charles	5.002_01	1996-Mar-25	
	5.003	1996-Jun-25	Security release.
	5.003_01	1996-Jul-31	
Nick	5.003_02	1996-Aug-10	
Andy	5.003_03	1996-Aug-28	
	5.003_04	1996-Sep-02	
	5.003_05	1996-Sep-12	
	5.003_06	1996-Oct-07	
	5.003_07	1996-Oct-10	
Chip	5.003_08	1996-Nov-19	
	5.003_09	1996-Nov-26	
	5.003_10	1996-Nov-29	
	5.003_11	1996-Dec-06	
	5.003_12	1996-Dec-19	
	5.003_13	1996-Dec-20	
	5.003_14	1996-Dec-23	
	5.003_15	1996-Dec-23	
	5.003_16	1996-Dec-24	
	5.003_17	1996-Dec-27	
	5.003_18	1996-Dec-31	
	5.003_19	1997-Jan-04	
	5.003_20	1997-Jan-07	
	5.003_21	1997-Jan-15	
	5.003_22	1997-Jan-16	
	5.003_23	1997-Jan-25	
	5.003_24	1997-Jan-29	
	5.003_25	1997-Feb-04	
	5.003_26	1997-Feb-10	
	5.003_27	1997-Feb-18	
	5.003_28	1997-Feb-21	
	5.003_90	1997-Feb-25	Ramping up to the 5.004 release.
	5.003_91	1997-Mar-01	
	5.003_92	1997-Mar-06	
	5.003_93	1997-Mar-10	
	5.003_94	1997-Mar-22	
	5.003_95	1997-Mar-25	
	5.003_96	1997-Apr-01	

	5.003_97	1997-Apr-03	Fairly widely used.
	5.003_97a	1997-Apr-05	
	5.003_97b	1997-Apr-08	
	5.003_97c	1997-Apr-10	
	5.003_97d	1997-Apr-13	
	5.003_97e	1997-Apr-15	
	5.003_97f	1997-Apr-17	
	5.003_97g	1997-Apr-18	
	5.003_97h	1997-Apr-24	
	5.003_97i	1997-Apr-25	
	5.003_97j	1997-Apr-28	
	5.003_98	1997-Apr-30	
	5.003_99	1997-May-01	
	5.003_99a	1997-May-09	
	p54rc1	1997-May-12	Release Candidates.
	p54rc2	1997-May-14	
Chip	5.004	1997-May-15	A major maintenance release.
Tim	5.004_01	1997-Jun-13	The 5.004 maintenance track.
	5.004_02	1997-Aug-07	
	5.004_03	1997-Sep-05	
	5.004_04	1997-Oct-15	
	5.004m5t1	1998-Mar-04	Maintenance Trials (for 5.004_05).
	5.004_04-m2	1997-May-01	
	5.004_04-m3	1998-May-15	
	5.004_04-m4	1998-May-19	
	5.004_04-MT5	1998-Jul-21	
	5.004_04-MT6	1998-Oct-09	
	5.004_04-MT7	1998-Nov-22	
	5.004_04-MT8	1998-Dec-03	
Chip	5.004_04-MT9	1999-Apr-26	
	5.004_05	1999-Apr-29	
Malcolm	5.004_50	1997-Sep-09	The 5.005 development track.
	5.004_51	1997-Oct-02	
	5.004_52	1997-Oct-15	
	5.004_53	1997-Oct-16	
	5.004_54	1997-Nov-14	
	5.004_55	1997-Nov-25	
	5.004_56	1997-Dec-18	
	5.004_57	1998-Feb-03	
	5.004_58	1998-Feb-06	
	5.004_59	1998-Feb-13	
	5.004_60	1998-Feb-20	
	5.004_61	1998-Feb-27	
	5.004_62	1998-Mar-06	
	5.004_63	1998-Mar-17	
	5.004_64	1998-Apr-03	
	5.004_65	1998-May-15	
	5.004_66	1998-May-29	
Sarathy	5.004_67	1998-Jun-15	
	5.004_68	1998-Jun-23	
	5.004_69	1998-Jun-29	
	5.004_70	1998-Jul-06	
	5.004_71	1998-Jul-09	

```
          5.004_72      1998-Jul-12
          5.004_73      1998-Jul-13
          5.004_74      1998-Jul-14     5.005 beta candidate.
          5.004_75      1998-Jul-15     5.005 beta1.
          5.004_76      1998-Jul-21     5.005 beta2.
          5.005         1998-Jul-22     Oneperl.

Sarathy   5.005_01      1998-Jul-27     The 5.005 maintenance track.
          5.005_02-T1   1998-Aug-02
          5.005_02-T2   1998-Aug-05
          5.005_02      1998-Aug-08
Graham    5.005_03-MT1  1998-Nov-30
          5.005_03-MT2  1999-Jan-04
          5.005_03-MT3  1999-Jan-17
          5.005_03-MT4  1999-Jan-26
          5.005_03-MT5  1999-Jan-28
          5.005_03      1999-Mar-28
Chip      5.005_04      2000-***-**

Sarathy   5.005_50      1998-Jul-26     The 5.6 development track.
          5.005_51      1998-Aug-10
          5.005_52      1998-Sep-25
          5.005_53      1998-Oct-31
          5.005_54      1998-Nov-30
          5.005_55      1999-Feb-16
          5.005_56      1999-Mar-01
          5.005_57      1999-May-25
          5.005_58      1999-Jul-27
          5.005_59      1999-Aug-02
          5.005_60      1999-Aug-02
          5.005_61      1999-Aug-20
          5.005_62      1999-Oct-15
          5.005_63      1999-Dec-09
          5.5.640       2000-Feb-02
          5.5.650       2000-Feb-08     beta1
          5.5.660       2000-Feb-22     beta2
          5.5.670       2000-Feb-29     beta3
          5.6.0-RC1     2000-Mar-09     release candidate 1
          5.6.0-RC2     2000-Mar-14     release candidate 2
          5.6.0-RC3     2000-Mar-21     release candidate 3
          5.6.0         2000-Mar-22

Sarathy   5.6.1         2000-***-**     The 5.6 maintenance track.

Jarkko    5.7.0         2000-Sep-02     The 5.7 track: Development.
```

SELECTED RELEASE SIZES

For example the notation "core: 212 29" in the release 1.000 means that it had in the core 212 kilobytes, in 29 files. The "core".."doc" are explained below.

```
release        core       lib         ext        t         doc
=======================================================================

1.000           212  29      -   -      -   -     38  51     62   3
1.014           219  29      -   -      -   -     39  52     68   4
2.000           309  31      2   3      -   -     55  57     92   4
2.001           312  31      2   3      -   -     55  57     94   4
3.000           508  36     24  11      -   -     79  73    156   5
```

```
3.044           645  37     61  20      -   -     90  74    190   6
4.000           635  37     59  20      -   -     91  75    198   4
4.019           680  37     85  29      -   -     98  76    199   4
4.036           709  37     89  30      -   -     98  76    208   5
5.000alpha2     785  50    114  32      -   -    112  86    209   5
5.000alpha3     801  50    117  33      -   -    121  87    209   5
5.000alpha9    1022  56    149  43    116  29    125  90    217   6
5.000a12h       978  49    140  49    205  46    152  97    228   9
5.000b3h       1035  53    232  70    216  38    162  94    218  21
5.000          1038  53    250  76    216  38    154  92    536  62
5.001m         1071  54    388  82    240  38    159  95    544  29
5.002          1121  54    661 101    287  43    155  94    847  35
5.003          1129  54    680 102    291  43    166 100    853  35
5.003_07       1231  60    748 106    396  53    213 137    976  39
5.004          1351  60   1230 136    408  51    355 161   1587  55
5.004_01       1356  60   1258 138    410  51    358 161   1587  55
5.004_04       1375  60   1294 139    413  51    394 162   1629  55
5.004_05       1463  60   1435 150    394  50    445 175   1855  59
5.004_51       1401  61   1260 140    413  53    358 162   1594  56
5.004_53       1422  62   1295 141    438  70    394 162   1637  56
5.004_56       1501  66   1301 140    447  74    408 165   1648  57
5.004_59       1555  72   1317 142    448  74    424 171   1678  58
5.004_62       1602  77   1327 144    629  92    428 173   1674  58
5.004_65       1626  77   1358 146    615  92    446 179   1698  60
5.004_68       1856  74   1382 152    619  92    463 187   1784  60
5.004_70       1863  75   1456 154    675  92    494 194   1809  60
5.004_73       1874  76   1467 152    762 102    506 196   1883  61
5.004_75       1877  76   1467 152    770 103    508 196   1896  62
5.005          1896  76   1469 152    795 103    509 197   1945  63
5.005_03       1936  77   1541 153    813 104    551 201   2176  72
5.005_51       1969  78   1842 301    795 103    514 198   1948  63
5.005_53       1999  79   1885 303    806 104    602 224   2002  67
5.005_56       2086  79   1970 307    866 113    672 238   2221  75
```

The "core"..."doc" mean the following files from the Perl source code distribution. The glob notation ** means recursively, (.) means regular files.

```
core    *.[hcy]
lib     lib/**/*.p[ml]
ext     ext/**/*.{[hcyt],xs,pm}
t       t/**/*(.)
doc     {README*,INSTALL,*[_.]man{,.?},pod/**/*.pod}
```

Here are some statistics for the other subdirectories and one file in the Perl source distribution for somewhat more selected releases.

```
================================================================================
  Legend:  kB   #

           1.014   2.001   3.044   4.000   4.019   4.036

atarist      -  -    -  -    -  -    -  -    -  -  113 31
Configure   31  1   37  1   62  1   73  1   83  1   86  1
eg           -  -   34 28   47 39   47 39   47 39   47 39
emacs        -  -    -  -    -  -   67  4   67  4   67  4
h2pl         -  -    -  -   12 12   12 12   12 12   12 12
hints        -  -    -  -    -  -    -  -    5 42   11 56
```

```
msdos        -  -    -  -   41 13   57 15   58 15   60 15
os2          -  -    -  -   63 22   81 29   81 29  113 31
usub         -  -    -  -   21 16   25  7   43  8   43  8
x2p        103 17  104 17  137 17  147 18  152 19  154 19

========================================================================

           5.000a2 5.000a12h 5.000b3h 5.000  5.001m  5.002   5.003

atarist    113 31  113 31    -  -      -  -    -  -    -  -    -  -
bench        -  -    0  1    -  -      -  -    -  -    -  -    -  -
Bugs         2  5   26  1    -  -      -  -    -  -    -  -    -  -
dlperl      40  5    -  -    -  -      -  -    -  -    -  -    -  -
do         127 71    -  -    -  -      -  -    -  -    -  -    -  -
Configure    -  -  153  1  159  1    160  1  180  1  201  1  201  1
Doc          -  -   26  1   75  7     11  1   11  1    -  -    -  -
eg          79 58   53 44   51 43     54 44   54 44   54 44   54 44
emacs       67  4  104  6  104  6    104  1  104  6  108  1  108  1
h2pl        12 12   12 12   12 12     12 12   12 12   12 12   12 12
hints       11 56   12 46   18 48     18 48   44 56   73 59   77 60
msdos       60 15   60 15    -  -      -  -    -  -    -  -    -  -
os2        113 31  113 31    -  -      -  -    -  -   84 17   56 10
U            -  -   62  8  112 42      -  -    -  -    -  -    -  -
usub        43  8    -  -    -  -      -  -    -  -    -  -    -  -
utils        -  -    -  -    -  -      -  -    -  -   87  7   88  7
vms          -  -   80  7  123  9    184 15  304 20  500 24  475 26
x2p        171 22  171 21  162 20    162 20  279 20  280 20  280 20

========================================================================

           5.003_07 5.004   5.004_04 5.004_62 5.004_65 5.004_68

beos         -  -     -  -    -  -      -  -     1   1    1   1
Configure  217  1   225  1  225  1   240  1   248   1  256   1
cygwin32     -  -    23  5   23  5    23  5    24   5   24   5
djgpp        -  -     -  -    -  -    14  5    14   5   14   5
eg          54 44    81 62   81 62    81 62    81  62   81  62
emacs      143  1   194  1  204  1   212  2   212   2  212   2
h2pl        12 12    12 12   12 12    12 12    12  12   12  12
hints       90 62   129 69  132 71   144 72   151  74  155  74
os2        117 42   121 42  127 42   127 44   129  44  129  44
plan9       79 15    82 15   82 15    82 15    82  15   82  15
Porting     51  1    94  2  109  4   203  6   234   8  241   9
qnx          -  -     1  2    1  2     1  2     1   2    1   2
utils       97  7   112  8  118  8   124  8   156   9  159   9
vms        505 27   518 34  524 34   538 34   569  34  569  34
win32        -  -   285 33  378 36   470 39   493  39  575  41
x2p        280 19   281 19  281 19   281 19   282  19  281  19

========================================================================

           5.004_70 5.004_73 5.004_75  5.005  5.005_03

apollo       -   -    -   -    -   -    -   -    0   1
beos         1   1    1   1    1   1    1   1    1   1
Configure  256   1  256   1  264   1  264   1  270   1
cygwin32    24   5   24   5   24   5   24   5   24   5
djgpp       14   5   14   5   14   5   14   5   15   5
eg          86  65   86  65   86  65   86  65   86  65
```

```
emacs      262   2  262   2  262 274  2 262   2
h2pl        12  12   12  12   12  12 12  12  12
hints      157  74  157  74  159  74 16 159  74
mint         -   -    -   -    -  4  - 7   -   -
mpeix        -   -    -   -    5  5  3 3   5   3
os2        129  44  139  44  142  44 14 148  44
plan9       82  15   82  15   82  82 15 82  15
Porting    241   9  253   9  259  10 26 272  12
qnx          1   2    1   2    1  1  2 2   1   2
utils      160   9  160   9  160 164  9 9 160   9
vms        570  34  572  34  573  34 57 583  34
vos          -   -    -   -    -156 -10 -   -   -
win32      577  41  585  41  585  41 56 670  41
x2p        281  19  281  19  281  19 28 281  19
```

SELECTED PATCH SIZES

The "diff lines kb" means that for example the patch 5.003_08, to be applied on top of the 5.003_07 (or whatever was before the 5.003_08) added lines for 110 kilobytes, it removed lines for 19 kilobytes, and changed lines for 424 kilobytes. Just the lines themselves are counted, not their context. The "+ – !" become from the diff(1) context diff output format.

Pumpking	Release	Date	diff lines kB		
			+	–	!
Chip	5.003_08	1996-Nov-19	110	19	424
	5.003_09	1996-Nov-26	38	9	248
	5.003_10	1996-Nov-29	29	2	27
	5.003_11	1996-Dec-06	73	12	165
	5.003_12	1996-Dec-19	275	6	436
	5.003_13	1996-Dec-20	95	1	56
	5.003_14	1996-Dec-23	23	7	333
	5.003_15	1996-Dec-23	0	0	1
	5.003_16	1996-Dec-24	12	3	50
	5.003_17	1996-Dec-27	19	1	14
	5.003_18	1996-Dec-31	21	1	32
	5.003_19	1997-Jan-04	80	3	85
	5.003_20	1997-Jan-07	18	1	146
	5.003_21	1997-Jan-15	38	10	221
	5.003_22	1997-Jan-16	4	0	18
	5.003_23	1997-Jan-25	71	15	119
	5.003_24	1997-Jan-29	426	1	20
	5.003_25	1997-Feb-04	21	8	169
	5.003_26	1997-Feb-10	16	1	15
	5.003_27	1997-Feb-18	32	10	38
	5.003_28	1997-Feb-21	58	4	66
	5.003_90	1997-Feb-25	22	2	34
	5.003_91	1997-Mar-01	37	1	39
	5.003_92	1997-Mar-06	16	3	69
	5.003_93	1997-Mar-10	12	3	15
	5.003_94	1997-Mar-22	407	7	200
	5.003_95	1997-Mar-25	41	1	37
	5.003_96	1997-Apr-01	283	5	261
	5.003_97	1997-Apr-03	13	2	34
	5.003_97a	1997-Apr-05	57	1	27

```
            5.003_97b     1997-Apr-08      14   1  20
            5.003_97c     1997-Apr-10      20   1  16
            5.003_97d     1997-Apr-13       8   0  16
            5.003_97e     1997-Apr-15      15   4  46
            5.003_97f     1997-Apr-17       7   1  33
            5.003_97g     1997-Apr-18       6   1  42
            5.003_97h     1997-Apr-24      23   3  68
            5.003_97i     1997-Apr-25      23   1  31
            5.003_97j     1997-Apr-28      36   1  49
            5.003_98      1997-Apr-30     171  12 539
            5.003_99      1997-May-01       6   0   7
            5.003_99a     1997-May-09      36   2  61
            p54rc1        1997-May-12       8   1  11
            p54rc2        1997-May-14       6   0  40

          5.004           1997-May-15       4   0   4

 Tim        5.004_01      1997-Jun-13     222  14  57
            5.004_02      1997-Aug-07     112  16 119
            5.004_03      1997-Sep-05     109   0  17
            5.004_04      1997-Oct-15      66   8 173
```

THE KEEPERS OF THE RECORDS

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Thanks to the collective memory of the Perlfolk. In addition to the Keepers of the Pumpkin also Alan Champion, Andreas König, John Macdonald, Matthias Neeracher, Jeff Okamoto, Michael Peppler, Randal Schwartz, and Paul D. Smith sent corrections and additions.

NAME

perlintern – autogenerated documentation of purely **internal** Perl functions

DESCRIPTION

This file is the autogenerated documentation of functions in the Perl interpreter that are documented using Perl's internal documentation format but are not marked as part of the Perl API. In other words, **they are not for use in extensions**!

is_gv_magical

Returns `TRUE` if given the name of a magical GV.

Currently only useful internally when determining if a GV should be created even in rvalue contexts.

`flags` is not used at present but available for future extension to allow selecting particular classes of magical variable.

```
bool    is_gv_magical(char *name, STRLEN len, U32 flags)
```

=for hackers Found in file gv.c

AUTHORS

The autodocumentation system was originally added to the Perl core by Benjamin Stuhl. Documentation is by whoever was kind enough to document their functions.

SEE ALSO

perlguts(1), perlapi(1)

NAME

perlipc – Perl interprocess communication (signals, fifos, pipes, safe subprocesses, sockets, and semaphores)

DESCRIPTION

The basic IPC facilities of Perl are built out of the good old Unix signals, named pipes, pipe opens, the Berkeley socket routines, and SysV IPC calls. Each is used in slightly different situations.

Signals

Perl uses a simple signal handling model: the %SIG hash contains names or references of user–installed signal handlers. These handlers will be called with an argument which is the name of the signal that triggered it. A signal may be generated intentionally from a particular keyboard sequence like control–C or control–Z, sent to you from another process, or triggered automatically by the kernel when special events transpire, like a child process exiting, your process running out of stack space, or hitting file size limit.

For example, to trap an interrupt signal, set up a handler like this. Do as little as you possibly can in your handler; notice how all we do is set a global variable and then raise an exception. That's because on most systems, libraries are not re–entrant; particularly, memory allocation and I/O routines are not. That means that doing nearly *anything* in your handler could in theory trigger a memory fault and subsequent core dump.

```
sub catch_zap {
    my $signame = shift;
    $shucks++;
    die "Somebody sent me a SIG$signame";
}
$SIG{INT} = 'catch_zap';  # could fail in modules
$SIG{INT} = \&catch_zap;  # best strategy
```

The names of the signals are the ones listed out by `kill -l` on your system, or you can retrieve them from the Config module. Set up an @signame list indexed by number to get the name and a %signo table indexed by name to get the number:

```
use Config;
defined $Config{sig_name} || die "No sigs?";
foreach $name (split(' ', $Config{sig_name})) {
    $signo{$name} = $i;
    $signame[$i] = $name;
    $i++;
}
```

So to check whether signal 17 and SIGALRM were the same, do just this:

```
print "signal #17 = $signame[17]\n";
if ($signo{ALRM}) {
    print "SIGALRM is $signo{ALRM}\n";
}
```

You may also choose to assign the strings `'IGNORE'` or `'DEFAULT'` as the handler, in which case Perl will try to discard the signal or do the default thing.

On most Unix platforms, the `CHLD` (sometimes also known as `CLD`) signal has special behavior with respect to a value of `'IGNORE'`. Setting `$SIG{CHLD}` to `'IGNORE'` on such a platform has the effect of not creating zombie processes when the parent process fails to `wait()` on its child processes (i.e. child processes are automatically reaped). Calling `wait()` with `$SIG{CHLD}` set to `'IGNORE'` usually returns `-1` on such platforms.

Some signals can be neither trapped nor ignored, such as the KILL and STOP (but not the TSTP) signals. One strategy for temporarily ignoring signals is to use a `local()` statement, which will be automatically

restored once your block is exited. (Remember that `local()` values are "inherited" by functions called from within that block.)

```
sub precious {
    local $SIG{INT} = 'IGNORE';
    &more_functions;
}
sub more_functions {
    # interrupts still ignored, for now...
}
```

Sending a signal to a negative process ID means that you send the signal to the entire Unix process-group. This code sends a hang-up signal to all processes in the current process group (and sets `$SIG{HUP}` to IGNORE so it doesn't kill itself):

```
{
    local $SIG{HUP} = 'IGNORE';
    kill HUP => -$$;
    # snazzy writing of: kill('HUP', -$$)
}
```

Another interesting signal to send is signal number zero. This doesn't actually affect another process, but instead checks whether it's alive or has changed its UID.

```
unless (kill 0 => $kid_pid) {
    warn "something wicked happened to $kid_pid";
}
```

You might also want to employ anonymous functions for simple signal handlers:

```
$SIG{INT} = sub { die "\nOutta here!\n" };
```

But that will be problematic for the more complicated handlers that need to reinstall themselves. Because Perl's signal mechanism is currently based on the signal(3) function from the C library, you may sometimes be so misfortunate as to run on systems where that function is "broken", that is, it behaves in the old unreliable SysV way rather than the newer, more reasonable BSD and POSIX fashion. So you'll see defensive people writing signal handlers like this:

```
sub REAPER {
    $waitedpid = wait;
    # loathe sysV: it makes us not only reinstate
    # the handler, but place it after the wait
    $SIG{CHLD} = \&REAPER;
}
$SIG{CHLD} = \&REAPER;
# now do something that forks...
```

or even the more elaborate:

```
use POSIX ":sys_wait_h";
sub REAPER {
    my $child;
    while (($child = waitpid(-1,WNOHANG)) > 0) {
        $Kid_Status{$child} = $?;
    }
    $SIG{CHLD} = \&REAPER;  # still loathe sysV
}
$SIG{CHLD} = \&REAPER;
# do something that forks...
```

Signal handling is also used for timeouts in Unix, While safely protected within an `eval{}` block, you set a signal handler to trap alarm signals and then schedule to have one delivered to you in some number of seconds. Then try your blocking operation, clearing the alarm when it's done but not before you've exited your `eval{}` block. If it goes off, you'll use `die()` to jump out of the block, much as you might using `longjmp()` or `throw()` in other languages.

Here's an example:

```
eval {
    local $SIG{ALRM} = sub { die "alarm clock restart" };
    alarm 10;
    flock(FH, 2);   # blocking write lock
    alarm 0;
};
if ($@ and $@ !~ /alarm clock restart/) { die }
```

If the operation being timed out is `system()` or `qx()`, this technique is liable to generate zombies. If this matters to you, you'll need to do your own `fork()` and `exec()`, and kill the errant child process.

For more complex signal handling, you might see the standard POSIX module. Lamentably, this is almost entirely undocumented, but the ***t/lib/posix.t*** file from the Perl source distribution has some examples in it.

Named Pipes

A named pipe (often referred to as a FIFO) is an old Unix IPC mechanism for processes communicating on the same machine. It works just like a regular, connected anonymous pipes, except that the processes rendezvous using a filename and don't have to be related.

To create a named pipe, use the Unix command mknod(1) or on some systems, mkfifo(1). These may not be in your normal path.

```
# system return val is backwards, so && not ||
#
$ENV{PATH} .= ":/etc:/usr/etc";
if  (      system('mknod',  $path, 'p')
        && system('mkfifo', $path) )
{
    die "mk{nod,fifo} $path failed";
}
```

A fifo is convenient when you want to connect a process to an unrelated one. When you open a fifo, the program will block until there's something on the other end.

For example, let's say you'd like to have your ***.signature*** file be a named pipe that has a Perl program on the other end. Now every time any program (like a mailer, news reader, finger program, etc.) tries to read from that file, the reading program will block and your program will supply the new signature. We'll use the pipe-checking file test **-p** to find out whether anyone (or anything) has accidentally removed our fifo.

```
chdir; # go home
$FIFO = '.signature';
$ENV{PATH} .= ":/etc:/usr/games";

while (1) {
    unless (-p $FIFO) {
        unlink $FIFO;
        system('mknod', $FIFO, 'p')
            && die "can't mknod $FIFO: $!";
    }

    # next line blocks until there's a reader
    open (FIFO, "> $FIFO") || die "can't write $FIFO: $!";
```

```
        print FIFO "John Smith (smith\@host.org)\n", `fortune -s`;
        close FIFO;
        sleep 2;    # to avoid dup signals
    }
```

WARNING

By installing Perl code to deal with signals, you're exposing yourself to danger from two things. First, few system library functions are re-entrant. If the signal interrupts while Perl is executing one function (like malloc(3) or printf(3)), and your signal handler then calls the same function again, you could get unpredictable behavior—often, a core dump. Second, Perl isn't itself re-entrant at the lowest levels. If the signal interrupts Perl while Perl is changing its own internal data structures, similarly unpredictable behaviour may result.

There are two things you can do, knowing this: be paranoid or be pragmatic. The paranoid approach is to do as little as possible in your signal handler. Set an existing integer variable that already has a value, and return. This doesn't help you if you're in a slow system call, which will just restart. That means you have to `die` to longjump(3) out of the handler. Even this is a little cavalier for the true paranoiac, who avoids `die` in a handler because the system *is* out to get you. The pragmatic approach is to say ``I know the risks, but prefer the convenience'', and to do anything you want in your signal handler, prepared to clean up core dumps now and again.

To forbid signal handlers altogether would bars you from many interesting programs, including virtually everything in this manpage, since you could no longer even write SIGCHLD handlers.

Using `open()` for IPC

Perl's basic `open()` statement can also be used for unidirectional interprocess communication by either appending or prepending a pipe symbol to the second argument to `open()`. Here's how to start something up in a child process you intend to write to:

```
open(SPOOLER, "| cat -v | lpr -h 2>/dev/null")
                || die "can't fork: $!";
local $SIG{PIPE} = sub { die "spooler pipe broke" };
print SPOOLER "stuff\n";
close SPOOLER || die "bad spool: $! $?";
```

And here's how to start up a child process you intend to read from:

```
open(STATUS, "netstat -an 2>&1 |")
                || die "can't fork: $!";
while (<STATUS>) {
    next if /^(tcp|udp)/;
    print;
}
close STATUS || die "bad netstat: $! $?";
```

If one can be sure that a particular program is a Perl script that is expecting filenames in @ARGV, the clever programmer can write something like this:

```
% program f1 "cmd1|" - f2 "cmd2|" f3 < tmpfile
```

and irrespective of which shell it's called from, the Perl program will read from the file ***f1***, the process ***cmd1***, standard input (***tmpfile*** in this case), the ***f2*** file, the ***cmd2*** command, and finally the ***f3*** file. Pretty nifty, eh?

You might notice that you could use backticks for much the same effect as opening a pipe for reading:

```
print grep { !/^(tcp|udp)/ } `netstat -an 2>&1`;
die "bad netstat" if $?;
```

While this is true on the surface, it's much more efficient to process the file one line or record at a time because then you don't have to read the whole thing into memory at once. It also gives you finer control of the whole process, letting you to kill off the child process early if you'd like.

Be careful to check both the `open()` and the `close()` return values. If you're *writing* to a pipe, you should also trap SIGPIPE. Otherwise, think of what happens when you start up a pipe to a command that doesn't exist: the `open()` will in all likelihood succeed (it only reflects the `fork()`'s success), but then your output will fail—spectacularly. Perl can't know whether the command worked because your command is actually running in a separate process whose `exec()` might have failed. Therefore, while readers of bogus commands return just a quick end of file, writers to bogus command will trigger a signal they'd better be prepared to handle. Consider:

```
open(FH, "|bogus")  or die "can't fork: $!";
print FH "bang\n"   or die "can't write: $!";
close FH            or die "can't close: $!";
```

That won't blow up until the close, and it will blow up with a SIGPIPE. To catch it, you could use this:

```
$SIG{PIPE} = 'IGNORE';
open(FH, "|bogus")  or die "can't fork: $!";
print FH "bang\n"   or die "can't write: $!";
close FH            or die "can't close: status=$?";
```

Filehandles

Both the main process and any child processes it forks share the same STDIN, STDOUT, and STDERR filehandles. If both processes try to access them at once, strange things can happen. You may also want to close or reopen the filehandles for the child. You can get around this by opening your pipe with `open()`, but on some systems this means that the child process cannot outlive the parent.

Background Processes

You can run a command in the background with:

```
system("cmd &");
```

The command's STDOUT and STDERR (and possibly STDIN, depending on your shell) will be the same as the parent's. You won't need to catch SIGCHLD because of the double-fork taking place (see below for more details).

Complete Dissociation of Child from Parent

In some cases (starting server processes, for instance) you'll want to completely dissociate the child process from the parent. This is often called daemonization. A well behaved daemon will also `chdir()` to the root directory (so it doesn't prevent unmounting the filesystem containing the directory from which it was launched) and redirect its standard file descriptors from and to ***/dev/null*** (so that random output doesn't wind up on the user's terminal).

```
use POSIX 'setsid';

sub daemonize {
    chdir '/'               or die "Can't chdir to /: $!";
    open STDIN, '/dev/null' or die "Can't read /dev/null: $!";
    open STDOUT, '>/dev/null'
                            or die "Can't write to /dev/null: $!";
    defined(my $pid = fork) or die "Can't fork: $!";
    exit if $pid;
    setsid                  or die "Can't start a new session: $!";
    open STDERR, '>&STDOUT' or die "Can't dup stdout: $!";
}
```

The `fork()` has to come before the `setsid()` to ensure that you aren't a process group leader (the `setsid()` will fail if you are). If your system doesn't have the `setsid()` function, open ***/dev/tty*** and use the `TIOCNOTTY ioctl()` on it instead. See *tty(4)* for details.

Non-Unix users should check their Your_OS::Process module for other solutions.

Safe Pipe Opens

Another interesting approach to IPC is making your single program go multiprocess and communicate between (or even amongst) yourselves. The `open()` function will accept a file argument of either `"-|"` or `"|-"` to do a very interesting thing: it forks a child connected to the filehandle you've opened. The child is running the same program as the parent. This is useful for safely opening a file when running under an assumed UID or GID, for example. If you open a pipe *to* minus, you can write to the filehandle you opened and your kid will find it in his STDIN. If you open a pipe *from* minus, you can read from the filehandle you opened whatever your kid writes to his STDOUT.

```
use English;
my $sleep_count = 0;

do {
    $pid = open(KID_TO_WRITE, "|-");
    unless (defined $pid) {
        warn "cannot fork: $!";
        die "bailing out" if $sleep_count++ > 6;
        sleep 10;
    }
} until defined $pid;

if ($pid) {  # parent
    print KID_TO_WRITE @some_data;
    close(KID_TO_WRITE) || warn "kid exited $?";
} else {     # child
    ($EUID, $EGID) = ($UID, $GID); # suid progs only
    open (FILE, "> /safe/file")
        || die "can't open /safe/file: $!";
    while (<STDIN>) {
        print FILE; # child's STDIN is parent's KID
    }
    exit;  # don't forget this
}
```

Another common use for this construct is when you need to execute something without the shell's interference. With `system()`, it's straightforward, but you can't use a pipe open or backticks safely. That's because there's no way to stop the shell from getting its hands on your arguments. Instead, use lower-level control to call `exec()` directly.

Here's a safe backtick or pipe open for read:

```
# add error processing as above
$pid = open(KID_TO_READ, "-|");

if ($pid) {   # parent
    while (<KID_TO_READ>) {
        # do something interesting
    }
    close(KID_TO_READ) || warn "kid exited $?";

} else {      # child
    ($EUID, $EGID) = ($UID, $GID); # suid only
    exec($program, @options, @args)
        || die "can't exec program: $!";
    # NOTREACHED
}
```

And here's a safe pipe open for writing:

```
# add error processing as above
$pid = open(KID_TO_WRITE, "|-");
$SIG{ALRM} = sub { die "whoops, $program pipe broke" };

if ($pid) {  # parent
    for (@data) {
        print KID_TO_WRITE;
    }
    close(KID_TO_WRITE) || warn "kid exited $?";

} else {     # child
    ($EUID, $EGID) = ($UID, $GID);
    exec($program, @options, @args)
        || die "can't exec program: $!";
    # NOTREACHED
}
```

Note that these operations are full Unix forks, which means they may not be correctly implemented on alien systems. Additionally, these are not true multithreading. If you'd like to learn more about threading, see the ***modules*** file mentioned below in the SEE ALSO section.

Bidirectional Communication with Another Process

While this works reasonably well for unidirectional communication, what about bidirectional communication? The obvious thing you'd like to do doesn't actually work:

```
open(PROG_FOR_READING_AND_WRITING, "| some program |")
```

and if you forget to use the `use warnings` pragma or the **−w** flag, then you'll miss out entirely on the diagnostic message:

```
Can't do bidirectional pipe at -e line 1.
```

If you really want to, you can use the standard `open2()` library function to catch both ends. There's also an `open3()` for tridirectional I/O so you can also catch your child's STDERR, but doing so would then require an awkward `select()` loop and wouldn't allow you to use normal Perl input operations.

If you look at its source, you'll see that `open2()` uses low−level primitives like Unix `pipe()` and `exec()` calls to create all the connections. While it might have been slightly more efficient by using `socketpair()`, it would have then been even less portable than it already is. The `open2()` and `open3()` functions are unlikely to work anywhere except on a Unix system or some other one purporting to be POSIX compliant.

Here's an example of using `open2()`:

```
use FileHandle;
use IPC::Open2;
$pid = open2(*Reader, *Writer, "cat -u -n" );
print Writer "stuff\n";
$got = <Reader>;
```

The problem with this is that Unix buffering is really going to ruin your day. Even though your `Writer` filehandle is auto−flushed, and the process on the other end will get your data in a timely manner, you can't usually do anything to force it to give it back to you in a similarly quick fashion. In this case, we could, because we gave *cat* a **−u** flag to make it unbuffered. But very few Unix commands are designed to operate over pipes, so this seldom works unless you yourself wrote the program on the other end of the double−ended pipe.

A solution to this is the nonstandard ***Comm.pl*** library. It uses pseudo−ttys to make your program behave more reasonably:

```
require 'Comm.pl';
```

```
$ph = open_proc('cat -n');
for (1..10) {
    print $ph "a line\n";
    print "got back ", scalar <$ph>;
}
```

This way you don't have to have control over the source code of the program you're using. The ***Comm*** library also has `expect()` and `interact()` functions. Find the library (and we hope its successor ***IPC::Chat***) at your nearest CPAN archive as detailed in the SEE ALSO section below.

The newer Expect.pm module from CPAN also addresses this kind of thing. This module requires two other modules from CPAN: IO::Pty and IO::Stty. It sets up a pseudo-terminal to interact with programs that insist on using talking to the terminal device driver. If your system is amongst those supported, this may be your best bet.

Bidirectional Communication with Yourself

If you want, you may make low-level `pipe()` and `fork()` to stitch this together by hand. This example only talks to itself, but you could reopen the appropriate handles to STDIN and STDOUT and call other processes.

```
#!/usr/bin/perl -w
# pipe1 - bidirectional communication using two pipe pairs
#         designed for the socketpair-challenged
use IO::Handle;     # thousands of lines just for autoflush :-(
pipe(PARENT_RDR, CHILD_WTR);                # XXX: failure?
pipe(CHILD_RDR,  PARENT_WTR);               # XXX: failure?
CHILD_WTR->autoflush(1);
PARENT_WTR->autoflush(1);

if ($pid = fork) {
    close PARENT_RDR; close PARENT_WTR;
    print CHILD_WTR "Parent Pid $$ is sending this\n";
    chomp($line = <CHILD_RDR>);
    print "Parent Pid $$ just read this: '$line'\n";
    close CHILD_RDR; close CHILD_WTR;
    waitpid($pid,0);
} else {
    die "cannot fork: $!" unless defined $pid;
    close CHILD_RDR; close CHILD_WTR;
    chomp($line = <PARENT_RDR>);
    print "Child Pid $$ just read this: '$line'\n";
    print PARENT_WTR "Child Pid $$ is sending this\n";
    close PARENT_RDR; close PARENT_WTR;
    exit;
}
```

But you don't actually have to make two pipe calls. If you have the `socketpair()` system call, it will do this all for you.

```
#!/usr/bin/perl -w
# pipe2 - bidirectional communication using socketpair
#   "the best ones always go both ways"

use Socket;
use IO::Handle;     # thousands of lines just for autoflush :-(
# We say AF_UNIX because although *_LOCAL is the
# POSIX 1003.1g form of the constant, many machines
# still don't have it.
```

```
socketpair(CHILD, PARENT, AF_UNIX, SOCK_STREAM, PF_UNSPEC)
                              or  die "socketpair: $!";

CHILD->autoflush(1);
PARENT->autoflush(1);

if ($pid = fork) {
    close PARENT;
    print CHILD "Parent Pid $$ is sending this\n";
    chomp($line = <CHILD>);
    print "Parent Pid $$ just read this: `$line'\n";
    close CHILD;
    waitpid($pid,0);
} else {
    die "cannot fork: $!" unless defined $pid;
    close CHILD;
    chomp($line = <PARENT>);
    print "Child Pid $$ just read this: `$line'\n";
    print PARENT "Child Pid $$ is sending this\n";
    close PARENT;
    exit;
}
```

Sockets: Client/Server Communication

While not limited to Unix−derived operating systems (e.g., WinSock on PCs provides socket support, as do some VMS libraries), you may not have sockets on your system, in which case this section probably isn't going to do you much good. With sockets, you can do both virtual circuits (i.e., TCP streams) and datagrams (i.e., UDP packets). You may be able to do even more depending on your system.

The Perl function calls for dealing with sockets have the same names as the corresponding system calls in C, but their arguments tend to differ for two reasons: first, Perl filehandles work differently than C file descriptors. Second, Perl already knows the length of its strings, so you don't need to pass that information.

One of the major problems with old socket code in Perl was that it used hard−coded values for some of the constants, which severely hurt portability. If you ever see code that does anything like explicitly setting `$AF_INET = 2`, you know you're in for big trouble: An immeasurably superior approach is to use the `Socket` module, which more reliably grants access to various constants and functions you'll need.

If you're not writing a server/client for an existing protocol like NNTP or SMTP, you should give some thought to how your server will know when the client has finished talking, and vice−versa. Most protocols are based on one−line messages and responses (so one party knows the other has finished when a "\n" is received) or multi−line messages and responses that end with a period on an empty line ("\n.\n" terminates a message/response).

Internet Line Terminators

The Internet line terminator is "\015\012". Under ASCII variants of Unix, that could usually be written as "\r\n", but under other systems, "\r\n" might at times be "\015\015\012", "\012\012\015", or something completely different. The standards specify writing "\015\012" to be conformant (be strict in what you provide), but they also recommend accepting a lone "\012" on input (but be lenient in what you require). We haven't always been very good about that in the code in this manpage, but unless you're on a Mac, you'll probably be ok.

Internet TCP Clients and Servers

Use Internet−domain sockets when you want to do client−server communication that might extend to machines outside of your own system.

Here's a sample TCP client using Internet−domain sockets:

```
#!/usr/bin/perl -w
use strict;
use Socket;
my ($remote,$port, $iaddr, $paddr, $proto, $line);

$remote  = shift || 'localhost';
$port    = shift || 2345;  # random port
if ($port =~ /\D/) { $port = getservbyname($port, 'tcp') }
die "No port" unless $port;
$iaddr   = inet_aton($remote)               || die "no host: $remote";
$paddr   = sockaddr_in($port, $iaddr);

$proto   = getprotobyname('tcp');
socket(SOCK, PF_INET, SOCK_STREAM, $proto)  || die "socket: $!";
connect(SOCK, $paddr)    || die "connect: $!";
while (defined($line = <SOCK>)) {
    print $line;
}

close (SOCK)            || die "close: $!";
exit;
```

And here's a corresponding server to go along with it. We'll leave the address as INADDR_ANY so that the kernel can choose the appropriate interface on multihomed hosts. If you want sit on a particular interface (like the external side of a gateway or firewall machine), you should fill this in with your real address instead.

```
#!/usr/bin/perl -Tw
use strict;
BEGIN { $ENV{PATH} = '/usr/ucb:/bin' }
use Socket;
use Carp;
$EOL = "\015\012";

sub logmsg { print "$0 $$: @_ at ", scalar localtime, "\n" }

my $port = shift || 2345;
my $proto = getprotobyname('tcp');

($port) = $port =~ /^(\d+)$/                      || die "invalid port";

socket(Server, PF_INET, SOCK_STREAM, $proto)      || die "socket: $!";
setsockopt(Server, SOL_SOCKET, SO_REUSEADDR,
                                    pack("l", 1)) || die "setsockopt: $!";
bind(Server, sockaddr_in($port, INADDR_ANY))      || die "bind: $!";
listen(Server,SOMAXCONN)                          || die "listen: $!";

logmsg "server started on port $port";

my $paddr;

$SIG{CHLD} = \&REAPER;

for ( ; $paddr = accept(Client,Server); close Client) {
    my($port,$iaddr) = sockaddr_in($paddr);
    my $name = gethostbyaddr($iaddr,AF_INET);

    logmsg "connection from $name [",
            inet_ntoa($iaddr), "]
            at port $port";
```

```
    print Client "Hello there, $name, it's now ",
                    scalar localtime, $EOL;
}
```

And here's a multithreaded version. It's multithreaded in that like most typical servers, it spawns (forks) a slave server to handle the client request so that the master server can quickly go back to service a new client.

```
#!/usr/bin/perl -Tw
use strict;
BEGIN { $ENV{PATH} = '/usr/ucb:/bin' }
use Socket;
use Carp;
$EOL = "\015\012";

sub spawn;  # forward declaration
sub logmsg { print "$0 $$: @_ at ", scalar localtime, "\n" }

my $port = shift || 2345;
my $proto = getprotobyname('tcp');

($port) = $port =~ /^(\d+)$/                        || die "invalid port";

socket(Server, PF_INET, SOCK_STREAM, $proto)        || die "socket: $!";
setsockopt(Server, SOL_SOCKET, SO_REUSEADDR,
                                    pack("l", 1))   || die "setsockopt: $!";
bind(Server, sockaddr_in($port, INADDR_ANY))        || die "bind: $!";
listen(Server,SOMAXCONN)                            || die "listen: $!";

logmsg "server started on port $port";

my $waitedpid = 0;
my $paddr;

sub REAPER {
    $waitedpid = wait;
    $SIG{CHLD} = \&REAPER;  # loathe sysV
    logmsg "reaped $waitedpid" . ($? ? " with exit $?" : '');
}

$SIG{CHLD} = \&REAPER;

for ( $waitedpid = 0;
      ($paddr = accept(Client,Server)) || $waitedpid;
      $waitedpid = 0, close Client)
{
    next if $waitedpid and not $paddr;
    my($port,$iaddr) = sockaddr_in($paddr);
    my $name = gethostbyaddr($iaddr,AF_INET);

    logmsg "connection from $name [",
            inet_ntoa($iaddr), "]
            at port $port";

    spawn sub {
        $|=1;
        print "Hello there, $name, it's now ", scalar localtime, $EOL;
        exec '/usr/games/fortune'           # XXX: 'wrong' line terminators
            or confess "can't exec fortune: $!";
    };

}
```

```
sub spawn {
    my $coderef = shift;

    unless (@_ == 0 && $coderef && ref($coderef) eq 'CODE') {
        confess "usage: spawn CODEREF";
    }

    my $pid;
    if (!defined($pid = fork)) {
        logmsg "cannot fork: $!";
        return;
    } elsif ($pid) {
        logmsg "begat $pid";
        return; # I'm the parent
    }
    # else I'm the child -- go spawn

    open(STDIN,  "<&Client")   || die "can't dup client to stdin";
    open(STDOUT, ">&Client")   || die "can't dup client to stdout";
    ## open(STDERR, ">&STDOUT") || die "can't dup stdout to stderr";
    exit &$coderef();
}
```

This server takes the trouble to clone off a child version via `fork()` for each incoming request. That way it can handle many requests at once, which you might not always want. Even if you don't `fork()`, the `listen()` will allow that many pending connections. Forking servers have to be particularly careful about cleaning up their dead children (called "zombies" in Unix parlance), because otherwise you'll quickly fill up your process table.

We suggest that you use the **–T** flag to use taint checking (see *perlsec*) even if we aren't running setuid or setgid. This is always a good idea for servers and other programs run on behalf of someone else (like CGI scripts), because it lessens the chances that people from the outside will be able to compromise your system.

Let's look at another TCP client. This one connects to the TCP "time" service on a number of different machines and shows how far their clocks differ from the system on which it's being run:

```
#!/usr/bin/perl  -w
use strict;
use Socket;

my $SECS_of_70_YEARS = 2208988800;
sub ctime { scalar localtime(shift) }

my $iaddr = gethostbyname('localhost');
my $proto = getprotobyname('tcp');
my $port = getservbyname('time', 'tcp');
my $paddr = sockaddr_in(0, $iaddr);
my($host);

$| = 1;
printf "%-24s %8s %s\n",  "localhost", 0, ctime(time());

foreach $host (@ARGV) {
    printf "%-24s ", $host;
    my $hisiaddr = inet_aton($host)     || die "unknown host";
    my $hispaddr = sockaddr_in($port, $hisiaddr);
    socket(SOCKET, PF_INET, SOCK_STREAM, $proto)   || die "socket: $!";
    connect(SOCKET, $hispaddr)          || die "bind: $!";
    my $rtime = '    ';
    read(SOCKET, $rtime, 4);
```

```
    close(SOCKET);
    my $histime = unpack("N", $rtime) - $SECS_of_70_YEARS ;
    printf "%8d %s\n", $histime - time, ctime($histime);
}
```

Unix–Domain TCP Clients and Servers

That's fine for Internet–domain clients and servers, but what about local communications? While you can use the same setup, sometimes you don't want to. Unix–domain sockets are local to the current host, and are often used internally to implement pipes. Unlike Internet domain sockets, Unix domain sockets can show up in the file system with an ls(1) listing.

```
% ls -l /dev/log
srw-rw-rw-  1 root            0 Oct 31 07:23 /dev/log
```

You can test for these with Perl's **–S** file test:

```
unless ( -S '/dev/log' ) {
    die "something's wicked with the log system";
}
```

Here's a sample Unix–domain client:

```
#!/usr/bin/perl -w
use Socket;
use strict;
my ($rendezvous, $line);

$rendezvous = shift || '/tmp/catsock';
socket(SOCK, PF_UNIX, SOCK_STREAM, 0)       || die "socket: $!";
connect(SOCK, sockaddr_un($rendezvous))     || die "connect: $!";
while (defined($line = <SOCK>)) {
    print $line;
}
exit;
```

And here's a corresponding server. You don't have to worry about silly network terminators here because Unix domain sockets are guaranteed to be on the localhost, and thus everything works right.

```
#!/usr/bin/perl -Tw
use strict;
use Socket;
use Carp;

BEGIN { $ENV{PATH} = '/usr/ucb:/bin' }
sub logmsg { print "$0 $$: @_ at ", scalar localtime, "\n" }

my $NAME = '/tmp/catsock';
my $uaddr = sockaddr_un($NAME);
my $proto = getprotobyname('tcp');

socket(Server,PF_UNIX,SOCK_STREAM,0)        || die "socket: $!";
unlink($NAME);
bind  (Server, $uaddr)                      || die "bind: $!";
listen(Server,SOMAXCONN)                    || die "listen: $!";

logmsg "server started on $NAME";

my $waitedpid;

sub REAPER {
    $waitedpid = wait;
    $SIG{CHLD} = \&REAPER;  # loathe sysV
```

```
    logmsg "reaped $waitedpid" . ($? ? " with exit $?" : '');
}

$SIG{CHLD} = \&REAPER;

for ( $waitedpid = 0;
      accept(Client,Server) || $waitedpid;
      $waitedpid = 0, close Client)
{
    next if $waitedpid;
    logmsg "connection on $NAME";
    spawn sub {
        print "Hello there, it's now ", scalar localtime, "\n";
        exec '/usr/games/fortune' or die "can't exec fortune: $!";
    };
}
```

As you see, it's remarkably similar to the Internet domain TCP server, so much so, in fact, that we've omitted several duplicate functions—`spawn()`, `logmsg()`, `ctime()`, and `REAPER()`—which are exactly the same as in the other server.

So why would you ever want to use a Unix domain socket instead of a simpler named pipe? Because a named pipe doesn't give you sessions. You can't tell one process's data from another's. With socket programming, you get a separate session for each client: that's why `accept()` takes two arguments.

For example, let's say that you have a long running database server daemon that you want folks from the World Wide Web to be able to access, but only if they go through a CGI interface. You'd have a small, simple CGI program that does whatever checks and logging you feel like, and then acts as a Unix-domain client and connects to your private server.

TCP Clients with IO::Socket

For those preferring a higher-level interface to socket programming, the IO::Socket module provides an object-oriented approach. IO::Socket is included as part of the standard Perl distribution as of the 5.004 release. If you're running an earlier version of Perl, just fetch IO::Socket from CPAN, where you'll also find modules providing easy interfaces to the following systems: DNS, FTP, Ident (RFC 931), NIS and NISPlus, NNTP, Ping, POP3, SMTP, SNMP, SSLeay, Telnet, and Time—just to name a few.

A Simple Client

Here's a client that creates a TCP connection to the "daytime" service at port 13 of the host name "localhost" and prints out everything that the server there cares to provide.

```
#!/usr/bin/perl -w
use IO::Socket;
$remote = IO::Socket::INET->new(
                    Proto    => "tcp",
                    PeerAddr => "localhost",
                    PeerPort => "daytime(13)",
                )
               or die "cannot connect to daytime port at localhost";
while ( <$remote> ) { print }
```

When you run this program, you should get something back that looks like this:

```
Wed May 14 08:40:46 MDT 1997
```

Here are what those parameters to the `new` constructor mean:

`Proto`

This is which protocol to use. In this case, the socket handle returned will be connected to a TCP socket, because we want a stream-oriented connection, that is, one that acts pretty much like a plain

old file. Not all sockets are this of this type. For example, the UDP protocol can be used to make a datagram socket, used for message−passing.

`PeerAddr`

This is the name or Internet address of the remote host the server is running on. We could have specified a longer name like `"www.perl.com"`, or an address like `"204.148.40.9"`. For demonstration purposes, we've used the special hostname `"localhost"`, which should always mean the current machine you're running on. The corresponding Internet address for localhost is `"127.1"`, if you'd rather use that.

`PeerPort`

This is the service name or port number we'd like to connect to. We could have gotten away with using just `"daytime"` on systems with a well−configured system services file,[FOOTNOTE: The system services file is in */etc/services* under Unix] but just in case, we've specified the port number (13) in parentheses. Using just the number would also have worked, but constant numbers make careful programmers nervous.

Notice how the return value from the `new` constructor is used as a filehandle in the `while` loop? That's what's called an indirect filehandle, a scalar variable containing a filehandle. You can use it the same way you would a normal filehandle. For example, you can read one line from it this way:

```
$line = <$handle>;
```

all remaining lines from is this way:

```
@lines = <$handle>;
```

and send a line of data to it this way:

```
print $handle "some data\n";
```

A Webget Client

Here's a simple client that takes a remote host to fetch a document from, and then a list of documents to get from that host. This is a more interesting client than the previous one because it first sends something to the server before fetching the server's response.

```
#!/usr/bin/perl -w
use IO::Socket;
unless (@ARGV > 1) { die "usage: $0 host document ..." }
$host = shift(@ARGV);
$EOL = "\015\012";
$BLANK = $EOL x 2;
foreach $document ( @ARGV ) {
    $remote = IO::Socket::INET->new( Proto     => "tcp",
                                     PeerAddr  => $host,
                                     PeerPort  => "http(80)",
                                    );
    unless ($remote) { die "cannot connect to http daemon on $host" }
    $remote->autoflush(1);
    print $remote "GET $document HTTP/1.0" . $BLANK;
    while ( <$remote> ) { print }
    close $remote;
}
```

The web server handing the "http" service, which is assumed to be at its standard port, number 80. If the web server you're trying to connect to is at a different port (like 1080 or 8080), you should specify as the named−parameter pair, `< PeerPort = 8080 .` The `autoflush` method is used on the socket because otherwise the system would buffer up the output we sent it. (If you're on a Mac, you'll also need to change every `"\n"` in your code that sends data over the network to be a `"\015\012"` instead.)

Connecting to the server is only the first part of the process: once you have the connection, you have to use the server's language. Each server on the network has its own little command language that it expects as input. The string that we send to the server starting with "GET" is in HTTP syntax. In this case, we simply request each specified document. Yes, we really are making a new connection for each document, even though it's the same host. That's the way you always used to have to speak HTTP. Recent versions of web browsers may request that the remote server leave the connection open a little while, but the server doesn't have to honor such a request.

Here's an example of running that program, which we'll call *webget*:

```
% webget www.perl.com /guanaco.html
HTTP/1.1 404 File Not Found
Date: Thu, 08 May 1997 18:02:32 GMT
Server: Apache/1.2b6
Connection: close
Content-type: text/html

<HEAD><TITLE>404 File Not Found</TITLE></HEAD>
<BODY><H1>File Not Found</H1>
The requested URL /guanaco.html was not found on this server.<P>
</BODY>
```

Ok, so that's not very interesting, because it didn't find that particular document. But a long response wouldn't have fit on this page.

For a more fully-featured version of this program, you should look to the *lwp-request* program included with the LWP modules from CPAN.

Interactive Client with IO::Socket

Well, that's all fine if you want to send one command and get one answer, but what about setting up something fully interactive, somewhat like the way *telnet* works? That way you can type a line, get the answer, type a line, get the answer, etc.

This client is more complicated than the two we've done so far, but if you're on a system that supports the powerful `fork` call, the solution isn't that rough. Once you've made the connection to whatever service you'd like to chat with, call `fork` to clone your process. Each of these two identical process has a very simple job to do: the parent copies everything from the socket to standard output, while the child simultaneously copies everything from standard input to the socket. To accomplish the same thing using just one process would be *much* harder, because it's easier to code two processes to do one thing than it is to code one process to do two things. (This keep-it-simple principle a cornerstones of the Unix philosophy, and good software engineering as well, which is probably why it's spread to other systems.)

Here's the code:

```
#!/usr/bin/perl -w
use strict;
use IO::Socket;
my ($host, $port, $kidpid, $handle, $line);

unless (@ARGV == 2) { die "usage: $0 host port" }
($host, $port) = @ARGV;

# create a tcp connection to the specified host and port
$handle = IO::Socket::INET->new(Proto     => "tcp",
                                PeerAddr  => $host,
                                PeerPort  => $port)
       or die "can't connect to port $port on $host: $!";

$handle->autoflush(1);              # so output gets there right away
print STDERR "[Connected to $host:$port]\n";
```

```
# split the program into two processes, identical twins
die "can't fork: $!" unless defined($kidpid = fork());

# the if{} block runs only in the parent process
if ($kidpid) {
    # copy the socket to standard output
    while (defined ($line = <$handle>)) {
        print STDOUT $line;
    }
    kill("TERM", $kidpid);                  # send SIGTERM to child
}
# the else{} block runs only in the child process
else {
    # copy standard input to the socket
    while (defined ($line = <STDIN>)) {
        print $handle $line;
    }
}
```

The `kill` function in the parent's `if` block is there to send a signal to our child process (current running in the `else` block) as soon as the remote server has closed its end of the connection.

If the remote server sends data a byte at time, and you need that data immediately without waiting for a newline (which might not happen), you may wish to replace the `while` loop in the parent with the following:

```
my $byte;
while (sysread($handle, $byte, 1) == 1) {
    print STDOUT $byte;
}
```

Making a system call for each byte you want to read is not very efficient (to put it mildly) but is the simplest to explain and works reasonably well.

TCP Servers with IO::Socket

As always, setting up a server is little bit more involved than running a client. The model is that the server creates a special kind of socket that does nothing but listen on a particular port for incoming connections. It does this by calling the `< IO::Socket::INET-new()` method with slightly different arguments than the client did.

Proto

This is which protocol to use. Like our clients, we'll still specify `"tcp"` here.

LocalPort

We specify a local port in the `LocalPort` argument, which we didn't do for the client. This is service name or port number for which you want to be the server. (Under Unix, ports under 1024 are restricted to the superuser.) In our sample, we'll use port 9000, but you can use any port that's not currently in use on your system. If you try to use one already in used, you'll get an "Address already in use" message. Under Unix, the `netstat -a` command will show which services current have servers.

Listen

The `Listen` parameter is set to the maximum number of pending connections we can accept until we turn away incoming clients. Think of it as a call−waiting queue for your telephone. The low−level Socket module has a special symbol for the system maximum, which is SOMAXCONN.

Reuse

The `Reuse` parameter is needed so that we restart our server manually without waiting a few minutes to allow system buffers to clear out.

Once the generic server socket has been created using the parameters listed above, the server then waits for a new client to connect to it. The server blocks in the `accept` method, which eventually an bidirectional connection to the remote client. (Make sure to autoflush this handle to circumvent buffering.)

To add to user−friendliness, our server prompts the user for commands. Most servers don't do this. Because of the prompt without a newline, you'll have to use the `sysread` variant of the interactive client above.

This server accepts one of five different commands, sending output back to the client. Note that unlike most network servers, this one only handles one incoming client at a time. Multithreaded servers are covered in Chapter 6 of the Camel.

Here's the code. We'll

```
#!/usr/bin/perl -w
use IO::Socket;
use Net::hostent;               # for OO version of gethostbyaddr

$PORT = 9000;                   # pick something not in use

$server = IO::Socket::INET->new( Proto     => 'tcp',
                                 LocalPort => $PORT,
                                 Listen    => SOMAXCONN,
                                 Reuse     => 1);

die "can't setup server" unless $server;
print "[Server $0 accepting clients]\n";

while ($client = $server->accept()) {
  $client->autoflush(1);
  print $client "Welcome to $0; type help for command list.\n";
  $hostinfo = gethostbyaddr($client->peeraddr);
  printf "[Connect from %s]\n", $hostinfo->name || $client->peerhost;
  print $client "Command? ";
  while ( <$client>) {
    next unless /\S/;       # blank line
    if    (/quit|exit/i)    { last;                                   }
    elsif (/date|time/i)    { printf $client "%s\n", scalar localtime;  }
    elsif (/who/i )         { print  $client `who 2>&1`;                }
    elsif (/cookie/i )      { print  $client `/usr/games/fortune 2>&1`; }
    elsif (/motd/i )        { print  $client `cat /etc/motd 2>&1`;      }
    else {
      print $client "Commands: quit date who cookie motd\n";
    }
  } continue {
     print $client "Command? ";
  }
  close $client;
}
```

UDP: Message Passing

Another kind of client−server setup is one that uses not connections, but messages. UDP communications involve much lower overhead but also provide less reliability, as there are no promises that messages will arrive at all, let alone in order and unmangled. Still, UDP offers some advantages over TCP, including being able to "broadcast" or "multicast" to a whole bunch of destination hosts at once (usually on your local subnet). If you find yourself overly concerned about reliability and start building checks into your message system, then you probably should use just TCP to start with.

Note that UDP datagrams are *not* a bytestream and should not be treated as such. This makes using I/O mechanisms with internal buffering like stdio (i.e. `print()` and friends) especially cumbersome. Use

`syswrite()`, or better `send()`, like in the example below.

Here's a UDP program similar to the sample Internet TCP client given earlier. However, instead of checking one host at a time, the UDP version will check many of them asynchronously by simulating a multicast and then using `select()` to do a timed–out wait for I/O. To do something similar with TCP, you'd have to use a different socket handle for each host.

```
#!/usr/bin/perl -w
use strict;
use Socket;
use Sys::Hostname;

my ( $count, $hisiaddr, $hispaddr, $histime,
     $host, $iaddr, $paddr, $port, $proto,
     $rin, $rout, $rtime, $SECS_of_70_YEARS);

$SECS_of_70_YEARS      = 2208988800;

$iaddr = gethostbyname(hostname());
$proto = getprotobyname('udp');
$port = getservbyname('time', 'udp');
$paddr = sockaddr_in(0, $iaddr); # 0 means let kernel pick

socket(SOCKET, PF_INET, SOCK_DGRAM, $proto)   || die "socket: $!";
bind(SOCKET, $paddr)                          || die "bind: $!";

$| = 1;
printf "%-12s %8s %s\n",  "localhost", 0, scalar localtime time;
$count = 0;
for $host (@ARGV) {
    $count++;
    $hisiaddr = inet_aton($host)    || die "unknown host";
    $hispaddr = sockaddr_in($port, $hisiaddr);
    defined(send(SOCKET, 0, 0, $hispaddr))    || die "send $host: $!";
}

$rin = '';
vec($rin, fileno(SOCKET), 1) = 1;

# timeout after 10.0 seconds
while ($count && select($rout = $rin, undef, undef, 10.0)) {
    $rtime = '';
    ($hispaddr = recv(SOCKET, $rtime, 4, 0))        || die "recv: $!";
    ($port, $hisiaddr) = sockaddr_in($hispaddr);
    $host = gethostbyaddr($hisiaddr, AF_INET);
    $histime = unpack("N", $rtime) - $SECS_of_70_YEARS ;
    printf "%-12s ", $host;
    printf "%8d %s\n", $histime - time, scalar localtime($histime);
    $count--;
}
```

Note that this example does not include any retries and may consequently fail to contact a reachable host. The most prominent reason for this is congestion of the queues on the sending host if the number of list of hosts to contact is sufficiently large.

SysV IPC

While System V IPC isn't so widely used as sockets, it still has some interesting uses. You can't, however, effectively use SysV IPC or Berkeley `mmap()` to have shared memory so as to share a variable amongst several processes. That's because Perl would reallocate your string when you weren't wanting it to.

Here's a small example showing shared memory usage.

```
use IPC::SysV qw(IPC_PRIVATE IPC_RMID S_IRWXU);

$size = 2000;
$id = shmget(IPC_PRIVATE, $size, S_IRWXU) || die "$!";
print "shm key $id\n";

$message = "Message #1";
shmwrite($id, $message, 0, 60) || die "$!";
print "wrote: '$message'\n";
shmread($id, $buff, 0, 60) || die "$!";
print "read : '$buff'\n";

# the buffer of shmread is zero-character end-padded.
substr($buff, index($buff, "\0")) = '';
print "un" unless $buff eq $message;
print "swell\n";

print "deleting shm $id\n";
shmctl($id, IPC_RMID, 0) || die "$!";
```

Here's an example of a semaphore:

```
use IPC::SysV qw(IPC_CREAT);

$IPC_KEY = 1234;
$id = semget($IPC_KEY, 10, 0666 | IPC_CREAT ) || die "$!";
print "shm key $id\n";
```

Put this code in a separate file to be run in more than one process. Call the file ***take***:

```
# create a semaphore

$IPC_KEY = 1234;
$id = semget($IPC_KEY,  0 , 0 );
die if !defined($id);

$semnum = 0;
$semflag = 0;

# 'take' semaphore
# wait for semaphore to be zero
$semop = 0;
$opstring1 = pack("s!s!s!", $semnum, $semop, $semflag);

# Increment the semaphore count
$semop = 1;
$opstring2 = pack("s!s!s!", $semnum, $semop,  $semflag);
$opstring = $opstring1 . $opstring2;

semop($id,$opstring) || die "$!";
```

Put this code in a separate file to be run in more than one process. Call this file ***give***:

```
# 'give' the semaphore
# run this in the original process and you will see
# that the second process continues

$IPC_KEY = 1234;
$id = semget($IPC_KEY, 0, 0);
die if !defined($id);
```

```
$semnum = 0;
$semflag = 0;

# Decrement the semaphore count
$semop = -1;
$opstring = pack("s!s!s!", $semnum, $semop, $semflag);

semop($id,$opstring) || die "$!";
```

The SysV IPC code above was written long ago, and it's definitely clunky looking. For a more modern look, see the IPC::SysV module which is included with Perl starting from Perl 5.005.

A small example demonstrating SysV message queues:

```
use IPC::SysV qw(IPC_PRIVATE IPC_RMID IPC_CREAT S_IRWXU);

my $id = msgget(IPC_PRIVATE, IPC_CREAT | S_IRWXU);

my $sent = "message";
my $type = 1234;
my $rcvd;
my $type_rcvd;

if (defined $id) {
    if (msgsnd($id, pack("l! a*", $type_sent, $sent), 0)) {
        if (msgrcv($id, $rcvd, 60, 0, 0)) {
            ($type_rcvd, $rcvd) = unpack("l! a*", $rcvd);
            if ($rcvd eq $sent) {
                print "okay\n";
            } else {
                print "not okay\n";
            }
        } else {
            die "# msgrcv failed\n";
        }
    } else {
        die "# msgsnd failed\n";
    }
    msgctl($id, IPC_RMID, 0) || die "# msgctl failed: $!\n";
} else {
    die "# msgget failed\n";
}
```

NOTES

Most of these routines quietly but politely return `undef` when they fail instead of causing your program to die right then and there due to an uncaught exception. (Actually, some of the new *Socket* conversion functions `croak()` on bad arguments.) It is therefore essential to check return values from these functions. Always begin your socket programs this way for optimal success, and don't forget to add **-T** taint checking flag to the #! line for servers:

```
#!/usr/bin/perl -Tw
use strict;
use sigtrap;
use Socket;
```

BUGS

All these routines create system-specific portability problems. As noted elsewhere, Perl is at the mercy of your C libraries for much of its system behaviour. It's probably safest to assume broken SysV semantics for signals and to stick with simple TCP and UDP socket operations; e.g., don't try to pass open file descriptors over a local UDP datagram socket if you want your code to stand a chance of being portable.

As mentioned in the signals section, because few vendors provide C libraries that are safely re−entrant, the prudent programmer will do little else within a handler beyond setting a numeric variable that already exists; or, if locked into a slow (restarting) system call, using `die()` to raise an exception and longjmp(3) out. In fact, even these may in some cases cause a core dump. It's probably best to avoid signals except where they are absolutely inevitable. This will be addressed in a future release of Perl.

AUTHOR

Tom Christiansen, with occasional vestiges of Larry Wall's original version and suggestions from the Perl Porters.

SEE ALSO

There's a lot more to networking than this, but this should get you started.

For intrepid programmers, the indispensable textbook is *Unix Network Programming* by W. Richard Stevens (published by Addison−Wesley). Note that most books on networking address networking from the perspective of a C programmer; translation to Perl is left as an exercise for the reader.

The IO::Socket(3) manpage describes the object library, and the Socket(3) manpage describes the low−level interface to sockets. Besides the obvious functions in *perlfunc*, you should also check out the ***modules*** file at your nearest CPAN site. (See *perlmodlib* or best yet, the ***Perl FAQ*** for a description of what CPAN is and where to get it.)

Section 5 of the ***modules*** file is devoted to "Networking, Device Control (modems), and Interprocess Communication", and contains numerous unbundled modules numerous networking modules, Chat and Expect operations, CGI programming, DCE, FTP, IPC, NNTP, Proxy, Ptty, RPC, SNMP, SMTP, Telnet, Threads, and ToolTalk—just to name a few.

NAME

perllexwarn – Perl Lexical Warnings

DESCRIPTION

The `use warnings` pragma is a replacement for both the command line flag **–w** and the equivalent Perl variable, `$^W`.

The pragma works just like the existing "strict" pragma. This means that the scope of the warning pragma is limited to the enclosing block. It also means that the pragma setting will not leak across files (via `use`, `require` or `do`). This allows authors to independently define the degree of warning checks that will be applied to their module.

By default, optional warnings are disabled, so any legacy code that doesn't attempt to control the warnings will work unchanged.

All warnings are enabled in a block by either of these:

```
use warnings ;
use warnings 'all' ;
```

Similarly all warnings are disabled in a block by either of these:

```
no warnings ;
no warnings 'all' ;
```

For example, consider the code below:

```
use warnings ;
my @a ;
{
    no warnings ;
    my $b = @a[0] ;
}
my $c = @a[0];
```

The code in the enclosing block has warnings enabled, but the inner block has them disabled. In this case that means the assignment to the scalar `$c` will trip the `"Scalar value @a[0] better written as $a[0]"` warning, but the assignment to the scalar `$b` will not.

Default Warnings and Optional Warnings

Before the introduction of lexical warnings, Perl had two classes of warnings: mandatory and optional.

As its name suggests, if your code tripped a mandatory warning, you would get a warning whether you wanted it or not. For example, the code below would always produce an `"isn't numeric"` warning about the "2:".

```
my $a = "2:" + 3;
```

With the introduction of lexical warnings, mandatory warnings now become *default* warnings. The difference is that although the previously mandatory warnings are still enabled by default, they can then be subsequently enabled or disabled with the lexical warning pragma. For example, in the code below, an `"isn't numeric"` warning will only be reported for the `$a` variable.

```
my $a = "2:" + 3;
no warnings ;
my $b = "2:" + 3;
```

Note that neither the **–w** flag or the `$^W` can be used to disable/enable default warnings. They are still mandatory in this case.

What's wrong with –w and $^W

Although very useful, the big problem with using **–w** on the command line to enable warnings is that it is all or nothing. Take the typical scenario when you are writing a Perl program. Parts of the code you will write yourself, but it's very likely that you will make use of pre–written Perl modules. If you use the **–w** flag in this case, you end up enabling warnings in pieces of code that you haven't written.

Similarly, using `$^W` to either disable or enable blocks of code is fundamentally flawed. For a start, say you want to disable warnings in a block of code. You might expect this to be enough to do the trick:

```
{
    local ($^W) = 0 ;
    my $a =+ 2 ;
    my $b ; chop $b ;
}
```

When this code is run with the **–w** flag, a warning will be produced for the `$a` line — `"Reversed += operator"`.

The problem is that Perl has both compile–time and run–time warnings. To disable compile–time warnings you need to rewrite the code like this:

```
{
    BEGIN { $^W = 0 }
    my $a =+ 2 ;
    my $b ; chop $b ;
}
```

The other big problem with `$^W` is the way you can inadvertently change the warning setting in unexpected places in your code. For example, when the code below is run (without the **–w** flag), the second call to `doit` will trip a `"Use of uninitialized value"` warning, whereas the first will not.

```
sub doit
{
    my $b ; chop $b ;
}

doit() ;

{
    local ($^W) = 1 ;
    doit()
}
```

This is a side–effect of `$^W` being dynamically scoped.

Lexical warnings get around these limitations by allowing finer control over where warnings can or can't be tripped.

Controlling Warnings from the Command Line

There are three Command Line flags that can be used to control when warnings are (or aren't) produced:

–w This is the existing flag. If the lexical warnings pragma is **not** used in any of you code, or any of the modules that you use, this flag will enable warnings everywhere. See *Backward Compatibility* for details of how this flag interacts with lexical warnings.

–W If the **–W** flag is used on the command line, it will enable all warnings throughout the program regardless of whether warnings were disabled locally using `no warnings` or `$^W =0`. This includes all files that get included via `use`, `require` or `do`. Think of it as the Perl equivalent of the "lint" command.

–X Does the exact opposite to the **–W** flag, i.e. it disables all warnings.

Backward Compatibility

If you are used with working with a version of Perl prior to the introduction of lexically scoped warnings, or have code that uses both lexical warnings and `$^W`, this section will describe how they interact.

How Lexical Warnings interact with **–w**/`$^W`:

1. If none of the three command line flags (**–w**, **–W** or **–X**) that control warnings is used and neither `$^W` or the `warnings` pragma are used, then default warnings will be enabled and optional warnings disabled. This means that legacy code that doesn't attempt to control the warnings will work unchanged.
2. The **–w** flag just sets the global `$^W` variable as in 5.005 — this means that any legacy code that currently relies on manipulating `$^W` to control warning behavior will still work as is.
3. Apart from now being a boolean, the `$^W` variable operates in exactly the same horrible uncontrolled global way, except that it cannot disable/enable default warnings.
4. If a piece of code is under the control of the `warnings` pragma, both the `$^W` variable and the **–w** flag will be ignored for the scope of the lexical warning.
5. The only way to override a lexical warnings setting is with the **–W** or **–X** command line flags.

The combined effect of 3 `&` 4 is that it will allow code which uses the `warnings` pragma to control the warning behavior of `$^W`–type code (using a `local $^W=0`) if it really wants to, but not vice–versa.

Category Hierarchy

A hierarchy of "categories" have been defined to allow groups of warnings to be enabled/disabled in isolation.

The current hierarchy is:

```
all -+
     |
     +- chmod
     |
     +- closure
     |
     +- exiting
     |
     +- glob
     |
     +- io ------------+
     |                 |
     |                 +- closed
     |                 |
     |                 +- exec
     |                 |
     |                 +- newline
     |                 |
     |                 +- pipe
     |                 |
     |                 +- unopened
     |
     +- misc
     |
     +- numeric
     |
```

```
+- once
|
+- overflow
|
+- pack
|
+- portable
|
+- recursion
|
+- redefine
|
+- regexp
|
+- severe -------+
|                |
|                +- debugging
|                |
|                +- inplace
|                |
|                +- internal
|                |
|                +- malloc
|
+- signal
|
+- substr
|
+- syntax -------+
|                |
|                +- ambiguous
|                |
|                +- bareword
|                |
|                +- deprecated
|                |
|                +- digit
|                |
|                +- parenthesis
|                |
|                +- precedence
|                |
|                +- printf
|                |
|                +- prototype
|                |
|                +- qw
|                |
|                +- reserved
|                |
|                +- semicolon
|
+- taint
|
```

```
    +- umask
    |
    +- uninitialized
    |
    +- unpack
    |
    +- untie
    |
    +- utf8
    |
    +- void
    |
    +- y2k
```

Just like the "strict" pragma any of these categories can be combined

```
use warnings qw(void redefine) ;
no warnings qw(io syntax untie) ;
```

Also like the "strict" pragma, if there is more than one instance of the `warnings` pragma in a given scope the cumulative effect is additive.

```
use warnings qw(void) ; # only "void" warnings enabled
...
use warnings qw(io) ;   # only "void" & "io" warnings enabled
...
no warnings qw(void) ;  # only "io" warnings enabled
```

To determine which category a specific warning has been assigned to see *perldiag*.

Fatal Warnings

The presence of the word "FATAL" in the category list will escalate any warnings detected from the categories specified in the lexical scope into fatal errors. In the code below, the use of `time`, `length` and `join` can all produce a `"Useless use of xxx in void context"` warning.

```
use warnings ;

time ;

{
    use warnings FATAL => qw(void) ;
    length "abc" ;
}

join "", 1,2,3 ;

print "done\n" ;
```

When run it produces this output

```
Useless use of time in void context at fatal line 3.
Useless use of length in void context at fatal line 7.
```

The scope where `length` is used has escalated the `void` warnings category into a fatal error, so the program terminates immediately it encounters the warning.

Reporting Warnings from a Module

The `warnings` pragma provides a number of functions that are useful for module authors. These are used when you want to report a module–specific warning to a calling module has enabled warnings via the `warnings` pragma.

Consider the module `MyMod::Abc` below.

```
package MyMod::Abc;

use warnings::register;

sub open {
    my $path = shift ;
    if (warnings::enabled() && $path !~ m#^/#) {
        warnings::warn("changing relative path to /tmp/");
        $path = "/tmp/$path" ;
    }
}

1 ;
```

The call to `warnings::register` will create a new warnings category called "MyMod::abc", i.e. the new category name matches the current package name. The `open` function in the module will display a warning message if it gets given a relative path as a parameter. This warnings will only be displayed if the code that uses `MyMod::Abc` has actually enabled them with the `warnings` pragma like below.

```
use MyMod::Abc;
use warnings 'MyMod::Abc';
...
abc::open("../fred.txt");
```

It is also possible to test whether the pre–defined warnings categories are set in the calling module with the `warnings::enabled` function. Consider this snippet of code:

```
package MyMod::Abc;

sub open {
    warnings::warnif("deprecated",
                     "open is deprecated, use new instead") ;
    new(@_) ;
}

sub new
...
1 ;
```

The function `open` has been deprecated, so code has been included to display a warning message whenever the calling module has (at least) the "deprecated" warnings category enabled. Something like this, say.

```
use warnings 'deprecated';
use MyMod::Abc;
...
MyMod::Abc::open($filename) ;
```

Either the `warnings::warn` or `warnings::warnif` function should be used to actually display the warnings message. This is because they can make use of the feature that allows warnings to be escalated into fatal errors. So in this case

```
use MyMod::Abc;
use warnings FATAL => 'MyMod::Abc';
...
MyMod::Abc::open('../fred.txt');
```

the `warnings::warnif` function will detect this and die after displaying the warning message.

The three warnings functions, `warnings::warn`, `warnings::warnif` and `warnings::enabled` can optionally take an object reference in place of a category name. In this case the functions will use the class name of the object as the warnings category.

Consider this example:

```
package Original ;

no warnings ;
use warnings::register ;

sub new
{
    my $class = shift ;
    bless [], $class ;
}

sub check
{
    my $self = shift ;
    my $value = shift ;

    if ($value % 2 && warnings::enabled($self))
      { warnings::warn($self, "Odd numbers are unsafe") }
}

sub doit
{
    my $self = shift ;
    my $value = shift ;
    $self->check($value) ;
    # ...
}

1 ;

package Derived ;

use warnings::register ;
use Original ;
our @ISA = qw( Original ) ;
sub new
{
    my $class = shift ;
    bless [], $class ;
}

1 ;
```

The code below makes use of both modules, but it only enables warnings from `Derived`.

```
use Original ;
use Derived ;
use warnings 'Derived';
my $a = new Original ;
$a->doit(1) ;
my $b = new Derived ;
$a->doit(1) ;
```

When this code is run only the `Derived` object, `$b`, will generate a warning.

```
Odd numbers are unsafe at main.pl line 7
```

Notice also that the warning is reported at the line where the object is first used.

TODO

perl5db.pl
  The debugger saves and restores C<$^W> at runtime. I haven't checked whether the debugger will still work with the lexical warnings patch applied.

diagnostics.pm
  I *think* I've got diagnostics to work with the lexical warnings patch, but there were design decisions made in diagnostics to work around the limitations of C<$^W>. Now that those limitations are gone, the module should be revisited.

document calling the warnings::* functions from XS

SEE ALSO

warnings, *perldiag*.

AUTHOR

Paul Marquess

NAME

perllocale – Perl locale handling (internationalization and localization)

DESCRIPTION

Perl supports language–specific notions of data such as "is this a letter", "what is the uppercase equivalent of this letter", and "which of these letters comes first". These are important issues, especially for languages other than English—but also for English: it would be naïve to imagine that `A-Za-z` defines all the "letters" needed to write in English. Perl is also aware that some character other than '.' may be preferred as a decimal point, and that output date representations may be language–specific. The process of making an application take account of its users' preferences in such matters is called **internationalization** (often abbreviated as **i18n**); telling such an application about a particular set of preferences is known as **localization** (**l10n**).

Perl can understand language–specific data via the standardized (ISO C, XPG4, POSIX 1.c) method called "the locale system". The locale system is controlled per application using one pragma, one function call, and several environment variables.

NOTE: This feature is new in Perl 5.004, and does not apply unless an application specifically requests it—see *Backward compatibility*. The one exception is that `write()` now **always** uses the current locale – see *"NOTES"*.

PREPARING TO USE LOCALES

If Perl applications are to understand and present your data correctly according a locale of your choice, **all** of the following must be true:

- **Your operating system must support the locale system**. If it does, you should find that the `setlocale()` function is a documented part of its C library.
- **Definitions for locales that you use must be installed**. You, or your system administrator, must make sure that this is the case. The available locales, the location in which they are kept, and the manner in which they are installed all vary from system to system. Some systems provide only a few, hard–wired locales and do not allow more to be added. Others allow you to add "canned" locales provided by the system supplier. Still others allow you or the system administrator to define and add arbitrary locales. (You may have to ask your supplier to provide canned locales that are not delivered with your operating system.) Read your system documentation for further illumination.
- **Perl must believe that the locale system is supported**. If it does, `perl -V:d_setlocale` will say that the value for `d_setlocale` is `define`.

If you want a Perl application to process and present your data according to a particular locale, the application code should include the `use locale` pragma (see L<The use locale pragma) where appropriate, and **at least one** of the following must be true:

- **The locale–determining environment variables (see *"ENVIRONMENT"*) must be correctly set up** at the time the application is started, either by yourself or by whoever set up your system account.
- **The application must set its own locale** using the method described in *The setlocale function*.

USING LOCALES

The use locale pragma

By default, Perl ignores the current locale. The `use locale` pragma tells Perl to use the current locale for some operations:

- **The comparison operators** (`lt`, `le`, `cmp`, `ge`, and `gt`) and the POSIX string collation functions `strcoll()` and `strxfrm()` use `LC_COLLATE`. `sort()` is also affected if used without an explicit comparison function, because it uses `cmp` by default.

  Note: `eq` and `ne` are unaffected by locale: they always perform a byte–by–byte comparison of their scalar operands. What's more, if `cmp` finds that its operands are equal according to the collation sequence specified by the current locale, it goes on to perform a byte–by–byte comparison, and only

returns (equal) if the operands are bit-for-bit identical. If you really want to know whether two strings—which `eq` and `cmp` may consider different—are equal as far as collation in the locale is concerned, see the discussion in *Category LC_COLLATE: Collation*.

- **Regular expressions and case-modification functions** (`uc()`, `lc()`, `ucfirst()`, and `lcfirst()`) use `LC_CTYPE`
- **The formatting functions** (`printf()`, `sprintf()` and `write()`) use `LC_NUMERIC`
- **The POSIX date formatting function** (`strftime()`) uses `LC_TIME`.

`LC_COLLATE`, `LC_CTYPE`, and so on, are discussed further in *LOCALE CATEGORIES*.

The default behavior is restored with the `no locale` pragma, or upon reaching the end of block enclosing `use locale`.

The string result of any operation that uses locale information is tainted, as it is possible for a locale to be untrustworthy. See *"SECURITY"*.

The setlocale function

You can switch locales as often as you wish at run time with the `POSIX::setlocale()` function:

```
# This functionality not usable prior to Perl 5.004
require 5.004;

# Import locale-handling tool set from POSIX module.
# This example uses: setlocale -- the function call
#                    LC_CTYPE -- explained below
use POSIX qw(locale_h);

# query and save the old locale
$old_locale = setlocale(LC_CTYPE);

setlocale(LC_CTYPE, "fr_CA.ISO8859-1");
# LC_CTYPE now in locale "French, Canada, codeset ISO 8859-1"

setlocale(LC_CTYPE, "");
# LC_CTYPE now reset to default defined by LC_ALL/LC_CTYPE/LANG
# environment variables.  See below for documentation.

# restore the old locale
setlocale(LC_CTYPE, $old_locale);
```

The first argument of `setlocale()` gives the **category**, the second the **locale**. The category tells in what aspect of data processing you want to apply locale-specific rules. Category names are discussed in *LOCALE CATEGORIES* and *"ENVIRONMENT"*. The locale is the name of a collection of customization information corresponding to a particular combination of language, country or territory, and codeset. Read on for hints on the naming of locales: not all systems name locales as in the example.

If no second argument is provided and the category is something else than LC_ALL, the function returns a string naming the current locale for the category. You can use this value as the second argument in a subsequent call to `setlocale()`.

If no second argument is provided and the category is LC_ALL, the result is implementation-dependent. It may be a string of concatenated locales names (separator also implementation-dependent) or a single locale name. Please consult your *setlocale(3)* for details.

If a second argument is given and it corresponds to a valid locale, the locale for the category is set to that value, and the function returns the now-current locale value. You can then use this in yet another call to `setlocale()`. (In some implementations, the return value may sometimes differ from the value you gave as the second argument—think of it as an alias for the value you gave.)

As the example shows, if the second argument is an empty string, the category's locale is returned to the

default specified by the corresponding environment variables. Generally, this results in a return to the default that was in force when Perl started up: changes to the environment made by the application after startup may or may not be noticed, depending on your system's C library.

If the second argument does not correspond to a valid locale, the locale for the category is not changed, and the function returns *undef*.

For further information about the categories, consult *setlocale(3)*.

Finding locales

For locales available in your system, consult also *setlocale(3)* to see whether it leads to the list of available locales (search for the *SEE ALSO* section). If that fails, try the following command lines:

```
locale -a

nlsinfo

ls /usr/lib/nls/loc

ls /usr/lib/locale

ls /usr/lib/nls

ls /usr/share/locale
```

and see whether they list something resembling these

```
en_US.ISO8859-1     de_DE.ISO8859-1     ru_RU.ISO8859-5
en_US.iso88591      de_DE.iso88591      ru_RU.iso88595
en_US               de_DE               ru_RU
en                  de                  ru
english             german              russian
english.iso88591    german.iso88591     russian.iso88595
english.roman8                          russian.koi8r
```

Sadly, even though the calling interface for `setlocale()` has been standardized, names of locales and the directories where the configuration resides have not been. The basic form of the name is *language_territory.codeset*, but the latter parts after *language* are not always present. The *language* and *country* are usually from the standards **ISO 3166** and **ISO 639**, the two-letter abbreviations for the countries and the languages of the world, respectively. The *codeset* part often mentions some **ISO 8859** character set, the Latin codesets. For example, `ISO 8859-1` is the so-called "Western European codeset" that can be used to encode most Western European languages adequately. Again, there are several ways to write even the name of that one standard. Lamentably.

Two special locales are worth particular mention: "C" and "POSIX". Currently these are effectively the same locale: the difference is mainly that the first one is defined by the C standard, the second by the POSIX standard. They define the **default locale** in which every program starts in the absence of locale information in its environment. (The *default* default locale, if you will.) Its language is (American) English and its character codeset ASCII.

NOTE: Not all systems have the "POSIX" locale (not all systems are POSIX-conformant), so use "C" when you need explicitly to specify this default locale.

LOCALE PROBLEMS

You may encounter the following warning message at Perl startup:

```
perl: warning: Setting locale failed.
perl: warning: Please check that your locale settings:
        LC_ALL = "En_US",
        LANG = (unset)
    are supported and installed on your system.
perl: warning: Falling back to the standard locale ("C").
```

This means that your locale settings had LC_ALL set to "En_US" and LANG exists but has no value. Perl tried to believe you but could not. Instead, Perl gave up and fell back to the "C" locale, the default locale that is supposed to work no matter what. This usually means your locale settings were wrong, they mention locales your system has never heard of, or the locale installation in your system has problems (for example, some system files are broken or missing). There are quick and temporary fixes to these problems, as well as more thorough and lasting fixes.

Temporarily fixing locale problems

The two quickest fixes are either to render Perl silent about any locale inconsistencies or to run Perl under the default locale "C".

Perl's moaning about locale problems can be silenced by setting the environment variable PERL_BADLANG to a zero value, for example "0". This method really just sweeps the problem under the carpet: you tell Perl to shut up even when Perl sees that something is wrong. Do not be surprised if later something locale-dependent misbehaves.

Perl can be run under the "C" locale by setting the environment variable LC_ALL to "C". This method is perhaps a bit more civilized than the PERL_BADLANG approach, but setting LC_ALL (or other locale variables) may affect other programs as well, not just Perl. In particular, external programs run from within Perl will see these changes. If you make the new settings permanent (read on), all programs you run see the changes. See *ENVIRONMENT* for the full list of relevant environment variables and *USING LOCALES* for their effects in Perl. Effects in other programs are easily deducible. For example, the variable LC_COLLATE may well affect your **sort** program (or whatever the program that arranges 'records' alphabetically in your system is called).

You can test out changing these variables temporarily, and if the new settings seem to help, put those settings into your shell startup files. Consult your local documentation for the exact details. For in Bourne-like shells (**sh**, **ksh**, **bash**, **zsh**):

```
LC_ALL=en_US.ISO8859-1
export LC_ALL
```

This assumes that we saw the locale "en_US.ISO8859-1" using the commands discussed above. We decided to try that instead of the above faulty locale "En_US"—and in Cshish shells (**csh**, **tcsh**)

```
setenv LC_ALL en_US.ISO8859-1
```

If you do not know what shell you have, consult your local helpdesk or the equivalent.

Permanently fixing locale problems

The slower but superior fixes are when you may be able to yourself fix the misconfiguration of your own environment variables. The mis(sing)configuration of the whole system's locales usually requires the help of your friendly system administrator.

First, see earlier in this document about *Finding locales*. That tells how to find which locales are really supported—and more importantly, installed—on your system. In our example error message, environment variables affecting the locale are listed in the order of decreasing importance (and unset variables do not matter). Therefore, having LC_ALL set to "En_US" must have been the bad choice, as shown by the error message. First try fixing locale settings listed first.

Second, if using the listed commands you see something **exactly** (prefix matches do not count and case usually counts) like "En_US" without the quotes, then you should be okay because you are using a locale name that should be installed and available in your system. In this case, see *Permanently fixing your system's locale configuration*.

Permanently fixing your system's locale configuration

This is when you see something like:

```
perl: warning: Please check that your locale settings:
        LC_ALL = "En_US",
```

```
        LANG = (unset)
    are supported and installed on your system.
```

but then cannot see that "En_US" listed by the above-mentioned commands. You may see things like "en_US.ISO8859-1", but that isn't the same. In this case, try running under a locale that you can list and which somehow matches what you tried. The rules for matching locale names are a bit vague because standardization is weak in this area. See again the *Finding locales* about general rules.

Fixing system locale configuration

Contact a system administrator (preferably your own) and report the exact error message you get, and ask them to read this same documentation you are now reading. They should be able to check whether there is something wrong with the locale configuration of the system. The *Finding locales* section is unfortunately a bit vague about the exact commands and places because these things are not that standardized.

The localeconv function

The `POSIX::localeconv()` function allows you to get particulars of the locale-dependent numeric formatting information specified by the current `LC_NUMERIC` and `LC_MONETARY` locales. (If you just want the name of the current locale for a particular category, use `POSIX::setlocale()` with a single parameter—see *The setlocale function*.)

```
use POSIX qw(locale_h);

# Get a reference to a hash of locale-dependent info
$locale_values = localeconv();

# Output sorted list of the values
for (sort keys %$locale_values) {
    printf "%-20s = %s\n", $_, $locale_values->{$_}
}
```

`localeconv()` takes no arguments, and returns **a reference to** a hash. The keys of this hash are variable names for formatting, such as `decimal_point` and `thousands_sep`. The values are the corresponding, er, values. See *localeconv* for a longer example listing the categories an implementation might be expected to provide; some provide more and others fewer. You don't need an explicit `use locale`, because `localeconv()` always observes the current locale.

Here's a simple-minded example program that rewrites its command-line parameters as integers correctly formatted in the current locale:

```
# See comments in previous example
require 5.004;
use POSIX qw(locale_h);

# Get some of locale's numeric formatting parameters
my ($thousands_sep, $grouping) =
     @{localeconv()}{'thousands_sep', 'grouping'};

# Apply defaults if values are missing
$thousands_sep = ',' unless $thousands_sep;

# grouping and mon_grouping are packed lists
# of small integers (characters) telling the
# grouping (thousand_seps and mon_thousand_seps
# being the group dividers) of numbers and
# monetary quantities.  The integers' meanings:
# 255 means no more grouping, 0 means repeat
# the previous grouping, 1-254 means use that
# as the current grouping.  Grouping goes from
# right to left (low to high digits).  In the
# below we cheat slightly by never using anything
```

```
# else than the first grouping (whatever that is).
if ($grouping) {
    @grouping = unpack("C*", $grouping);
} else {
    @grouping = (3);
}

# Format command line params for current locale
for (@ARGV) {
    $_ = int;    # Chop non-integer part
    1 while
    s/(\d)(\d{$grouping[0]}($|$thousands_sep))/$1$thousands_sep$2/;
    print "$_";
}
print "\n";
```

LOCALE CATEGORIES

The following subsections describe basic locale categories. Beyond these, some combination categories allow manipulation of more than one basic category at a time. See *"ENVIRONMENT"* for a discussion of these.

Category LC_COLLATE: Collation

In the scope of `use locale`, Perl looks to the `LC_COLLATE` environment variable to determine the application's notions on collation (ordering) of characters. For example, 'b' follows 'a' in Latin alphabets, but where do 'á' and 'å' belong? And while 'color' follows 'chocolate' in English, what about in Spanish?

The following collations all make sense and you may meet any of them if you "use locale".

```
A B C D E a b c d e
A a B b C c D d D e
a A b B c C d D e E
a b c d e A B C D E
```

Here is a code snippet to tell what "word" characters are in the current locale, in that locale's order:

```
use locale;
print +(sort grep /\w/, map { chr() } 0..255), "\n";
```

Compare this with the characters that you see and their order if you state explicitly that the locale should be ignored:

```
no locale;
print +(sort grep /\w/, map { chr() } 0..255), "\n";
```

This machine-native collation (which is what you get unless `use locale` has appeared earlier in the same block) must be used for sorting raw binary data, whereas the locale-dependent collation of the first example is useful for natural text.

As noted in *USING LOCALES*, `cmp` compares according to the current collation locale when `use locale` is in effect, but falls back to a byte-by-byte comparison for strings that the locale says are equal. You can use `POSIX::strcoll()` if you don't want this fall-back:

```
use POSIX qw(strcoll);
$equal_in_locale =
    !strcoll("space and case ignored", "SpaceAndCaseIgnored");
```

`$equal_in_locale` will be true if the collation locale specifies a dictionary-like ordering that ignores space characters completely and which folds case.

If you have a single string that you want to check for "equality in locale" against several others, you might think you could gain a little efficiency by using `POSIX::strxfrm()` in conjunction with `eq`:

```
use POSIX qw(strxfrm);
$xfrm_string = strxfrm("Mixed-case string");
print "locale collation ignores spaces\n"
    if $xfrm_string eq strxfrm("Mixed-casestring");
print "locale collation ignores hyphens\n"
    if $xfrm_string eq strxfrm("Mixedcase string");
print "locale collation ignores case\n"
    if $xfrm_string eq strxfrm("mixed-case string");
```

`strxfrm()` takes a string and maps it into a transformed string for use in byte-by-byte comparisons against other transformed strings during collation. "Under the hood", locale-affected Perl comparison operators call `strxfrm()` for both operands, then do a byte-by-byte comparison of the transformed strings. By calling `strxfrm()` explicitly and using a non locale-affected comparison, the example attempts to save a couple of transformations. But in fact, it doesn't save anything: Perl magic (see *Magic Variables*) creates the transformed version of a string the first time it's needed in a comparison, then keeps this version around in case it's needed again. An example rewritten the easy way with `cmp` runs just about as fast. It also copes with null characters embedded in strings; if you call `strxfrm()` directly, it treats the first null it finds as a terminator. don't expect the transformed strings it produces to be portable across systems—or even from one revision of your operating system to the next. In short, don't call `strxfrm()` directly: let Perl do it for you.

Note: `use locale` isn't shown in some of these examples because it isn't needed: `strcoll()` and `strxfrm()` exist only to generate locale-dependent results, and so always obey the current `LC_COLLATE` locale.

Category LC_CTYPE: Character Types

In the scope of `use locale`, Perl obeys the `LC_CTYPE` locale setting. This controls the application's notion of which characters are alphabetic. This affects Perl's `\w` regular expression metanotation, which stands for alphanumeric characters—that is, alphabetic, numeric, and including other special characters such as the underscore or hyphen. (Consult *perlre* for more information about regular expressions.) Thanks to `LC_CTYPE`, depending on your locale setting, characters like 'æ', 'ð', '', and 'ø' may be understood as `\w` characters.

The `LC_CTYPE` locale also provides the map used in transliterating characters between lower and uppercase. This affects the case-mapping functions—`lc()`, lcfirst, `uc()`, and `ucfirst()`; case-mapping interpolation with `\l`, `\L`, `\u`, or `\U` in double-quoted strings and `s///` substitutions; and case-independent regular expression pattern matching using the `i` modifier.

Finally, `LC_CTYPE` affects the POSIX character-class test functions—`isalpha()`, `islower()`, and so on. For example, if you move from the "C" locale to a 7-bit Scandinavian one, you may find—possibly to your surprise—that "|" moves from the `ispunct()` class to `isalpha()`.

Note: A broken or malicious `LC_CTYPE` locale definition may result in clearly ineligible characters being considered to be alphanumeric by your application. For strict matching of (mundane) letters and digits—for example, in command strings—locale-aware applications should use `\w` inside a `no locale` block. See *"SECURITY"*.

Category LC_NUMERIC: Numeric Formatting

In the scope of `use locale`, Perl obeys the `LC_NUMERIC` locale information, which controls an application's idea of how numbers should be formatted for human readability by the `printf()`, `sprintf()`, and `write()` functions. String-to-numeric conversion by the `POSIX::strtod()` function is also affected. In most implementations the only effect is to change the

character used for the decimal point—perhaps from '.' to ','. These functions aren't aware of such niceties as thousands separation and so on. (See *The localeconv function* if you care about these things.)

Output produced by `print()` is **never** affected by the current locale: it is independent of whether `use locale` or `no locale` is in effect, and corresponds to what you'd get from `printf()` in the "C" locale. The same is true for Perl's internal conversions between numeric and string formats:

```
use POSIX qw(strtod);
use locale;

$n = 5/2;   # Assign numeric 2.5 to $n

$a = " $n"; # Locale-independent conversion to string

print "half five is $n\n";       # Locale-independent output

printf "half five is %g\n", $n;  # Locale-dependent output

print "DECIMAL POINT IS COMMA\n"
    if $n == (strtod("2,5"))[0]; # Locale-dependent conversion
```

Category LC_MONETARY: Formatting of monetary amounts

The C standard defines the `LC_MONETARY` category, but no function that is affected by its contents. (Those with experience of standards committees will recognize that the working group decided to punt on the issue.) Consequently, Perl takes no notice of it. If you really want to use `LC_MONETARY`, you can query its contents—see *The localeconv function*—and use the information that it returns in your application's own formatting of currency amounts. However, you may well find that the information, voluminous and complex though it may be, still does not quite meet your requirements: currency formatting is a hard nut to crack.

LC_TIME

Output produced by `POSIX::strftime()`, which builds a formatted human-readable date/time string, is affected by the current `LC_TIME` locale. Thus, in a French locale, the output produced by the `%B` format element (full month name) for the first month of the year would be "janvier". Here's how to get a list of long month names in the current locale:

```
use POSIX qw(strftime);
for (0..11) {
    $long_month_name[$_] =
        strftime("%B", 0, 0, 0, 1, $_, 96);
}
```

Note: `use locale` isn't needed in this example: as a function that exists only to generate locale-dependent results, `strftime()` always obeys the current `LC_TIME` locale.

Other categories

The remaining locale category, `LC_MESSAGES` (possibly supplemented by others in particular implementations) is not currently used by Perl—except possibly to affect the behavior of library functions called by extensions outside the standard Perl distribution and by the operating system and its utilities. Note especially that the string value of `$!` and the error messages given by external utilities may be changed by `LC_MESSAGES`. If you want to have portable error codes, use `%!`. See *Errno*.

SECURITY

Although the main discussion of Perl security issues can be found in *perlsec*, a discussion of Perl's locale handling would be incomplete if it did not draw your attention to locale-dependent security issues. Locales—particularly on systems that allow unprivileged users to build their own locales—are untrustworthy. A malicious (or just plain broken) locale can make a locale-aware application give unexpected results. Here are a few possibilities:

- Regular expression checks for safe file names or mail addresses using \w may be spoofed by an LC_CTYPE locale that claims that characters such as ">" and "|" are alphanumeric.
- String interpolation with case−mapping, as in, say, $dest = "C:\U$name.$ext", may produce dangerous results if a bogus LC_CTYPE case−mapping table is in effect.
- Some systems are broken in that they allow the "C" locale to be overridden by users. If the decimal point character in the LC_NUMERIC category of the "C" locale is surreptitiously changed from a dot to a comma, sprintf("%g", 0.123456e3) produces a string result of "123,456". Many people would interpret this as one hundred and twenty−three thousand, four hundred and fifty−six.
- A sneaky LC_COLLATE locale could result in the names of students with "D" grades appearing ahead of those with "A"s.
- An application that takes the trouble to use information in LC_MONETARY may format debits as if they were credits and vice versa if that locale has been subverted. Or it might make payments in US dollars instead of Hong Kong dollars.
- The date and day names in dates formatted by strftime() could be manipulated to advantage by a malicious user able to subvert the LC_DATE locale. ("Look—it says I wasn't in the building on Sunday.")

Such dangers are not peculiar to the locale system: any aspect of an application's environment which may be modified maliciously presents similar challenges. Similarly, they are not specific to Perl: any programming language that allows you to write programs that take account of their environment exposes you to these issues.

Perl cannot protect you from all possibilities shown in the examples—there is no substitute for your own vigilance—but, when use locale is in effect, Perl uses the tainting mechanism (see *perlsec*) to mark string results that become locale−dependent, and which may be untrustworthy in consequence. Here is a summary of the tainting behavior of operators and functions that may be affected by the locale:

Comparison operators (lt, le, ge, gt and cmp):

Scalar true/false (or less/equal/greater) result is never tainted.

Case−mapping interpolation (with \l, \L, \u or \U)

Result string containing interpolated material is tainted if use locale is in effect.

Matching operator (m//):

Scalar true/false result never tainted.

Subpatterns, either delivered as a list−context result or as $1 etc. are tainted if use locale is in effect, and the subpattern regular expression contains \w (to match an alphanumeric character), \W (non−alphanumeric character), \s (white−space character), or \S (non white−space character). The matched−pattern variable, $&, $` (pre−match), $' (post−match), and $+ (last match) are also tainted if use locale is in effect and the regular expression contains \w, \W, \s, or \S.

Substitution operator (s///):

Has the same behavior as the match operator. Also, the left operand of =~ becomes tainted when use locale in effect if modified as a result of a substitution based on a regular expression match involving \w, \W, \s, or \S; or of case−mapping with \l, \L,\u or \U.

Output formatting functions (printf() and write()):

Success/failure result is never tainted.

Case−mapping functions (lc(), lcfirst(), uc(), ucfirst()):

Results are tainted if use locale is in effect.

POSIX locale–dependent functions (`localeconv()`, `strcoll()`, `strftime()`, `strxfrm()`):

Results are never tainted.

POSIX character class tests (`isalnum()`, `isalpha()`, `isdigit()`, `isgraph()`, `islower()`, `isprint()`, `ispunct()`, `isspace()`, `isupper()`, `isxdigit()`):

True/false results are never tainted.

Three examples illustrate locale–dependent tainting. The first program, which ignores its locale, won't run: a value taken directly from the command line may not be used to name an output file when taint checks are enabled.

```
#/usr/local/bin/perl -T
# Run with taint checking

# Command line sanity check omitted...
$tainted_output_file = shift;

open(F, ">$tainted_output_file")
    or warn "Open of $untainted_output_file failed: $!\n";
```

The program can be made to run by "laundering" the tainted value through a regular expression: the second example—which still ignores locale information—runs, creating the file named on its command line if it can.

```
#/usr/local/bin/perl -T

$tainted_output_file = shift;
$tainted_output_file =~ m%[\w/]+%;
$untainted_output_file = $&;

open(F, ">$untainted_output_file")
    or warn "Open of $untainted_output_file failed: $!\n";
```

Compare this with a similar but locale–aware program:

```
#/usr/local/bin/perl -T

$tainted_output_file = shift;
use locale;
$tainted_output_file =~ m%[\w/]+%;
$localized_output_file = $&;

open(F, ">$localized_output_file")
    or warn "Open of $localized_output_file failed: $!\n";
```

This third program fails to run because `$&` is tainted: it is the result of a match involving `\w` while `use locale` is in effect.

ENVIRONMENT

PERL_BADLANG

A string that can suppress Perl's warning about failed locale settings at startup. Failure can occur if the locale support in the operating system is lacking (broken) in some way—or if you mistyped the name of a locale when you set up your environment. If this environment variable is absent, or has a value that does not evaluate to integer zero—that is, "0" or ""—Perl will complain about locale setting failures.

NOTE: PERL_BADLANG only gives you a way to hide the warning message. The message tells about some problem in your system's locale support, and you should

investigate what the problem is.

The following environment variables are not specific to Perl: They are part of the standardized (ISO C, XPG4, POSIX 1.c) `setlocale()` method for controlling an application's opinion on data.

LC_ALL `LC_ALL` is the "override-all" locale environment variable. If set, it overrides all the rest of the locale environment variables.

LANGUAGE **NOTE**: `LANGUAGE` is a GNU extension, it affects you only if you are using the GNU libc. This is the case if you are using e.g. Linux. If you are using "commercial" UNIXes you are most probably *not* using GNU libc and you can ignore `LANGUAGE`.

However, in the case you are using `LANGUAGE`: it affects the language of informational, warning, and error messages output by commands (in other words, it's like `LC_MESSAGES`) but it has higher priority than *LC_ALL*. Moreover, it's not a single value but instead a "path" (":"-separated list) of *languages* (not locales). See the GNU `gettext` library documentation for more information.

LC_CTYPE In the absence of `LC_ALL`, `LC_CTYPE` chooses the character type locale. In the absence of both `LC_ALL` and `LC_CTYPE`, `LANG` chooses the character type locale.

LC_COLLATE In the absence of `LC_ALL`, `LC_COLLATE` chooses the collation (sorting) locale. In the absence of both `LC_ALL` and `LC_COLLATE`, `LANG` chooses the collation locale.

LC_MONETARY

In the absence of `LC_ALL`, `LC_MONETARY` chooses the monetary formatting locale. In the absence of both `LC_ALL` and `LC_MONETARY`, `LANG` chooses the monetary formatting locale.

LC_NUMERIC In the absence of `LC_ALL`, `LC_NUMERIC` chooses the numeric format locale. In the absence of both `LC_ALL` and `LC_NUMERIC`, `LANG` chooses the numeric format.

LC_TIME In the absence of `LC_ALL`, `LC_TIME` chooses the date and time formatting locale. In the absence of both `LC_ALL` and `LC_TIME`, `LANG` chooses the date and time formatting locale.

LANG `LANG` is the "catch-all" locale environment variable. If it is set, it is used as the last resort after the overall `LC_ALL` and the category-specific `LC_....`

NOTES

Backward compatibility

Versions of Perl prior to 5.004 **mostly** ignored locale information, generally behaving as if something similar to the `"C"` locale were always in force, even if the program environment suggested otherwise (see *The setlocale function*). By default, Perl still behaves this way for backward compatibility. If you want a Perl application to pay attention to locale information, you **must** use the `use locale` pragma (see *The use locale pragma*) to instruct it to do so.

Versions of Perl from 5.002 to 5.003 did use the `LC_CTYPE` information if available; that is, `\w` did understand what were the letters according to the locale environment variables. The problem was that the user had no control over the feature: if the C library supported locales, Perl used them.

I18N:Collate obsolete

In versions of Perl prior to 5.004, per-locale collation was possible using the `I18N::Collate` library module. This module is now mildly obsolete and should be avoided in new applications. The `LC_COLLATE` functionality is now integrated into the Perl core language: One can use locale-specific scalar data completely normally with `use locale`, so there is no longer any need to juggle with the scalar references of `I18N::Collate`.

Sort speed and memory use impacts

Comparing and sorting by locale is usually slower than the default sorting; slow−downs of two to four times have been observed. It will also consume more memory: once a Perl scalar variable has participated in any string comparison or sorting operation obeying the locale collation rules, it will take 3−15 times more memory than before. (The exact multiplier depends on the string's contents, the operating system and the locale.) These downsides are dictated more by the operating system's implementation of the locale system than by Perl.

`write()` and LC_NUMERIC

Formats are the only part of Perl that unconditionally use information from a program's locale; if a program's environment specifies an LC_NUMERIC locale, it is always used to specify the decimal point character in formatted output. Formatted output cannot be controlled by `use locale` because the pragma is tied to the block structure of the program, and, for historical reasons, formats exist outside that block structure.

Freely available locale definitions

There is a large collection of locale definitions at `ftp://dkuug.dk/i18n/WG15-collection`. You should be aware that it is unsupported, and is not claimed to be fit for any purpose. If your system allows installation of arbitrary locales, you may find the definitions useful as they are, or as a basis for the development of your own locales.

I18n and l10n

"Internationalization" is often abbreviated as **i18n** because its first and last letters are separated by eighteen others. (You may guess why the internalin ... internaliti ... i18n tends to get abbreviated.) In the same way, "localization" is often abbreviated to **l10n**.

An imperfect standard

Internationalization, as defined in the C and POSIX standards, can be criticized as incomplete, ungainly, and having too large a granularity. (Locales apply to a whole process, when it would arguably be more useful to have them apply to a single thread, window group, or whatever.) They also have a tendency, like standards groups, to divide the world into nations, when we all know that the world can equally well be divided into bankers, bikers, gamers, and so on. But, for now, it's the only standard we've got. This may be construed as a bug.

BUGS

Broken systems

In certain systems, the operating system's locale support is broken and cannot be fixed or used by Perl. Such deficiencies can and will result in mysterious hangs and/or Perl core dumps when the `use locale` is in effect. When confronted with such a system, please report in excruciating detail to ***<perlbug@perl.org***, and complain to your vendor: bug fixes may exist for these problems in your operating system. Sometimes such bug fixes are called an operating system upgrade.

SEE ALSO

isalnum, *isalpha*, *isdigit*, *isgraph*, *islower*, *isprint*, *ispunct*, *isspace*, *isupper*, *isxdigit*, *localeconv*, *setlocale*, *strcoll*, *strftime*, *strtod*, *strxfrm*.

HISTORY

Jarkko Hietaniemi's original ***perli18n.pod*** heavily hacked by Dominic Dunlop, assisted by the perl5−porters. Prose worked over a bit by Tom Christiansen.

Last update: Thu Jun 11 08:44:13 MDT 1998

NAME

perllol – Manipulating Arrays of Arrays in Perl

DESCRIPTION

Declaration and Access of Arrays of Arrays

The simplest thing to build an array of arrays (sometimes imprecisely called a list of lists). It's reasonably easy to understand, and almost everything that applies here will also be applicable later on with the fancier data structures.

An array of an array is just a regular old array @AoA that you can get at with two subscripts, like `$AoA[3][2]`. Here's a declaration of the array:

```
# assign to our array, an array of array references
@AoA = (
       [ "fred", "barney" ],
       [ "george", "jane", "elroy" ],
       [ "homer", "marge", "bart" ],
);

print $AoA[2][2];
bart
```

Now you should be very careful that the outer bracket type is a round one, that is, a parenthesis. That's because you're assigning to an @array, so you need parentheses. If you wanted there *not* to be an @AoA, but rather just a reference to it, you could do something more like this:

```
# assign a reference to array of array references
$ref_to_AoA = [
    [ "fred", "barney", "pebbles", "bambam", "dino", ],
    [ "homer", "bart", "marge", "maggie", ],
    [ "george", "jane", "elroy", "judy", ],
];

print $ref_to_AoA->[2][2];
```

Notice that the outer bracket type has changed, and so our access syntax has also changed. That's because unlike C, in perl you can't freely interchange arrays and references thereto. `$ref_to_AoA` is a reference to an array, whereas @AoA is an array proper. Likewise, `$AoA[2]` is not an array, but an array ref. So how come you can write these:

```
$AoA[2][2]
$ref_to_AoA->[2][2]
```

instead of having to write these:

```
$AoA[2]->[2]
$ref_to_AoA->[2]->[2]
```

Well, that's because the rule is that on adjacent brackets only (whether square or curly), you are free to omit the pointer dereferencing arrow. But you cannot do so for the very first one if it's a scalar containing a reference, which means that `$ref_to_AoA` always needs it.

Growing Your Own

That's all well and good for declaration of a fixed data structure, but what if you wanted to add new elements on the fly, or build it up entirely from scratch?

First, let's look at reading it in from a file. This is something like adding a row at a time. We'll assume that there's a flat file in which each line is a row and each word an element. If you're trying to develop an @AoA array containing all these, here's the right way to do that:

```
while (<>) {
    @tmp = split;
    push @AoA, [ @tmp ];
}
```

You might also have loaded that from a function:

```
for $i ( 1 .. 10 ) {
    $AoA[$i] = [ somefunc($i) ];
}
```

Or you might have had a temporary variable sitting around with the array in it.

```
for $i ( 1 .. 10 ) {
    @tmp = somefunc($i);
    $AoA[$i] = [ @tmp ];
}
```

It's very important that you make sure to use the `[]` array reference constructor. That's because this will be very wrong:

```
$AoA[$i] = @tmp;
```

You see, assigning a named array like that to a scalar just counts the number of elements in @tmp, which probably isn't what you want.

If you are running under `use strict`, you'll have to add some declarations to make it happy:

```
use strict;
my(@AoA, @tmp);
while (<>) {
    @tmp = split;
    push @AoA, [ @tmp ];
}
```

Of course, you don't need the temporary array to have a name at all:

```
while (<>) {
    push @AoA, [ split ];
}
```

You also don't have to use `push()`. You could just make a direct assignment if you knew where you wanted to put it:

```
my (@AoA, $i, $line);
for $i ( 0 .. 10 ) {
    $line = <>;
    $AoA[$i] = [ split ' ', $line ];
}
```

or even just

```
my (@AoA, $i);
for $i ( 0 .. 10 ) {
    $AoA[$i] = [ split ' ', <> ];
}
```

You should in general be leery of using functions that could potentially return lists in scalar context without explicitly stating such. This would be clearer to the casual reader:

```
my (@AoA, $i);
for $i ( 0 .. 10 ) {
    $AoA[$i] = [ split ' ', scalar(<>) ];
```

```
}
```

If you wanted to have a `$ref_to_AoA` variable as a reference to an array, you'd have to do something like this:

```
while (<>) {
    push @$ref_to_AoA, [ split ];
}
```

Now you can add new rows. What about adding new columns? If you're dealing with just matrices, it's often easiest to use simple assignment:

```
for $x (1 .. 10) {
    for $y (1 .. 10) {
        $AoA[$x][$y] = func($x, $y);
    }
}

for $x ( 3, 7, 9 ) {
    $AoA[$x][20] += func2($x);
}
```

It doesn't matter whether those elements are already there or not: it'll gladly create them for you, setting intervening elements to `undef` as need be.

If you wanted just to append to a row, you'd have to do something a bit funnier looking:

```
# add new columns to an existing row
push @{ $AoA[0] }, "wilma", "betty";
```

Notice that I *couldn't* say just:

```
push $AoA[0], "wilma", "betty";  # WRONG!
```

In fact, that wouldn't even compile. How come? Because the argument to `push()` must be a real array, not just a reference to such.

Access and Printing

Now it's time to print your data structure out. How are you going to do that? Well, if you want only one of the elements, it's trivial:

```
print $AoA[0][0];
```

If you want to print the whole thing, though, you can't say

```
print @AoA;          # WRONG
```

because you'll get just references listed, and perl will never automatically dereference things for you. Instead, you have to roll yourself a loop or two. This prints the whole structure, using the shell–style `for()` construct to loop across the outer set of subscripts.

```
for $aref ( @AoA ) {
    print "\t [ @$aref ],\n";
}
```

If you wanted to keep track of subscripts, you might do this:

```
for $i ( 0 .. $#AoA ) {
    print "\t elt $i is [ @{$AoA[$i]} ],\n";
}
```

or maybe even this. Notice the inner loop.

```
for $i ( 0 .. $#AoA ) {
    for $j ( 0 .. $#{$AoA[$i]} ) {
```

```
            print "elt $i $j is $AoA[$i][$j]\n";
        }
    }
```

As you can see, it's getting a bit complicated. That's why sometimes is easier to take a temporary on your way through:

```
    for $i ( 0 .. $#AoA ) {
        $aref = $AoA[$i];
        for $j ( 0 .. $#{$aref} ) {
            print "elt $i $j is $AoA[$i][$j]\n";
        }
    }
```

Hmm... that's still a bit ugly. How about this:

```
    for $i ( 0 .. $#AoA ) {
        $aref = $AoA[$i];
        $n = @$aref - 1;
        for $j ( 0 .. $n ) {
            print "elt $i $j is $AoA[$i][$j]\n";
        }
    }
```

Slices

If you want to get at a slice (part of a row) in a multidimensional array, you're going to have to do some fancy subscripting. That's because while we have a nice synonym for single elements via the pointer arrow for dereferencing, no such convenience exists for slices. (Remember, of course, that you can always write a loop to do a slice operation.)

Here's how to do one operation using a loop. We'll assume an @AoA variable as before.

```
    @part = ();
    $x = 4;
    for ($y = 7; $y < 13; $y++) {
        push @part, $AoA[$x][$y];
    }
```

That same loop could be replaced with a slice operation:

```
    @part = @{ $AoA[4] } [ 7..12 ];
```

but as you might well imagine, this is pretty rough on the reader.

Ah, but what if you wanted a *two-dimensional slice*, such as having `$x` run from 4..8 and `$y` run from 7 to 12? Hmm... here's the simple way:

```
    @newAoA = ();
    for ($startx = $x = 4; $x <= 8; $x++) {
        for ($starty = $y = 7; $y <= 12; $y++) {
            $newAoA[$x - $startx][$y - $starty] = $AoA[$x][$y];
        }
    }
```

We can reduce some of the looping through slices

```
    for ($x = 4; $x <= 8; $x++) {
        push @newAoA, [ @{ $AoA[$x] } [ 7..12 ] ];
    }
```

If you were into Schwartzian Transforms, you would probably have selected map for that

```
@newAoA = map { [ @{ $AoA[$_] } [ 7..12 ] ] } 4 .. 8;
```

Although if your manager accused of seeking job security (or rapid insecurity) through inscrutable code, it would be hard to argue. :–) If I were you, I'd put that in a function:

```
@newAoA = splice_2D( \@AoA, 4 => 8, 7 => 12 );
sub splice_2D {
    my $lrr = shift;        # ref to array of array refs!
    my ($x_lo, $x_hi,
        $y_lo, $y_hi) = @_;

    return map {
        [ @{ $lrr->[$_] } [ $y_lo .. $y_hi ] ]
    } $x_lo .. $x_hi;
}
```

SEE ALSO

perldata(1), perlref(1), perldsc(1)

AUTHOR

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NAME

perlmod – Perl modules (packages and symbol tables)

DESCRIPTION

Packages

Perl provides a mechanism for alternative namespaces to protect packages from stomping on each other's variables. In fact, there's really no such thing as a global variable in Perl. The package statement declares the compilation unit as being in the given namespace. The scope of the package declaration is from the declaration itself through the end of the enclosing block, `eval`, or file, whichever comes first (the same scope as the `my()` and `local()` operators). Unqualified dynamic identifiers will be in this namespace, except for those few identifiers that if unqualified, default to the main package instead of the current one as described below. A package statement affects only dynamic variables—including those you've used `local()` on—but *not* lexical variables created with `my()`. Typically it would be the first declaration in a file included by the `do`, `require`, or `use` operators. You can switch into a package in more than one place; it merely influences which symbol table is used by the compiler for the rest of that block. You can refer to variables and filehandles in other packages by prefixing the identifier with the package name and a double colon: `$Package::Variable`. If the package name is null, the `main` package is assumed. That is, `$::sail` is equivalent to `$main::sail`.

The old package delimiter was a single quote, but double colon is now the preferred delimiter, in part because it's more readable to humans, and in part because it's more readable to **emacs** macros. It also makes C++ programmers feel like they know what's going on—as opposed to using the single quote as separator, which was there to make Ada programmers feel like they knew what's going on. Because the old-fashioned syntax is still supported for backwards compatibility, if you try to use a string like `"This is $owner's house"`, you'll be accessing `$owner::s;` that is, the `$s` variable in package `owner`, which is probably not what you meant. Use braces to disambiguate, as in `"This is ${owner}'s house"`.

Packages may themselves contain package separators, as in `$OUTER::INNER::var`. This implies nothing about the order of name lookups, however. There are no relative packages: all symbols are either local to the current package, or must be fully qualified from the outer package name down. For instance, there is nowhere within package `OUTER` that `$INNER::var` refers to `$OUTER::INNER::var`. It would treat package `INNER` as a totally separate global package.

Only identifiers starting with letters (or underscore) are stored in a package's symbol table. All other symbols are kept in package `main`, including all punctuation variables, like `$_`. In addition, when unqualified, the identifiers STDIN, STDOUT, STDERR, ARGV, ARGVOUT, ENV, INC, and SIG are forced to be in package `main`, even when used for other purposes than their built-in one. If you have a package called `m`, `s`, or `y`, then you can't use the qualified form of an identifier because it would be instead interpreted as a pattern match, a substitution, or a transliteration.

Variables beginning with underscore used to be forced into package main, but we decided it was more useful for package writers to be able to use leading underscore to indicate private variables and method names. `$_` is still global though. See also *Technical Note on the Syntax of Variable Names in perlvar*.

`eval`ed strings are compiled in the package in which the `eval()` was compiled. (Assignments to `$SIG{}`, however, assume the signal handler specified is in the `main` package. Qualify the signal handler name if you wish to have a signal handler in a package.) For an example, examine ***perldb.pl*** in the Perl library. It initially switches to the `DB` package so that the debugger doesn't interfere with variables in the program you are trying to debug. At various points, however, it temporarily switches back to the `main` package to evaluate various expressions in the context of the `main` package (or wherever you came from). See *perldebug*.

The special symbol `__PACKAGE__` contains the current package, but cannot (easily) be used to construct variables.

See *perlsub* for other scoping issues related to `my()` and `local()`, and *perlref* regarding closures.

Symbol Tables

The symbol table for a package happens to be stored in the hash of that name with two colons appended. The main symbol table's name is thus `%main::`, or `%::` for short. Likewise the symbol table for the nested package mentioned earlier is named `%OUTER::INNER::`.

The value in each entry of the hash is what you are referring to when you use the `*name` typeglob notation. In fact, the following have the same effect, though the first is more efficient because it does the symbol table lookups at compile time:

```
local *main::foo    = *main::bar;
local $main::{foo}  = $main::{bar};
```

(Be sure to note the **vast** difference between the second line above and `local $main::foo = $main::bar`. The former is accessing the hash `%main::`, which is the symbol table of package `main`. The latter is simply assigning scalar `$bar` in package `main` to scalar `$foo` of the same package.)

You can use this to print out all the variables in a package, for instance. The standard but antiquated ***dumpvar.pl*** library and the CPAN module Devel::Symdump make use of this.

Assignment to a typeglob performs an aliasing operation, i.e.,

```
*dick = *richard;
```

causes variables, subroutines, formats, and file and directory handles accessible via the identifier `richard` also to be accessible via the identifier `dick`. If you want to alias only a particular variable or subroutine, assign a reference instead:

```
*dick = \$richard;
```

Which makes `$richard` and `$dick` the same variable, but leaves @richard and @dick as separate arrays. Tricky, eh?

This mechanism may be used to pass and return cheap references into or from subroutines if you don't want to copy the whole thing. It only works when assigning to dynamic variables, not lexicals.

```
%some_hash = ();                    # can't be my()
*some_hash = fn( \%another_hash );
sub fn {
    local *hashsym = shift;
    # now use %hashsym normally, and you
    # will affect the caller's %another_hash
    my %nhash = (); # do what you want
    return \%nhash;
}
```

On return, the reference will overwrite the hash slot in the symbol table specified by the *some_hash typeglob. This is a somewhat tricky way of passing around references cheaply when you don't want to have to remember to dereference variables explicitly.

Another use of symbol tables is for making "constant" scalars.

```
*PI = \3.14159265358979;
```

Now you cannot alter `$PI`, which is probably a good thing all in all. This isn't the same as a constant subroutine, which is subject to optimization at compile-time. A constant subroutine is one prototyped to take no arguments and to return a constant expression. See *perlsub* for details on these. The `use constant` pragma is a convenient shorthand for these.

You can say `*foo{PACKAGE}` and `*foo{NAME}` to find out what name and package the *foo symbol table entry comes from. This may be useful in a subroutine that gets passed typeglobs as arguments:

```
sub identify_typeglob {
```

```
    my $glob = shift;
    print 'You gave me ', *{$glob}{PACKAGE}, '::', *{$glob}{NAME}, "\n";
}
identify_typeglob *foo;
identify_typeglob *bar::baz;
```

This prints

```
You gave me main::foo
You gave me bar::baz
```

The `*foo{THING}` notation can also be used to obtain references to the individual elements of *foo. See *perlref*.

Subroutine definitions (and declarations, for that matter) need not necessarily be situated in the package whose symbol table they occupy. You can define a subroutine outside its package by explicitly qualifying the name of the subroutine:

```
package main;
sub Some_package::foo { ... }   # &foo defined in Some_package
```

This is just a shorthand for a typeglob assignment at compile time:

```
BEGIN { *Some_package::foo = sub { ... } }
```

and is *not* the same as writing:

```
{
    package Some_package;
    sub foo { ... }
}
```

In the first two versions, the body of the subroutine is lexically in the main package, *not* in Some_package. So something like this:

```
package main;

$Some_package::name = "fred";
$main::name = "barney";

sub Some_package::foo {
    print "in ", __PACKAGE__, ": \$name is '$name'\n";
}

Some_package::foo();
```

prints:

```
in main: $name is 'barney'
```

rather than:

```
in Some_package: $name is 'fred'
```

This also has implications for the use of the SUPER:: qualifier (see *perlobj*).

Package Constructors and Destructors

Four special subroutines act as package constructors and destructors. These are the `BEGIN`, `CHECK`, `INIT`, and `END` routines. The `sub` is optional for these routines.

A `BEGIN` subroutine is executed as soon as possible, that is, the moment it is completely defined, even before the rest of the containing file is parsed. You may have multiple `BEGIN` blocks within a file—they will execute in order of definition. Because a `BEGIN` block executes immediately, it can pull in definitions of subroutines and such from other files in time to be visible to the rest of the file. Once a `BEGIN` has run, it is immediately undefined and any code it used is returned to Perl's memory pool. This means you can't ever

explicitly call a BEGIN.

An END subroutine is executed as late as possible, that is, after perl has finished running the program and just before the interpreter is being exited, even if it is exiting as a result of a die() function. (But not if it's polymorphing into another program via exec, or being blown out of the water by a signal—you have to trap that yourself (if you can).) You may have multiple END blocks within a file—they will execute in reverse order of definition; that is: last in, first out (LIFO). END blocks are not executed when you run perl with the -c switch, or if compilation fails.

Inside an END subroutine, $? contains the value that the program is going to pass to exit(). You can modify $? to change the exit value of the program. Beware of changing $? by accident (e.g. by running something via system).

Similar to BEGIN blocks, INIT blocks are run just before the Perl runtime begins execution, in "first in, first out" (FIFO) order. For example, the code generators documented in *perlcc* make use of INIT blocks to initialize and resolve pointers to XSUBs.

Similar to END blocks, CHECK blocks are run just after the Perl compile phase ends and before the run time begins, in LIFO order. CHECK blocks are again useful in the Perl compiler suite to save the compiled state of the program.

When you use the **-n** and **-p** switches to Perl, BEGIN and END work just as they do in **awk**, as a degenerate case. Both BEGIN and CHECK blocks are run when you use the **-c** switch for a compile-only syntax check, although your main code is not.

Perl Classes

There is no special class syntax in Perl, but a package may act as a class if it provides subroutines to act as methods. Such a package may also derive some of its methods from another class (package) by listing the other package name(s) in its global @ISA array (which must be a package global, not a lexical).

For more on this, see *perltoot* and *perlobj*.

Perl Modules

A module is just a set of related functions in a library file, i.e., a Perl package with the same name as the file. It is specifically designed to be reusable by other modules or programs. It may do this by providing a mechanism for exporting some of its symbols into the symbol table of any package using it. Or it may function as a class definition and make its semantics available implicitly through method calls on the class and its objects, without explicitly exporting anything. Or it can do a little of both.

For example, to start a traditional, non-OO module called Some::Module, create a file called ***Some/Module.pm*** and start with this template:

```
package Some::Module;  # assumes Some/Module.pm

use strict;
use warnings;

BEGIN {
    use Exporter   ();
    our ($VERSION, @ISA, @EXPORT, @EXPORT_OK, %EXPORT_TAGS);

    # set the version for version checking
    $VERSION     = 1.00;
    # if using RCS/CVS, this may be preferred
    $VERSION = do { my @r = (q$Revision: 2.21 $ =~ /\d+/g); sprintf "%d."."%02d"

    @ISA         = qw(Exporter);
    @EXPORT      = qw(&func1 &func2 &func4);
    %EXPORT_TAGS = ( );     # eg: TAG => [ qw!name1 name2! ],

    # your exported package globals go here,
    # as well as any optionally exported functions
```

```
    @EXPORT_OK   = qw($Var1 %Hashit &func3);
}
our @EXPORT_OK;

# exported package globals go here
our $Var1;
our %Hashit;

# non-exported package globals go here
our @more;
our $stuff;

# initialize package globals, first exported ones
$Var1   = '';
%Hashit = ();

# then the others (which are still accessible as $Some::Module::stuff)
$stuff  = '';
@more   = ();

# all file-scoped lexicals must be created before
# the functions below that use them.

# file-private lexicals go here
my $priv_var    = '';
my %secret_hash = ();

# here's a file-private function as a closure,
# callable as &$priv_func;  it cannot be prototyped.
my $priv_func = sub {
    # stuff goes here.
};

# make all your functions, whether exported or not;
# remember to put something interesting in the {} stubs
sub func1      {}    # no prototype
sub func2()    {}    # proto'd void
sub func3($$)  {}    # proto'd to 2 scalars

# this one isn't exported, but could be called!
sub func4(\%)  {}    # proto'd to 1 hash ref

END { }       # module clean-up code here (global destructor)

## YOUR CODE GOES HERE

1;  # don't forget to return a true value from the file
```

Then go on to declare and use your variables in functions without any qualifications. See *Exporter* and the *perlmodlib* for details on mechanics and style issues in module creation.

Perl modules are included into your program by saying

```
use Module;
```

or

```
use Module LIST;
```

This is exactly equivalent to

```
BEGIN { require Module; import Module; }
```

or

```
BEGIN { require Module; import Module LIST; }
```

As a special case

```
use Module ();
```

is exactly equivalent to

```
BEGIN { require Module; }
```

All Perl module files have the extension ***.pm***. The `use` operator assumes this so you don't have to spell out "***Module.pm***" in quotes. This also helps to differentiate new modules from old ***.pl*** and ***.ph*** files. Module names are also capitalized unless they're functioning as pragmas; pragmas are in effect compiler directives, and are sometimes called "pragmatic modules" (or even "pragmata" if you're a classicist).

The two statements:

```
require SomeModule;
require "SomeModule.pm";
```

differ from each other in two ways. In the first case, any double colons in the module name, such as `Some::Module`, are translated into your system's directory separator, usually "/". The second case does not, and would have to be specified literally. The other difference is that seeing the first `require` clues in the compiler that uses of indirect object notation involving "SomeModule", as in `$ob = purge SomeModule`, are method calls, not function calls. (Yes, this really can make a difference.)

Because the `use` statement implies a `BEGIN` block, the importing of semantics happens as soon as the `use` statement is compiled, before the rest of the file is compiled. This is how it is able to function as a pragma mechanism, and also how modules are able to declare subroutines that are then visible as list or unary operators for the rest of the current file. This will not work if you use `require` instead of `use`. With `require` you can get into this problem:

```
require Cwd;                # make Cwd:: accessible
$here = Cwd::getcwd();

use Cwd;                    # import names from Cwd::
$here = getcwd();

require Cwd;                # make Cwd:: accessible
$here = getcwd();           # oops! no main::getcwd()
```

In general, `use Module ()` is recommended over `require Module`, because it determines module availability at compile time, not in the middle of your program's execution. An exception would be if two modules each tried to `use` each other, and each also called a function from that other module. In that case, it's easy to use `requires` instead.

Perl packages may be nested inside other package names, so we can have package names containing `::`. But if we used that package name directly as a filename it would make for unwieldy or impossible filenames on some systems. Therefore, if a module's name is, say, `Text::Soundex`, then its definition is actually found in the library file ***Text/Soundex.pm***.

Perl modules always have a ***.pm*** file, but there may also be dynamically linked executables (often ending in ***.so***) or autoloaded subroutine definitions (often ending in ***.al***) associated with the module. If so, these will be entirely transparent to the user of the module. It is the responsibility of the ***.pm*** file to load (or arrange to autoload) any additional functionality. For example, although the POSIX module happens to do both dynamic loading and autoloading, the user can say just `use POSIX` to get it all.

SEE ALSO

See *perlmodlib* for general style issues related to building Perl modules and classes, as well as descriptions of the standard library and CPAN, *Exporter* for how Perl's standard import/export mechanism works, *perltoot* and *perltootc* for an in-depth tutorial on creating classes, *perlobj* for a hard-core reference document on objects, *perlsub* for an explanation of functions and scoping, and *perlxstut* and *perlguts* for

more information on writing extension modules.

NAME

perlmodinstall – Installing CPAN Modules

DESCRIPTION

You can think of a module as the fundamental unit of reusable Perl code; See *perlmod* for details. Whenever anyone creates a chunk of Perl code that they think will be useful to the world, they register as a Perl developer at http://www.perl.com/CPAN/modules/04pause.html so that they can then upload their code to CPAN. CPAN is the Comprehensive Perl Archive Network and can be accessed at http://www.perl.com/CPAN/, or searched via http://cpan.perl.com/ and http://theory.uwinnipeg.ca/mod_perl/cpan−search.pl .

This documentation is for people who want to download CPAN modules and install them on their own computer.

PREAMBLE

You have a file ending in ***.tar.gz*** (or, less often, ***.zip***). You know there's a tasty module inside. You must now take four steps:

DECOMPRESS the file
UNPACK the file into a directory
BUILD the module (sometimes unnecessary)
INSTALL the module.

Here's how to perform each step for each operating system. This is *not* a substitute for reading the README and INSTALL files that might have come with your module!

Also note that these instructions are tailored for installing the module into your system's repository of Perl modules. But you can install modules into any directory you wish. For instance, where I say `perl Makefile.PL`, you can substitute `perl Makefile.PL PREFIX=/my/perl_directory` to install the modules into `/my/perl_directory`. Then you can use the modules from your Perl programs with `use lib "/my/perl_directory/lib/site_perl"` or sometimes just `use "/my/perl_directory"`.

- **If you're on Unix,**

  You can use Andreas Koenig's CPAN module (which comes standard with Perl, or can itself be downloaded from http://www.perl.com/CPAN/modules/by−module/CPAN) to automate the following steps, from DECOMPRESS through INSTALL.

  A. DECOMPRESS

  Decompress the file with `gzip -d yourmodule.tar.gz`

  You can get gzip from ftp://prep.ai.mit.edu/pub/gnu.

  Or, you can combine this step with the next to save disk space:

  ```
  gzip -dc yourmodule.tar.gz | tar -xof -
  ```

  B. UNPACK

  Unpack the result with `tar -xof yourmodule.tar`

  C. BUILD

  Go into the newly−created directory and type:

  ```
  perl Makefile.PL
  make
  make test
  ```

  D. INSTALL

While still in that directory, type:

```
make install
```

Make sure you have appropriate permissions to install the module in your Perl 5 library directory. Often, you'll need to be root.

Perl maintains a record of all module installations. To look at this list, simply type:

```
perldoc perllocal
```

That's all you need to do on Unix systems with dynamic linking. Most Unix systems have dynamic linking—if yours doesn't, or if for another reason you have a statically−linked perl, *and* the module requires compilation, you'll need to build a new Perl binary that includes the module. Again, you'll probably need to be root.

- **If you're running Windows 95 or NT with the ActiveState port of Perl**

  A. DECOMPRESS

  You can use the shareware **Winzip** program (http://www.winzip.com) to decompress and unpack modules.

  B. UNPACK

  If you used WinZip, this was already done for you.

  C. BUILD

  Does the module require compilation (i.e. does it have files that end in .xs, .c, .h, .y, .cc, .cxx, or .C)? If it does, you're on your own. You can try compiling it yourself if you have a C compiler. If you're successful, consider uploading the resulting binary to CPAN for others to use. If it doesn't, go to INSTALL.

  D. INSTALL

  Copy the module into your Perl's *lib* directory. That'll be one of the directories you see when you type

  ```
  perl -e 'print "@INC"'
  ```

- **If you're running Windows 95 or NT with the core Windows distribution of Perl,**

  A. DECOMPRESS

  When you download the module, make sure it ends in either ***.tar.gz*** or ***.zip***. Windows browsers sometimes download `.tar.gz` files as `_tar.tar`, because early versions of Windows prohibited more than one dot in a filename.

  You can use the shareware **WinZip** program (http://www.winzip.com) to decompress and unpack modules.

  Or, you can use InfoZip's `unzip` utility (http://www.cdrom.com/pub/infozip/) to uncompress `.zip` files; type `unzip yourmodule.zip` in your shell.

  Or, if you have a working `tar` and `gzip`, you can type

  ```
  gzip -cd yourmodule.tar.gz | tar xvf -
  ```

  in the shell to decompress `yourmodule.tar.gz`. This will UNPACK your module as well.

  B. UNPACK

  The methods in DECOMPRESS will have done this for you.

  C. BUILD

Go into the newly−created directory and type:

```
perl Makefile.PL
dmake
dmake test
```

Depending on your perl configuration, `dmake` might not be available. You might have to substitute whatever `perl -V:make` says. (Usually, that will be `nmake` or `make`.)

```
D. INSTALL
```

While still in that directory, type:

```
dmake install
```

- **If you're using a Macintosh,**

  A. DECOMPRESS

  First thing you should do is make sure you have the latest **cpan−mac** distribution (http://www.cpan.org/authors/id/CNANDOR/), which has utilities for doing all of the steps. Read the cpan−mac directions carefully and install it. If you choose not to use cpan−mac for some reason, there are alternatives listed here.

  After installing cpan−mac, drop the module archive on the **untarzipme** droplet, which will decompress and unpack for you.

  Or, you can either use the shareware **StuffIt Expander** program (http://www.aladdinsys.com/expander/) in combination with **DropStuff with Expander Enhancer** (http://www.aladdinsys.com/dropstuff/) or the freeware **MacGzip** program (http://persephone.cps.unizar.es/general/gente/spd/gzip/gzip.html).

  B. UNPACK

  If you're using untarzipme or StuffIt, the archive should be extracted now. **Or**, you can use the freeware **suntar** or *Tar* (http://hyperarchive.lcs.mit.edu/HyperArchive/Archive/cmp/).

  C. BUILD

  Check the contents of the distribution. Read the module's documentation, looking for reasons why you might have trouble using it with MacPerl. Look for ***.xs*** and ***.c*** files, which normally denote that the distribution must be compiled, and you cannot install it "out of the box." (See *"PORTABILITY"*.)

  If a module does not work on MacPerl but should, or needs to be compiled, see if the module exists already as a port on the MacPerl Module Porters site (http://pudge.net/mmp/). For more information on doing XS with MacPerl yourself, see Arved Sandstrom's XS tutorial (http://macperl.com/depts/Tutorials/), and then consider uploading your binary to the CPAN and registering it on the MMP site.

  D. INSTALL

  If you are using cpan−mac, just drop the folder on the **installme** droplet, and use the module.

  Or, if you aren't using cpan−mac, do some manual labor.

  Make sure the newlines for the modules are in Mac format, not Unix format. If they are not then you might have decompressed them incorrectly. Check your decompression and unpacking utilities settings to make sure they are translating text files properly.

  As a last resort, you can use the perl one−liner:

  ```
  perl -i.bak -pe 's/(?:\015)?\012/\015/g' <filenames>
  ```

  on the source files.

Then move the files (probably just the ***.pm*** files, though there may be some additional ones, too; check the module documentation) to their final destination: This will most likely be in `$ENV{MACPERL}site_lib:` (i.e., `HD:MacPerl folder:site_lib:`). You can add new paths to the default `@INC` in the Preferences menu item in the MacPerl application (`$ENV{MACPERL}site_lib:` is added automagically). Create whatever directory structures are required (i.e., for `Some::Module`, create `$ENV{MACPERL}site_lib:Some:` and put `Module.pm` in that directory).

Then run the following script (or something like it):

```
#!perl -w
use AutoSplit;
my $dir = "${MACPERL}site_perl";
autosplit("$dir:Some:Module.pm", "$dir:auto", 0, 1, 1);
```

- **If you're on the DJGPP port of DOS,**

  `A. DECOMPRESS`

  djtarx (ftp://ftp.simtel.net/pub/simtelnet/gnu/djgpp/v2/) will both uncompress and unpack.

  `B. UNPACK`

  See above.

  `C. BUILD`

  Go into the newly−created directory and type:

  ```
  perl Makefile.PL
  make
  make test
  ```

  You will need the packages mentioned in ***README.dos*** in the Perl distribution.

  `D. INSTALL`

  While still in that directory, type:

  ```
  make install
  ```

  You will need the packages mentioned in ***README.dos*** in the Perl distribution.

- **If you're on OS/2,**

  Get the EMX development suite and gzip/tar, from either Hobbes (http://hobbes.nmsu.edu) or Leo (http://www.leo.org), and then follow the instructions for Unix.

- **If you're on VMS,**

  When downloading from CPAN, save your file with a ***.tgz*** extension instead of ***.tar.gz***. All other periods in the filename should be replaced with underscores. For example, `Your-Module-1.33.tar.gz` should be downloaded as `Your-Module-1_33.tgz`.

  A. DECOMPRESS

  Type

  ```
  gzip -d Your-Module.tgz
  ```

  or, for zipped modules, type

  ```
  unzip Your-Module.zip
  ```

  Executables for gzip, zip, and VMStar (Alphas: http://www.openvms.digital.com/freeware/000TOOLS/ALPHA/ and Vaxen: http://www.openvms.digital.com/freeware/000TOOLS/VAX/).

gzip and tar are also available at ftp://ftp.digital.com/pub/VMS.

Note that GNU's gzip/gunzip is not the same as Info-ZIP's zip/unzip package. The former is a simple compression tool; the latter permits creation of multi-file archives.

B. UNPACK

If you're using VMStar:

```
VMStar xf Your-Module.tar
```

Or, if you're fond of VMS command syntax:

```
tar/extract/verbose Your_Module.tar
```

C. BUILD

Make sure you have MMS (from Digital) or the freeware MMK (available from MadGoat at http://www.madgoat.com). Then type this to create the DESCRIP.MMS for the module:

```
perl Makefile.PL
```

Now you're ready to build:

```
mms
mms test
```

Substitute `mmk` for `mms` above if you're using MMK.

D. INSTALL

Type

```
mms install
```

Substitute `mmk` for `mms` above if you're using MMK.

- **If you're on MVS**,

  Introduce the ***.tar.gz*** file into an HFS as binary; don't translate from ASCII to EBCDIC.

  A. DECOMPRESS

  ```
  Decompress the file with C<gzip -d yourmodule.tar.gz>

  You can get gzip from
  http://www.s390.ibm.com/products/oe/bpxqp1.html.
  ```

  B. UNPACK

  Unpack the result with

  ```
  pax -o to=IBM-1047,from=ISO8859-1 -r < yourmodule.tar
  ```

  The BUILD and INSTALL steps are identical to those for Unix. Some modules generate Makefiles that work better with GNU make, which is available from http://www.mks.com/s390/gnu/index.htm.

PORTABILITY

Note that not all modules will work with on all platforms. See *perlport* for more information on portability issues. Read the documentation to see if the module will work on your system. There are basically three categories of modules that will not work "out of the box" with all platforms (with some possibility of overlap):

- **Those that should, but don't.** These need to be fixed; consider contacting the author and possibly writing a patch.

- **Those that need to be compiled, where the target platform doesn't have compilers readily available.** (These modules contain ***.xs*** or ***.c*** files, usually.) You might be able to find existing binaries on the CPAN or elsewhere, or you might want to try getting compilers and building it yourself, and then release the binary for other poor souls to use.
- **Those that are targeted at a specific platform.** (Such as the Win32:: modules.) If the module is targeted specifically at a platform other than yours, you're out of luck, most likely.

Check the CPAN Testers if a module should work with your platform but it doesn't behave as you'd expect, or you aren't sure whether or not a module will work under your platform. If the module you want isn't listed there, you can test it yourself and let CPAN Testers know, you can join CPAN Testers, or you can request it be tested.

```
http://testers.cpan.org/
```

HEY

If you have any suggested changes for this page, let me know. Please don't send me mail asking for help on how to install your modules. There are too many modules, and too few Orwants, for me to be able to answer or even acknowledge all your questions. Contact the module author instead, or post to comp.lang.perl.modules, or ask someone familiar with Perl on your operating system.

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NAME

perlmodlib – constructing new Perl modules and finding existing ones

DESCRIPTION

THE PERL MODULE LIBRARY

Many modules are included the Perl distribution. These are described below, and all end in ***.pm***. You may discover compiled library file (usually ending in ***.so***) or small pieces of modules to be autoloaded (ending in ***.al***); these were automatically generated by the installation process. You may also discover files in the library directory that end in either ***.pl*** or ***.ph***. These are old libraries supplied so that old programs that use them still run. The ***.pl*** files will all eventually be converted into standard modules, and the ***.ph*** files made by **h2ph** will probably end up as extension modules made by **h2xs**. (Some ***.ph*** values may already be available through the POSIX, Errno, or Fcntl modules.) The **pl2pm** file in the distribution may help in your conversion, but it's just a mechanical process and therefore far from bulletproof.

Pragmatic Modules

They work somewhat like compiler directives (pragmata) in that they tend to affect the compilation of your program, and thus will usually work well only when used within a `use`, or `no`. Most of these are lexically scoped, so an inner BLOCK may countermand them by saying:

```
no integer;
no strict 'refs';
no warnings;
```

which lasts until the end of that BLOCK.

Some pragmas are lexically scoped—typically those that affect the `$^H` hints variable. Others affect the current package instead, like `use vars` and `use subs`, which allow you to predeclare a variables or subroutines within a particular *file* rather than just a block. Such declarations are effective for the entire file for which they were declared. You cannot rescind them with `no vars` or `no subs`.

The following pragmas are defined (and have their own documentation).

attributes	Get/set subroutine or variable attributes
attrs	Set/get attributes of a subroutine (deprecated)
autouse	Postpone load of modules until a function is used
base	Establish IS–A relationship with base class at compile time
blib	Use MakeMaker's uninstalled version of a package
bytes	Force byte semantics rather than character semantics
charnames	Define character names for `\N{named}` string literal escape.
constant	Declare constants
diagnostics	Perl compiler pragma to force verbose warning diagnostics
fields	Compile–time class fields
filetest	Control the filetest permission operators
integer	Compute arithmetic in integer instead of double
less	Request less of something from the compiler
locale	Use and avoid POSIX locales for built–in operations
open	Set default disciplines for input and output

ops	Restrict unsafe operations when compiling
overload	Package for overloading perl operations
re	Alter regular expression behaviour
sigtrap	Enable simple signal handling
strict	Restrict unsafe constructs
subs	Predeclare sub names
utf8	Enable/disable UTF−8 in source code
vars	Predeclare global variable names (obsolete)
warnings	Control optional warnings
warnings::register	Warnings import function

Standard Modules

Standard, bundled modules are all expected to behave in a well−defined manner with respect to namespace pollution because they use the Exporter module. See their own documentation for details.

AnyDBM_File	Provide framework for multiple DBMs
AutoLoader	Load subroutines only on demand
AutoSplit	Split a package for autoloading
B	The Perl Compiler
B::Asmdata	Autogenerated data about Perl ops, used to generate bytecode
B::Assembler	Assemble Perl bytecode
B::Bblock	Walk basic blocks
B::Bytecode	Perl compiler‘s bytecode backend
B::C	Perl compiler‘s C backend
B::CC	Perl compiler‘s optimized C translation backend
B::Debug	Walk Perl syntax tree, printing debug info about ops
B::Deparse	Perl compiler backend to produce perl code
B::Disassembler	Disassemble Perl bytecode
B::Lint	Perl lint
B::Showlex	Show lexical variables used in functions or files
B::Stackobj	Helper module for CC backend
B::Stash	Show what stashes are loaded
B::Terse	Walk Perl syntax tree, printing terse info about ops
B::Xref	Generates cross reference reports for Perl programs
Benchmark	Benchmark running times of Perl code
ByteLoader	Load byte compiled perl code

CGI	Simple Common Gateway Interface Class
CGI::Apache	Backward compatibility module for CGI.pm
CGI::Carp	CGI routines for writing to the HTTPD (or other) error log
CGI::Cookie	Interface to Netscape Cookies
CGI::Fast	CGI Interface for Fast CGI
CGI::Pretty	Module to produce nicely formatted HTML code
CGI::Push	Simple Interface to Server Push
CGI::Switch	Backward compatibility module for defunct CGI::Switch
CPAN	Query, download and build perl modules from CPAN sites
CPAN::FirstTime	Utility for CPAN::Config file Initialization
CPAN::Nox	Wrapper around CPAN.pm without using any XS module
Carp	Warn of errors (from perspective of caller)
Carp::Heavy	Carp guts
Class::Struct	Declare struct−like datatypes as Perl classes
Cwd	Get pathname of current working directory
DB	Programmatic interface to the Perl debugging API (draft, subject to
DB_File	Perl5 access to Berkeley DB version 1.x
Devel::SelfStubber	Generate stubs for a SelfLoading module
DirHandle	Supply object methods for directory handles
Dumpvalue	Provides screen dump of Perl data.
Encode	Character encodings
English	Use nice English (or awk) names for ugly punctuation variables
Env	Perl module that imports environment variables as scalars or arrays
Exporter	Implements default import method for modules
Exporter::Heavy	Exporter guts
ExtUtils::Command	Utilities to replace common UNIX commands in Makefiles etc.
ExtUtils::Embed	Utilities for embedding Perl in C/C++ applications
ExtUtils::Install	Install files from here to there
ExtUtils::Installed	Inventory management of installed modules
ExtUtils::Liblist	Determine libraries to use and how to use them

ExtUtils::MM_Cygwin
: Methods to override UN*X behaviour in ExtUtils::MakeMaker

ExtUtils::MM_OS2
: Methods to override UN*X behaviour in ExtUtils::MakeMaker

ExtUtils::MM_Unix
: Methods used by ExtUtils::MakeMaker

ExtUtils::MM_VMS
: Methods to override UN*X behaviour in ExtUtils::MakeMaker

ExtUtils::MM_Win32
: Methods to override UN*X behaviour in ExtUtils::MakeMaker

ExtUtils::MakeMaker
: Create an extension Makefile

ExtUtils::Manifest
: Utilities to write and check a MANIFEST file

ExtUtils::Mkbootstrap
: Make a bootstrap file for use by DynaLoader

ExtUtils::Mksymlists
: Write linker options files for dynamic extension

ExtUtils::Packlist
: Manage .packlist files

ExtUtils::testlib Add blib/* directories to @INC

Fatal Replace functions with equivalents which succeed or die

Fcntl Load the C Fcntl.h defines

File::Basename
: Split a pathname into pieces

File::CheckTree
: Run many filetest checks on a tree

File::Compare Compare files or filehandles

File::Copy Copy files or filehandles

File::DosGlob DOS like globbing and then some

File::Find Traverse a file tree

File::Path Create or remove directory trees

File::Spec Portably perform operations on file names

File::Spec::Functions
: Portably perform operations on file names

File::Spec::Mac
: File::Spec for MacOS

File::Spec::OS2
: Methods for OS/2 file specs

File::Spec::Unix	Methods used by File::Spec
File::Spec::VMS	Methods for VMS file specs
File::Spec::Win32	Methods for Win32 file specs
File::Temp	Return name and handle of a temporary file safely
File::stat	By−name interface to Perl's built−in `stat()` functions
FileCache	Keep more files open than the system permits
FileHandle	Supply object methods for filehandles
FindBin	Locate directory of original perl script
Getopt::Long	Extended processing of command line options
Getopt::Std	Process single−character switches with switch clustering
I18N::Collate	Compare 8−bit scalar data according to the current locale
IO	Load various IO modules
IPC::Open2	Open a process for both reading and writing
IPC::Open3	Open a process for reading, writing, and error handling
Math::BigFloat	Arbitrary length float math package
Math::BigInt	Arbitrary size integer math package
Math::Complex	Complex numbers and associated mathematical functions
Math::Trig	Trigonometric functions
NDBM_File	Tied access to ndbm files
Net::Ping	Check a remote host for reachability
Net::hostent	By−name interface to Perl's built−in `gethost*()` functions
Net::netent	By−name interface to Perl's built−in `getnet*()` functions
Net::protoent	By−name interface to Perl's built−in `getproto*()` functions
Net::servent	By−name interface to Perl's built−in `getserv*()` functions
O	Generic interface to Perl Compiler backends
ODBM_File	Tied access to odbm files
Opcode	Disable named opcodes when compiling perl code
Pod::Checker	Check pod documents for syntax errors
Pod::Find	Find POD documents in directory trees
Pod::Html	Module to convert pod files to HTML
Pod::InputObjects	Objects representing POD input paragraphs, commands, etc.

Pod::LaTeX	Convert Pod data to formatted Latex
Pod::Man	Convert POD data to formatted *roff input
Pod::ParseUtils	Helpers for POD parsing and conversion
Pod::Parser	Base class for creating POD filters and translators
Pod::Plainer	Perl extension for converting Pod to old style Pod.
Pod::Select	Extract selected sections of POD from input
Pod::Text	Convert POD data to formatted ASCII text
Pod::Text::Color	Convert POD data to formatted color ASCII text
Pod::Text::Termcap	Convert POD data to ASCII text with format escapes
Pod::Usage	Print a usage message from embedded pod documentation
SDBM_File	Tied access to sdbm files
Safe	Compile and execute code in restricted compartments
Search::Dict	Search for key in dictionary file
SelectSaver	Save and restore selected file handle
SelfLoader	Load functions only on demand
Shell	Run shell commands transparently within perl
Socket	Load the C socket.h defines and structure manipulators
Storable	Persistency for perl data structures
Symbol	Manipulate Perl symbols and their names
Term::ANSIColor	Color screen output using ANSI escape sequences
Term::Cap	Perl termcap interface
Term::Complete	Perl word completion module
Term::ReadLine	Perl interface to various `readline` packages. If
Test	Provides a simple framework for writing test scripts
Test::Harness	Run perl standard test scripts with statistics
Text::Abbrev	Create an abbreviation table from a list
Text::ParseWords	Parse text into an array of tokens or array of arrays
Text::Soundex	Implementation of the Soundex Algorithm as Described by Knuth
Text::Wrap	Line wrapping to form simple paragraphs

Tie::Array	Base class for tied arrays
Tie::Handle	Base class definitions for tied handles
Tie::Hash	Base class definitions for tied hashes
Tie::RefHash	Use references as hash keys
Tie::Scalar	Base class definitions for tied scalars
Tie::SubstrHash	Fixed−table−size, fixed−key−length hashing
Time::Local	Efficiently compute time from local and GMT time
Time::gmtime	By−name interface to Perl's built−in `gmtime()` function
Time::localtime	By−name interface to Perl's built−in `localtime()` function
Time::tm	Internal object used by Time::gmtime and Time::localtime
UNIVERSAL	Base class for ALL classes (blessed references)
User::grent	By−name interface to Perl's built−in `getgr*()` functions
User::pwent	By−name interface to Perl's built−in `getpw*()` functions

To find out *all* modules installed on your system, including those without documentation or outside the standard release, just do this:

```
% find `perl -e 'print "@INC"'` -name '*.pm' -print
```

They should all have their own documentation installed and accessible via your system man(1) command. If you do not have a **find** program, you can use the Perl **find2perl** program instead, which generates Perl code as output you can run through perl. If you have a **man** program but it doesn't find your modules, you'll have to fix your manpath. See *perl* for details. If you have no system **man** command, you might try the **perldoc** program.

Extension Modules

Extension modules are written in C (or a mix of Perl and C). They are usually dynamically loaded into Perl if and when you need them, but may also be be linked in statically. Supported extension modules include Socket, Fcntl, and POSIX.

Many popular C extension modules do not come bundled (at least, not completely) due to their sizes, volatility, or simply lack of time for adequate testing and configuration across the multitude of platforms on which Perl was beta−tested. You are encouraged to look for them on CPAN (described below), or using web search engines like Alta Vista or Deja News.

CPAN

CPAN stands for Comprehensive Perl Archive Network; it's a globally replicated trove of Perl materials, including documentation, style guides, tricks and traps, alternate ports to non−Unix systems and occasional binary distributions for these. Search engines for CPAN can be found at http://cpan.perl.com/ and at http://theory.uwinnipeg.ca/mod_perl/cpan−search.pl .

Most importantly, CPAN includes around a thousand unbundled modules, some of which require a C compiler to build. Major categories of modules are:

- Language Extensions and Documentation Tools
- Development Support

- Operating System Interfaces
- Networking, Device Control (modems) and InterProcess Communication
- Data Types and Data Type Utilities
- Database Interfaces
- User Interfaces
- Interfaces to / Emulations of Other Programming Languages
- File Names, File Systems and File Locking (see also File Handles)
- String Processing, Language Text Processing, Parsing, and Searching
- Option, Argument, Parameter, and Configuration File Processing
- Internationalization and Locale
- Authentication, Security, and Encryption
- World Wide Web, HTML, HTTP, CGI, MIME
- Server and Daemon Utilities
- Archiving and Compression
- Images, Pixmap and Bitmap Manipulation, Drawing, and Graphing
- Mail and Usenet News
- Control Flow Utilities (callbacks and exceptions etc)
- File Handle and Input/Output Stream Utilities
- Miscellaneous Modules

Registered CPAN sites as of this writing include the following. You should try to choose one close to you:

Africa

```
        South Africa    ftp://ftp.is.co.za/programming/perl/CPAN/
                        ftp://ftp.saix.net/pub/CPAN/
                        ftp://ftp.sun.ac.za/CPAN/
                        ftp://ftpza.co.za/pub/mirrors/cpan/
```

Asia

```
        China           ftp://freesoft.cei.gov.cn/pub/languages/perl/CPAN/
        Hong Kong       ftp://ftp.pacific.net.hk/pub/mirror/CPAN/
        Indonesia       ftp://malone.piksi.itb.ac.id/pub/CPAN/
        Israel          ftp://bioinfo.weizmann.ac.il/pub/software/perl/CPAN/
        Japan           ftp://ftp.dti.ad.jp/pub/lang/CPAN/
                        ftp://ftp.jaist.ac.jp/pub/lang/perl/CPAN/
                        ftp://ftp.lab.kdd.co.jp/lang/perl/CPAN/
                        ftp://ftp.meisei-u.ac.jp/pub/CPAN/
                        ftp://ftp.ring.gr.jp/pub/lang/perl/CPAN/
                        ftp://mirror.nucba.ac.jp/mirror/Perl/
        Saudi-Arabia    ftp://ftp.isu.net.sa/pub/CPAN/
        Singapore       ftp://ftp.nus.edu.sg/pub/unix/perl/CPAN/
        South Korea     ftp://ftp.bora.net/pub/CPAN/
                        ftp://ftp.kornet.net/pub/CPAN/
                        ftp://ftp.nuri.net/pub/CPAN/
        Taiwan          ftp://coda.nctu.edu.tw/computer-languages/perl/CPAN/
                        ftp://ftp.ee.ncku.edu.tw/pub3/perl/CPAN/
```

```
                    ftp://ftp1.sinica.edu.tw/pub1/perl/CPAN/
        Thailand    ftp://ftp.nectec.or.th/pub/mirrors/CPAN/
```

Australasia

```
        Australia   ftp://cpan.topend.com.au/pub/CPAN/
                    ftp://ftp.labyrinth.net.au/pub/perl-CPAN/
                    ftp://ftp.sage-au.org.au/pub/compilers/perl/CPAN/
                    ftp://mirror.aarnet.edu.au/pub/perl/CPAN/
        New Zealand ftp://ftp.auckland.ac.nz/pub/perl/CPAN/
                    ftp://sunsite.net.nz/pub/languages/perl/CPAN/
```

Central America

```
        Costa Rica  ftp://ftp.ucr.ac.cr/pub/Unix/CPAN/
```

Europe

```
        Austria     ftp://ftp.tuwien.ac.at/pub/languages/perl/CPAN/
        Belgium     ftp://ftp.kulnet.kuleuven.ac.be/pub/mirror/CPAN/
        Bulgaria    ftp://ftp.ntrl.net/pub/mirrors/CPAN/
        Croatia     ftp://ftp.linux.hr/pub/CPAN/
        Czech Republic ftp://ftp.fi.muni.cz/pub/perl/
                    ftp://sunsite.mff.cuni.cz/Languages/Perl/CPAN/
        Denmark     ftp://sunsite.auc.dk/pub/languages/perl/CPAN/
        Estonia     ftp://ftp.ut.ee/pub/languages/perl/CPAN/
        Finland     ftp://ftp.funet.fi/pub/languages/perl/CPAN/
        France      ftp://ftp.grolier.fr/pub/perl/CPAN/
                    ftp://ftp.lip6.fr/pub/perl/CPAN/
                    ftp://ftp.oleane.net/pub/mirrors/CPAN/
                    ftp://ftp.pasteur.fr/pub/computing/CPAN/
                    ftp://ftp.uvsq.fr/pub/perl/CPAN/
        German      ftp://ftp.gigabell.net/pub/CPAN/
        Germany     ftp://ftp.archive.de.uu.net/pub/CPAN/
                    ftp://ftp.freenet.de/pub/ftp.cpan.org/pub/
                    ftp://ftp.gmd.de/packages/CPAN/
                    ftp://ftp.gwdg.de/pub/languages/perl/CPAN/
```

ftp://ftp.leo.org/pub/comp/general/programming/languages/script/perl/CPAN/
ftp://ftp.mpi−sb.mpg.de/pub/perl/CPAN/
ftp://ftp.rz.ruhr−uni−bochum.de/pub/CPAN/
ftp://ftp.uni−erlangen.de/pub/source/CPAN/
ftp://ftp.uni−hamburg.de/pub/soft/lang/perl/CPAN/
Germany ftp://ftp.archive.de.uu.net/pub/CPAN/
ftp://ftp.freenet.de/pub/ftp.cpan.org/pub/
ftp://ftp.gmd.de/packages/CPAN/
ftp://ftp.gwdg.de/pub/languages/perl/CPAN/

ftp://ftp.leo.org/pub/comp/general/programming/languages/script/perl/CPAN/
ftp://ftp.mpi−sb.mpg.de/pub/perl/CPAN/
ftp://ftp.rz.ruhr−uni−bochum.de/pub/CPAN/
ftp://ftp.uni−erlangen.de/pub/source/CPAN/
ftp://ftp.uni−hamburg.de/pub/soft/lang/perl/CPAN/
Greece ftp://ftp.ntua.gr/pub/lang/perl/
Hungary ftp://ftp.kfki.hu/pub/packages/perl/CPAN/
Iceland ftp://ftp.gm.is/pub/CPAN/
Ireland ftp://cpan.indigo.ie/pub/CPAN/
ftp://sunsite.compapp.dcu.ie/pub/perl/
Italy ftp://cis.uniRoma2.it/CPAN/

ftp://ftp.flashnet.it/pub/CPAN/
ftp://ftp.unina.it/pub/Other/CPAN/
ftp://ftp.unipi.it/pub/mirror/perl/CPAN/
Netherlands ftp://ftp.cs.uu.nl/mirror/CPAN/
ftp://ftp.nluug.nl/pub/languages/perl/CPAN/
Norway ftp://ftp.uit.no/pub/languages/perl/cpan/
ftp://sunsite.uio.no/pub/languages/perl/CPAN/
Poland ftp://ftp.man.torun.pl/pub/CPAN/
ftp://ftp.pk.edu.pl/pub/lang/perl/CPAN/
ftp://sunsite.icm.edu.pl/pub/CPAN/
Portugal ftp://ftp.ci.uminho.pt/pub/mirrors/cpan/
ftp://ftp.ist.utl.pt/pub/CPAN/
ftp://ftp.ua.pt/pub/CPAN/
Romania ftp://ftp.dnttm.ro/pub/CPAN/
Russia ftp://ftp.chg.ru/pub/lang/perl/CPAN/
ftp://ftp.sai.msu.su/pub/lang/perl/CPAN/
Slovakia ftp://ftp.entry.sk/pub/languages/perl/CPAN/
Slovenia ftp://ftp.arnes.si/software/perl/CPAN/
Spain ftp://ftp.etse.urv.es/pub/perl/
ftp://ftp.rediris.es/mirror/CPAN/
Sweden ftp://ftp.sunet.se/pub/lang/perl/CPAN/
Switzerland ftp://sunsite.cnlab−switch.ch/mirror/CPAN/
Turkey ftp://sunsite.bilkent.edu.tr/pub/languages/CPAN/
United Kingdom ftp://ftp.demon.co.uk/pub/mirrors/perl/CPAN/
ftp://ftp.flirble.org/pub/languages/perl/CPAN/

ftp://ftp.mirror.ac.uk/sites/ftp.funet.fi/pub/languages/perl/CPAN/
ftp://ftp.plig.org/pub/CPAN/
ftp://sunsite.doc.ic.ac.uk/packages/CPAN/

North America

```
Alberta         ftp://sunsite.ualberta.ca/pub/Mirror/CPAN/
California      ftp://cpan.nas.nasa.gov/pub/perl/CPAN/
                ftp://cpan.valueclick.com/CPAN/
                ftp://ftp.cdrom.com/pub/perl/CPAN/
                http://download.sourceforge.net/mirrors/CPAN/
Colorado        ftp://ftp.cs.colorado.edu/pub/perl/CPAN/
Florida         ftp://ftp.cise.ufl.edu/pub/perl/CPAN/
Georgia         ftp://ftp.twoguys.org/CPAN/
Illinois        ftp://uiarchive.uiuc.edu/pub/lang/perl/CPAN/
Indiana         ftp://csociety-ftp.ecn.purdue.edu/pub/CPAN/
                ftp://ftp.uwsg.indiana.edu/pub/perl/CPAN/
Kentucky        ftp://ftp.uky.edu/CPAN/
Manitoba        ftp://theoryx5.uwinnipeg.ca/pub/CPAN/
Massachusetts
```

ftp://ftp.ccs.neu.edu/net/mirrors/ftp.funet.fi/pub/languages/perl/CPAN/
ftp://ftp.iguide.com/pub/mirrors/packages/perl/CPAN/
Mexico ftp://ftp.msg.com.mx/pub/CPAN/
New York ftp://ftp.deao.net/pub/CPAN/
ftp://ftp.rge.com/pub/languages/perl/
North Carolina ftp://ftp.duke.edu/pub/perl/
Nova Scotia ftp://cpan.chebucto.ns.ca/pub/CPAN/
Oklahoma ftp://ftp.ou.edu/mirrors/CPAN/
Ontario ftp://ftp.crc.ca/pub/packages/lang/perl/CPAN/
Oregon ftp://ftp.orst.edu/pub/packages/CPAN/

Pennsylvania ftp://ftp.epix.net/pub/languages/perl/
Tennessee ftp://ftp.sunsite.utk.edu/pub/CPAN/
Texas ftp://ftp.sedl.org/pub/mirrors/CPAN/
ftp://jhcloos.com/pub/mirror/CPAN/
Utah ftp://mirror.xmission.com/CPAN/
Virginia ftp://ftp.perl.org/pub/perl/CPAN/
ftp://ruff.cs.jmu.edu/pub/CPAN/
Washington ftp://ftp−mirror.internap.com/pub/CPAN/
ftp://ftp.llarian.net/pub/CPAN/
ftp://ftp.spu.edu/pub/CPAN/

South America

```
Brazil          ftp://cpan.if.usp.br/pub/mirror/CPAN/
                ftp://ftp.matrix.com.br/pub/perl/
Chile           ftp://sunsite.dcc.uchile.cl/pub/Lang/PERL/
```

For an up−to−date listing of CPAN sites, see http://www.perl.com/perl/CPAN/SITES or ftp://www.perl.com/CPAN/SITES .

Modules: Creation, Use, and Abuse

(The following section is borrowed directly from Tim Bunce's modules file, available at your nearest CPAN site.)

Perl implements a class using a package, but the presence of a package doesn't imply the presence of a class. A package is just a namespace. A class is a package that provides subroutines that can be used as methods. A method is just a subroutine that expects, as its first argument, either the name of a package (for "static" methods), or a reference to something (for "virtual" methods).

A module is a file that (by convention) provides a class of the same name (sans the .pm), plus an import method in that class that can be called to fetch exported symbols. This module may implement some of its methods by loading dynamic C or C++ objects, but that should be totally transparent to the user of the module. Likewise, the module might set up an AUTOLOAD function to slurp in subroutine definitions on demand, but this is also transparent. Only the ***.pm*** file is required to exist. See *perlsub*, *perltoot*, and *AutoLoader* for details about the AUTOLOAD mechanism.

Guidelines for Module Creation

Do similar modules already exist in some form?

If so, please try to reuse the existing modules either in whole or by inheriting useful features into a new class. If this is not practical try to get together with the module authors to work on extending or enhancing the functionality of the existing modules. A perfect example is the plethora of packages in perl4 for dealing with command line options.

If you are writing a module to expand an already existing set of modules, please coordinate with the author of the package. It helps if you follow the same naming scheme and module interaction scheme as the original author.

Try to design the new module to be easy to extend and reuse.

Try to `use warnings;` (or `use warnings qw(...);`). Remember that you can add `no warnings qw(...);` to individual blocks of code that need less warnings.

Use blessed references. Use the two argument form of bless to bless into the class name given as the first parameter of the constructor, e.g.,:

```
sub new {
    my $class = shift;
    return bless {}, $class;
}
```

or even this if you'd like it to be used as either a static or a virtual method.

```
sub new {
    my $self  = shift;
    my $class = ref($self) || $self;
    return bless {}, $class;
}
```

Pass arrays as references so more parameters can be added later (it's also faster). Convert functions into methods where appropriate. Split large methods into smaller more flexible ones. Inherit methods from other modules if appropriate.

Avoid class name tests like: `die "Invalid" unless ref $ref eq 'FOO'`. Generally you can delete the `eq 'FOO'` part with no harm at all. Let the objects look after themselves! Generally, avoid hard–wired class names as far as possible.

Avoid `< $r-Class::func()` where using `@ISA=qw(... Class ...)` and `< $r-func()` would work (see *perlbot* for more details).

Use autosplit so little used or newly added functions won't be a burden to programs that don't use them. Add test functions to the module after __END__ either using AutoSplit or by saying:

```
eval join('',<main::DATA>) || die $@ unless caller();
```

Does your module pass the 'empty subclass' test? If you say `@SUBCLASS::ISA = qw(YOURCLASS);` your applications should be able to use SUBCLASS in exactly the same way as YOURCLASS. For example, does your application still work if you change: `$obj = new YOURCLASS;` into: `$obj = new SUBCLASS;` ?

Avoid keeping any state information in your packages. It makes it difficult for multiple other packages to use yours. Keep state information in objects.

Always use **–w**.

Try to `use strict;` (or `use strict qw(...);`). Remember that you can add `no strict qw(...);` to individual blocks of code that need less strictness.

Always use **–w**.

Follow the guidelines in the perlstyle(1) manual.

Always use **–w**.

Some simple style guidelines

The perlstyle manual supplied with Perl has many helpful points.

Coding style is a matter of personal taste. Many people evolve their style over several years as they learn what helps them write and maintain good code. Here's one set of assorted suggestions that seem to be widely used by experienced developers:

Use underscores to separate words. It is generally easier to read `$var_names_like_this` than `$VarNamesLikeThis`, especially for non–native speakers of English. It's also a simple rule that works consistently with VAR_NAMES_LIKE_THIS.

Package/Module names are an exception to this rule. Perl informally reserves lowercase module names for 'pragma' modules like integer and strict. Other modules normally begin with a capital letter and use mixed case with no underscores (need to be short and portable).

You may find it helpful to use letter case to indicate the scope or nature of a variable. For example:

```
$ALL_CAPS_HERE   constants only (beware clashes with Perl vars)
$Some_Caps_Here  package-wide global/static
$no_caps_here    function scope my() or local() variables
```

Function and method names seem to work best as all lowercase. e.g., `< $obj-as_string()`.

You can use a leading underscore to indicate that a variable or function should not be used outside the package that defined it.

Select what to export.

Do NOT export method names!

Do NOT export anything else by default without a good reason!

Exports pollute the namespace of the module user. If you must export try to use @EXPORT_OK in preference to @EXPORT and avoid short or common names to reduce the risk of name clashes.

Generally anything not exported is still accessible from outside the module using the ModuleName::item_name (or `< $blessed_ref-method`) syntax. By convention you can use a leading underscore on names to indicate informally that they are 'internal' and not for public use.

(It is actually possible to get private functions by saying: `my $subref = sub { ... }; &$subref;`. But there's no way to call that directly as a method, because a method must have a name in the symbol table.)

As a general rule, if the module is trying to be object oriented then export nothing. If it's just a collection of functions then @EXPORT_OK anything but use @EXPORT with caution.

Select a name for the module.

This name should be as descriptive, accurate, and complete as possible. Avoid any risk of ambiguity. Always try to use two or more whole words. Generally the name should reflect what is special about what the module does rather than how it does it. Please use nested module names to group informally or categorize a module. There should be a very good reason for a module not to have a nested name. Module names should begin with a capital letter.

Having 57 modules all called Sort will not make life easy for anyone (though having 23 called Sort::Quick is only marginally better :-). Imagine someone trying to install your module alongside many others. If in any doubt ask for suggestions in comp.lang.perl.misc.

If you are developing a suite of related modules/classes it's good practice to use nested classes with a common prefix as this will avoid namespace clashes. For example: Xyz::Control, Xyz::View, Xyz::Model etc. Use the modules in this list as a naming guide.

If adding a new module to a set, follow the original author's standards for naming modules and the interface to methods in those modules.

To be portable each component of a module name should be limited to 11 characters. If it might be used on MS-DOS then try to ensure each is unique in the first 8 characters. Nested modules make this easier.

Have you got it right?

How do you know that you've made the right decisions? Have you picked an interface design that will cause problems later? Have you picked the most appropriate name? Do you have any questions?

The best way to know for sure, and pick up many helpful suggestions, is to ask someone who knows. Comp.lang.perl.misc is read by just about all the people who develop modules and it's the best place to ask.

All you need to do is post a short summary of the module, its purpose and interfaces. A few lines on each of the main methods is probably enough. (If you post the whole module it might be ignored by busy people - generally the very people you want to read it!)

Don't worry about posting if you can't say when the module will be ready - just say so in the message. It might be worth inviting others to help you, they may be able to complete it for you!

README and other Additional Files.

It's well known that software developers usually fully document the software they write. If, however, the world is in urgent need of your software and there is not enough time to write the full documentation please at least provide a README file containing:

- A description of the module/package/extension etc.
- A copyright notice – see below.
- Prerequisites – what else you may need to have.
- How to build it – possible changes to Makefile.PL etc.
- How to install it.
- Recent changes in this release, especially incompatibilities
- Changes / enhancements you plan to make in the future.

If the README file seems to be getting too large you may wish to split out some of the sections into separate files: INSTALL, Copying, ToDo etc.

Adding a Copyright Notice.

How you choose to license your work is a personal decision. The general mechanism is to assert your Copyright and then make a declaration of how others may copy/use/modify your work.

Perl, for example, is supplied with two types of licence: The GNU GPL and The Artistic Licence (see the files README, Copying, and Artistic). Larry has good reasons for NOT just using the GNU GPL.

My personal recommendation, out of respect for Larry, Perl, and the Perl community at large is to state something simply like:

```
Copyright (c) 1995 Your Name. All rights reserved.
This program is free software; you can redistribute it and/or
modify it under the same terms as Perl itself.
```

This statement should at least appear in the README file. You may also wish to include it in a Copying file and your source files. Remember to include the other words in addition to the Copyright.

Give the module a version/issue/release number.

To be fully compatible with the Exporter and MakeMaker modules you should store your module's version number in a non–my package variable called `$VERSION`. This should be a floating point number with at least two digits after the decimal (i.e., hundredths, e.g, `$VERSION = "0.01"`). Don't use a "1.3.2" style version. See *Exporter* for details.

It may be handy to add a function or method to retrieve the number. Use the number in announcements and archive file names when releasing the module (ModuleName–1.02.tar.Z). See perldoc ExtUtils::MakeMaker.pm for details.

How to release and distribute a module.

It's good idea to post an announcement of the availability of your module (or the module itself if small) to the comp.lang.perl.announce Usenet newsgroup. This will at least ensure very wide once–off distribution.

If possible, register the module with CPAN. You should include details of its location in your announcement.

Some notes about ftp archives: Please use a long descriptive file name that includes the version number. Most incoming directories will not be readable/listable, i.e., you won't be able to see your file after uploading it. Remember to send your email notification message as soon as

possible after uploading else your file may get deleted automatically. Allow time for the file to be processed and/or check the file has been processed before announcing its location.

FTP Archives for Perl Modules:

Follow the instructions and links on:

```
http://www.perl.com/CPAN/modules/00modlist.long.html
http://www.perl.com/CPAN/modules/04pause.html
```

or upload to one of these sites:

```
https://pause.kbx.de/pause/
http://pause.perl.org/pause/
```

and notify <modules@perl.org.

By using the WWW interface you can ask the Upload Server to mirror your modules from your ftp or WWW site into your own directory on CPAN!

Please remember to send me an updated entry for the Module list!

Take care when changing a released module.

Always strive to remain compatible with previous released versions. Otherwise try to add a mechanism to revert to the old behavior if people rely on it. Document incompatible changes.

Guidelines for Converting Perl 4 Library Scripts into Modules

There is no requirement to convert anything.

If it ain't broke, don't fix it! Perl 4 library scripts should continue to work with no problems. You may need to make some minor changes (like escaping non–array @'s in double quoted strings) but there is no need to convert a .pl file into a Module for just that.

Consider the implications.

All Perl applications that make use of the script will need to be changed (slightly) if the script is converted into a module. Is it worth it unless you plan to make other changes at the same time?

Make the most of the opportunity.

If you are going to convert the script to a module you can use the opportunity to redesign the interface. The guidelines for module creation above include many of the issues you should consider.

The pl2pm utility will get you started.

This utility will read *.pl files (given as parameters) and write corresponding *.pm files. The pl2pm utilities does the following:

- Adds the standard Module prologue lines
- Converts package specifiers from ' to ::
- Converts die(...) to croak(...)
- Several other minor changes

Being a mechanical process pl2pm is not bullet proof. The converted code will need careful checking, especially any package statements. Don't delete the original .pl file till the new .pm one works!

Guidelines for Reusing Application Code

Complete applications rarely belong in the Perl Module Library.
Many applications contain some Perl code that could be reused.

Help save the world! Share your code in a form that makes it easy to reuse.

Break–out the reusable code into one or more separate module files.
Take the opportunity to reconsider and redesign the interfaces.
In some cases the 'application' can then be reduced to a small

fragment of code built on top of the reusable modules. In these cases the application could invoked as:

```
% perl -e 'use Module::Name; method(@ARGV)' ...
```

or

% perl –mModule::Name ... (in perl5.002 or higher)

NOTE

Perl does not enforce private and public parts of its modules as you may have been used to in other languages like C++, Ada, or Modula–17. Perl doesn't have an infatuation with enforced privacy. It would prefer that you stayed out of its living room because you weren't invited, not because it has a shotgun.

The module and its user have a contract, part of which is common law, and part of which is "written". Part of the common law contract is that a module doesn't pollute any namespace it wasn't asked to. The written contract for the module (A.K.A. documentation) may make other provisions. But then you know when you `use RedefineTheWorld` that you're redefining the world and willing to take the consequences.

NAME

perlnewmod – preparing a new module for distribution

DESCRIPTION

This document gives you some suggestions about how to go about writing Perl modules, preparing them for distribution, and making them available via CPAN.

One of the things that makes Perl really powerful is the fact that Perl hackers tend to want to share the solutions to problems they've faced, so you and I don't have to battle with the same problem again.

The main way they do this is by abstracting the solution into a Perl module. If you don't know what one of these is, the rest of this document isn't going to be much use to you. You're also missing out on an awful lot of useful code; consider having a look at *perlmod*, *perlmodlib* and *perlmodinstall* before coming back here.

When you've found that there isn't a module available for what you're trying to do, and you've had to write the code yourself, consider packaging up the solution into a module and uploading it to CPAN so that others can benefit.

Warning

We're going to primarily concentrate on Perl–only modules here, rather than XS modules. XS modules serve a rather different purpose, and you should consider different things before distributing them – the popularity of the library you are gluing, the portability to other operating systems, and so on. However, the notes on preparing the Perl side of the module and packaging and distributing it will apply equally well to an XS module as a pure–Perl one.

What should I make into a module?

You should make a module out of any code that you think is going to be useful to others. Anything that's likely to fill a hole in the communal library and which someone else can slot directly into their program. Any part of your code which you can isolate and extract and plug into something else is a likely candidate.

Let's take an example. Suppose you're reading in data from a local format into a hash–of–hashes in Perl, turning that into a tree, walking the tree and then piping each node to an Acme Transmogrifier Server.

Now, quite a few people have the Acme Transmogrifier, and you've had to write something to talk the protocol from scratch – you'd almost certainly want to make that into a module. The level at which you pitch it is up to you: you might want protocol–level modules analogous to *Net::SMTP|Net::SMTP* which then talk to higher level modules analogous to *Mail::Send|Mail::Send*. The choice is yours, but you do want to get a module out for that server protocol.

Nobody else on the planet is going to talk your local data format, so we can ignore that. But what about the thing in the middle? Building tree structures from Perl variables and then traversing them is a nice, general problem, and if nobody's already written a module that does that, you might want to modularise that code too.

So hopefully you've now got a few ideas about what's good to modularise. Let's now see how it's done.

Step–by–step: Preparing the ground

Before we even start scraping out the code, there are a few things we'll want to do in advance.

Look around

Dig into a bunch of modules to see how they're written. I'd suggest starting with *Text::Tabs|Text::Tabs*, since it's in the standard library and is nice and simple, and then looking at something like *Time::Zone|Time::Zone*, *File::Copy|File::Copy* and then some of the `Mail::*` modules if you're planning on writing object oriented code.

These should give you an overall feel for how modules are laid out and written.

Check it's new

There are a lot of modules on CPAN, and it's easy to miss one that's similar to what you're planning on contributing. Have a good plough through the modules list and the ***by–module*** directories, and make

sure you're not the one reinventing the wheel!

Discuss the need

You might love it. You might feel that everyone else needs it. But there might not actually be any real demand for it out there. If you're unsure about the demand you're module will have, consider sending out feelers on the `comp.lang.perl.modules` newsgroup, or as a last resort, ask the modules list at `modules@perl.org`. Remember that this is a closed list with a very long turn–around time – be prepared to wait a good while for a response from them.

Choose a name

Perl modules included on CPAN have a naming hierarchy you should try to fit in with. See *perlmodlib* for more details on how this works, and browse around CPAN and the modules list to get a feel of it. At the very least, remember this: modules should be title capitalised, (This::Thing) fit in with a category, and explain their purpose succinctly.

Check again

While you're doing that, make really sure you haven't missed a module similar to the one you're about to write.

When you've got your name sorted out and you're sure that your module is wanted and not currently available, it's time to start coding.

Step–by–step: Making the module

Start with *h2xs*

Originally a utility to convert C header files into XS modules, *h2xs|h2xs* has become a useful utility for churning out skeletons for Perl–only modules as well. If you don't want to use the *Autoloader|Autoloader* which splits up big modules into smaller subroutine–sized chunks, you'll say something like this:

```
h2xs -AX -n Net::Acme
```

The `-A` omits the Autoloader code, `-X` omits XS elements, and `-n` specifies the name of the module.

Use *strict|strict* and *warnings|warnings*

A module's code has to be warning and strict–clean, since you can't guarantee the conditions that it'll be used under. Besides, you wouldn't want to distribute code that wasn't warning or strict–clean anyway, right?

Use *Carp|Carp*

The *Carp|Carp* module allows you to present your error messages from the caller's perspective; this gives you a way to signal a problem with the caller and not your module. For instance, if you say this:

```
warn "No hostname given";
```

the user will see something like this:

```
No hostname given at /usr/local/lib/perl5/site_perl/5.6.0/Net/Acme.pm
line 123.
```

which looks like your module is doing something wrong. Instead, you want to put the blame on the user, and say this:

```
No hostname given at bad_code, line 10.
```

You do this by using *Carp|Carp* and replacing your `warns` with `carps`. If you need to `die`, say `croak` instead. However, keep `warn` and `die` in place for your sanity checks – where it really is your module at fault.

Use *Exporter|Exporter* – wisely!

`h2xs` provides stubs for *Exporter|Exporter*, which gives you a standard way of exporting symbols and subroutines from your module into the caller's namespace. For instance, saying `use Net::Acme`

`qw(&frob)` would import the `frob` subroutine.

The package variable `@EXPORT` will determine which symbols will get exported when the caller simply says `use Net::Acme` – you will hardly ever want to put anything in there. `@EXPORT_OK`, on the other hand, specifies which symbols you're willing to export. If you do want to export a bunch of symbols, use the `%EXPORT_TAGS` and define a standard export set – look at *Exporter* for more details.

Use *plain old documentation|perlpod*

The work isn't over until the paperwork is done, and you're going to need to put in some time writing some documentation for your module. `h2xs` will provide a stub for you to fill in; if you're not sure about the format, look at *perlpod* for an introduction. Provide a good synopsis of how your module is used in code, a description, and then notes on the syntax and function of the individual subroutines or methods. Use Perl comments for developer notes and POD for end–user notes.

Write tests

You're encouraged to create self–tests for your module to ensure it's working as intended on the myriad platforms Perl supports; if you upload your module to CPAN, a host of testers will build your module and send you the results of the tests. Again, `h2xs` provides a test framework which you can extend – you should do something more than just checking your module will compile.

Write the README

If you're uploading to CPAN, the automated gremlins will extract the README file and place that in your CPAN directory. It'll also appear in the main ***by–module*** and ***by–category*** directories if you make it onto the modules list. It's a good idea to put here what the module actually does in detail, and the user–visible changes since the last release.

Step–by–step: Distributing your module

Get a CPAN user ID

Every developer publishing modules on CPAN needs a CPAN ID. See the instructions at `http://www.cpan.org/modules/04pause.html` (or equivalent on your nearest mirror) to find out how to do this.

`perl Makefile.PL; make test; make dist`

Once again, `h2xs` has done all the work for you. It produces the standard `Makefile.PL` you'll have seen when you downloaded and installs modules, and this produces a Makefile with a `dist` target.

Once you've ensured that your module passes its own tests – always a good thing to make sure – you can `make dist`, and the Makefile will hopefully produce you a nice tarball of your module, ready for upload.

Upload the tarball

The email you got when you received your CPAN ID will tell you how to log in to PAUSE, the Perl Authors Upload SErver. From the menus there, you can upload your module to CPAN.

Announce to the modules list

Once uploaded, it'll sit unnoticed in your author directory. If you want it connected to the rest of the CPAN, you'll need to tell the modules list about it. The best way to do this is to email them a line in the style of the modules list, like this:

```
Net::Acme bdpO  Interface to Acme Frobnicator servers          FOOBAR
^         ^^^^  ^                                              ^
|         ||||  Module description                            Your ID
|         ||||
|         |||\- Interface: (O)OP, (r)eferences, (h)ybrid, (f)unctions
|         |||
|         ||\-- Language: (p)ure Perl, C(+)+, (h)ybrid, (C), (o)ther
|         ||
Module    |\--- Support: (d)eveloper, (m)ailing list, (u)senet, (n)one
```

```
    Name        |
                \---- Maturity: (i)dea, (c)onstructions, (a)lpha, (b)eta,
                                (R)eleased, (M)ature, (S)tandard
```

plus a description of the module and why you think it should be included. If you hear nothing back, that means your module will probably appear on the modules list at the next update. Don't try subscribing to `modules@perl.org`; it's not another mailing list. Just have patience.

Announce to clpa

If you have a burning desire to tell the world about your release, post an announcement to the moderated `comp.lang.perl.announce` newsgroup.

Fix bugs!

Once you start accumulating users, they'll send you bug reports. If you're lucky, they'll even send you patches. Welcome to the joys of maintaining a software project...

AUTHOR

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SEE ALSO

perlmod, *perlmodlib*, *perlmodinstall*, *h2xs*, *strict*, *Carp*, *Exporter*, *perlpod*, *Test*, *ExtUtils::MakeMaker*, http://www.cpan.org/

NAME

perlnumber – semantics of numbers and numeric operations in Perl

SYNOPSIS

```
$n = 1234;                # decimal integer
$n = 0b1110011;           # binary integer
$n = 01234;               # octal integer
$n = 0x1234;              # hexadecimal integer
$n = 12.34e-56;           # exponential notation
$n = "-12.34e56";         # number specified as a string
$n = "1234";              # number specified as a string
$n = v49.50.51.52;        # number specified as a string, which in
                          # turn is specified in terms of numbers :-)
```

DESCRIPTION

This document describes how Perl internally handles numeric values.

Perl's operator overloading facility is completely ignored here. Operator overloading allows user–defined behaviors for numbers, such as operations over arbitrarily large integers, floating points numbers with arbitrary precision, operations over "exotic" numbers such as modular arithmetic or p–adic arithmetic, and so on. See *overload* for details.

Storing numbers

Perl can internally represent numbers in 3 different ways: as native integers, as native floating point numbers, and as decimal strings. Decimal strings may have an exponential notation part, as in `"12.34e-56"`. *Native* here means "a format supported by the C compiler which was used to build perl".

The term "native" does not mean quite as much when we talk about native integers, as it does when native floating point numbers are involved. The only implication of the term "native" on integers is that the limits for the maximal and the minimal supported true integral quantities are close to powers of 2. However, "native" floats have a most fundamental restriction: they may represent only those numbers which have a relatively "short" representation when converted to a binary fraction. For example, 0.9 cannot be represented by a native float, since the binary fraction for 0.9 is infinite:

```
binary0.1110011001100...
```

with the sequence `1100` repeating again and again. In addition to this limitation, the exponent of the binary number is also restricted when it is represented as a floating point number. On typical hardware, floating point values can store numbers with up to 53 binary digits, and with binary exponents between –1024 and 1024. In decimal representation this is close to 16 decimal digits and decimal exponents in the range of –304..304. The upshot of all this is that Perl cannot store a number like 12345678901234567 as a floating point number on such architectures without loss of information.

Similarly, decimal strings can represent only those numbers which have a finite decimal expansion. Being strings, and thus of arbitrary length, there is no practical limit for the exponent or number of decimal digits for these numbers. (But realize that what we are discussing the rules for just the *storage* of these numbers. The fact that you can store such "large" numbers does not mean that the *operations* over these numbers will use all of the significant digits. See *"Numeric operators and numeric conversions"* for details.)

In fact numbers stored in the native integer format may be stored either in the signed native form, or in the unsigned native form. Thus the limits for Perl numbers stored as native integers would typically be –2**31..2**32–1, with appropriate modifications in the case of 64–bit integers. Again, this does not mean that Perl can do operations only over integers in this range: it is possible to store many more integers in floating point format.

Summing up, Perl numeric values can store only those numbers which have a finite decimal expansion or a "short" binary expansion.

Numeric operators and numeric conversions

As mentioned earlier, Perl can store a number in any one of three formats, but most operators typically understand only one of those formats. When a numeric value is passed as an argument to such an operator, it will be converted to the format understood by the operator.

Six such conversions are possible:

```
native integer        --> native floating point       (*)
native integer        --> decimal string
native floating_point --> native integer              (*)
native floating_point --> decimal string              (*)
decimal string        --> native integer
decimal string        --> native floating point       (*)
```

These conversions are governed by the following general rules:

- If the source number can be represented in the target form, that representation is used.
- If the source number is outside of the limits representable in the target form, a representation of the closest limit is used. (*Loss of information*)
- If the source number is between two numbers representable in the target form, a representation of one of these numbers is used. (*Loss of information*)
- In `< native floating point` − native integer conversions the magnitude of the result is less than or equal to the magnitude of the source. (*"Rounding to zero"*.)
- If the `< decimal string` − native integer conversion cannot be done without loss of information, the result is compatible with the conversion sequence `< decimal_string` − native_floating_point — native_integer . In particular, rounding is strongly biased to 0, though a number like `"0.99999999999999999"` has a chance of being rounded to 1.

RESTRICTION: The conversions marked with `(*)` above involve steps performed by the C compiler. In particular, bugs/features of the compiler used may lead to breakage of some of the above rules.

Flavors of Perl numeric operations

Perl operations which take a numeric argument treat that argument in one of four different ways: they may force it to one of the integer/floating/ string formats, or they may behave differently depending on the format of the operand. Forcing a numeric value to a particular format does not change the number stored in the value.

All the operators which need an argument in the integer format treat the argument as in modular arithmetic, e.g., `mod 2**32` on a 32–bit architecture. `sprintf "%u", -1` therefore provides the same result as `sprintf "%u", ~0`.

Arithmetic operators except, `no integer`

force the argument into the floating point format.

Arithmetic operators except, `use integer`
Bitwise operators, `no integer`

force the argument into the integer format if it is not a string.

Bitwise operators, `use integer`

force the argument into the integer format

Operators which expect an integer

force the argument into the integer format. This is applicable to the third and fourth arguments of `sysread`, for example.

Operators which expect a string

force the argument into the string format. For example, this is applicable to `printf "%s", $value`.

Though forcing an argument into a particular form does not change the stored number, Perl remembers the result of such conversions. In particular, though the first such conversion may be time–consuming, repeated operations will not need to redo the conversion.

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SEE ALSO

overload

NAME

perlobj – Perl objects

DESCRIPTION

First you need to understand what references are in Perl. See *perlref* for that. Second, if you still find the following reference work too complicated, a tutorial on object–oriented programming in Perl can be found in *perltoot* and *perltootc*.

If you're still with us, then here are three very simple definitions that you should find reassuring.

1. An object is simply a reference that happens to know which class it belongs to.
2. A class is simply a package that happens to provide methods to deal with object references.
3. A method is simply a subroutine that expects an object reference (or a package name, for class methods) as the first argument.

We'll cover these points now in more depth.

An Object is Simply a Reference

Unlike say C++, Perl doesn't provide any special syntax for constructors. A constructor is merely a subroutine that returns a reference to something "blessed" into a class, generally the class that the subroutine is defined in. Here is a typical constructor:

```
package Critter;
sub new { bless {} }
```

That word `new` isn't special. You could have written a construct this way, too:

```
package Critter;
sub spawn { bless {} }
```

This might even be preferable, because the C++ programmers won't be tricked into thinking that `new` works in Perl as it does in C++. It doesn't. We recommend that you name your constructors whatever makes sense in the context of the problem you're solving. For example, constructors in the Tk extension to Perl are named after the widgets they create.

One thing that's different about Perl constructors compared with those in C++ is that in Perl, they have to allocate their own memory. (The other things is that they don't automatically call overridden base–class constructors.) The `{}` allocates an anonymous hash containing no key/value pairs, and returns it The `bless()` takes that reference and tells the object it references that it's now a Critter, and returns the reference. This is for convenience, because the referenced object itself knows that it has been blessed, and the reference to it could have been returned directly, like this:

```
sub new {
    my $self = {};
    bless $self;
    return $self;
}
```

You often see such a thing in more complicated constructors that wish to call methods in the class as part of the construction:

```
sub new {
    my $self = {};
    bless $self;
    $self->initialize();
    return $self;
}
```

If you care about inheritance (and you should; see *Modules: Creation, Use, and Abuse in perlmodlib*), then

you want to use the two−arg form of bless so that your constructors may be inherited:

```
sub new {
    my $class = shift;
    my $self = {};
    bless $self, $class;
    $self->initialize();
    return $self;
}
```

Or if you expect people to call not just `< CLASS->new()` but also `< $obj->new()` , then use something like this. The `initialize()` method used will be of whatever `$class` we blessed the object into:

```
sub new {
    my $this = shift;
    my $class = ref($this) || $this;
    my $self = {};
    bless $self, $class;
    $self->initialize();
    return $self;
}
```

Within the class package, the methods will typically deal with the reference as an ordinary reference. Outside the class package, the reference is generally treated as an opaque value that may be accessed only through the class‘s methods.

Although a constructor can in theory re−bless a referenced object currently belonging to another class, this is almost certainly going to get you into trouble. The new class is responsible for all cleanup later. The previous blessing is forgotten, as an object may belong to only one class at a time. (Although of course it‘s free to inherit methods from many classes.) If you find yourself having to do this, the parent class is probably misbehaving, though.

A clarification: Perl objects are blessed. References are not. Objects know which package they belong to. References do not. The `bless()` function uses the reference to find the object. Consider the following example:

```
$a = {};
$b = $a;
bless $a, BLAH;
print "\$b is a ", ref($b), "\n";
```

This reports `$b` as being a BLAH, so obviously `bless()` operated on the object and not on the reference.

A Class is Simply a Package

Unlike say C++, Perl doesn‘t provide any special syntax for class definitions. You use a package as a class by putting method definitions into the class.

There is a special array within each package called @ISA, which says where else to look for a method if you can‘t find it in the current package. This is how Perl implements inheritance. Each element of the @ISA array is just the name of another package that happens to be a class package. The classes are searched (depth first) for missing methods in the order that they occur in @ISA. The classes accessible through @ISA are known as base classes of the current class.

All classes implicitly inherit from class `UNIVERSAL` as their last base class. Several commonly used methods are automatically supplied in the UNIVERSAL class; see *"Default UNIVERSAL methods"* for more details.

If a missing method is found in a base class, it is cached in the current class for efficiency. Changing @ISA or defining new subroutines invalidates the cache and causes Perl to do the lookup again.

If neither the current class, its named base classes, nor the UNIVERSAL class contains the requested method, these three places are searched all over again, this time looking for a method named `AUTOLOAD()`. If an AUTOLOAD is found, this method is called on behalf of the missing method, setting the package global `$AUTOLOAD` to be the fully qualified name of the method that was intended to be called.

If none of that works, Perl finally gives up and complains.

If you want to stop the AUTOLOAD inheritance say simply

```
sub AUTOLOAD;
```

and the call will die using the name of the sub being called.

Perl classes do method inheritance only. Data inheritance is left up to the class itself. By and large, this is not a problem in Perl, because most classes model the attributes of their object using an anonymous hash, which serves as its own little namespace to be carved up by the various classes that might want to do something with the object. The only problem with this is that you can't sure that you aren't using a piece of the hash that isn't already used. A reasonable workaround is to prepend your fieldname in the hash with the package name.

```
sub bump {
    my $self = shift;
    $self->{ __PACKAGE__ . ".count"}++;
}
```

A Method is Simply a Subroutine

Unlike say C++, Perl doesn't provide any special syntax for method definition. (It does provide a little syntax for method invocation though. More on that later.) A method expects its first argument to be the object (reference) or package (string) it is being invoked on. There are two ways of calling methods, which we'll call class methods and instance methods.

A class method expects a class name as the first argument. It provides functionality for the class as a whole, not for any individual object belonging to the class. Constructors are often class methods, but see *perltoot* and *perltootc* for alternatives. Many class methods simply ignore their first argument, because they already know what package they're in and don't care what package they were invoked via. (These aren't necessarily the same, because class methods follow the inheritance tree just like ordinary instance methods.) Another typical use for class methods is to look up an object by name:

```
sub find {
    my ($class, $name) = @_;
    $objtable{$name};
}
```

An instance method expects an object reference as its first argument. Typically it shifts the first argument into a "self" or "this" variable, and then uses that as an ordinary reference.

```
sub display {
    my $self = shift;
    my @keys = @_ ? @_ : sort keys %$self;
    foreach $key (@keys) {
        print "\t$key => $self->{$key}\n";
    }
}
```

Method Invocation

There are two ways to invoke a method, one of which you're already familiar with, and the other of which will look familiar. Perl 4 already had an "indirect object" syntax that you use when you say

```
print STDERR "help!!!\n";
```

This same syntax can be used to call either class or instance methods. We'll use the two methods defined

above, the class method to lookup an object reference and the instance method to print out its attributes.

```
$fred = find Critter "Fred";
display $fred 'Height', 'Weight';
```

These could be combined into one statement by using a BLOCK in the indirect object slot:

```
display {find Critter "Fred"} 'Height', 'Weight';
```

For C++ fans, there's also a syntax using - notation that does exactly the same thing. The parentheses are required if there are any arguments.

```
$fred = Critter->find("Fred");
$fred->display('Height', 'Weight');
```

or in one statement,

```
Critter->find("Fred")->display('Height', 'Weight');
```

There are times when one syntax is more readable, and times when the other syntax is more readable. The indirect object syntax is less cluttered, but it has the same ambiguity as ordinary list operators. Indirect object method calls are usually parsed using the same rule as list operators: "If it looks like a function, it is a function". (Presuming for the moment that you think two words in a row can look like a function name. C++ programmers seem to think so with some regularity, especially when the first word is "new".) Thus, the parentheses of

```
new Critter ('Barney', 1.5, 70)
```

are assumed to surround ALL the arguments of the method call, regardless of what comes after. Saying

```
new Critter ('Bam' x 2), 1.4, 45
```

would be equivalent to

```
Critter->new('Bam' x 2), 1.4, 45
```

which is unlikely to do what you want. Confusingly, however, this rule applies only when the indirect object is a bareword package name, not when it's a scalar, a BLOCK, or a `Package::` qualified package name. In those cases, the arguments are parsed in the same way as an indirect object list operator like print, so

```
new Critter:: ('Bam' x 2), 1.4, 45
```

is the same as

```
Critter::->new(('Bam' x 2), 1.4, 45)
```

For more reasons why the indirect object syntax is ambiguous, see *"WARNING"* below.

There are times when you wish to specify which class's method to use. Here you can call your method as an ordinary subroutine call, being sure to pass the requisite first argument explicitly:

```
$fred =  MyCritter::find("Critter", "Fred");
MyCritter::display($fred, 'Height', 'Weight');
```

Unlike method calls, function calls don't consider inheritance. If you wish merely to specify that Perl should *START* looking for a method in a particular package, use an ordinary method call, but qualify the method name with the package like this:

```
$fred = Critter->MyCritter::find("Fred");
$fred->MyCritter::display('Height', 'Weight');
```

If you're trying to control where the method search begins *and* you're executing in the class itself, then you may use the SUPER pseudo class, which says to start looking in your base class's @ISA list without having to name it explicitly:

```
$self->SUPER::display('Height', 'Weight');
```

Please note that the SUPER:: construct is meaningful *only* within the class.

Sometimes you want to call a method when you don't know the method name ahead of time. You can use the arrow form, replacing the method name with a simple scalar variable containing the method name or a reference to the function.

```
$method = $fast ? "findfirst" : "findbest";
$fred->$method(@args);          # call by name

if ($coderef = $fred->can($parent . "::findbest")) {
    $self->$coderef(@args);     # call by coderef
}
```

WARNING

While indirect object syntax may well be appealing to English speakers and to C++ programmers, be not seduced! It suffers from two grave problems.

The first problem is that an indirect object is limited to a name, a scalar variable, or a block, because it would have to do too much lookahead otherwise, just like any other postfix dereference in the language. (These are the same quirky rules as are used for the filehandle slot in functions like print and printf.) This can lead to horribly confusing precedence problems, as in these next two lines:

```
move $obj->{FIELD};             # probably wrong!
move $ary[$i];                  # probably wrong!
```

Those actually parse as the very surprising:

```
$obj->move->{FIELD};            # Well, lookee here
$ary->move([$i]);               # Didn't expect this one, eh?
```

Rather than what you might have expected:

```
$obj->{FIELD}->move();          # You should be so lucky.
$ary[$i]->move;                 # Yeah, sure.
```

The left side of ''-'' is not so limited, because it's an infix operator, not a postfix operator.

As if that weren't bad enough, think about this: Perl must guess *at compile time* whether name and move above are functions or methods. Usually Perl gets it right, but when it doesn't it, you get a function call compiled as a method, or vice versa. This can introduce subtle bugs that are hard to unravel. For example, calling a method new in indirect notation—as C++ programmers are so wont to do—can be miscompiled into a subroutine call if there's already a new function in scope. You'd end up calling the current package's new as a subroutine, rather than the desired class's method. The compiler tries to cheat by remembering bareword requires, but the grief if it messes up just isn't worth the years of debugging it would likely take you to track such subtle bugs down.

The infix arrow notation using ''< -'' doesn't suffer from either of these disturbing ambiguities, so we recommend you use it exclusively.

Default UNIVERSAL methods

The UNIVERSAL package automatically contains the following methods that are inherited by all other classes:

isa(CLASS)

isa returns *true* if its object is blessed into a subclass of CLASS

isa is also exportable and can be called as a sub with two arguments. This allows the ability to check what a reference points to. Example

```
use UNIVERSAL qw(isa);

if(isa($ref, 'ARRAY')) {
    #...
```

```
}
```

can(METHOD)

`can` checks to see if its object has a method called `METHOD`, if it does then a reference to the sub is returned, if it does not then *undef* is returned.

VERSION([NEED])

`VERSION` returns the version number of the class (package). If the NEED argument is given then it will check that the current version (as defined by the `$VERSION` variable in the given package) not less than NEED; it will die if this is not the case. This method is normally called as a class method. This method is called automatically by the `VERSION` form of `use`.

```
use A 1.2 qw(some imported subs);
# implies:
A->VERSION(1.2);
```

NOTE: `can` directly uses Perl's internal code for method lookup, and `isa` uses a very similar method and cache−ing strategy. This may cause strange effects if the Perl code dynamically changes @ISA in any package.

You may add other methods to the UNIVERSAL class via Perl or XS code. You do not need to `use UNIVERSAL` to make these methods available to your program. This is necessary only if you wish to have `isa` available as a plain subroutine in the current package.

Destructors

When the last reference to an object goes away, the object is automatically destroyed. (This may even be after you exit, if you've stored references in global variables.) If you want to capture control just before the object is freed, you may define a DESTROY method in your class. It will automatically be called at the appropriate moment, and you can do any extra cleanup you need to do. Perl passes a reference to the object under destruction as the first (and only) argument. Beware that the reference is a read−only value, and cannot be modified by manipulating `$_[0]` within the destructor. The object itself (i.e. the thingy the reference points to, namely `${$_[0]}`, `@{$_[0]}`, `%{$_[0]}` etc.) is not similarly constrained.

If you arrange to re−bless the reference before the destructor returns, perl will again call the DESTROY method for the re−blessed object after the current one returns. This can be used for clean delegation of object destruction, or for ensuring that destructors in the base classes of your choosing get called. Explicitly calling DESTROY is also possible, but is usually never needed.

Do not confuse the previous discussion with how objects *CONTAINED* in the current one are destroyed. Such objects will be freed and destroyed automatically when the current object is freed, provided no other references to them exist elsewhere.

Summary

That's about all there is to it. Now you need just to go off and buy a book about object−oriented design methodology, and bang your forehead with it for the next six months or so.

Two−Phased Garbage Collection

For most purposes, Perl uses a fast and simple, reference−based garbage collection system. That means there's an extra dereference going on at some level, so if you haven't built your Perl executable using your C compiler's `-O` flag, performance will suffer. If you *have* built Perl with `cc -O`, then this probably won't matter.

A more serious concern is that unreachable memory with a non−zero reference count will not normally get freed. Therefore, this is a bad idea:

```
{
    my $a;
    $a = \$a;
}
```

Even thought $a *should* go away, it can't. When building recursive data structures, you'll have to break the self−reference yourself explicitly if you don't care to leak. For example, here's a self−referential node such as one might use in a sophisticated tree structure:

```
sub new_node {
    my $self = shift;
    my $class = ref($self) || $self;
    my $node = {};
    $node->{LEFT} = $node->{RIGHT} = $node;
    $node->{DATA} = [ @_ ];
    return bless $node => $class;
}
```

If you create nodes like that, they (currently) won't go away unless you break their self reference yourself. (In other words, this is not to be construed as a feature, and you shouldn't depend on it.)

Almost.

When an interpreter thread finally shuts down (usually when your program exits), then a rather costly but complete mark−and−sweep style of garbage collection is performed, and everything allocated by that thread gets destroyed. This is essential to support Perl as an embedded or a multithreadable language. For example, this program demonstrates Perl's two−phased garbage collection:

```
#!/usr/bin/perl
package Subtle;

sub new {
    my $test;
    $test = \$test;
    warn "CREATING " . \$test;
    return bless \$test;
}

sub DESTROY {
    my $self = shift;
    warn "DESTROYING $self";
}

package main;

warn "starting program";
{
    my $a = Subtle->new;
    my $b = Subtle->new;
    $$a = 0;  # break selfref
    warn "leaving block";
}

warn "just exited block";
warn "time to die...";
exit;
```

When run as ***/tmp/test***, the following output is produced:

```
starting program at /tmp/test line 18.
CREATING SCALAR(0x8e5b8) at /tmp/test line 7.
CREATING SCALAR(0x8e57c) at /tmp/test line 7.
leaving block at /tmp/test line 23.
DESTROYING Subtle=SCALAR(0x8e5b8) at /tmp/test line 13.
just exited block at /tmp/test line 26.
```

```
time to die... at /tmp/test line 27.
DESTROYING Subtle=SCALAR(0x8e57c) during global destruction.
```

Notice that "global destruction" bit there? That's the thread garbage collector reaching the unreachable.

Objects are always destructed, even when regular refs aren't. Objects are destructed in a separate pass before ordinary refs just to prevent object destructors from using refs that have been themselves destructed. Plain refs are only garbage–collected if the destruct level is greater than 0. You can test the higher levels of global destruction by setting the PERL_DESTRUCT_LEVEL environment variable, presuming `-DDEBUGGING` was enabled during perl build time.

A more complete garbage collection strategy will be implemented at a future date.

In the meantime, the best solution is to create a non–recursive container class that holds a pointer to the self–referential data structure. Define a DESTROY method for the containing object's class that manually breaks the circularities in the self–referential structure.

SEE ALSO

A kinder, gentler tutorial on object–oriented programming in Perl can be found in *perltoot* and *perltootc*. You should also check out *perlbot* for other object tricks, traps, and tips, as well as *perlmodlib* for some style guides on constructing both modules and classes.

NAME

perlop – Perl operators and precedence

SYNOPSIS

Perl operators have the following associativity and precedence, listed from highest precedence to lowest. Operators borrowed from C keep the same precedence relationship with each other, even where C's precedence is slightly screwy. (This makes learning Perl easier for C folks.) With very few exceptions, these all operate on scalar values only, not array values.

```
left        terms and list operators (leftward)
left        ->
nonassoc    ++ --
right       **
right       ! ~ \ and unary + and -
left        =~ !~
left        * / % x
left        + - .
left        << >>
nonassoc    named unary operators
nonassoc    < > <= >= lt gt le ge
nonassoc    == != <=> eq ne cmp
left        &
left        | ^
left        &&
left        ||
nonassoc    ..  ...
right       ?:
right       = += -= *= etc.
left        , =>
nonassoc    list operators (rightward)
right       not
left        and
left        or xor
```

In the following sections, these operators are covered in precedence order.

Many operators can be overloaded for objects. See *overload*.

DESCRIPTION

Terms and List Operators (Leftward)

A TERM has the highest precedence in Perl. They include variables, quote and quote–like operators, any expression in parentheses, and any function whose arguments are parenthesized. Actually, there aren't really functions in this sense, just list operators and unary operators behaving as functions because you put parentheses around the arguments. These are all documented in *perlfunc*.

If any list operator (`print()`, etc.) or any unary operator (`chdir()`, etc.) is followed by a left parenthesis as the next token, the operator and arguments within parentheses are taken to be of highest precedence, just like a normal function call.

In the absence of parentheses, the precedence of list operators such as `print`, `sort`, or `chmod` is either very high or very low depending on whether you are looking at the left side or the right side of the operator. For example, in

```
@ary = (1, 3, sort 4, 2);
print @ary;         # prints 1324
```

the commas on the right of the sort are evaluated before the sort, but the commas on the left are evaluated

after. In other words, list operators tend to gobble up all arguments that follow, and then act like a simple TERM with regard to the preceding expression. Be careful with parentheses:

```
# These evaluate exit before doing the print:
print($foo, exit);  # Obviously not what you want.
print $foo, exit;   # Nor is this.

# These do the print before evaluating exit:
(print $foo), exit; # This is what you want.
print($foo), exit;  # Or this.
print ($foo), exit; # Or even this.
```

Also note that

```
print ($foo & 255) + 1, "\n";
```

probably doesn't do what you expect at first glance. See *Named Unary Operators* for more discussion of this.

Also parsed as terms are the `do {}` and `eval {}` constructs, as well as subroutine and method calls, and the anonymous constructors `[]` and `{}`.

See also *Quote and Quote-like Operators* toward the end of this section, as well as *O Operators"*.

The Arrow Operator

"`->`" is an infix dereference operator, just as it is in C and C++. If the right side is either a `[...]`, `{...}`, or a `(...)` subscript, then the left side must be either a hard or symbolic reference to an array, a hash, or a subroutine respectively. (Or technically speaking, a location capable of holding a hard reference, if it's an array or hash reference being used for assignment.) See *perlreftut* and *perlref*.

Otherwise, the right side is a method name or a simple scalar variable containing either the method name or a subroutine reference, and the left side must be either an object (a blessed reference) or a class name (that is, a package name). See *perlobj*.

Auto-increment and Auto-decrement

"++" and "--" work as in C. That is, if placed before a variable, they increment or decrement the variable before returning the value, and if placed after, increment or decrement the variable after returning the value.

The auto-increment operator has a little extra builtin magic to it. If you increment a variable that is numeric, or that has ever been used in a numeric context, you get a normal increment. If, however, the variable has been used in only string contexts since it was set, and has a value that is not the empty string and matches the pattern `/^[a-zA-Z]*[0-9]*\z/`, the increment is done as a string, preserving each character within its range, with carry:

```
print ++($foo = '99');      # prints '100'
print ++($foo = 'a0');      # prints 'a1'
print ++($foo = 'Az');      # prints 'Ba'
print ++($foo = 'zz');      # prints 'aaa'
```

The auto-decrement operator is not magical.

Exponentiation

Binary "**" is the exponentiation operator. It binds even more tightly than unary minus, so -2**4 is -(2**4), not (-2)**4. (This is implemented using C's pow(3) function, which actually works on doubles internally.)

Symbolic Unary Operators

Unary "!" performs logical negation, i.e., "not". See also `not` for a lower precedence version of this.

Unary "-" performs arithmetic negation if the operand is numeric. If the operand is an identifier, a string consisting of a minus sign concatenated with the identifier is returned. Otherwise, if the string starts with a plus or minus, a string starting with the opposite sign is returned. One effect of these rules is that

`-bareword` is equivalent to `"-bareword"`.

Unary "~" performs bitwise negation, i.e., 1's complement. For example, `0666 & ~027` is 0640. (See also *Integer Arithmetic* and *Bitwise String Operators*.) Note that the width of the result is platform-dependent: ~0 is 32 bits wide on a 32-bit platform, but 64 bits wide on a 64-bit platform, so if you are expecting a certain bit width, remember use the `&` operator to mask off the excess bits.

Unary "+" has no effect whatsoever, even on strings. It is useful syntactically for separating a function name from a parenthesized expression that would otherwise be interpreted as the complete list of function arguments. (See examples above under *Terms and List Operators (Leftward)*.)

Unary "\" creates a reference to whatever follows it. See *perlreftut* and *perlref*. Do not confuse this behavior with the behavior of backslash within a string, although both forms do convey the notion of protecting the next thing from interpolation.

Binding Operators

Binary "=~" binds a scalar expression to a pattern match. Certain operations search or modify the string `$_` by default. This operator makes that kind of operation work on some other string. The right argument is a search pattern, substitution, or transliteration. The left argument is what is supposed to be searched, substituted, or transliterated instead of the default `$_`. When used in scalar context, the return value generally indicates the success of the operation. Behavior in list context depends on the particular operator. See for details.

If the right argument is an expression rather than a search pattern, substitution, or transliteration, it is interpreted as a search pattern at run time. This can be less efficient than an explicit search, because the pattern must be compiled every time the expression is evaluated.

Binary "!~" is just like "=~" except the return value is negated in the logical sense.

Multiplicative Operators

Binary "*" multiplies two numbers.

Binary "/" divides two numbers.

Binary "%" computes the modulus of two numbers. Given integer operands `$a` and `$b`: If `$b` is positive, then `$a % $b` is `$a` minus the largest multiple of `$b` that is not greater than `$a`. If `$b` is negative, then `$a % $b` is `$a` minus the smallest multiple of `$b` that is not less than `$a` (i.e. the result will be less than or equal to zero). Note than when `use integer` is in scope, "%" gives you direct access to the modulus operator as implemented by your C compiler. This operator is not as well defined for negative operands, but it will execute faster.

Binary "x" is the repetition operator. In scalar context or if the left operand is not enclosed in parentheses, it returns a string consisting of the left operand repeated the number of times specified by the right operand. In list context, if the left operand is enclosed in parentheses, it repeats the list.

```
print '-' x 80;             # print row of dashes

print "\t" x ($tab/8), ' ' x ($tab%8);      # tab over

@ones = (1) x 80;           # a list of 80 1's
@ones = (5) x @ones;        # set all elements to 5
```

Additive Operators

Binary "+" returns the sum of two numbers.

Binary "-" returns the difference of two numbers.

Binary "." concatenates two strings.

Shift Operators

Binary "<<" returns the value of its left argument shifted left by the number of bits specified by the right argument. Arguments should be integers. (See also *Integer Arithmetic*.)

Binary "" returns the value of its left argument shifted right by the number of bits specified by the right argument. Arguments should be integers. (See also *Integer Arithmetic*.)

Named Unary Operators

The various named unary operators are treated as functions with one argument, with optional parentheses. These include the filetest operators, like `-f`, `-M`, etc. See *perlfunc*.

If any list operator (`print()`, etc.) or any unary operator (`chdir()`, etc.) is followed by a left parenthesis as the next token, the operator and arguments within parentheses are taken to be of highest precedence, just like a normal function call. Examples:

```
chdir $foo    || die;       # (chdir $foo) || die
chdir($foo)   || die;       # (chdir $foo) || die
chdir ($foo)  || die;       # (chdir $foo) || die
chdir +($foo) || die;       # (chdir $foo) || die
```

but, because * is higher precedence than ||:

```
chdir $foo * 20;    # chdir ($foo * 20)
chdir($foo) * 20;   # (chdir $foo) * 20
chdir ($foo) * 20;  # (chdir $foo) * 20
chdir +($foo) * 20; # chdir ($foo * 20)

rand 10 * 20;       # rand (10 * 20)
rand(10) * 20;      # (rand 10) * 20
rand (10) * 20;     # (rand 10) * 20
rand +(10) * 20;    # rand (10 * 20)
```

See also *"Terms and List Operators (Leftward)"*.

Relational Operators

Binary "<" returns true if the left argument is numerically less than the right argument.

Binary "" returns true if the left argument is numerically greater than the right argument.

Binary "<=" returns true if the left argument is numerically less than or equal to the right argument.

Binary "=" returns true if the left argument is numerically greater than or equal to the right argument.

Binary "lt" returns true if the left argument is stringwise less than the right argument.

Binary "gt" returns true if the left argument is stringwise greater than the right argument.

Binary "le" returns true if the left argument is stringwise less than or equal to the right argument.

Binary "ge" returns true if the left argument is stringwise greater than or equal to the right argument.

Equality Operators

Binary "==" returns true if the left argument is numerically equal to the right argument.

Binary "!=" returns true if the left argument is numerically not equal to the right argument.

Binary "<=" returns −1, 0, or 1 depending on whether the left argument is numerically less than, equal to, or greater than the right argument. If your platform supports NaNs (not−a−numbers) as numeric values, using them with "<=" (or any other numeric comparison) returns undef.

Binary "eq" returns true if the left argument is stringwise equal to the right argument.

Binary "ne" returns true if the left argument is stringwise not equal to the right argument.

Binary "cmp" returns −1, 0, or 1 depending on whether the left argument is stringwise less than, equal to, or greater than the right argument.

"lt", "le", "ge", "gt" and "cmp" use the collation (sort) order specified by the current locale if `use locale` is in effect. See *perllocale*.

Bitwise And

Binary "&" returns its operators ANDed together bit by bit. (See also *Integer Arithmetic* and *Bitwise String Operators*.)

Bitwise Or and Exclusive Or

Binary "|" returns its operators ORed together bit by bit. (See also *Integer Arithmetic* and *Bitwise String Operators*.)

Binary "^" returns its operators XORed together bit by bit. (See also *Integer Arithmetic* and *Bitwise String Operators*.)

C–style Logical And

Binary "&&" performs a short–circuit logical AND operation. That is, if the left operand is false, the right operand is not even evaluated. Scalar or list context propagates down to the right operand if it is evaluated.

C–style Logical Or

Binary "||" performs a short–circuit logical OR operation. That is, if the left operand is true, the right operand is not even evaluated. Scalar or list context propagates down to the right operand if it is evaluated.

The || and && operators differ from C's in that, rather than returning 0 or 1, they return the last value evaluated. Thus, a reasonably portable way to find out the home directory (assuming it's not "0") might be:

```
$home = $ENV{'HOME'} || $ENV{'LOGDIR'} ||
    (getpwuid($<))[7] || die "You're homeless!\n";
```

In particular, this means that you shouldn't use this for selecting between two aggregates for assignment:

```
@a = @b || @c;              # this is wrong
@a = scalar(@b) || @c;      # really meant this
@a = @b ? @b : @c;          # this works fine, though
```

As more readable alternatives to && and || when used for control flow, Perl provides and and or operators (see below). The short–circuit behavior is identical. The precedence of "and" and "or" is much lower, however, so that you can safely use them after a list operator without the need for parentheses:

```
unlink "alpha", "beta", "gamma"
        or gripe(), next LINE;
```

With the C–style operators that would have been written like this:

```
unlink("alpha", "beta", "gamma")
        || (gripe(), next LINE);
```

Using "or" for assignment is unlikely to do what you want; see below.

Range Operators

Binary ".." is the range operator, which is really two different operators depending on the context. In list context, it returns an array of values counting (up by ones) from the left value to the right value. If the left value is greater than the right value then it returns the empty array. The range operator is useful for writing foreach (1..10) loops and for doing slice operations on arrays. In the current implementation, no temporary array is created when the range operator is used as the expression in foreach loops, but older versions of Perl might burn a lot of memory when you write something like this:

```
for (1 .. 1_000_000) {
    # code
}
```

In scalar context, ".." returns a boolean value. The operator is bistable, like a flip–flop, and emulates the line–range (comma) operator of **sed**, **awk**, and various editors. Each ".." operator maintains its own boolean state. It is false as long as its left operand is false. Once the left operand is true, the range operator stays true until the right operand is true, *AFTER* which the range operator becomes false again. It doesn't become false

till the next time the range operator is evaluated. It can test the right operand and become false on the same evaluation it became true (as in **awk**), but it still returns true once. If you don't want it to test the right operand till the next evaluation, as in **sed**, just use three dots ("...") instead of two. In all other regards, "..." behaves just like ".." does.

The right operand is not evaluated while the operator is in the "false" state, and the left operand is not evaluated while the operator is in the "true" state. The precedence is a little lower than || and &&. The value returned is either the empty string for false, or a sequence number (beginning with 1) for true. The sequence number is reset for each range encountered. The final sequence number in a range has the string "E0" appended to it, which doesn't affect its numeric value, but gives you something to search for if you want to exclude the endpoint. You can exclude the beginning point by waiting for the sequence number to be greater than 1. If either operand of scalar ".." is a constant expression, that operand is implicitly compared to the $. variable, the current line number. Examples:

As a scalar operator:

```
if (101 .. 200) { print; }  # print 2nd hundred lines
next line if (1 .. /^$/);   # skip header lines
s/^/> / if (/^$/ .. eof()); # quote body

# parse mail messages
while (<>) {
    $in_header =   1  .. /^$/;
    $in_body   = /^$/ .. eof();
    # do something based on those
} continue {
    close ARGV if eof;              # reset $. each file
}
```

As a list operator:

```
for (101 .. 200) { print; } # print $_ 100 times
@foo = @foo[0 .. $#foo];    # an expensive no-op
@foo = @foo[$#foo-4 .. $#foo];      # slice last 5 items
```

The range operator (in list context) makes use of the magical auto−increment algorithm if the operands are strings. You can say

```
@alphabet = ('A' .. 'Z');
```

to get all normal letters of the alphabet, or

```
$hexdigit = (0 .. 9, 'a' .. 'f')[$num & 15];
```

to get a hexadecimal digit, or

```
@z2 = ('01' .. '31');  print $z2[$mday];
```

to get dates with leading zeros. If the final value specified is not in the sequence that the magical increment would produce, the sequence goes until the next value would be longer than the final value specified.

Conditional Operator

Ternary "?:" is the conditional operator, just as in C. It works much like an if−then−else. If the argument before the ? is true, the argument before the : is returned, otherwise the argument after the : is returned. For example:

```
printf "I have %d dog%s.\n", $n,
        ($n == 1) ? '' : "s";
```

Scalar or list context propagates downward into the 2nd or 3rd argument, whichever is selected.

```
$a = $ok ? $b : $c;  # get a scalar
@a = $ok ? @b : @c;  # get an array
```

```
$a = $ok ? @b : @c;  # oops, that's just a count!
```

The operator may be assigned to if both the 2nd and 3rd arguments are legal lvalues (meaning that you can assign to them):

```
($a_or_b ? $a : $b) = $c;
```

Because this operator produces an assignable result, using assignments without parentheses will get you in trouble. For example, this:

```
$a % 2 ? $a += 10 : $a += 2
```

Really means this:

```
(($a % 2) ? ($a += 10) : $a) += 2
```

Rather than this:

```
($a % 2) ? ($a += 10) : ($a += 2)
```

That should probably be written more simply as:

```
$a += ($a % 2) ? 10 : 2;
```

Assignment Operators

"=" is the ordinary assignment operator.

Assignment operators work as in C. That is,

```
$a += 2;
```

is equivalent to

```
$a = $a + 2;
```

although without duplicating any side effects that dereferencing the lvalue might trigger, such as from `tie()`. Other assignment operators work similarly. The following are recognized:

```
**=     +=     *=     &=     <<=     &&=
        -=     /=     |=     >>=     ||=
        .=     %=     ^=
               x=
```

Although these are grouped by family, they all have the precedence of assignment.

Unlike in C, the scalar assignment operator produces a valid lvalue. Modifying an assignment is equivalent to doing the assignment and then modifying the variable that was assigned to. This is useful for modifying a copy of something, like this:

```
($tmp = $global) =~ tr [A-Z] [a-z];
```

Likewise,

```
($a += 2) *= 3;
```

is equivalent to

```
$a += 2;
$a *= 3;
```

Similarly, a list assignment in list context produces the list of lvalues assigned to, and a list assignment in scalar context returns the number of elements produced by the expression on the right hand side of the assignment.

Comma Operator

Binary "," is the comma operator. In scalar context it evaluates its left argument, throws that value away, then evaluates its right argument and returns that value. This is just like C's comma operator.

In list context, it's just the list argument separator, and inserts both its arguments into the list.

The = digraph is mostly just a synonym for the comma operator. It's useful for documenting arguments that come in pairs. As of release 5.001, it also forces any word to the left of it to be interpreted as a string.

List Operators (Rightward)

On the right side of a list operator, it has very low precedence, such that it controls all comma−separated expressions found there. The only operators with lower precedence are the logical operators "and", "or", and "not", which may be used to evaluate calls to list operators without the need for extra parentheses:

```
open HANDLE, "filename"
    or die "Can't open: $!\n";
```

See also discussion of list operators in *Terms and List Operators (Leftward)*.

Logical Not

Unary "not" returns the logical negation of the expression to its right. It's the equivalent of "!" except for the very low precedence.

Logical And

Binary "and" returns the logical conjunction of the two surrounding expressions. It's equivalent to && except for the very low precedence. This means that it short−circuits: i.e., the right expression is evaluated only if the left expression is true.

Logical or and Exclusive Or

Binary "or" returns the logical disjunction of the two surrounding expressions. It's equivalent to || except for the very low precedence. This makes it useful for control flow

```
print FH $data              or die "Can't write to FH: $!";
```

This means that it short−circuits: i.e., the right expression is evaluated only if the left expression is false. Due to its precedence, you should probably avoid using this for assignment, only for control flow.

```
$a = $b or $c;              # bug: this is wrong
($a = $b) or $c;            # really means this
$a = $b || $c;              # better written this way
```

However, when it's a list−context assignment and you're trying to use "||" for control flow, you probably need "or" so that the assignment takes higher precedence.

```
@info = stat($file) || die;     # oops, scalar sense of stat!
@info = stat($file) or die;     # better, now @info gets its due
```

Then again, you could always use parentheses.

Binary "xor" returns the exclusive−OR of the two surrounding expressions. It cannot short circuit, of course.

C Operators Missing From Perl

Here is what C has that Perl doesn't:

unary & Address−of operator. (But see the "\" operator for taking a reference.)

unary * Dereference−address operator. (Perl's prefix dereferencing operators are typed: $, @, %, and &.)

(TYPE) Type−casting operator.

Quote and Quote−like Operators

While we usually think of quotes as literal values, in Perl they function as operators, providing various kinds of interpolating and pattern matching capabilities. Perl provides customary quote characters for these behaviors, but also provides a way for you to choose your quote character for any of them. In the following table, a { } represents any pair of delimiters you choose.

```
Customary  Generic        MeaningInterpolates
    ''       q{}          Literal     no
    ""      qq{}          Literal     yes
    ``      qx{}          Command             yes (unless '' is delimiter)
            qw{}         Word list            no
    //       m{}       Pattern match  yes (unless '' is delimiter)
            qr{}          Pattern             yes (unless '' is delimiter)
             s{}{}      Substitution  yes (unless '' is delimiter)
            tr{}{}    Transliteration no (but see below)
```

Non-bracketing delimiters use the same character fore and aft, but the four sorts of brackets (round, angle, square, curly) will all nest, which means that

```
q{foo{bar}baz}
```

is the same as

```
'foo{bar}baz'
```

Note, however, that this does not always work for quoting Perl code:

```
$s = q{ if($a eq "}") ... }; # WRONG
```

is a syntax error. The `Text::Balanced` module on CPAN is able to do this properly.

There can be whitespace between the operator and the quoting characters, except when # is being used as the quoting character. `q#foo#` is parsed as the string `foo`, while `q #foo#` is the operator `q` followed by a comment. Its argument will be taken from the next line. This allows you to write:

```
s {foo}  # Replace foo
  {bar}  # with bar.
```

For constructs that do interpolate, variables beginning with "$" or "@" are interpolated, as are the following escape sequences. Within a transliteration, the first eleven of these sequences may be used.

```
\t          tab             (HT, TAB)
\n          newline         (NL)
\r          return          (CR)
\f          form feed       (FF)
\b          backspace       (BS)
\a          alarm (bell)    (BEL)
\e          escape          (ESC)
\033        octal char      (ESC)
\x1b        hex char        (ESC)
\x{263a}    wide hex char   (SMILEY)
\c[         control char    (ESC)
\N{name}    named char

\l          lowercase next char
\u          uppercase next char
\L          lowercase till \E
\U          uppercase till \E
\E          end case modification
\Q          quote non-word characters till \E
```

If `use locale` is in effect, the case map used by `\l`, `\L`, `\u` and `\U` is taken from the current locale. See *perllocale*. For documentation of `\N{name}`, see *charnames*.

All systems use the virtual `"\n"` to represent a line terminator, called a "newline". There is no such thing as an unvarying, physical newline character. It is only an illusion that the operating system, device drivers, C libraries, and Perl all conspire to preserve. Not all systems read `"\r"` as ASCII CR and `"\n"` as ASCII LF.

For example, on a Mac, these are reversed, and on systems without line terminator, printing "\n" may emit no actual data. In general, use "\n" when you mean a "newline" for your system, but use the literal ASCII when you need an exact character. For example, most networking protocols expect and prefer a CR+LF ("\015\012" or "\cM\cJ") for line terminators, and although they often accept just "\012", they seldom tolerate just "\015". If you get in the habit of using "\n" for networking, you may be burned some day.

You cannot include a literal $ or @ within a \Q sequence. An unescaped $ or @ interpolates the corresponding variable, while escaping will cause the literal string \$ to be inserted. You'll need to write something like m/\Quser\E\@\Qhost/.

Patterns are subject to an additional level of interpretation as a regular expression. This is done as a second pass, after variables are interpolated, so that regular expressions may be incorporated into the pattern from the variables. If this is not what you want, use \Q to interpolate a variable literally.

Apart from the behavior described above, Perl does not expand multiple levels of interpolation. In particular, contrary to the expectations of shell programmers, back–quotes do *NOT* interpolate within double quotes, nor do single quotes impede evaluation of variables when used within double quotes.

Regexp Quote–Like Operators

Here are the quote–like operators that apply to pattern matching and related activities.

?PATTERN?

This is just like the /pattern/ search, except that it matches only once between calls to the reset() operator. This is a useful optimization when you want to see only the first occurrence of something in each file of a set of files, for instance. Only ?? patterns local to the current package are reset.

```
while (<>) {
    if (?^$?) {
                            # blank line between header and body
    }
} continue {
    reset if eof;           # clear ?? status for next file
}
```

This usage is vaguely depreciated, which means it just might possibly be removed in some distant future version of Perl, perhaps somewhere around the year 2168.

m/PATTERN/cgimosx
/PATTERN/cgimosx

Searches a string for a pattern match, and in scalar context returns true if it succeeds, false if it fails. If no string is specified via the =~ or !~ operator, the $_ string is searched. (The string specified with =~ need not be an lvalue—it may be the result of an expression evaluation, but remember the =~ binds rather tightly.) See also *perlre*. See *perllocale* for discussion of additional considerations that apply when use locale is in effect.

Options are:

```
c   Do not reset search position on a failed match when /g is in effect.
g   Match globally, i.e., find all occurrences.
i   Do case-insensitive pattern matching.
m   Treat string as multiple lines.
o   Compile pattern only once.
s   Treat string as single line.
x   Use extended regular expressions.
```

If "/" is the delimiter then the initial m is optional. With the m you can use any pair of non–alphanumeric, non–whitespace characters as delimiters. This is particularly useful for

matching path names that contain "/", to avoid LTS (leaning toothpick syndrome). If "?" is the delimiter, then the match-only-once rule of `?PATTERN?` applies. If "`" is the delimiter, no interpolation is performed on the PATTERN.

PATTERN may contain variables, which will be interpolated (and the pattern recompiled) every time the pattern search is evaluated, except for when the delimiter is a single quote. (Note that `$(`, `$)`, and `$|` are not interpolated because they look like end-of-string tests.) If you want such a pattern to be compiled only once, add a `/o` after the trailing delimiter. This avoids expensive run-time recompilations, and is useful when the value you are interpolating won't change over the life of the script. However, mentioning `/o` constitutes a promise that you won't change the variables in the pattern. If you change them, Perl won't even notice. See also *imosx"*.

If the PATTERN evaluates to the empty string, the last *successfully* matched regular expression is used instead.

If the `/g` option is not used, `m//` in list context returns a list consisting of the subexpressions matched by the parentheses in the pattern, i.e., `($1, $2, $3...)`. (Note that here `$1` etc. are also set, and that this differs from Perl 4's behavior.) When there are no parentheses in the pattern, the return value is the list `(1)` for success. With or without parentheses, an empty list is returned upon failure.

Examples:

```
open(TTY, '/dev/tty');
<TTY> =~ /^y/i && foo();    # do foo if desired

if (/Version: *([0-9.]*)/) { $version = $1; }

next if m#^/usr/spool/uucp#;

# poor man's grep
$arg = shift;
while (<>) {
    print if /$arg/o;       # compile only once
}

if (($F1, $F2, $Etc) = ($foo =~ /^(\S+)\s+(\S+)\s*(.*)/))
```

This last example splits `$foo` into the first two words and the remainder of the line, and assigns those three fields to `$F1`, `$F2`, and `$Etc`. The conditional is true if any variables were assigned, i.e., if the pattern matched.

The `/g` modifier specifies global pattern matching—that is, matching as many times as possible within the string. How it behaves depends on the context. In list context, it returns a list of the substrings matched by any capturing parentheses in the regular expression. If there are no parentheses, it returns a list of all the matched strings, as if there were parentheses around the whole pattern.

In scalar context, each execution of `m//g` finds the next match, returning true if it matches, and false if there is no further match. The position after the last match can be read or set using the `pos()` function; see *pos*. A failed match normally resets the search position to the beginning of the string, but you can avoid that by adding the `/c` modifier (e.g. `m//gc`). Modifying the target string also resets the search position.

You can intermix `m//g` matches with `m/\G.../g`, where `\G` is a zero-width assertion that matches the exact position where the previous `m//g`, if any, left off. Without the `/g` modifier, the `\G` assertion still anchors at `pos()`, but the match is of course only attempted once. Using `\G` without `/g` on a target string that has not previously had a `/g` match applied to it is the same as using the `\A` assertion to match the beginning of the string.

Examples:

```
# list context
($one,$five,$fifteen) = (`uptime` =~ /(\d+\.\d+)/g);

# scalar context
$/ = "";
while (defined($paragraph = <>)) {
    while ($paragraph =~ /[a-z]['")]*[.!?]+['")]*\s/g) {
        $sentences++;
    }
}
print "$sentences\n";

# using m//gc with \G
$_ = "ppooqppqq";
while ($i++ < 2) {
    print "1: '";
    print $1 while /(o)/gc; print "', pos=", pos, "\n";
    print "2: '";
    print $1 if /\G(q)/gc;  print "', pos=", pos, "\n";
    print "3: '";
    print $1 while /(p)/gc; print "', pos=", pos, "\n";
}
print "Final: '$1', pos=",pos,"\n" if /\G(.)/;
```

The last example should print:

```
1: 'oo', pos=4
2: 'q', pos=5
3: 'pp', pos=7
1: '', pos=7
2: 'q', pos=8
3: '', pos=8
Final: 'q', pos=8
```

Notice that the final match matched `q` instead of `p`, which a match without the `\G` anchor would have done. Also note that the final match did not update `pos` — `pos` is only updated on a `/g` match. If the final match did indeed match `p`, it's a good bet that you're running an older (pre–5.6.0) Perl.

A useful idiom for `lex`–like scanners is `/\G.../gc`. You can combine several regexps like this to process a string part–by–part, doing different actions depending on which regexp matched. Each regexp tries to match where the previous one leaves off.

```
$_ = <<'EOL';
     $url = new URI::URL "http://www/";   die if $url eq "xXx";
EOL
LOOP:
   {
     print(" digits"),          redo LOOP if /\G\d+\b[,.;]?\s*/gc;
     print(" lowercase"),       redo LOOP if /\G[a-z]+\b[,.;]?\s*/gc;
     print(" UPPERCASE"),       redo LOOP if /\G[A-Z]+\b[,.;]?\s*/gc;
     print(" Capitalized"),     redo LOOP if /\G[A-Z][a-z]+\b[,.;]?\s*/gc;
     print(" MiXeD"),           redo LOOP if /\G[A-Za-z]+\b[,.;]?\s*/gc;
     print(" alphanumeric"),    redo LOOP if /\G[A-Za-z0-9]+\b[,.;]?\s*/gc;
     print(" line-noise"),      redo LOOP if /\G[^A-Za-z0-9]+/gc;
     print ". That's all!\n";
```

```
    }
```

Here is the output (split into several lines):

```
line-noise lowercase line-noise lowercase UPPERCASE line-noise
UPPERCASE line-noise lowercase line-noise lowercase line-noise
lowercase lowercase line-noise lowercase lowercase line-noise
MiXeD line-noise. That's all!
```

q/STRING/
'STRING'

A single-quoted, literal string. A backslash represents a backslash unless followed by the delimiter or another backslash, in which case the delimiter or backslash is interpolated.

```
$foo = q!I said, "You said, 'She said it.'"!;
$bar = q('This is it.');
$baz = '\n';                # a two-character string
```

qq/STRING/
"STRING"

A double-quoted, interpolated string.

```
$_ .= qq
 (*** The previous line contains the naughty word "$1".\n)
            if /\b(tcl|java|python)\b/i;      # :-)
$baz = "\n";                # a one-character string
```

qr/STRING/imosx

This operator quotes (and possibly compiles) its *STRING* as a regular expression. *STRING* is interpolated the same way as *PATTERN* in `m/PATTERN/`. If "`" is used as the delimiter, no interpolation is done. Returns a Perl value which may be used instead of the corresponding `/STRING/imosx` expression.

For example,

```
$rex = qr/my.STRING/is;
s/$rex/foo/;
```

is equivalent to

```
s/my.STRING/foo/is;
```

The result may be used as a subpattern in a match:

```
$re = qr/$pattern/;
$string =~ /foo${re}bar/;   # can be interpolated in other patterns
$string =~ $re;             # or used standalone
$string =~ /$re/;           # or this way
```

Since Perl may compile the pattern at the moment of execution of `qr()` operator, using `qr()` may have speed advantages in some situations, notably if the result of `qr()` is used standalone:

```
sub match {
    my $patterns = shift;
    my @compiled = map qr/$_/i, @$patterns;
    grep {
        my $success = 0;
        foreach my $pat (@compiled) {
            $success = 1, last if /$pat/;
        }
        $success;
```

```
    } @_;
}
```

Precompilation of the pattern into an internal representation at the moment of `qr()` avoids a need to recompile the pattern every time a match `/$pat/` is attempted. (Perl has many other internal optimizations, but none would be triggered in the above example if we did not use `qr()` operator.)

Options are:

```
i   Do case-insensitive pattern matching.
m   Treat string as multiple lines.
o   Compile pattern only once.
s   Treat string as single line.
x   Use extended regular expressions.
```

See *perlre* for additional information on valid syntax for STRING, and for a detailed look at the semantics of regular expressions.

qx/STRING/
‘STRING‘ A string which is (possibly) interpolated and then executed as a system command with `/bin/sh` or its equivalent. Shell wildcards, pipes, and redirections will be honored. The collected standard output of the command is returned; standard error is unaffected. In scalar context, it comes back as a single (potentially multi−line) string, or undef if the command failed. In list context, returns a list of lines (however you‘ve defined lines with `$/` or `$INPUT_RECORD_SEPARATOR)`, or an empty list if the command failed.

Because backticks do not affect standard error, use shell file descriptor syntax (assuming the shell supports this) if you care to address this. To capture a command‘s STDERR and STDOUT together:

```
$output = ‘cmd 2>&1‘;
```

To capture a command‘s STDOUT but discard its STDERR:

```
$output = ‘cmd 2>/dev/null‘;
```

To capture a command‘s STDERR but discard its STDOUT (ordering is important here):

```
$output = ‘cmd 2>&1 1>/dev/null‘;
```

To exchange a command‘s STDOUT and STDERR in order to capture the STDERR but leave its STDOUT to come out the old STDERR:

```
$output = ‘cmd 3>&1 1>&2 2>&3 3>&-‘;
```

To read both a command‘s STDOUT and its STDERR separately, it‘s easiest and safest to redirect them separately to files, and then read from those files when the program is done:

```
system("program args 1>/tmp/program.stdout 2>/tmp/program.stderr");
```

Using single−quote as a delimiter protects the command from Perl‘s double−quote interpolation, passing it on to the shell instead:

```
$perl_info  = qx(ps $$);            # that’s Perl’s $$
$shell_info = qx’ps $$’;            # that’s the new shell’s $$
```

How that string gets evaluated is entirely subject to the command interpreter on your system. On most platforms, you will have to protect shell metacharacters if you want them treated literally. This is in practice difficult to do, as it‘s unclear how to escape which characters. See *perlsec* for a clean and safe example of a manual `fork()` and `exec()` to emulate backticks safely.

On some platforms (notably DOS−like ones), the shell may not be capable of dealing with multiline commands, so putting newlines in the string may not get you what you want. You may

be able to evaluate multiple commands in a single line by separating them with the command separator character, if your shell supports that (e.g. `;` on many Unix shells; `&` on the Windows NT `cmd` shell).

Beginning with v5.6.0, Perl will attempt to flush all files opened for output before starting the child process, but this may not be supported on some platforms (see *perlport*). To be safe, you may need to set `$|` (`$AUTOFLUSH` in English) or call the `autoflush()` method of `IO::Handle` on any open handles.

Beware that some command shells may place restrictions on the length of the command line. You must ensure your strings don't exceed this limit after any necessary interpolations. See the platform-specific release notes for more details about your particular environment.

Using this operator can lead to programs that are difficult to port, because the shell commands called vary between systems, and may in fact not be present at all. As one example, the `type` command under the POSIX shell is very different from the `type` command under DOS. That doesn't mean you should go out of your way to avoid backticks when they're the right way to get something done. Perl was made to be a glue language, and one of the things it glues together is commands. Just understand what you're getting yourself into.

See *O Operators"* for more discussion.

qw/STRING/

Evaluates to a list of the words extracted out of STRING, using embedded whitespace as the word delimiters. It can be understood as being roughly equivalent to:

```
split(' ', q/STRING/);
```

the difference being that it generates a real list at compile time. So this expression:

```
qw(foo bar baz)
```

is semantically equivalent to the list:

```
'foo', 'bar', 'baz'
```

Some frequently seen examples:

```
use POSIX qw( setlocale localeconv )
@EXPORT = qw( foo bar baz );
```

A common mistake is to try to separate the words with comma or to put comments into a multi-line `qw`-string. For this reason, the `use warnings` pragma and the **-w** switch (that is, the `$^W` variable) produces warnings if the STRING contains the "," or the "#" character.

s/PATTERN/REPLACEMENT/egimosx

Searches a string for a pattern, and if found, replaces that pattern with the replacement text and returns the number of substitutions made. Otherwise it returns false (specifically, the empty string).

If no string is specified via the `=~` or `!~` operator, the `$_` variable is searched and modified. (The string specified with `=~` must be scalar variable, an array element, a hash element, or an assignment to one of those, i.e., an lvalue.)

If the delimiter chosen is a single quote, no interpolation is done on either the PATTERN or the REPLACEMENT. Otherwise, if the PATTERN contains a `$` that looks like a variable rather than an end-of-string test, the variable will be interpolated into the pattern at run-time. If you want the pattern compiled only once the first time the variable is interpolated, use the `/o` option. If the pattern evaluates to the empty string, the last successfully executed regular expression is used instead. See *perlre* for further explanation on these. See *perllocale* for discussion of additional considerations that apply when `use locale` is in effect.

Options are:

```
e   Evaluate the right side as an expression.
g   Replace globally, i.e., all occurrences.
i   Do case-insensitive pattern matching.
m   Treat string as multiple lines.
o   Compile pattern only once.
s   Treat string as single line.
x   Use extended regular expressions.
```

Any non-alphanumeric, non-whitespace delimiter may replace the slashes. If single quotes are used, no interpretation is done on the replacement string (the `/e` modifier overrides this, however). Unlike Perl 4, Perl 5 treats backticks as normal delimiters; the replacement text is not evaluated as a command. If the PATTERN is delimited by bracketing quotes, the REPLACEMENT has its own pair of quotes, which may or may not be bracketing quotes, e.g., `s(foo)(bar)` or `< s<foo/bar/` . A `/e` will cause the replacement portion to be treated as a full-fledged Perl expression and evaluated right then and there. It is, however, syntax checked at compile-time. A second `e` modifier will cause the replacement portion to be `eval`ed before being run as a Perl expression.

Examples:

```
s/\bgreen\b/mauve/g;                # don't change wintergreen

$path =~ s|/usr/bin|/usr/local/bin|;

s/Login: $foo/Login: $bar/; # run-time pattern

($foo = $bar) =~ s/this/that/;      # copy first, then change

$count = ($paragraph =~ s/Mister\b/Mr./g);  # get change-count

$_ = 'abc123xyz';
s/\d+/$&*2/e;               # yields 'abc246xyz'
s/\d+/sprintf("%5d",$&)/e;  # yields 'abc  246xyz'
s/\w/$& x 2/eg;             # yields 'aabbcc  224466xxyyzz'

s/%(.)/$percent{$1}/g;      # change percent escapes; no /e
s/%(.)/$percent{$1} || $&/ge;       # expr now, so /e
s/^=(\w+)/&pod($1)/ge;      # use function call

# expand variables in $_, but dynamics only, using
# symbolic dereferencing
s/\$(\w+)/${$1}/g;

# Add one to the value of any numbers in the string
s/(\d+)/1 + $1/eg;

# This will expand any embedded scalar variable
# (including lexicals) in $_ : First $1 is interpolated
# to the variable name, and then evaluated
s/(\$\w+)/$1/eeg;

# Delete (most) C comments.
$program =~ s {
    /\*     # Match the opening delimiter.
    .*?     # Match a minimal number of characters.
    \*/     # Match the closing delimiter.
} []gsx;

s/^\s*(.*?)\s*$/$1/;        # trim white space in $_, expensively
```

```
for ($variable) {    # trim white space in $variable, cheap
    s/^\s+//;
    s/\s+$//;
}

s/([^ ]*) *([^ ]*)/$2 $1/;  # reverse 1st two fields
```

Note the use of $ instead of \ in the last example. Unlike **sed**, we use the \<*digit* form in only the left hand side. Anywhere else it's $<*digit*.

Occasionally, you can't use just a /g to get all the changes to occur that you might want. Here are two common cases:

```
# put commas in the right places in an integer
1 while s/(\d)(\d\d\d)(?!\d)/$1,$2/g;

# expand tabs to 8-column spacing
1 while s/\t+/' ' x (length($&)*8 - length($`)%8)/e;
```

tr/SEARCHLIST/REPLACEMENTLIST/cds
y/SEARCHLIST/REPLACEMENTLIST/cds

Transliterates all occurrences of the characters found in the search list with the corresponding character in the replacement list. It returns the number of characters replaced or deleted. If no string is specified via the =~ or !~ operator, the $_ string is transliterated. (The string specified with =~ must be a scalar variable, an array element, a hash element, or an assignment to one of those, i.e., an lvalue.)

A character range may be specified with a hyphen, so tr/A-J/0-9/ does the same replacement as tr/ACEGIBDFHJ/0246813579/. For **sed** devotees, y is provided as a synonym for tr. If the SEARCHLIST is delimited by bracketing quotes, the REPLACEMENTLIST has its own pair of quotes, which may or may not be bracketing quotes, e.g., tr[A-Z][a-z] or tr(+\-*/)/ABCD/.

Note that tr does **not** do regular expression character classes such as \d or [:lower:]. The <tr operator is not equivalent to the tr(1) utility. If you want to map strings between lower/upper cases, see *lc* and *uc*, and in general consider using the s operator if you need regular expressions.

Note also that the whole range idea is rather unportable between character sets—and even within character sets they may cause results you probably didn't expect. A sound principle is to use only ranges that begin from and end at either alphabets of equal case (a–e, A–E), or digits (0–4). Anything else is unsafe. If in doubt, spell out the character sets in full.

Options:

```
c   Complement the SEARCHLIST.
d   Delete found but unreplaced characters.
s   Squash duplicate replaced characters.
```

If the /c modifier is specified, the SEARCHLIST character set is complemented. If the /d modifier is specified, any characters specified by SEARCHLIST not found in REPLACEMENTLIST are deleted. (Note that this is slightly more flexible than the behavior of some **tr** programs, which delete anything they find in the SEARCHLIST, period.) If the /s modifier is specified, sequences of characters that were transliterated to the same character are squashed down to a single instance of the character.

If the /d modifier is used, the REPLACEMENTLIST is always interpreted exactly as specified. Otherwise, if the REPLACEMENTLIST is shorter than the SEARCHLIST, the final character is replicated till it is long enough. If the REPLACEMENTLIST is empty, the SEARCHLIST is replicated. This latter is useful for counting characters in a class or for squashing character sequences in a class.

Examples:

```
$ARGV[1] =~ tr/A-Z/a-z/;     # canonicalize to lower case

$cnt = tr/*/*/;              # count the stars in $_

$cnt = $sky =~ tr/*/*/;      # count the stars in $sky

$cnt = tr/0-9//;             # count the digits in $_

tr/a-zA-Z//s;                # bookkeeper -> bokeper

($HOST = $host) =~ tr/a-z/A-Z/;

tr/a-zA-Z/ /cs;              # change non-alphas to single space

tr [\200-\377]
   [\000-\177];              # delete 8th bit
```

If multiple transliterations are given for a character, only the first one is used:

```
tr/AAA/XYZ/
```

will transliterate any A to X.

Because the transliteration table is built at compile time, neither the SEARCHLIST nor the REPLACEMENTLIST are subjected to double quote interpolation. That means that if you want to use variables, you must use an `eval()`:

```
eval "tr/$oldlist/$newlist/";
die $@ if $@;

eval "tr/$oldlist/$newlist/, 1" or die $@;
```

Gory details of parsing quoted constructs

When presented with something that might have several different interpretations, Perl uses the **DWIM** (that's "Do What I Mean") principle to pick the most probable interpretation. This strategy is so successful that Perl programmers often do not suspect the ambivalence of what they write. But from time to time, Perl's notions differ substantially from what the author honestly meant.

This section hopes to clarify how Perl handles quoted constructs. Although the most common reason to learn this is to unravel labyrinthine regular expressions, because the initial steps of parsing are the same for all quoting operators, they are all discussed together.

The most important Perl parsing rule is the first one discussed below: when processing a quoted construct, Perl first finds the end of that construct, then interprets its contents. If you understand this rule, you may skip the rest of this section on the first reading. The other rules are likely to contradict the user's expectations much less frequently than this first one.

Some passes discussed below are performed concurrently, but because their results are the same, we consider them individually. For different quoting constructs, Perl performs different numbers of passes, from one to five, but these passes are always performed in the same order.

Finding the end

The first pass is finding the end of the quoted construct, whether it be a multicharacter delimiter `"\nEOF\n"` in the `<<EOF` construct, a `/` that terminates a `qq//` construct, a `]` which terminates `qq[]` construct, or a `<` which terminates a fileglob started with `<`. `<`.

When searching for single-character non-pairing delimiters, such as `/`, combinations of `\\` and `\/` are skipped. However, when searching for single-character pairing delimiter like `[`, combinations of `\\`, `\]`, and `\[` are all skipped, and nested `[`, `]` are skipped as well. When searching for multicharacter delimiters, nothing is skipped.

For constructs with three-part delimiters (`s///`, `y///`, and `tr///`), the search is repeated once more.

During this search no attention is paid to the semantics of the construct. Thus:

```
"$hash{"$foo/$bar"}"
```

or:

```
m/
  bar       # NOT a comment, this slash / terminated m//!
 /x
```

do not form legal quoted expressions. The quoted part ends on the first " and /, and the rest happens to be a syntax error. Because the slash that terminated m// was followed by a SPACE, the example above is not m//x, but rather m// with no /x modifier. So the embedded # is interpreted as a literal #.

Removal of backslashes before delimiters

During the second pass, text between the starting and ending delimiters is copied to a safe location, and the \ is removed from combinations consisting of \ and delimiter—or delimiters, meaning both starting and ending delimiters will should these differ. This removal does not happen for multi−character delimiters. Note that the combination \\ is left intact, just as it was.

Starting from this step no information about the delimiters is used in parsing.

Interpolation

The next step is interpolation in the text obtained, which is now delimiter−independent. There are four different cases.

<<'EOF', m'', s''', tr///, y///

No interpolation is performed.

'', q//

The only interpolation is removal of \ from pairs \\.

"", ``, qq//, qx//, < <file*glob

\Q, \U, \u, \L, \l (possibly paired with \E) are converted to corresponding Perl constructs. Thus, "$foo\Qbaz$bar" is converted to $foo . (quotemeta("baz" . $bar)) internally. The other combinations are replaced with appropriate expansions.

Let it be stressed that *whatever falls between \Q and \E* is interpolated in the usual way. Something like "\Q\\E" has no \E inside. instead, it has \Q, \\, and E, so the result is the same as for "\\\\E". As a general rule, backslashes between \Q and \E may lead to counterintuitive results. So, "\Q\t\E" is converted to quotemeta("\t"), which is the same as "\\\t" (since TAB is not alphanumeric). Note also that:

```
$str = '\t';
return "\Q$str";
```

may be closer to the conjectural *intention* of the writer of "\Q\t\E".

Interpolated scalars and arrays are converted internally to the join and . catenation operations. Thus, "$foo XXX '@arr'" becomes:

```
$foo . " XXX '" . (join $", @arr) . "'";
```

All operations above are performed simultaneously, left to right.

Because the result of "\Q STRING \E" has all metacharacters quoted, there is no way to insert a literal $ or @ inside a \Q\E pair. If protected by \, $ will be quoted to became "\\\$"; if not, it is interpreted as the start of an interpolated scalar.

Note also that the interpolation code needs to make a decision on where the interpolated scalar ends. For instance, whether < "a $b −{c}" really means:

```
"a " . $b . " -> {c}";
```

or:

```
"a " . $b -> {c};
```

Most of the time, the longest possible text that does not include spaces between components and which contains matching braces or brackets. because the outcome may be determined by voting based on heuristic estimators, the result is not strictly predictable. Fortunately, it's usually correct for ambiguous cases.

`?RE?`, `/RE/`, `m/RE/`, `s/RE/foo/`,

Processing of `\Q`, `\U`, `\u`, `\L`, `\l`, and interpolation happens (almost) as with `qq//` constructs, but the substitution of `\` followed by RE–special chars (including `\`) is not performed. Moreover, inside `(?{BLOCK})`, `(?# comment )`, and a `#`–comment in a `//x`–regular expression, no processing is performed whatsoever. This is the first step at which the presence of the `//x` modifier is relevant.

Interpolation has several quirks: `$|`, `$(`, and `$)` are not interpolated, and constructs `$var[SOMETHING]` are voted (by several different estimators) to be either an array element or `$var` followed by an RE alternative. This is where the notation `${arr[$bar]}` comes handy: `/${arr[0-9]}/` is interpreted as array element `-9`, not as a regular expression from the variable `$arr` followed by a digit, which would be the interpretation of `/$arr[0-9]/`. Since voting among different estimators may occur, the result is not predictable.

It is at this step that `\1` is begrudgingly converted to `$1` in the replacement text of `s///` to correct the incorrigible *sed* hackers who haven't picked up the saner idiom yet. A warning is emitted if the `use warnings` pragma or the **–w** command–line flag (that is, the `$^W` variable) was set.

The lack of processing of `\\` creates specific restrictions on the post–processed text. If the delimiter is `/`, one cannot get the combination `\/` into the result of this step. `/` will finish the regular expression, `\/` will be stripped to `/` on the previous step, and `\\/` will be left as is. Because `/` is equivalent to `\/` inside a regular expression, this does not matter unless the delimiter happens to be character special to the RE engine, such as in `s*foo*bar*`, `m[foo]`, or `?foo?`; or an alphanumeric char, as in:

```
m m ^ a \s* b mmx;
```

In the RE above, which is intentionally obfuscated for illustration, the delimiter is `m`, the modifier is `mx`, and after backslash–removal the RE is the same as for `m/ ^ a s* b /mx`). There's more than one reason you're encouraged to restrict your delimiters to non–alphanumeric, non–whitespace choices.

This step is the last one for all constructs except regular expressions, which are processed further.

Interpolation of regular expressions

Previous steps were performed during the compilation of Perl code, but this one happens at run time—although it may be optimized to be calculated at compile time if appropriate. After preprocessing described above, and possibly after evaluation if catenation, joining, casing translation, or metaquoting are involved, the resulting *string* is passed to the RE engine for compilation.

Whatever happens in the RE engine might be better discussed in *perlre*, but for the sake of continuity, we shall do so here.

This is another step where the presence of the `//x` modifier is relevant. The RE engine scans the string from left to right and converts it to a finite automaton.

Backslashed characters are either replaced with corresponding literal strings (as with `\{`), or else they generate special nodes in the finite automaton (as with `\b`). Characters special to the RE engine (such as `|`) generate corresponding nodes or groups of nodes. `(?#...)` comments are ignored. All the rest

is either converted to literal strings to match, or else is ignored (as is whitespace and #–style comments if //x is present).

Parsing of the bracketed character class construct, [...], is rather different than the rule used for the rest of the pattern. The terminator of this construct is found using the same rules as for finding the terminator of a {}–delimited construct, the only exception being that] immediately following [is treated as though preceded by a backslash. Similarly, the terminator of (?{...}) is found using the same rules as for finding the terminator of a {}–delimited construct.

It is possible to inspect both the string given to RE engine and the resulting finite automaton. See the arguments debug/debugcolor in the use re pragma, as well as Perl's **–Dr** command–line switch documented in *Command Switches in perlrun*.

Optimization of regular expressions

This step is listed for completeness only. Since it does not change semantics, details of this step are not documented and are subject to change without notice. This step is performed over the finite automaton that was generated during the previous pass.

It is at this stage that split() silently optimizes /^/ to mean /^/m.

I/O Operators

There are several I/O operators you should know about.

A string enclosed by backticks (grave accents) first undergoes double–quote interpolation. It is then interpreted as an external command, and the output of that command is the value of the pseudo–literal, j string consisting of all output is returned. In list context, a list of values is returned, one per line of output. (You can set $/ to use a different line terminator.) The command is executed each time the pseudo–literal is evaluated. The status value of the command is returned in $? (see *perlvar* for the interpretation of $?). Unlike in **csh**, no translation is done on the return data—newlines remain newlines. Unlike in any of the shells, single quotes do not hide variable names in the command from interpretation. To pass a literal dollar–sign through to the shell you need to hide it with a backslash. The generalized form of backticks is qx//. (Because backticks always undergo shell expansion as well, see *perlsec* for security concerns.)

In scalar context, evaluating a filehandle in angle brackets yields the next line from that file (the newline, if any, included), or undef at end–of–file or on error. When $/ is set to undef (sometimes known as file–slurp mode) and the file is empty, it returns '' the first time, followed by undef subsequently.

Ordinarily you must assign the returned value to a variable, but there is one situation where an automatic assignment happens. If and only if the input symbol is the only thing inside the conditional of a while statement (even if disguised as a for(;;) loop), the value is automatically assigned to the global variable $_, destroying whatever was there previously. (This may seem like an odd thing to you, but you'll use the construct in almost every Perl script you write.) The $_ variables is not implicitly localized. You'll have to put a local $_; before the loop if you want that to happen.

The following lines are equivalent:

```
while (defined($_ = <STDIN>)) { print; }
while ($_ = <STDIN>) { print; }
while (<STDIN>) { print; }
for (;<STDIN>;) { print; }
print while defined($_ = <STDIN>);
print while ($_ = <STDIN>);
print while <STDIN>;
```

This also behaves similarly, but avoids $_ :

```
while (my $line = <STDIN>) { print $line }
```

In these loop constructs, the assigned value (whether assignment is automatic or explicit) is then tested to see whether it is defined. The defined test avoids problems where line has a string value that would be treated as false by Perl, for example a "" or a "0" with no trailing newline. If you really mean for such values to

terminate the loop, they should be tested for explicitly:

```
while (($_ = <STDIN>) ne '0') { ... }
while (<STDIN>) { last unless $_; ... }
```

In other boolean contexts, `< <filehandle>` without an explicit `defined` test or comparison elicit a warning if the `use warnings` pragma or the **–w** command–line switch (the `$^W` variable) is in effect.

The filehandles STDIN, STDOUT, and STDERR are predefined. (The filehandles `stdin`, `stdout`, and `stderr` will also work except in packages, where they would be interpreted as local identifiers rather than global.) Additional filehandles may be created with the `open()` function, amongst others. See *perlopentut* and *open* for details on this.

If a <FILEHANDLE is used in a context that is looking for a list, a list comprising all input lines is returned, one line per list element. It's easy to grow to a rather large data space this way, so use with care.

<FILEHANDLE may also be spelled `readline(*FILEHANDLE)`. See *readline*.

The null filehandle < is special: it can be used to emulate the behavior of **sed** and **awk**. Input from < comes either from standard input, or from each file listed on the command line. Here's how it works: the first time < is evaluated, the @ARGV array is checked, and if it is empty, `$ARGV[0]` is set to "–", which when opened gives you standard input. The @ARGV array is then processed as a list of filenames. The loop

```
while (<>) {
    ...                     # code for each line
}
```

is equivalent to the following Perl–like pseudo code:

```
unshift(@ARGV, '-') unless @ARGV;
while ($ARGV = shift) {
    open(ARGV, $ARGV);
    while (<ARGV>) {
        ...         # code for each line
    }
}
```

except that it isn't so cumbersome to say, and will actually work. It really does shift the @ARGV array and put the current filename into the `$ARGV` variable. It also uses filehandle *ARGV* internally—< is just a synonym for <ARGV, which is magical. (The pseudo code above doesn't work because it treats <ARGV as non–magical.)

You can modify @ARGV before the first < as long as the array ends up containing the list of filenames you really want. Line numbers (`$.`) continue as though the input were one big happy file. See the example in *eof* for how to reset line numbers on each file.

If you want to set @ARGV to your own list of files, go right ahead. This sets @ARGV to all plain text files if no @ARGV was given:

```
@ARGV = grep { -f && -T } glob('*') unless @ARGV;
```

You can even set them to pipe commands. For example, this automatically filters compressed arguments through **gzip**:

```
@ARGV = map { /\.(gz|Z)$/ ? "gzip -dc < $_ |" : $_ } @ARGV;
```

If you want to pass switches into your script, you can use one of the Getopts modules or put a loop on the front like this:

```
while ($_ = $ARGV[0], /^-/) {
    shift;
    last if /^--$/;
    if (/^-D(.*)/) { $debug = $1 }
```

```
    if (/^-v/)      { $verbose++  }
    # ...            # other switches
}

while (<>) {
    # ...            # code for each line
}
```

The < symbol will return `undef` for end−of−file only once. If you call it again after this, it will assume you are processing another @ARGV list, and if you haven't set @ARGV, will read input from STDIN.

If angle brackets contain is a simple scalar variable (e.g., <$foo), then that variable contains the name of the filehandle to input from, or its typeglob, or a reference to the same. For example:

```
$fh = \*STDIN;
$line = <$fh>;
```

If what's within the angle brackets is neither a filehandle nor a simple scalar variable containing a filehandle name, typeglob, or typeglob reference, it is interpreted as a filename pattern to be globbed, and either a list of filenames or the next filename in the list is returned, depending on context. This distinction is determined on syntactic grounds alone. That means `< <$x>` is always a `readline()` from an indirect handle, but `< <$hash{key}>` is always a `glob()`. That's because `$x` is a simple scalar variable, but `$hash{key}` is not—it's a hash element.

One level of double−quote interpretation is done first, but you can't say `< <$foo>` because that's an indirect filehandle as explained in the previous paragraph. (In older versions of Perl, programmers would insert curly brackets to force interpretation as a filename glob: `< <${foo}>`. These days, it's considered cleaner to call the internal function directly as `glob($foo)`, which is probably the right way to have done it in the first place.) For example:

```
while (<*.c>) {
    chmod 0644, $_;
}
```

is roughly equivalent to:

```
open(FOO, "echo *.c | tr -s ' \t\r\f' '\\012\\012\\012\\012'|");
while (<FOO>) {
    chop;
    chmod 0644, $_;
}
```

except that the globbing is actually done internally using the standard `File::Glob` extension. Of course, the shortest way to do the above is:

```
chmod 0644, <*.c>;
```

A (file)glob evaluates its (embedded) argument only when it is starting a new list. All values must be read before it will start over. In list context, this isn't important because you automatically get them all anyway. However, in scalar context the operator returns the next value each time it's called, or `undef` when the list has run out. As with filehandle reads, an automatic `defined` is generated when the glob occurs in the test part of a `while`, because legal glob returns (e.g. a file called) would otherwise terminate the loop. Again, `undef` is returned only once. So if you're expecting a single value from a glob, it is much better to say

```
($file) = <blurch*>;
```

than

```
$file = <blurch*>;
```

because the latter will alternate between returning a filename and returning false.

It you're trying to do variable interpolation, it's definitely better to use the `glob()` function, because the older notation can cause people to become confused with the indirect filehandle notation.

```
@files = glob("$dir/*.[ch]");
@files = glob($files[$i]);
```

Constant Folding

Like C, Perl does a certain amount of expression evaluation at compile time whenever it determines that all arguments to an operator are static and have no side effects. In particular, string concatenation happens at compile time between literals that don't do variable substitution. Backslash interpolation also happens at compile time. You can say

```
'Now is the time for all' . "\n" .
    'good men to come to.'
```

and this all reduces to one string internally. Likewise, if you say

```
foreach $file (@filenames) {
    if (-s $file > 5 + 100 * 2**16) {  }
}
```

the compiler will precompute the number which that expression represents so that the interpreter won't have to.

Bitwise String Operators

Bitstrings of any size may be manipulated by the bitwise operators (`~ | & ^`).

If the operands to a binary bitwise op are strings of different sizes, **|** and **^** ops act as though the shorter operand had additional zero bits on the right, while the **&** op acts as though the longer operand were truncated to the length of the shorter. The granularity for such extension or truncation is one or more bytes.

```
# ASCII-based examples
print "j p \n" ^ " a h";            # prints "JAPH\n"
print "JA" | "  ph\n";              # prints "japh\n"
print "japh\nJunk" & '_____';       # prints "JAPH\n";
print 'p N$' ^ " E<H\n";            # prints "Perl\n";
```

If you are intending to manipulate bitstrings, be certain that you're supplying bitstrings: If an operand is a number, that will imply a **numeric** bitwise operation. You may explicitly show which type of operation you intend by using `""` or `0+`, as in the examples below.

```
$foo =  150  |  105 ;       # yields 255  (0x96 | 0x69 is 0xFF)
$foo = '150' |  105 ;       # yields 255
$foo =  150  | '105';       # yields 255
$foo = '150' | '105';       # yields string '155' (under ASCII)

$baz = 0+$foo & 0+$bar;     # both ops explicitly numeric
$biz = "$foo" ^ "$bar";     # both ops explicitly stringy
```

See *vec* for information on how to manipulate individual bits in a bit vector.

Integer Arithmetic

By default, Perl assumes that it must do most of its arithmetic in floating point. But by saying

```
use integer;
```

you may tell the compiler that it's okay to use integer operations (if it feels like it) from here to the end of the enclosing BLOCK. An inner BLOCK may countermand this by saying

```
no integer;
```

which lasts until the end of that BLOCK. Note that this doesn't mean everything is only an integer, merely that Perl may use integer operations if it is so inclined. For example, even under `use integer`, if you

take the `sqrt(2)`, you'll still get `1.4142135623731` or so.

Used on numbers, the bitwise operators ("`&`", "`|`", "`^`", "`~`", "`<<`", and "`>>`") always produce integral results. (But see also *Bitwise String Operators*.) However, `use integer` still has meaning for them. By default, their results are interpreted as unsigned integers, but if `use integer` is in effect, their results are interpreted as signed integers. For example, `~0` usually evaluates to a large integral value. However, `use integer; ~0` is `-1` on twos-complement machines.

Floating-point Arithmetic

While `use integer` provides integer-only arithmetic, there is no analogous mechanism to provide automatic rounding or truncation to a certain number of decimal places. For rounding to a certain number of digits, `sprintf()` or `printf()` is usually the easiest route. See *perlfaq4*.

Floating-point numbers are only approximations to what a mathematician would call real numbers. There are infinitely more reals than floats, so some corners must be cut. For example:

```
printf "%.20g\n", 123456789123456789;
#        produces 123456789123456784
```

Testing for exact equality of floating-point equality or inequality is not a good idea. Here's a (relatively expensive) work-around to compare whether two floating-point numbers are equal to a particular number of decimal places. See Knuth, volume II, for a more robust treatment of this topic.

```
sub fp_equal {
    my ($X, $Y, $POINTS) = @_;
    my ($tX, $tY);
    $tX = sprintf("%.${POINTS}g", $X);
    $tY = sprintf("%.${POINTS}g", $Y);
    return $tX eq $tY;
}
```

The POSIX module (part of the standard perl distribution) implements `ceil()`, `floor()`, and other mathematical and trigonometric functions. The Math::Complex module (part of the standard perl distribution) defines mathematical functions that work on both the reals and the imaginary numbers. Math::Complex not as efficient as POSIX, but POSIX can't work with complex numbers.

Rounding in financial applications can have serious implications, and the rounding method used should be specified precisely. In these cases, it probably pays not to trust whichever system rounding is being used by Perl, but to instead implement the rounding function you need yourself.

Bigger Numbers

The standard Math::BigInt and Math::BigFloat modules provide variable-precision arithmetic and overloaded operators, although they're currently pretty slow. At the cost of some space and considerable speed, they avoid the normal pitfalls associated with limited-precision representations.

```
use Math::BigInt;
$x = Math::BigInt->new('123456789123456789');
print $x * $x;

# prints +15241578780673678515622620750190521
```

The non-standard modules SSLeay::BN and Math::Pari provide equivalent functionality (and much more) with a substantial performance savings.

NAME

perlopentut – tutorial on opening things in Perl

DESCRIPTION

Perl has two simple, built–in ways to open files: the shell way for convenience, and the C way for precision. The choice is yours.

Open à la shell

Perl's `open` function was designed to mimic the way command–line redirection in the shell works. Here are some basic examples from the shell:

```
$ myprogram file1 file2 file3
$ myprogram    <  inputfile
$ myprogram    >  outputfile
$ myprogram    >> outputfile
$ myprogram    |  otherprogram
$ otherprogram |  myprogram
```

And here are some more advanced examples:

```
$ otherprogram      | myprogram f1 - f2
$ otherprogram 2>&1 | myprogram -
$ myprogram     <&3
$ myprogram     >&4
```

Programmers accustomed to constructs like those above can take comfort in learning that Perl directly supports these familiar constructs using virtually the same syntax as the shell.

Simple Opens

The `open` function takes two arguments: the first is a filehandle, and the second is a single string comprising both what to open and how to open it. `open` returns true when it works, and when it fails, returns a false value and sets the special variable `$!` to reflect the system error. If the filehandle was previously opened, it will be implicitly closed first.

For example:

```
open(INFO,      "datafile") || die("can't open datafile: $!");
open(INFO,   "<  datafile") || die("can't open datafile: $!");
open(RESULTS,">  runstats") || die("can't open runstats: $!");
open(LOG,    ">> logfile ") || die("can't open logfile:  $!");
```

If you prefer the low–punctuation version, you could write that this way:

```
open INFO,   "<  datafile"  or die "can't open datafile: $!";
open RESULTS,">  runstats"  or die "can't open runstats: $!";
open LOG,    ">> logfile "  or die "can't open logfile:  $!";
```

A few things to notice. First, the leading less–than is optional. If omitted, Perl assumes that you want to open the file for reading.

The other important thing to notice is that, just as in the shell, any white space before or after the filename is ignored. This is good, because you wouldn't want these to do different things:

```
open INFO,   "<datafile"
open INFO,   "< datafile"
open INFO,   "<  datafile"
```

Ignoring surround whitespace also helps for when you read a filename in from a different file, and forget to trim it before opening:

```
$filename = <INFO>;         # oops, \n still there
```

```
open(EXTRA, "< $filename") || die "can't open $filename: $!";
```

This is not a bug, but a feature. Because open mimics the shell in its style of using redirection arrows to specify how to open the file, it also does so with respect to extra white space around the filename itself as well. For accessing files with naughty names, see *"Dispelling the Dweomer"*.

Pipe Opens

In C, when you want to open a file using the standard I/O library, you use the fopen function, but when opening a pipe, you use the popen function. But in the shell, you just use a different redirection character. That's also the case for Perl. The open call remains the same—just its argument differs.

If the leading character is a pipe symbol, open starts up a new command and open a write–only filehandle leading into that command. This lets you write into that handle and have what you write show up on that command's standard input. For example:

```
open(PRINTER, "| lpr -Plp1")     || die "cannot fork: $!";
print PRINTER "stuff\n";
close(PRINTER)                   || die "can't close lpr: $!";
```

If the trailing character is a pipe, you start up a new command and open a read–only filehandle leading out of that command. This lets whatever that command writes to its standard output show up on your handle for reading. For example:

```
open(NET, "netstat -i -n |")     || die "cannot fork: $!";
while (<NET>) { }                # do something with input
close(NET)                       || die "can't close netstat: $!";
```

What happens if you try to open a pipe to or from a non–existent command? In most systems, such an open will not return an error. That's because in the traditional fork/exec model, running the other program happens only in the forked child process, which means that the failed exec can't be reflected in the return value of open. Only a failed fork shows up there. See *"Why doesn't open() return an error when a pipe open fails?"* to see how to cope with this. There's also an explanation in *perlipc*.

If you would like to open a bidirectional pipe, the IPC::Open2 library will handle this for you. Check out *Bidirectional Communication with Another Process in perlipc*

The Minus File

Again following the lead of the standard shell utilities, Perl's open function treats a file whose name is a single minus, "–", in a special way. If you open minus for reading, it really means to access the standard input. If you open minus for writing, it really means to access the standard output.

If minus can be used as the default input or default output, what happens if you open a pipe into or out of minus? What's the default command it would run? The same script as you're currently running! This is actually a stealth fork hidden inside an open call. See *Safe Pipe Opens in perlipc* for details.

Mixing Reads and Writes

It is possible to specify both read and write access. All you do is add a "+" symbol in front of the redirection. But as in the shell, using a less–than on a file never creates a new file; it only opens an existing one. On the other hand, using a greater–than always clobbers (truncates to zero length) an existing file, or creates a brand–new one if there isn't an old one. Adding a "+" for read–write doesn't affect whether it only works on existing files or always clobbers existing ones.

```
open(WTMP, "+< /usr/adm/wtmp")
    || die "can't open /usr/adm/wtmp: $!";

open(SCREEN, "+> /tmp/lkscreen")
    || die "can't open /tmp/lkscreen: $!";

open(LOGFILE, "+>> /tmp/applog"
    || die "can't open /tmp/applog: $!";
```

The first one won't create a new file, and the second one will always clobber an old one. The third one will create a new file if necessary and not clobber an old one, and it will allow you to read at any point in the file, but all writes will always go to the end. In short, the first case is substantially more common than the second and third cases, which are almost always wrong. (If you know C, the plus in Perl's `open` is historically derived from the one in C's fopen(3S), which it ultimately calls.)

In fact, when it comes to updating a file, unless you're working on a binary file as in the WTMP case above, you probably don't want to use this approach for updating. Instead, Perl's **–i** flag comes to the rescue. The following command takes all the C, C++, or yacc source or header files and changes all their foo's to bar's, leaving the old version in the original file name with a ".orig" tacked on the end:

```
$ perl -i.orig -pe 's/\bfoo\b/bar/g' *.[Cchy]
```

This is a short cut for some renaming games that are really the best way to update textfiles. See the second question in *perlfaq5* for more details.

Filters

One of the most common uses for `open` is one you never even notice. When you process the ARGV filehandle using `< <ARGV>`, Perl actually does an implicit open on each file in @ARGV. Thus a program called like this:

```
$ myprogram file1 file2 file3
```

Can have all its files opened and processed one at a time using a construct no more complex than:

```
while (<>) {
    # do something with $_
}
```

If @ARGV is empty when the loop first begins, Perl pretends you've opened up minus, that is, the standard input. In fact, `$ARGV`, the currently open file during `< <ARGV>` processing, is even set to "–" in these circumstances.

You are welcome to pre–process your @ARGV before starting the loop to make sure it's to your liking. One reason to do this might be to remove command options beginning with a minus. While you can always roll the simple ones by hand, the Getopts modules are good for this.

```
use Getopt::Std;

# -v, -D, -o ARG, sets $opt_v, $opt_D, $opt_o
getopts("vDo:");

# -v, -D, -o ARG, sets $args{v}, $args{D}, $args{o}
getopts("vDo:", \%args);
```

Or the standard Getopt::Long module to permit named arguments:

```
use Getopt::Long;
GetOptions( "verbose"  => \$verbose,        # --verbose
            "Debug"    => \$debug,          # --Debug
            "output=s" => \$output );
        # --output=somestring or --output somestring
```

Another reason for preprocessing arguments is to make an empty argument list default to all files:

```
@ARGV = glob("*") unless @ARGV;
```

You could even filter out all but plain, text files. This is a bit silent, of course, and you might prefer to mention them on the way.

```
@ARGV = grep { -f && -T } @ARGV;
```

If you're using the **–n** or **–p** command–line options, you should put changes to @ARGV in a `BEGIN{}` block.

Remember that a normal open has special properties, in that it might call fopen(3S) or it might called popen(3S), depending on what its argument looks like; that's why it's sometimes called "magic open". Here's an example:

```
$pwdinfo = 'domainname' =~ /^(\(none\))?$/
                ? '< /etc/passwd'
                : 'ypcat passwd |';

open(PWD, $pwdinfo)
            or die "can't open $pwdinfo: $!";
```

This sort of thing also comes into play in filter processing. Because < <ARGV processing employs the normal, shell-style Perl open, it respects all the special things we've already seen:

```
$ myprogram f1 "cmd1|" - f2 "cmd2|" f3 < tmpfile
```

That program will read from the file ***f1***, the process ***cmd1***, standard input (***tmpfile*** in this case), the ***f2*** file, the ***cmd2*** command, and finally the ***f3*** file.

Yes, this also means that if you have a file named "-" (and so on) in your directory, that they won't be processed as literal files by open. You'll need to pass them as "./-" much as you would for the *rm* program. Or you could use sysopen as described below.

One of the more interesting applications is to change files of a certain name into pipes. For example, to autoprocess gzipped or compressed files by decompressing them with *gzip*:

```
@ARGV = map { /^\.(gz|Z)$/ ? "gzip -dc $_ |" : $_  } @ARGV;
```

Or, if you have the *GET* program installed from LWP, you can fetch URLs before processing them:

```
@ARGV = map { m#^\w+://# ? "GET $_ |" : $_ } @ARGV;
```

It's not for nothing that this is called magic < <ARGV . Pretty nifty, eh?

Open à la C

If you want the convenience of the shell, then Perl's open is definitely the way to go. On the other hand, if you want finer precision than C's simplistic fopen(3S) provides, then you should look to Perl's sysopen, which is a direct hook into the open(2) system call. That does mean it's a bit more involved, but that's the price of precision.

sysopen takes 3 (or 4) arguments.

```
sysopen HANDLE, PATH, FLAGS, [MASK]
```

The HANDLE argument is a filehandle just as with open. The PATH is a literal path, one that doesn't pay attention to any greater-thans or less-thans or pipes or minuses, nor ignore white space. If it's there, it's part of the path. The FLAGS argument contains one or more values derived from the Fcntl module that have been or'd together using the bitwise "|" operator. The final argument, the MASK, is optional; if present, it is combined with the user's current umask for the creation mode of the file. You should usually omit this.

Although the traditional values of read-only, write-only, and read-write are 0, 1, and 2 respectively, this is known not to hold true on some systems. Instead, it's best to load in the appropriate constants first from the Fcntl module, which supplies the following standard flags:

```
O_RDONLY            Read only
O_WRONLY            Write only
O_RDWR              Read and write
O_CREAT             Create the file if it doesn't exist
O_EXCL              Fail if the file already exists
O_APPEND            Append to the file
O_TRUNC             Truncate the file
O_NONBLOCK          Non-blocking access
```

Less common flags that are sometimes available on some operating systems include O_BINARY, O_TEXT, O_SHLOCK, O_EXLOCK, O_DEFER, O_SYNC, O_ASYNC, O_DSYNC, O_RSYNC, O_NOCTTY, O_NDELAY and O_LARGEFILE. Consult your open(2) manpage or its local equivalent for details. (Note: starting from Perl release 5.6 the O_LARGEFILE flag, if available, is automatically added to the sysopen() flags because large files are the default.)

Here's how to use sysopen to emulate the simple open calls we had before. We'll omit the || die $! checks for clarity, but make sure you always check the return values in real code. These aren't quite the same, since open will trim leading and trailing white space, but you'll get the idea:

To open a file for reading:

```
open(FH, "< $path");
sysopen(FH, $path, O_RDONLY);
```

To open a file for writing, creating a new file if needed or else truncating an old file:

```
open(FH, "> $path");
sysopen(FH, $path, O_WRONLY | O_TRUNC | O_CREAT);
```

To open a file for appending, creating one if necessary:

```
open(FH, ">> $path");
sysopen(FH, $path, O_WRONLY | O_APPEND | O_CREAT);
```

To open a file for update, where the file must already exist:

```
open(FH, "+< $path");
sysopen(FH, $path, O_RDWR);
```

And here are things you can do with sysopen that you cannot do with a regular open. As you see, it's just a matter of controlling the flags in the third argument.

To open a file for writing, creating a new file which must not previously exist:

```
sysopen(FH, $path, O_WRONLY | O_EXCL | O_CREAT);
```

To open a file for appending, where that file must already exist:

```
sysopen(FH, $path, O_WRONLY | O_APPEND);
```

To open a file for update, creating a new file if necessary:

```
sysopen(FH, $path, O_RDWR | O_CREAT);
```

To open a file for update, where that file must not already exist:

```
sysopen(FH, $path, O_RDWR | O_EXCL | O_CREAT);
```

To open a file without blocking, creating one if necessary:

```
sysopen(FH, $path, O_WRONLY | O_NONBLOCK | O_CREAT);
```

Permissions à la mode

If you omit the MASK argument to sysopen, Perl uses the octal value 0666. The normal MASK to use for executables and directories should be 0777, and for anything else, 0666.

Why so permissive? Well, it isn't really. The MASK will be modified by your process's current umask. A umask is a number representing *disabled* permissions bits; that is, bits that will not be turned on in the created files' permissions field.

For example, if your umask were 027, then the 020 part would disable the group from writing, and the 007 part would disable others from reading, writing, or executing. Under these conditions, passing sysopen 0666 would create a file with mode 0640, since 0666 &~ 027 is 0640.

You should seldom use the MASK argument to sysopen(). That takes away the user's freedom to choose

what permission new files will have. Denying choice is almost always a bad thing. One exception would be for cases where sensitive or private data is being stored, such as with mail folders, cookie files, and internal temporary files.

Obscure Open Tricks

Re–Opening Files (dups)

Sometimes you already have a filehandle open, and want to make another handle that's a duplicate of the first one. In the shell, we place an ampersand in front of a file descriptor number when doing redirections. For example, `< 2&1` makes descriptor 2 (that's STDERR in Perl) be redirected into descriptor 1 (which is usually Perl's STDOUT). The same is essentially true in Perl: a filename that begins with an ampersand is treated instead as a file descriptor if a number, or as a filehandle if a string.

```
open(SAVEOUT, ">&SAVEERR") || die "couldn't dup SAVEERR: $!";
open(MHCONTEXT, "<&4")     || die "couldn't dup fd4: $!";
```

That means that if a function is expecting a filename, but you don't want to give it a filename because you already have the file open, you can just pass the filehandle with a leading ampersand. It's best to use a fully qualified handle though, just in case the function happens to be in a different package:

```
somefunction("&main::LOGFILE");
```

This way if `somefunction()` is planning on opening its argument, it can just use the already opened handle. This differs from passing a handle, because with a handle, you don't open the file. Here you have something you can pass to open.

If you have one of those tricky, newfangled I/O objects that the C++ folks are raving about, then this doesn't work because those aren't a proper filehandle in the native Perl sense. You'll have to use `fileno()` to pull out the proper descriptor number, assuming you can:

```
use IO::Socket;
$handle = IO::Socket::INET->new("www.perl.com:80");
$fd = $handle->fileno;
somefunction("&$fd");  # not an indirect function call
```

It can be easier (and certainly will be faster) just to use real filehandles though:

```
use IO::Socket;
local *REMOTE = IO::Socket::INET->new("www.perl.com:80");
die "can't connect" unless defined(fileno(REMOTE));
somefunction("&main::REMOTE");
```

If the filehandle or descriptor number is preceded not just with a simple `"&"` but rather with a `"&="` combination, then Perl will not create a completely new descriptor opened to the same place using the dup(2) system call. Instead, it will just make something of an alias to the existing one using the fdopen(3S) library call This is slightly more parsimonious of systems resources, although this is less a concern these days. Here's an example of that:

```
$fd = $ENV{"MHCONTEXTFD"};
open(MHCONTEXT, "<&=$fd")   or die "couldn't fdopen $fd: $!";
```

If you're using magic `< <ARGV` , you could even pass in as a command line argument in @ARGV something like `"<&=$MHCONTEXTFD",` but we've never seen anyone actually do this.

Dispelling the Dweomer

Perl is more of a DWIMmer language than something like Java—where DWIM is an acronym for "do what I mean". But this principle sometimes leads to more hidden magic than one knows what to do with. In this way, Perl is also filled with *dweomer*, an obscure word meaning an enchantment. Sometimes, Perl's DWIMmer is just too much like dweomer for comfort.

If magic `open` is a bit too magical for you, you don't have to turn to `sysopen`. To open a file with arbitrary weird characters in it, it's necessary to protect any leading and trailing whitespace. Leading

whitespace is protected by inserting a "./" in front of a filename that starts with whitespace. Trailing whitespace is protected by appending an ASCII NUL byte ("\0") at the end off the string.

```
$file =~ s#^(\s)#./$1#;
open(FH, "< $file\0")   || die "can't open $file: $!";
```

This assumes, of course, that your system considers dot the current working directory, slash the directory separator, and disallows ASCII NULs within a valid filename. Most systems follow these conventions, including all POSIX systems as well as proprietary Microsoft systems. The only vaguely popular system that doesn't work this way is the proprietary Macintosh system, which uses a colon where the rest of us use a slash. Maybe sysopen isn't such a bad idea after all.

If you want to use < <ARGV processing in a totally boring and non-magical way, you could do this first:

```
#   "Sam sat on the ground and put his head in his hands.
#   'I wish I had never come here, and I don't want to see
#   no more magic,' he said, and fell silent."
for (@ARGV) {
    s#^([^./])#./$1#;
    $_ .= "\0";
}
while (<>) {
    # now process $_
}
```

But be warned that users will not appreciate being unable to use "-" to mean standard input, per the standard convention.

Paths as Opens

You've probably noticed how Perl's warn and die functions can produce messages like:

```
Some warning at scriptname line 29, <FH> line 7.
```

That's because you opened a filehandle FH, and had read in seven records from it. But what was the name of the file, not the handle?

If you aren't running with strict refs, or if you've turn them off temporarily, then all you have to do is this:

```
open($path, "< $path") || die "can't open $path: $!";
while (<$path>) {
    # whatever
}
```

Since you're using the pathname of the file as its handle, you'll get warnings more like

```
Some warning at scriptname line 29, </etc/motd> line 7.
```

Single Argument Open

Remember how we said that Perl's open took two arguments? That was a passive prevarication. You see, it can also take just one argument. If and only if the variable is a global variable, not a lexical, you can pass open just one argument, the filehandle, and it will get the path from the global scalar variable of the same name.

```
$FILE = "/etc/motd";
open FILE or die "can't open $FILE: $!";
while (<FILE>) {
    # whatever
}
```

Why is this here? Someone has to cater to the hysterical porpoises. It's something that's been in Perl since the very beginning, if not before.

Playing with STDIN and STDOUT

One clever move with STDOUT is to explicitly close it when you're done with the program.

```
END { close(STDOUT) || die "can't close stdout: $!" }
```

If you don't do this, and your program fills up the disk partition due to a command line redirection, it won't report the error exit with a failure status.

You don't have to accept the STDIN and STDOUT you were given. You are welcome to reopen them if you'd like.

```
open(STDIN, "< datafile")
    || die "can't open datafile: $!";

open(STDOUT, "> output")
    || die "can't open output: $!";
```

And then these can be read directly or passed on to subprocesses. This makes it look as though the program were initially invoked with those redirections from the command line.

It's probably more interesting to connect these to pipes. For example:

```
$pager = $ENV{PAGER} || "(less || more)";
open(STDOUT, "| $pager")
    || die "can't fork a pager: $!";
```

This makes it appear as though your program were called with its stdout already piped into your pager. You can also use this kind of thing in conjunction with an implicit fork to yourself. You might do this if you would rather handle the post processing in your own program, just in a different process:

```
head(100);
while (<>) {
    print;
}

sub head {
    my $lines = shift || 20;
    return unless $pid = open(STDOUT, "|-");
    die "cannot fork: $!" unless defined $pid;
    while (<STDIN>) {
        print;
        last if --$lines < 0;
    }
    exit;
}
```

This technique can be applied to repeatedly push as many filters on your output stream as you wish.

Other I/O Issues

These topics aren't really arguments related to `open` or `sysopen`, but they do affect what you do with your open files.

Opening Non-File Files

When is a file not a file? Well, you could say when it exists but isn't a plain file. We'll check whether it's a symbolic link first, just in case.

```
if (-l $file || ! -f _) {
    print "$file is not a plain file\n";
}
```

What other kinds of files are there than, well, files? Directories, symbolic links, named pipes, Unix-domain

sockets, and block and character devices. Those are all files, too—just not *plain* files. This isn't the same issue as being a text file. Not all text files are plain files. Not all plain files are textfiles. That's why there are separate `-f` and `-T` file tests.

To open a directory, you should use the `opendir` function, then process it with `readdir`, carefully restoring the directory name if necessary:

```
opendir(DIR, $dirname) or die "can't opendir $dirname: $!";
while (defined($file = readdir(DIR))) {
    # do something with "$dirname/$file"
}
closedir(DIR);
```

If you want to process directories recursively, it's better to use the File::Find module. For example, this prints out all files recursively, add adds a slash to their names if the file is a directory.

```
@ARGV = qw(.) unless @ARGV;
use File::Find;
find sub { print $File::Find::name, -d && '/', "\n" }, @ARGV;
```

This finds all bogus symbolic links beneath a particular directory:

```
find sub { print "$File::Find::name\n" if -l && !-e }, $dir;
```

As you see, with symbolic links, you can just pretend that it is what it points to. Or, if you want to know *what* it points to, then `readlink` is called for:

```
if (-l $file) {
    if (defined($whither = readlink($file))) {
        print "$file points to $whither\n";
    } else {
        print "$file points nowhere: $!\n";
    }
}
```

Named pipes are a different matter. You pretend they're regular files, but their opens will normally block until there is both a reader and a writer. You can read more about them in *Named Pipes in perlipc*. Unix-domain sockets are rather different beasts as well; they're described in *Unix-Domain TCP Clients and Servers in perlipc*.

When it comes to opening devices, it can be easy and it can tricky. We'll assume that if you're opening up a block device, you know what you're doing. The character devices are more interesting. These are typically used for modems, mice, and some kinds of printers. This is described in *How do I read and write the serial port? in perlfaq8* It's often enough to open them carefully:

```
sysopen(TTYIN, "/dev/ttyS1", O_RDWR | O_NDELAY | O_NOCTTY)
            # (O_NOCTTY no longer needed on POSIX systems)
    or die "can't open /dev/ttyS1: $!";
open(TTYOUT, "+>&TTYIN")
    or die "can't dup TTYIN: $!";

$ofh = select(TTYOUT); $| = 1; select($ofh);

print TTYOUT "+++at\015";
$answer = <TTYIN>;
```

With descriptors that you haven't opened using `sysopen`, such as a socket, you can set them to be non-blocking using `fcntl`:

```
use Fcntl;
fcntl(Connection, F_SETFL, O_NONBLOCK)
    or die "can't set non blocking: $!";
```

Rather than losing yourself in a morass of twisting, turning `ioctl`s, all dissimilar, if you're going to manipulate ttys, it's best to make calls out to the stty(1) program if you have it, or else use the portable POSIX interface. To figure this all out, you'll need to read the termios(3) manpage, which describes the POSIX interface to tty devices, and then *POSIX*, which describes Perl's interface to POSIX. There are also some high-level modules on CPAN that can help you with these games. Check out Term::ReadKey and Term::ReadLine.

What else can you open? To open a connection using sockets, you won't use one of Perl's two open functions. See *Sockets: Client/Server Communication in perlipc* for that. Here's an example. Once you have it, you can use FH as a bidirectional filehandle.

```
use IO::Socket;
local *FH = IO::Socket::INET->new("www.perl.com:80");
```

For opening up a URL, the LWP modules from CPAN are just what the doctor ordered. There's no filehandle interface, but it's still easy to get the contents of a document:

```
use LWP::Simple;
$doc = get('http://www.linpro.no/lwp/');
```

Binary Files

On certain legacy systems with what could charitably be called terminally convoluted (some would say broken) I/O models, a file isn't a file—at least, not with respect to the C standard I/O library. On these old systems whose libraries (but not kernels) distinguish between text and binary streams, to get files to behave properly you'll have to bend over backwards to avoid nasty problems. On such infelicitous systems, sockets and pipes are already opened in binary mode, and there is currently no way to turn that off. With files, you have more options.

Another option is to use the `binmode` function on the appropriate handles before doing regular I/O on them:

```
binmode(STDIN);
binmode(STDOUT);
while (<STDIN>) { print }
```

Passing `sysopen` a non-standard flag option will also open the file in binary mode on those systems that support it. This is the equivalent of opening the file normally, then calling `binmode`ing on the handle.

```
sysopen(BINDAT, "records.data", O_RDWR | O_BINARY)
    || die "can't open records.data: $!";
```

Now you can use `read` and `print` on that handle without worrying about the system non-standard I/O library breaking your data. It's not a pretty picture, but then, legacy systems seldom are. CP/M will be with us until the end of days, and after.

On systems with exotic I/O systems, it turns out that, astonishingly enough, even unbuffered I/O using `sysread` and `syswrite` might do sneaky data mutilation behind your back.

```
while (sysread(WHENCE, $buf, 1024)) {
    syswrite(WHITHER, $buf, length($buf));
}
```

Depending on the vicissitudes of your runtime system, even these calls may need `binmode` or `O_BINARY` first. Systems known to be free of such difficulties include Unix, the Mac OS, Plan9, and Inferno.

File Locking

In a multitasking environment, you may need to be careful not to collide with other processes who want to do I/O on the same files as others are working on. You'll often need shared or exclusive locks on files for reading and writing respectively. You might just pretend that only exclusive locks exist.

Never use the existence of a file `-e $file` as a locking indication, because there is a race condition between the test for the existence of the file and its creation. Atomicity is critical.

Perl's most portable locking interface is via the `flock` function, whose simplicity is emulated on systems that don't directly support it, such as SysV or WindowsNT. The underlying semantics may affect how it all works, so you should learn how `flock` is implemented on your system's port of Perl.

File locking *does not* lock out another process that would like to do I/O. A file lock only locks out others trying to get a lock, not processes trying to do I/O. Because locks are advisory, if one process uses locking and another doesn't, all bets are off.

By default, the `flock` call will block until a lock is granted. A request for a shared lock will be granted as soon as there is no exclusive locker. A request for a exclusive lock will be granted as soon as there is no locker of any kind. Locks are on file descriptors, not file names. You can't lock a file until you open it, and you can't hold on to a lock once the file has been closed.

Here's how to get a blocking shared lock on a file, typically used for reading:

```
use 5.004;
use Fcntl qw(:DEFAULT :flock);
open(FH, "< filename")  or die "can't open filename: $!";
flock(FH, LOCK_SH)      or die "can't lock filename: $!";
# now read from FH
```

You can get a non-blocking lock by using `LOCK_NB`.

```
flock(FH, LOCK_SH | LOCK_NB)
    or die "can't lock filename: $!";
```

This can be useful for producing more user-friendly behaviour by warning if you're going to be blocking:

```
use 5.004;
use Fcntl qw(:DEFAULT :flock);
open(FH, "< filename")  or die "can't open filename: $!";
unless (flock(FH, LOCK_SH | LOCK_NB)) {
    $| = 1;
    print "Waiting for lock...";
    flock(FH, LOCK_SH)  or die "can't lock filename: $!";
    print "got it.\n"
}
# now read from FH
```

To get an exclusive lock, typically used for writing, you have to be careful. We `sysopen` the file so it can be locked before it gets emptied. You can get a nonblocking version using `LOCK_EX | LOCK_NB`.

```
use 5.004;
use Fcntl qw(:DEFAULT :flock);
sysopen(FH, "filename", O_WRONLY | O_CREAT)
    or die "can't open filename: $!";
flock(FH, LOCK_EX)
    or die "can't lock filename: $!";
truncate(FH, 0)
    or die "can't truncate filename: $!";
# now write to FH
```

Finally, due to the uncounted millions who cannot be dissuaded from wasting cycles on useless vanity devices called hit counters, here's how to increment a number in a file safely:

```
use Fcntl qw(:DEFAULT :flock);

sysopen(FH, "numfile", O_RDWR | O_CREAT)
    or die "can't open numfile: $!";
# autoflush FH
$ofh = select(FH); $| = 1; select ($ofh);
```

```
flock(FH, LOCK_EX)
    or die "can't write-lock numfile: $!";

$num = <FH> || 0;
seek(FH, 0, 0)
    or die "can't rewind numfile : $!";
print FH $num+1, "\n"
    or die "can't write numfile: $!";

truncate(FH, tell(FH))
    or die "can't truncate numfile: $!";
close(FH)
    or die "can't close numfile: $!";
```

SEE ALSO

The `open` and `sysopen` function in perlfunc(1); the standard open(2), dup(2), fopen(3), and fdopen(3) manpages; the POSIX documentation.

AUTHOR and COPYRIGHT

HISTORY

First release: Sat Jan 9 08:09:11 MST 1999

NAME

perlpod – plain old documentation

DESCRIPTION

A pod–to–whatever translator reads a pod file paragraph by paragraph, and translates it to the appropriate output format. There are three kinds of paragraphs: *Verbatim Paragraph in verbatim*\|, *Command Paragraph in command*\|, and *Ordinary Block of Text in ordinary text*\|.

Verbatim Paragraph

A verbatim paragraph, distinguished by being indented (that is, it starts with space or tab). It should be reproduced exactly, with tabs assumed to be on 8–column boundaries. There are no special formatting escapes, so you can't italicize or anything like that. A \ means \, and nothing else.

Command Paragraph

All command paragraphs start with "=", followed by an identifier, followed by arbitrary text that the command can use however it pleases. Currently recognized commands are

```
=head1 heading
=head2 heading
=item text
=over N
=back
=cut
=pod
=for X
=begin X
=end X
```

=pod

=cut The "=pod" directive does nothing beyond telling the compiler to lay off parsing code through the next "=cut". It's useful for adding another paragraph to the doc if you're mixing up code and pod a lot.

=head1

=head2

Head1 and head2 produce first and second level headings, with the text in the same paragraph as the "=headn" directive forming the heading description.

=over

=back

=item

Item, over, and back require a little more explanation: "=over" starts a section specifically for the generation of a list using "=item" commands. At the end of your list, use "=back" to end it. You will probably want to give "4" as the number to "=over", as some formatters will use this for indentation. This should probably be a default. Note also that there are some basic rules to using =item: don't use them outside of an =over/=back block, use at least one inside an =over/=back block, you don't _have_ to include the =back if the list just runs off the document, and perhaps most importantly, keep the items consistent: either use "=item *" for all of them, to produce bullets, or use "=item 1.", "=item 2.", etc., to produce numbered lists, or use "=item foo", "=item bar", etc., i.e., things that looks nothing like bullets or numbers. If you start with bullets or numbers, stick with them, as many formatters use the first "=item" type to decide how to format the list.

=for

=begin

=end

For, begin, and end let you include sections that are not interpreted as pod text, but passed directly to particular formatters. A formatter that can utilize that format will use the section, otherwise it will be completely ignored. The directive "=for" specifies that the entire next paragraph is in the format

indicated by the first word after "=for", like this:

```
=for html <br>
 <p> This is a raw HTML paragraph </p>
```

The paired commands "=begin" and "=end" work very similarly to "=for", but instead of only accepting a single paragraph, all text from "=begin" to a paragraph with a matching "=end" are treated as a particular format.

Here are some examples of how to use these:

```
=begin html

<br>Figure 1.<IMG SRC="figure1.png"><br>

=end html

=begin text

  ---------------
  |  foo        |
  |        bar  |
  ---------------

^^^^ Figure 1. ^^^^

=end text
```

Some format names that formatters currently are known to accept include "roff", "man", "latex", "tex", "text", and "html". (Some formatters will treat some of these as synonyms.)

And don't forget, when using any command, that the command lasts up until the end of the **paragraph**, not the line. Hence in the examples below, you can see the empty lines after each command to end its paragraph.

Some examples of lists include:

```
=over 4

=item *

First item

=item *

Second item

=back

=over 4

=item Foo()

Description of Foo function

=item Bar()

Description of Bar function

=back
```

Ordinary Block of Text

It will be filled, and maybe even justified. Certain interior sequences are recognized both here and in commands:

```
I<text>     Italicize text, used for emphasis or variables
B<text>     Embolden text, used for switches and programs
S<text>     Text contains non-breaking spaces
```

```
C<code>     Render code in a typewriter font, or give some other
            indication that this represents program text
L<name>     A link (cross reference) to name
                L<name>             manual page
                L<name/ident>       item in manual page
                L<name/"sec">       section in other manual page
                L<"sec">            section in this manual page
                                    (the quotes are optional)
                L</"sec">           ditto
            same as above but only 'text' is used for output.
            (Text can not contain the characters '/' and '|',
            and should contain matched '<' or '>')
                L<text|name>
                L<text|name/ident>
                L<text|name/"sec">
                L<text|"sec">
                L<text|/"sec">
F<file>     Used for filenames
X<index>    An index entry
Z<>         A zero-width character
E<escape>   A named character (very similar to HTML escapes)
                E<lt>               A literal <
                E<gt>               A literal >
                E<sol>              A literal /
                E<verbar>           A literal |
                (these are optional except in other interior
                 sequences and when preceded by a capital letter)
                E<n>                Character number n (probably in ASCII)
                E<html>             Some non-numeric HTML entity, such
                                    as E<Agrave>
```

Most of the time, you will only need a single set of angle brackets to delimit the beginning and end of interior sequences. However, sometimes you will want to put a right angle bracket (or greater–than sign '') inside of a sequence. This is particularly common when using a sequence to provide a different font–type for a snippet of code. As with all things in Perl, there is more than one way to do it. One way is to simply escape the closing bracket using an E sequence:

```
C<$a E<lt>=E<gt> $b>
```

This will produce: "`$a <=> $b`"

A more readable, and perhaps more "plain" way is to use an alternate set of delimiters that doesn't require a "" to be escaped. As of perl5.5.660, doubled angle brackets ("<<" and "") may be used *if and only if there is whitespace immediately following the opening delimiter and immediately preceding the closing delimiter!* For example, the following will do the trick:

```
C<< $a <=> $b >>
```

In fact, you can use as many repeated angle–brackets as you like so long as you have the same number of them in the opening and closing delimiters, and make sure that whitespace immediately follows the last '<' of the opening delimiter, and immediately precedes the first '' of the closing delimiter. So the following will also work:

```
C<<< $a <=> $b >>>
C<<<< $a <=> $b >>>>
```

This is currently supported by pod2text (Pod::Text), pod2man (Pod::Man), and any other pod2xxx and Pod::Xxxx translator that uses Pod::Parser 1.093 or later.

The Intent

That's it. The intent is simplicity, not power. I wanted paragraphs to look like paragraphs (block format), so that they stand out visually, and so that I could run them through fmt easily to reformat them (that's F7 in my version of **vi**). I wanted the translator (and not me) to worry about whether " or ' is a left quote or a right quote within filled text, and I wanted it to leave the quotes alone, dammit, in verbatim mode, so I could slurp in a working program, shift it over 4 spaces, and have it print out, er, verbatim. And presumably in a constant width font.

In particular, you can leave things like this verbatim in your text:

```
Perl
FILEHANDLE
$variable
function()
manpage(3r)
```

Doubtless a few other commands or sequences will need to be added along the way, but I've gotten along surprisingly well with just these.

Note that I'm not at all claiming this to be sufficient for producing a book. I'm just trying to make an idiot−proof common source for nroff, TeX, and other markup languages, as used for online documentation. Translators exist for **pod2man** (that's for nroff(1) and troff(1)), **pod2text**, **pod2html**, **pod2latex**, and **pod2fm**.

Embedding Pods in Perl Modules

You can embed pod documentation in your Perl scripts. Start your documentation with a "=head1" command at the beginning, and end it with a "=cut" command. Perl will ignore the pod text. See any of the supplied library modules for examples. If you're going to put your pods at the end of the file, and you're using an __END__ or __DATA__ cut mark, make sure to put an empty line there before the first pod directive.

```
__END__

=head1 NAME

modern - I am a modern module
```

If you had not had that empty line there, then the translators wouldn't have seen it.

Common Pod Pitfalls

- Pod translators usually will require paragraphs to be separated by completely empty lines. If you have an apparently empty line with some spaces on it, this can cause odd formatting.
- Translators will mostly add wording around a L<> link, so that `L<foo(1)>` becomes "the *foo*(1) manpage", for example (see **pod2man** for details). Thus, you shouldn't write things like `the L<foo> manpage`, if you want the translated document to read sensibly.

  If you need total control of the text used for a link in the output use the form L<show this text|foo> instead.
- The **podchecker** command is provided to check pod syntax for errors and warnings. For example, it checks for completely blank lines in pod segments and for unknown escape sequences. It is still advised to pass it through one or more translators and proofread the result, or print out the result and proofread that. Some of the problems found may be bugs in the translators, which you may or may not wish to work around.

SEE ALSO

pod2man, *PODs: Embedded Documentation in perlsyn*, *podchecker*

AUTHOR

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NAME

perlport – Writing portable Perl

DESCRIPTION

Perl runs on numerous operating systems. While most of them share much in common, they also have their own unique features.

This document is meant to help you to find out what constitutes portable Perl code. That way once you make a decision to write portably, you know where the lines are drawn, and you can stay within them.

There is a tradeoff between taking full advantage of one particular type of computer and taking advantage of a full range of them. Naturally, as you broaden your range and become more diverse, the common factors drop, and you are left with an increasingly smaller area of common ground in which you can operate to accomplish a particular task. Thus, when you begin attacking a problem, it is important to consider under which part of the tradeoff curve you want to operate. Specifically, you must decide whether it is important that the task that you are coding have the full generality of being portable, or whether to just get the job done right now. This is the hardest choice to be made. The rest is easy, because Perl provides many choices, whichever way you want to approach your problem.

Looking at it another way, writing portable code is usually about willfully limiting your available choices. Naturally, it takes discipline and sacrifice to do that. The product of portability and convenience may be a constant. You have been warned.

Be aware of two important points:

Not all Perl programs have to be portable

There is no reason you should not use Perl as a language to glue Unix tools together, or to prototype a Macintosh application, or to manage the Windows registry. If it makes no sense to aim for portability for one reason or another in a given program, then don't bother.

Nearly all of Perl already *is* portable

Don't be fooled into thinking that it is hard to create portable Perl code. It isn't. Perl tries its level-best to bridge the gaps between what's available on different platforms, and all the means available to use those features. Thus almost all Perl code runs on any machine without modification. But there are some significant issues in writing portable code, and this document is entirely about those issues.

Here's the general rule: When you approach a task commonly done using a whole range of platforms, think about writing portable code. That way, you don't sacrifice much by way of the implementation choices you can avail yourself of, and at the same time you can give your users lots of platform choices. On the other hand, when you have to take advantage of some unique feature of a particular platform, as is often the case with systems programming (whether for Unix, Windows, Mac OS, VMS, etc.), consider writing platform-specific code.

When the code will run on only two or three operating systems, you may need to consider only the differences of those particular systems. The important thing is to decide where the code will run and to be deliberate in your decision.

The material below is separated into three main sections: main issues of portability (*"ISSUES"*, platform-specific issues (*"PLATFORMS"*, and built-in perl functions that behave differently on various ports (*"FUNCTION IMPLEMENTATIONS"*.

This information should not be considered complete; it includes possibly transient information about idiosyncrasies of some of the ports, almost all of which are in a state of constant evolution. Thus, this material should be considered a perpetual work in progress (<IMG SRC="yellow_sign.gif" ALT="Under Construction").

ISSUES

Newlines

In most operating systems, lines in files are terminated by newlines. Just what is used as a newline may vary from OS to OS. Unix traditionally uses `\012`, one type of DOSish I/O uses `\015\012`, and Mac OS uses `\015`.

Perl uses `\n` to represent the "logical" newline, where what is logical may depend on the platform in use. In MacPerl, `\n` always means `\015`. In DOSish perls, `\n` usually means `\012`, but when accessing a file in "text" mode, STDIO translates it to (or from) `\015\012`, depending on whether you're reading or writing. Unix does the same thing on ttys in canonical mode. `\015\012` is commonly referred to as CRLF.

Because of the "text" mode translation, DOSish perls have limitations in using `seek` and `tell` on a file accessed in "text" mode. Stick to `seek`–ing to locations you got from `tell` (and no others), and you are usually free to use `seek` and `tell` even in "text" mode. Using `seek` or `tell` or other file operations may be non–portable. If you use `binmode` on a file, however, you can usually `seek` and `tell` with arbitrary values in safety.

A common misconception in socket programming is that `\n` eq `\012` everywhere. When using protocols such as common Internet protocols, `\012` and `\015` are called for specifically, and the values of the logical `\n` and `\r` (carriage return) are not reliable.

```
print SOCKET "Hi there, client!\r\n";      # WRONG
print SOCKET "Hi there, client!\015\012"; # RIGHT
```

However, using `\015\012` (or `\cM\cJ`, or `\x0D\x0A`) can be tedious and unsightly, as well as confusing to those maintaining the code. As such, the Socket module supplies the Right Thing for those who want it.

```
use Socket qw(:DEFAULT :crlf);
print SOCKET "Hi there, client!$CRLF"      # RIGHT
```

When reading from a socket, remember that the default input record separator `$/` is `\n`, but robust socket code will recognize as either `\012` or `\015\012` as end of line:

```
while (<SOCKET>) {
    # ...
}
```

Because both CRLF and LF end in LF, the input record separator can be set to LF and any CR stripped later. Better to write:

```
use Socket qw(:DEFAULT :crlf);
local($/) = LF;      # not needed if $/ is already \012

while (<SOCKET>) {
    s/$CR?$LF/\n/;   # not sure if socket uses LF or CRLF, OK
#   s/\015?\012/\n/; # same thing
}
```

This example is preferred over the previous one—even for Unix platforms—because now any `\015`'s (`\cM`'s) are stripped out (and there was much rejoicing).

Similarly, functions that return text data—such as a function that fetches a web page—should sometimes translate newlines before returning the data, if they've not yet been translated to the local newline representation. A single line of code will often suffice:

```
$data =~ s/\015?\012/\n/g;
return $data;
```

Some of this may be confusing. Here's a handy reference to the ASCII CR and LF characters. You can print it out and stick it in your wallet.

```
LF  ==  \012  ==  \x0A  ==  \cJ  ==  ASCII 10
CR  ==  \015  ==  \x0D  ==  \cM  ==  ASCII 13

          | Unix | DOS  | Mac  |
    ---------------------------
    \n    |  LF  |  LF  |  CR  |
    \r    |  CR  |  CR  |  LF  |
    \n *  |  LF  | CRLF |  CR  |
    \r *  |  CR  |  CR  |  LF  |
    ---------------------------
    * text-mode STDIO
```

The Unix column assumes that you are not accessing a serial line (like a tty) in canonical mode. If you are, then CR on input becomes "\n", and "\n" on output becomes CRLF.

These are just the most common definitions of `\n` and `\r` in Perl. There may well be others.

Numbers endianness and Width

Different CPUs store integers and floating point numbers in different orders (called *endianness*) and widths (32−bit and 64−bit being the most common today). This affects your programs when they attempt to transfer numbers in binary format from one CPU architecture to another, usually either "live" via network connection, or by storing the numbers to secondary storage such as a disk file or tape.

Conflicting storage orders make utter mess out of the numbers. If a little−endian host (Intel, VAX) stores 0x12345678 (305419896 in decimal), a big−endian host (Motorola, Sparc, PA) reads it as 0x78563412 (2018915346 in decimal). Alpha and MIPS can be either: Digital/Compaq used/uses them in little−endian mode; SGI/Cray uses them in big−endian mode. To avoid this problem in network (socket) connections use the `pack` and `unpack` formats `n` and `N`, the "network" orders. These are guaranteed to be portable.

You can explore the endianness of your platform by unpacking a data structure packed in native format such as:

```
print unpack("h*", pack("s2", 1, 2)), "\n";
# '10002000' on e.g. Intel x86 or Alpha 21064 in little-endian mode
# '00100020' on e.g. Motorola 68040
```

If you need to distinguish between endian architectures you could use either of the variables set like so:

```
$is_big_endian   = unpack("h*", pack("s", 1)) =~ /01/;
$is_little_endian = unpack("h*", pack("s", 1)) =~ /^1/;
```

Differing widths can cause truncation even between platforms of equal endianness. The platform of shorter width loses the upper parts of the number. There is no good solution for this problem except to avoid transferring or storing raw binary numbers.

One can circumnavigate both these problems in two ways. Either transfer and store numbers always in text format, instead of raw binary, or else consider using modules like Data::Dumper (included in the standard distribution as of Perl 5.005) and Storable. Keeping all data as text significantly simplifies matters.

Files and Filesystems

Most platforms these days structure files in a hierarchical fashion. So, it is reasonably safe to assume that all platforms support the notion of a "path" to uniquely identify a file on the system. How that path is really written, though, differs considerably.

Although similar, file path specifications differ between Unix, Windows, Mac OS, OS/2, VMS, VOS, RISC OS, and probably others. Unix, for example, is one of the few OSes that has the elegant idea of a single root directory.

DOS, OS/2, VMS, VOS, and Windows can work similarly to Unix with `/` as path separator, or in their own idiosyncratic ways (such as having several root directories and various "unrooted" device files such NIL: and LPT:).

Mac OS uses `:` as a path separator instead of `/`.

The filesystem may support neither hard links (`link`) nor symbolic links (`symlink`, `readlink`, `lstat`).

The filesystem may support neither access timestamp nor change timestamp (meaning that about the only portable timestamp is the modification timestamp), or one second granularity of any timestamps (e.g. the FAT filesystem limits the time granularity to two seconds).

VOS perl can emulate Unix filenames with `/` as path separator. The native pathname characters greater−than, less−than, number−sign, and percent−sign are always accepted.

RISC OS perl can emulate Unix filenames with `/` as path separator, or go native and use `.` for path separator and `:` to signal filesystems and disk names.

If all this is intimidating, have no (well, maybe only a little) fear. There are modules that can help. The File::Spec modules provide methods to do the Right Thing on whatever platform happens to be running the program.

```
use File::Spec::Functions;
chdir(updir());        # go up one directory
$file = catfile(curdir(), 'temp', 'file.txt');
# on Unix and Win32, './temp/file.txt'
# on Mac OS, ':temp:file.txt'
# on VMS, '[.temp]file.txt'
```

File::Spec is available in the standard distribution as of version 5.004_05. File::Spec::Functions is only in File::Spec 0.7 and later, and some versions of perl come with version 0.6. If File::Spec is not updated to 0.7 or later, you must use the object−oriented interface from File::Spec (or upgrade File::Spec).

In general, production code should not have file paths hardcoded. Making them user−supplied or read from a configuration file is better, keeping in mind that file path syntax varies on different machines.

This is especially noticeable in scripts like Makefiles and test suites, which often assume `/` as a path separator for subdirectories.

Also of use is File::Basename from the standard distribution, which splits a pathname into pieces (base filename, full path to directory, and file suffix).

Even when on a single platform (if you can call Unix a single platform), remember not to count on the existence or the contents of particular system−specific files or directories, like ***/etc/passwd***, ***/etc/sendmail.conf***, ***/etc/resolv.conf***, or even ***/tmp/***. For example, ***/etc/passwd*** may exist but not contain the encrypted passwords, because the system is using some form of enhanced security. Or it may not contain all the accounts, because the system is using NIS. If code does need to rely on such a file, include a description of the file and its format in the code's documentation, then make it easy for the user to override the default location of the file.

Don't assume a text file will end with a newline. They should, but people forget.

Do not have two files of the same name with different case, like ***test.pl*** and ***Test.pl***, as many platforms have case−insensitive filenames. Also, try not to have non−word characters (except for `.`) in the names, and keep them to the 8.3 convention, for maximum portability, onerous a burden though this may appear.

Likewise, when using the AutoSplit module, try to keep your functions to 8.3 naming and case−insensitive conventions; or, at the least, make it so the resulting files have a unique (case−insensitively) first 8 characters.

Whitespace in filenames is tolerated on most systems, but not all. Many systems (DOS, VMS) cannot have more than one `.` in their filenames.

Don't assume `<` won't be the first character of a filename. Always use `< <` explicitly to open a file for reading, unless you want the user to be able to specify a pipe open.

```
open(FILE, "< $existing_file") or die $!;
```

If filenames might use strange characters, it is safest to open it with `sysopen` instead of `open`. `open` is magic and can translate characters like `<` , `< <` , and `|`, which may be the wrong thing to do. (Sometimes, though, it's the right thing.)

System Interaction

Not all platforms provide a command line. These are usually platforms that rely primarily on a Graphical User Interface (GUI) for user interaction. A program requiring a command line interface might not work everywhere. This is probably for the user of the program to deal with, so don't stay up late worrying about it.

Some platforms can't delete or rename files held open by the system. Remember to `close` files when you are done with them. Don't `unlink` or `rename` an open file. Don't `tie` or `open` a file already tied or opened; `untie` or `close` it first.

Don't open the same file more than once at a time for writing, as some operating systems put mandatory locks on such files.

Don't count on a specific environment variable existing in `%ENV`. Don't count on `%ENV` entries being case−sensitive, or even case−preserving. Don't try to clear %ENV by saying `%ENV = ();`, or, if you really have to, make it conditional on `$^O ne 'VMS'` since in VMS the `%ENV` table is much more than a per−process key−value string table.

Don't count on signals or `%SIG` for anything.

Don't count on filename globbing. Use `opendir`, `readdir`, and `closedir` instead.

Don't count on per−program environment variables, or per−program current directories.

Don't count on specific values of `$!`.

Interprocess Communication (IPC)

In general, don't directly access the system in code meant to be portable. That means, no `system`, `exec`, `fork`, `pipe`, ``, `qx//`, `open` with a `|`, nor any of the other things that makes being a perl hacker worth being.

Commands that launch external processes are generally supported on most platforms (though many of them do not support any type of forking). The problem with using them arises from what you invoke them on. External tools are often named differently on different platforms, may not be available in the same location, might accept different arguments, can behave differently, and often present their results in a platform−dependent way. Thus, you should seldom depend on them to produce consistent results. (Then again, if you're calling *netstat −a*, you probably don't expect it to run on both Unix and CP/M.)

One especially common bit of Perl code is opening a pipe to **sendmail**:

```
open(MAIL, '|/usr/lib/sendmail -t')
    or die "cannot fork sendmail: $!";
```

This is fine for systems programming when sendmail is known to be available. But it is not fine for many non−Unix systems, and even some Unix systems that may not have sendmail installed. If a portable solution is needed, see the various distributions on CPAN that deal with it. Mail::Mailer and Mail::Send in the MailTools distribution are commonly used, and provide several mailing methods, including mail, sendmail, and direct SMTP (via Net::SMTP) if a mail transfer agent is not available. Mail::Sendmail is a standalone module that provides simple, platform−independent mailing.

The Unix System V IPC (`msg*(), sem*(), shm*()`) is not available even on all Unix platforms.

The rule of thumb for portable code is: Do it all in portable Perl, or use a module (that may internally implement it with platform−specific code, but expose a common interface).

External Subroutines (XS)

XS code can usually be made to work with any platform, but dependent libraries, header files, etc., might not be readily available or portable, or the XS code itself might be platform−specific, just as Perl code might be. If the libraries and headers are portable, then it is normally reasonable to make sure the XS code is portable, too.

A different type of portability issue arises when writing XS code: availability of a C compiler on the end−user‘s system. C brings with it its own portability issues, and writing XS code will expose you to some of those. Writing purely in Perl is an easier way to achieve portability.

Standard Modules

In general, the standard modules work across platforms. Notable exceptions are the CPAN module (which currently makes connections to external programs that may not be available), platform−specific modules (like ExtUtils::MM_VMS), and DBM modules.

There is no one DBM module available on all platforms. SDBM_File and the others are generally available on all Unix and DOSish ports, but not in MacPerl, where only NBDM_File and DB_File are available.

The good news is that at least some DBM module should be available, and AnyDBM_File will use whichever module it can find. Of course, then the code needs to be fairly strict, dropping to the greatest common factor (e.g., not exceeding 1K for each record), so that it will work with any DBM module. See *AnyDBM_File* for more details.

Time and Date

The system‘s notion of time of day and calendar date is controlled in widely different ways. Don‘t assume the timezone is stored in `$ENV{TZ}`, and even if it is, don‘t assume that you can control the timezone through that variable.

Don‘t assume that the epoch starts at 00:00:00, January 1, 1970, because that is OS− and implementation−specific. It is better to store a date in an unambiguous representation. The ISO−8601 standard defines "YYYY−MM−DD" as the date format. A text representation (like "1987−12−18") can be easily converted into an OS−specific value using a module like Date::Parse. An array of values, such as those returned by `localtime`, can be converted to an OS−specific representation using Time::Local.

When calculating specific times, such as for tests in time or date modules, it may be appropriate to calculate an offset for the epoch.

```
require Time::Local;
$offset = Time::Local::timegm(0, 0, 0, 1, 0, 70);
```

The value for `$offset` in Unix will be , but in Mac OS will be some large number. `$offset` can then be added to a Unix time value to get what should be the proper value on any system.

Character sets and character encoding

Assume little about character sets. Assume nothing about numerical values (`ord`, `chr`) of characters. Do not assume that the alphabetic characters are encoded contiguously (in the numeric sense). Do not assume anything about the ordering of the characters. The lowercase letters may come before or after the uppercase letters; the lowercase and uppercase may be interlaced so that both ‘a’ and ‘A’ come before ‘b‘; the accented and other international characters may be interlaced so that ä comes before ‘b’.

Internationalisation

If you may assume POSIX (a rather large assumption), you may read more about the POSIX locale system from *perllocale*. The locale system at least attempts to make things a little bit more portable, or at least more convenient and native−friendly for non−English users. The system affects character sets and encoding, and date and time formatting—amongst other things.

System Resources

If your code is destined for systems with severely constrained (or missing!) virtual memory systems then you want to be *especially* mindful of avoiding wasteful constructs such as:

```
# NOTE: this is no longer "bad" in perl5.005
for (0..10000000) {}                    # bad
for (my $x = 0; $x <= 10000000; ++$x) {}   # good

@lines = <VERY_LARGE_FILE>;             # bad

while (<FILE>) {$file .= $_}            # sometimes bad
$file = join('', <FILE>);               # better
```

The last two constructs may appear unintuitive to most people. The first repeatedly grows a string, whereas the second allocates a large chunk of memory in one go. On some systems, the second is more efficient that the first.

Security

Most multi–user platforms provide basic levels of security, usually implemented at the filesystem level. Some, however, do not—unfortunately. Thus the notion of user id, or "home" directory, or even the state of being logged–in, may be unrecognizable on many platforms. If you write programs that are security–conscious, it is usually best to know what type of system you will be running under so that you can write code explicitly for that platform (or class of platforms).

Style

For those times when it is necessary to have platform–specific code, consider keeping the platform–specific code in one place, making porting to other platforms easier. Use the Config module and the special variable `$^O` to differentiate platforms, as described in *"PLATFORMS"*.

Be careful in the tests you supply with your module or programs. Module code may be fully portable, but its tests might not be. This often happens when tests spawn off other processes or call external programs to aid in the testing, or when (as noted above) the tests assume certain things about the filesystem and paths. Be careful not to depend on a specific output style for errors, such as when checking `$!` after an system call. Some platforms expect a certain output format, and perl on those platforms may have been adjusted accordingly. Most specifically, don't anchor a regex when testing an error value.

CPAN Testers

Modules uploaded to CPAN are tested by a variety of volunteers on different platforms. These CPAN testers are notified by mail of each new upload, and reply to the list with PASS, FAIL, NA (not applicable to this platform), or UNKNOWN (unknown), along with any relevant notations.

The purpose of the testing is twofold: one, to help developers fix any problems in their code that crop up because of lack of testing on other platforms; two, to provide users with information about whether a given module works on a given platform.

Mailing list: cpan–testers@perl.org
Testing results: http://testers.cpan.org/

PLATFORMS

As of version 5.002, Perl is built with a `$^O` variable that indicates the operating system it was built on. This was implemented to help speed up code that would otherwise have to `use Config` and use the value of `$Config{osname}`. Of course, to get more detailed information about the system, looking into `%Config` is certainly recommended.

`%Config` cannot always be trusted, however, because it was built at compile time. If perl was built in one place, then transferred elsewhere, some values may be wrong. The values may even have been edited after the fact.

Unix

Perl works on a bewildering variety of Unix and Unix-like platforms (see e.g. most of the files in the ***hints/*** directory in the source code kit). On most of these systems, the value of `$^O` (hence `$Config{'osname'}`, too) is determined either by lowercasing and stripping punctuation from the first field of the string returned by typing `uname -a` (or a similar command) at the shell prompt or by testing the file system for the presence of uniquely named files such as a kernel or header file. Here, for example, are a few of the more popular Unix flavors:

```
uname          $^O        $Config{'archname'}
--------------------------------------------
AIX            aix        aix
BSD/OS         bsdos      i386-bsdos
dgux           dgux       AViiON-dgux
DYNIX/ptx      dynixptx   i386-dynixptx
FreeBSD        freebsd    freebsd-i386
Linux          linux      arm-linux
Linux          linux      i386-linux
Linux          linux      i586-linux
Linux          linux      ppc-linux
HP-UX          hpux       PA-RISC1.1
IRIX           irix       irix
Mac OS X       rhapsody   rhapsody
MachTen PPC    machten    powerpc-machten
NeXT 3         next       next-fat
NeXT 4         next       OPENSTEP-Mach
openbsd        openbsd    i386-openbsd
OSF1           dec_osf    alpha-dec_osf
reliantunix-n  svr4       RM400-svr4
SCO_SV         sco_sv     i386-sco_sv
SINIX-N        svr4       RM400-svr4
sn4609         unicos     CRAY_C90-unicos
sn6521         unicosmk   t3e-unicosmk
sn9617         unicos     CRAY_J90-unicos
SunOS          solaris    sun4-solaris
SunOS          solaris    i86pc-solaris
SunOS4         sunos      sun4-sunos
```

Because the value of `$Config{archname}` may depend on the hardware architecture, it can vary more than the value of `$^O`.

DOS and Derivatives

Perl has long been ported to Intel-style microcomputers running under systems like PC-DOS, MS-DOS, OS/2, and most Windows platforms you can bring yourself to mention (except for Windows CE, if you count that). Users familiar with *COMMAND.COM* or *CMD.EXE* style shells should be aware that each of these file specifications may have subtle differences:

```
$filespec0 = "c:/foo/bar/file.txt";
$filespec1 = "c:\\foo\\bar\\file.txt";
$filespec2 = 'c:\foo\bar\file.txt';
$filespec3 = 'c:\\foo\\bar\\file.txt';
```

System calls accept either `/` or `\` as the path separator. However, many command-line utilities of DOS vintage treat `/` as the option prefix, so may get confused by filenames containing `/`. Aside from calling any external programs, `/` will work just fine, and probably better, as it is more consistent with popular usage, and avoids the problem of remembering what to backwhack and what not to.

The DOS FAT filesystem can accommodate only "8.3" style filenames. Under the "case-insensitive, but case-preserving" HPFS (OS/2) and NTFS (NT) filesystems you may have to be careful about case returned with functions like `readdir` or used with functions like `open` or `opendir`.

DOS also treats several filenames as special, such as AUX, PRN, NUL, CON, COM1, LPT1, LPT2, etc. Unfortunately, sometimes these filenames won't even work if you include an explicit directory prefix. It is best to avoid such filenames, if you want your code to be portable to DOS and its derivatives. It's hard to know what these all are, unfortunately.

Users of these operating systems may also wish to make use of scripts such as *pl2bat.bat* or *pl2cmd* to put wrappers around your scripts.

Newline (`\n`) is translated as `\015\012` by STDIO when reading from and writing to files (see *"Newlines"*). `binmode(FILEHANDLE)` will keep `\n` translated as `\012` for that filehandle. Since it is a no-op on other systems, `binmode` should be used for cross-platform code that deals with binary data. That's assuming you realize in advance that your data is in binary. General-purpose programs should often assume nothing about their data.

The `$^O` variable and the `$Config{archname}` values for various DOSish perls are as follows:

```
OS              $^O         $Config{'archname'}
--------------------------------------------
MS-DOS          dos
PC-DOS          dos
OS/2            os2
Windows 95      MSWin32     MSWin32-x86
Windows 98      MSWin32     MSWin32-x86
Windows NT      MSWin32     MSWin32-x86
Windows NT      MSWin32     MSWin32-ALPHA
Windows NT      MSWin32     MSWin32-ppc
Cygwin          cygwin
```

Also see:

- The djgpp environment for DOS, http://www.delorie.com/djgpp/ and *perldos*.
- The EMX environment for DOS, OS/2, etc. emx@iaehv.nl, http://www.leo.org/pub/comp/os/os2/leo/gnu/emx+gcc/index.html or ftp://hobbes.nmsu.edu/pub/os2/dev/emx. Also *perlos2*.
- Build instructions for Win32 in *perlwin32*, or under the Cygnus environment in *perlcygwin*.
- The `Win32::*` modules in *Win32*.
- The ActiveState Pages, http://www.activestate.com/
- The Cygwin environment for Win32; ***README.cygwin*** (installed as *perlcygwin*), http://www.cygwin.com/
- The U/WIN environment for Win32, <http://www.research.att.com/sw/tools/uwin/

Build instructions for OS/2, *perlos2*

Mac OS

Any module requiring XS compilation is right out for most people, because MacPerl is built using non-free (and non-cheap!) compilers. Some XS modules that can work with MacPerl are built and distributed in binary form on CPAN.

Directories are specified as:

```
volume:folder:file              for absolute pathnames
volume:folder:                  for absolute pathnames
:folder:file                    for relative pathnames
```

```
:folder:                        for relative pathnames
:file                           for relative pathnames
file                            for relative pathnames
```

Files are stored in the directory in alphabetical order. Filenames are limited to 31 characters, and may include any character except for null and `:`, which is reserved as the path separator.

Instead of `flock`, see `FSpSetFLock` and `FSpRstFLock` in the Mac::Files module, or `chmod(0444, ...)` and `chmod(0666, ...)`.

In the MacPerl application, you can't run a program from the command line; programs that expect `@ARGV` to be populated can be edited with something like the following, which brings up a dialog box asking for the command line arguments.

```
if (!@ARGV) {
    @ARGV = split /\s+/, MacPerl::Ask('Arguments?');
}
```

A MacPerl script saved as a "droplet" will populate `@ARGV` with the full pathnames of the files dropped onto the script.

Mac users can run programs under a type of command line interface under MPW (Macintosh Programmer's Workshop, a free development environment from Apple). MacPerl was first introduced as an MPW tool, and MPW can be used like a shell:

```
perl myscript.plx some arguments
```

ToolServer is another app from Apple that provides access to MPW tools from MPW and the MacPerl app, which allows MacPerl programs to use `system`, backticks, and piped `open`.

"Mac OS" is the proper name for the operating system, but the value in `$^O` is "MacOS". To determine architecture, version, or whether the application or MPW tool version is running, check:

```
$is_app     = $MacPerl::Version =~ /App/;
$is_tool    = $MacPerl::Version =~ /MPW/;
($version) = $MacPerl::Version =~ /^(\S+)/;
$is_ppc     = $MacPerl::Architecture eq 'MacPPC';
$is_68k     = $MacPerl::Architecture eq 'Mac68K';
```

Mac OS X and Mac OS X Server, based on NeXT's OpenStep OS, will (in theory) be able to run MacPerl natively, under the "Classic" environment. The new "Cocoa" environment (formerly called the "Yellow Box") may run a slightly modified version of MacPerl, using the Carbon interfaces.

Mac OS X Server and its Open Source version, Darwin, both run Unix perl natively (with a few patches). Full support for these is slated for perl 5.6.

Also see:

- The MacPerl Pages, http://www.macperl.com/ .
- The MacPerl mailing lists, http://www.macperl.org/ .
- MacPerl Module Porters, http://pudge.net/mmp/ .

VMS

Perl on VMS is discussed in *perlvms* in the perl distribution. Perl on VMS can accept either VMS- or Unix-style file specifications as in either of the following:

```
$ perl -ne "print if /perl_setup/i" SYS$LOGIN:LOGIN.COM
$ perl -ne "print if /perl_setup/i" /sys$login/login.com
```

but not a mixture of both as in:

```
$ perl -ne "print if /perl_setup/i" sys$login:/login.com
```

```
Can't open sys$login:/login.com: file specification syntax error
```

Interacting with Perl from the Digital Command Language (DCL) shell often requires a different set of quotation marks than Unix shells do. For example:

```
$ perl -e "print ""Hello, world.\n"""
Hello, world.
```

There are several ways to wrap your perl scripts in DCL ***.COM*** files, if you are so inclined. For example:

```
$ write sys$output "Hello from DCL!"
$ if p1 .eqs. ""
$ then perl -x 'f$environment("PROCEDURE")
$ else perl -x - 'p1 'p2 'p3 'p4 'p5 'p6 'p7 'p8
$ deck/dollars="__END__"
#!/usr/bin/perl

print "Hello from Perl!\n";

__END__
$ endif
```

Do take care with `$ ASSIGN/nolog/user SYS$COMMAND: SYS$INPUT` if your perl-in-DCL script expects to do things like `< $read = <STDIN>;`.

Filenames are in the format "name.extension;version". The maximum length for filenames is 39 characters, and the maximum length for extensions is also 39 characters. Version is a number from 1 to 32767. Valid characters are `/[A-Z0-9$_-]/`.

VMS's RMS filesystem is case-insensitive and does not preserve case. `readdir` returns lowercased filenames, but specifying a file for opening remains case-insensitive. Files without extensions have a trailing period on them, so doing a `readdir` with a file named ***A.;5*** will return ***a.*** (though that file could be opened with `open(FH, 'A')`).

RMS had an eight level limit on directory depths from any rooted logical (allowing 16 levels overall) prior to VMS 7.2. Hence `PERL_ROOT:[LIB.2.3.4.5.6.7.8]` is a valid directory specification but `PERL_ROOT:[LIB.2.3.4.5.6.7.8.9]` is not. ***Makefile.PL*** authors might have to take this into account, but at least they can refer to the former as `/PERL_ROOT/lib/2/3/4/5/6/7/8/`.

The VMS::Filespec module, which gets installed as part of the build process on VMS, is a pure Perl module that can easily be installed on non-VMS platforms and can be helpful for conversions to and from RMS native formats.

What `\n` represents depends on the type of file opened. It could be `\015`, `\012`, `\015\012`, or nothing. The VMS::Stdio module provides access to the special `fopen()` requirements of files with unusual attributes on VMS.

TCP/IP stacks are optional on VMS, so socket routines might not be implemented. UDP sockets may not be supported.

The value of `$^O` on OpenVMS is "VMS". To determine the architecture that you are running on without resorting to loading all of `%Config` you can examine the content of the `@INC` array like so:

```
if (grep(/VMS_AXP/, @INC)) {
    print "I'm on Alpha!\n";

} elsif (grep(/VMS_VAX/, @INC)) {
    print "I'm on VAX!\n";

} else {
    print "I'm not so sure about where $^O is...\n";
}
```

On VMS, perl determines the UTC offset from the `SYS$TIMEZONE_DIFFERENTIAL` logical name. Although the VMS epoch began at 17−NOV−1858 00:00:00.00, calls to `localtime` are adjusted to count offsets from 01−JAN−1970 00:00:00.00, just like Unix.

Also see:

- ***README.vms*** (installed as *README_vms*), *perlvms*
- vmsperl list, majordomo@perl.org

  (Put the words `subscribe vmsperl` in message body.)
- vmsperl on the web, http://www.sidhe.org/vmsperl/index.html

VOS

Perl on VOS is discussed in ***README.vos*** in the perl distribution (installed as *perlvos*). Perl on VOS can accept either VOS− or Unix−style file specifications as in either of the following:

```
$ perl -ne "print if /perl_setup/i" >system>notices
$ perl -ne "print if /perl_setup/i" /system/notices
```

or even a mixture of both as in:

```
$ perl -ne "print if /perl_setup/i" >system/notices
```

Even though VOS allows the slash character to appear in object names, because the VOS port of Perl interprets it as a pathname delimiting character, VOS files, directories, or links whose names contain a slash character cannot be processed. Such files must be renamed before they can be processed by Perl. Note that VOS limits file names to 32 or fewer characters.

See ***README.vos*** for restrictions that apply when Perl is built with the alpha version of VOS POSIX.1 support.

Perl on VOS is built without any extensions and does not support dynamic loading.

The value of `$^O` on VOS is "VOS". To determine the architecture that you are running on without resorting to loading all of `%Config` you can examine the content of the @INC array like so:

```
if ($^O =~ /VOS/) {
    print "I'm on a Stratus box!\n";
} else {
    print "I'm not on a Stratus box!\n";
    die;
}

if (grep(/860/, @INC)) {
    print "This box is a Stratus XA/R!\n";

} elsif (grep(/7100/, @INC)) {
    print "This box is a Stratus HP 7100 or 8xxx!\n";

} elsif (grep(/8000/, @INC)) {
    print "This box is a Stratus HP 8xxx!\n";

} else {
    print "This box is a Stratus 68K!\n";
}
```

Also see:

- ***README.vos***
- The VOS mailing list.

  There is no specific mailing list for Perl on VOS. You can post comments to the comp.sys.stratus

newsgroup, or subscribe to the general Stratus mailing list. Send a letter with "Subscribe Info-Stratus" in the message body to majordomo@list.stratagy.com.

- VOS Perl on the web at http://ftp.stratus.com/pub/vos/vos.html

EBCDIC Platforms

Recent versions of Perl have been ported to platforms such as OS/400 on AS/400 minicomputers as well as OS/390, VM/ESA, and BS2000 for S/390 Mainframes. Such computers use EBCDIC character sets internally (usually Character Code Set ID 0037 for OS/400 and either 1047 or POSIX-BC for S/390 systems). On the mainframe perl currently works under the "Unix system services for OS/390" (formerly known as OpenEdition), VM/ESA OpenEdition, or the BS200 POSIX-BC system (BS2000 is supported in perl 5.6 and greater). See *perlos390* for details.

As of R2.5 of USS for OS/390 and Version 2.3 of VM/ESA these Unix sub-systems do not support the `#!` shebang trick for script invocation. Hence, on OS/390 and VM/ESA perl scripts can be executed with a header similar to the following simple script:

```
: # use perl
    eval 'exec /usr/local/bin/perl -S $0 ${1+"$@"}'
        if 0;
#!/usr/local/bin/perl     # just a comment really

print "Hello from perl!\n";
```

OS/390 will support the `#!` shebang trick in release 2.8 and beyond. Calls to `system` and backticks can use POSIX shell syntax on all S/390 systems.

On the AS/400, if PERL5 is in your library list, you may need to wrap your perl scripts in a CL procedure to invoke them like so:

```
BEGIN
  CALL PGM(PERL5/PERL) PARM('/QOpenSys/hello.pl')
ENDPGM
```

This will invoke the perl script ***hello.pl*** in the root of the QOpenSys file system. On the AS/400 calls to `system` or backticks must use CL syntax.

On these platforms, bear in mind that the EBCDIC character set may have an effect on what happens with some perl functions (such as `chr`, `pack`, `print`, `printf`, `ord`, `sort`, `sprintf`, `unpack`), as well as bit-fiddling with ASCII constants using operators like `^`, `&` and `|`, not to mention dealing with socket interfaces to ASCII computers (see *"Newlines"*).

Fortunately, most web servers for the mainframe will correctly translate the `\n` in the following statement to its ASCII equivalent (`\r` is the same under both Unix and OS/390 & VM/ESA):

```
print "Content-type: text/html\r\n\r\n";
```

The values of `$^O` on some of these platforms includes:

```
uname         $^O        $Config{'archname'}
--------------------------------------------
OS/390        os390      os390
OS400         os400      os400
POSIX-BC      posix-bc   BS2000-posix-bc
VM/ESA        vmesa      vmesa
```

Some simple tricks for determining if you are running on an EBCDIC platform could include any of the following (perhaps all):

```
if ("\t" eq "\05")   { print "EBCDIC may be spoken here!\n"; }

if (ord('A') == 193) { print "EBCDIC may be spoken here!\n"; }
```

```
if (chr(169) eq 'z') { print "EBCDIC may be spoken here!\n"; }
```

One thing you may not want to rely on is the EBCDIC encoding of punctuation characters since these may differ from code page to code page (and once your module or script is rumoured to work with EBCDIC, folks will want it to work with all EBCDIC character sets).

Also see:

- *

  perlos390, ***README.os390***, ***perlposix-bc***, ***README.vmesa***, *perlebcdic*.

- The perl-mvs@perl.org list is for discussion of porting issues as well as general usage issues for all EBCDIC Perls. Send a message body of "subscribe perl-mvs" to majordomo@perl.org.

- AS/400 Perl information at http://as400.rochester.ibm.com/ as well as on CPAN in the ***ports/*** directory.

Acorn RISC OS

Because Acorns use ASCII with newlines (`\n`) in text files as `\012` like Unix, and because Unix filename emulation is turned on by default, most simple scripts will probably work "out of the box". The native filesystem is modular, and individual filesystems are free to be case-sensitive or insensitive, and are usually case-preserving. Some native filesystems have name length limits, which file and directory names are silently truncated to fit. Scripts should be aware that the standard filesystem currently has a name length limit of **10** characters, with up to 77 items in a directory, but other filesystems may not impose such limitations.

Native filenames are of the form

```
Filesystem#Special_Field::DiskName.$.Directory.Directory.File
```

where

```
Special_Field is not usually present, but may contain . and $ .
Filesystem =~ m|[A-Za-z0-9_]|
DsicName   =~ m|[A-Za-z0-9_/]|
$ represents the root directory
. is the path separator
@ is the current directory (per filesystem but machine global)
^ is the parent directory
Directory and File =~ m|[^\0- "\.\$\%\&:\@\\^\|\177]+|
```

The default filename translation is roughly `tr|/.|./|;`

Note that `"ADFS::HardDisk.$.File" ne 'ADFS::HardDisk.$.File'` and that the second stage of `$` interpolation in regular expressions will fall foul of the `$.` if scripts are not careful.

Logical paths specified by system variables containing comma-separated search lists are also allowed; hence `System:Modules` is a valid filename, and the filesystem will prefix `Modules` with each section of `System$Path` until a name is made that points to an object on disk. Writing to a new file `System:Modules` would be allowed only if `System$Path` contains a single item list. The filesystem will also expand system variables in filenames if enclosed in angle brackets, so `<<System$Dir.Modules>>` would look for the file `$ENV{'System$Dir'} . 'Modules'`. The obvious implication of this is that **fully qualified filenames can start with `<` `<`** and should be protected when `open` is used for input.

Because `.` was in use as a directory separator and filenames could not be assumed to be unique after 10 characters, Acorn implemented the C compiler to strip the trailing `.c` `.h` `.s` and `.o` suffix from filenames specified in source code and store the respective files in subdirectories named after the suffix. Hence files are translated:

```
foo.h           h.foo
```

```
C:foo.h         C:h.foo         (logical path variable)
sys/os.h        sys.h.os        (C compiler groks Unix-speak)
10charname.c    c.10charname
10charname.o    o.10charname
11charname_.c   c.11charname    (assuming filesystem truncates at 10)
```

The Unix emulation library's translation of filenames to native assumes that this sort of translation is required, and it allows a user-defined list of known suffixes that it will transpose in this fashion. This may seem transparent, but consider that with these rules `foo/bar/baz.h` and `foo/bar/h/baz` both map to `foo.bar.h.baz`, and that `readdir` and `glob` cannot and do not attempt to emulate the reverse mapping. Other `.`'s in filenames are translated to `/`.

As implied above, the environment accessed through `%ENV` is global, and the convention is that program specific environment variables are of the form `Program$Name`. Each filesystem maintains a current directory, and the current filesystem's current directory is the **global** current directory. Consequently, sociable programs don't change the current directory but rely on full pathnames, and programs (and Makefiles) cannot assume that they can spawn a child process which can change the current directory without affecting its parent (and everyone else for that matter).

Because native operating system filehandles are global and are currently allocated down from 255, with 0 being a reserved value, the Unix emulation library emulates Unix filehandles. Consequently, you can't rely on passing `STDIN`, `STDOUT`, or `STDERR` to your children.

The desire of users to express filenames of the form `< <Foo$Dir.Bar` on the command line unquoted causes problems, too: `` `` `` command output capture has to perform a guessing game. It assumes that a string `< <[^<]+\$[^<]` is a reference to an environment variable, whereas anything else involving `< <` or `<` is redirection, and generally manages to be 99% right. Of course, the problem remains that scripts cannot rely on any Unix tools being available, or that any tools found have Unix-like command line arguments.

Extensions and XS are, in theory, buildable by anyone using free tools. In practice, many don't, as users of the Acorn platform are used to binary distributions. MakeMaker does run, but no available make currently copes with MakeMaker's makefiles; even if and when this should be fixed, the lack of a Unix-like shell will cause problems with makefile rules, especially lines of the form `cd sdbm && make all`, and anything using quoting.

"RISC OS" is the proper name for the operating system, but the value in `$^O` is "riscos" (because we don't like shouting).

Other perls

Perl has been ported to many platforms that do not fit into any of the categories listed above. Some, such as AmigaOS, Atari MiNT, BeOS, HP MPE/iX, QNX, Plan 9, and VOS, have been well-integrated into the standard Perl source code kit. You may need to see the ***ports/*** directory on CPAN for information, and possibly binaries, for the likes of: aos, Atari ST, lynxos, riscos, Novell Netware, Tandem Guardian, *etc.* (Yes, we know that some of these OSes may fall under the Unix category, but we are not a standards body.)

Some approximate operating system names and their `$^O` values in the "OTHER" category include:

```
OS              $^O         $Config{'archname'}
--------------------------------------------
Amiga DOS       amigaos     m68k-amigos
MPE/iX          mpeix       PA-RISC1.1
```

See also:

- Amiga, ***README.amiga*** (installed as *perlamiga*).
- Atari, ***README.mint*** and Guido Flohr's web page http://stud.uni-sb.de/~gufl0000/
- Be OS, ***README.beos***

- HP 300 MPE/iX, ***README.mpeix*** and Mark Bixby's web page http://www.cccd.edu/~markb/perlix.html
- A free perl5-based PERL.NLM for Novell Netware is available in precompiled binary and source code form from http://www.novell.com/ as well as from CPAN.
- Plan 9, ***README.plan9***

FUNCTION IMPLEMENTATIONS

Listed below are functions that are either completely unimplemented or else have been implemented differently on various platforms. Following each description will be, in parentheses, a list of platforms that the description applies to.

The list may well be incomplete, or even wrong in some places. When in doubt, consult the platform-specific README files in the Perl source distribution, and any other documentation resources accompanying a given port.

Be aware, moreover, that even among Unix-ish systems there are variations.

For many functions, you can also query `%Config`, exported by default from the Config module. For example, to check whether the platform has the `lstat` call, check `$Config{d_lstat}`. See *Config* for a full description of available variables.

Alphabetical Listing of Perl Functions

–X FILEHANDLE
–X EXPR
–X `-r`, `-w`, and `-x` have a limited meaning only; directories and applications are executable, and there are no uid/gid considerations. `-o` is not supported. (Mac OS)

`-r`, `-w`, `-x`, and `-o` tell whether the file is accessible, which may not reflect UIC-based file protections. (VMS)

`-s` returns the size of the data fork, not the total size of data fork plus resource fork. (Mac OS).

`-s` by name on an open file will return the space reserved on disk, rather than the current extent. `-s` on an open filehandle returns the current size. (RISC OS)

`-R`, `-W`, `-X`, `-O` are indistinguishable from `-r`, `-w`, `-x`, `-o`. (Mac OS, Win32, VMS, RISC OS)

`-b`, `-c`, `-k`, `-g`, `-p`, `-u`, `-A` are not implemented. (Mac OS)

`-g`, `-k`, `-l`, `-p`, `-u`, `-A` are not particularly meaningful. (Win32, VMS, RISC OS)

`-d` is true if passed a device spec without an explicit directory. (VMS)

`-T` and `-B` are implemented, but might misclassify Mac text files with foreign characters; this is the case will all platforms, but may affect Mac OS often. (Mac OS)

`-x` (or `-X`) determine if a file ends in one of the executable suffixes. `-S` is meaningless. (Win32)

`-x` (or `-X`) determine if a file has an executable file type. (RISC OS)

alarm SECONDS
alarm Not implemented. (Win32)

binmode FILEHANDLE

Meaningless. (Mac OS, RISC OS)

Reopens file and restores pointer; if function fails, underlying filehandle may be closed, or pointer may be in a different position. (VMS)

The value returned by `tell` may be affected after the call, and the filehandle may be flushed. (Win32)

chmod LIST

Only limited meaning. Disabling/enabling write permission is mapped to locking/unlocking the file. (Mac OS)

Only good for changing "owner" read–write access, "group", and "other" bits are meaningless. (Win32)

Only good for changing "owner" and "other" read–write access. (RISC OS)

Access permissions are mapped onto VOS access–control list changes. (VOS)

chown LIST

Not implemented. (Mac OS, Win32, Plan9, RISC OS, VOS)

Does nothing, but won't fail. (Win32)

chroot FILENAME

chroot Not implemented. (Mac OS, Win32, VMS, Plan9, RISC OS, VOS, VM/ESA)

crypt PLAINTEXT,SALT

May not be available if library or source was not provided when building perl. (Win32)

Not implemented. (VOS)

dbmclose HASH

Not implemented. (VMS, Plan9, VOS)

dbmopen HASH,DBNAME,MODE

Not implemented. (VMS, Plan9, VOS)

dump LABEL

Not useful. (Mac OS, RISC OS)

Not implemented. (Win32)

Invokes VMS debugger. (VMS)

exec LIST

Not implemented. (Mac OS)

Implemented via Spawn. (VM/ESA)

Does not automatically flush output handles on some platforms. (SunOS, Solaris, HP–UX)

fcntl FILEHANDLE,FUNCTION,SCALAR

Not implemented. (Win32, VMS)

flock FILEHANDLE,OPERATION

Not implemented (Mac OS, VMS, RISC OS, VOS).

Available only on Windows NT (not on Windows 95). (Win32)

fork Not implemented. (Mac OS, AmigaOS, RISC OS, VOS, VM/ESA)

Emulated using multiple interpreters. See *perlfork*. (Win32)

Does not automatically flush output handles on some platforms. (SunOS, Solaris, HP–UX)

getlogin Not implemented. (Mac OS, RISC OS)

getpgrp PID

Not implemented. (Mac OS, Win32, VMS, RISC OS, VOS)

getppid Not implemented. (Mac OS, Win32, VMS, RISC OS)

getpriority WHICH,WHO
Not implemented. (Mac OS, Win32, VMS, RISC OS, VOS, VM/ESA)

getpwnam NAME
Not implemented. (Mac OS, Win32)

Not useful. (RISC OS)

getgrnam NAME
Not implemented. (Mac OS, Win32, VMS, RISC OS)

getnetbyname NAME
Not implemented. (Mac OS, Win32, Plan9)

getpwuid UID
Not implemented. (Mac OS, Win32)

Not useful. (RISC OS)

getgrgid GID
Not implemented. (Mac OS, Win32, VMS, RISC OS)

getnetbyaddr ADDR,ADDRTYPE
Not implemented. (Mac OS, Win32, Plan9)

getprotobynumber NUMBER
Not implemented. (Mac OS)

getservbyport PORT,PROTO
Not implemented. (Mac OS)

getpwent Not implemented. (Mac OS, Win32, VM/ESA)

getgrent Not implemented. (Mac OS, Win32, VMS, VM/ESA)

gethostent
Not implemented. (Mac OS, Win32)

getnetent Not implemented. (Mac OS, Win32, Plan9)

getprotoent
Not implemented. (Mac OS, Win32, Plan9)

getservent
Not implemented. (Win32, Plan9)

setpwent Not implemented. (Mac OS, Win32, RISC OS)

setgrent Not implemented. (Mac OS, Win32, VMS, RISC OS)

sethostent STAYOPEN
Not implemented. (Mac OS, Win32, Plan9, RISC OS)

setnetent STAYOPEN
Not implemented. (Mac OS, Win32, Plan9, RISC OS)

setprotoent STAYOPEN
Not implemented. (Mac OS, Win32, Plan9, RISC OS)

setservent STAYOPEN

Not implemented. (Plan9, Win32, RISC OS)

endpwent

Not implemented. (Mac OS, MPE/iX, VM/ESA, Win32)

endgrent Not implemented. (Mac OS, MPE/iX, RISC OS, VM/ESA, VMS, Win32)

endhostent

Not implemented. (Mac OS, Win32)

endnetent

Not implemented. (Mac OS, Win32, Plan9)

endprotoent

Not implemented. (Mac OS, Win32, Plan9)

endservent

Not implemented. (Plan9, Win32)

getsockopt SOCKET,LEVEL,OPTNAME

Not implemented. (Mac OS, Plan9)

glob EXPR
glob Globbing built−in, but only `*` and `?` metacharacters are supported. (Mac OS)

This operator is implemented via the File::Glob extension on most platforms. See *File::Glob* for portability information.

ioctl FILEHANDLE,FUNCTION,SCALAR

Not implemented. (VMS)

Available only for socket handles, and it does what the `ioctlsocket()` call in the Winsock API does. (Win32)

Available only for socket handles. (RISC OS)

kill SIGNAL, LIST

Not implemented, hence not useful for taint checking. (Mac OS, RISC OS)

`kill()` doesn't have the semantics of `raise()`, i.e. it doesn't send a signal to the identified process like it does on Unix platforms. Instead `kill($sig, $pid)` terminates the process identified by `$pid`, and makes it exit immediately with exit status `$sig`. As in Unix, if `$sig` is 0 and the specified process exists, it returns true without actually terminating it. (Win32)

link OLDFILE,NEWFILE

Not implemented. (Mac OS, MPE/iX, VMS, RISC OS)

Link count not updated because hard links are not quite that hard (They are sort of half−way between hard and soft links). (AmigaOS)

Hard links are implemented on Win32 (Windows NT and Windows 2000) under NTFS only.

lstat FILEHANDLE
lstat EXPR
lstat Not implemented. (VMS, RISC OS)

Return values (especially for device and inode) may be bogus. (Win32)

msgctl ID,CMD,ARG

msgget KEY,FLAGS
msgsnd ID,MSG,FLAGS
msgrcv ID,VAR,SIZE,TYPE,FLAGS

Not implemented. (Mac OS, Win32, VMS, Plan9, RISC OS, VOS)

open FILEHANDLE,EXPR
open FILEHANDLE

The | variants are supported only if ToolServer is installed. (Mac OS)

open to |– and –| are unsupported. (Mac OS, Win32, RISC OS)

Opening a process does not automatically flush output handles on some platforms. (SunOS, Solaris, HP–UX)

pipe READHANDLE,WRITEHANDLE

Not implemented. (Mac OS)

Very limited functionality. (MiNT)

readlink EXPR
readlink Not implemented. (Win32, VMS, RISC OS)

select RBITS,WBITS,EBITS,TIMEOUT

Only implemented on sockets. (Win32)

Only reliable on sockets. (RISC OS)

Note that the `socket FILEHANDLE` form is generally portable.

semctl ID,SEMNUM,CMD,ARG
semget KEY,NSEMS,FLAGS
semop KEY,OPSTRING

Not implemented. (Mac OS, Win32, VMS, RISC OS, VOS)

setgrent Not implemented. (MPE/iX, Win32)

setpgrp PID,PGRP

Not implemented. (Mac OS, Win32, VMS, RISC OS, VOS)

setpriority WHICH,WHO,PRIORITY

Not implemented. (Mac OS, Win32, VMS, RISC OS, VOS)

setpwent Not implemented. (MPE/iX, Win32)

setsockopt SOCKET,LEVEL,OPTNAME,OPTVAL

Not implemented. (Mac OS, Plan9)

shmctl ID,CMD,ARG
shmget KEY,SIZE,FLAGS
shmread ID,VAR,POS,SIZE
shmwrite ID,STRING,POS,SIZE

Not implemented. (Mac OS, Win32, VMS, RISC OS, VOS)

socketpair SOCKET1,SOCKET2,DOMAIN,TYPE,PROTOCOL

Not implemented. (Mac OS, Win32, VMS, RISC OS, VOS, VM/ESA)

stat FILEHANDLE
stat EXPR
stat Platforms that do not have rdev, blksize, or blocks will return these as '', so numeric comparison or manipulation of these fields may cause 'not numeric' warnings.

mtime and atime are the same thing, and ctime is creation time instead of inode change time.

(Mac OS)

device and inode are not meaningful. (Win32)

device and inode are not necessarily reliable. (VMS)

mtime, atime and ctime all return the last modification time. Device and inode are not necessarily reliable. (RISC OS)

dev, rdev, blksize, and blocks are not available. inode is not meaningful and will differ between stat calls on the same file. (os2)

symlink OLDFILE,NEWFILE

Not implemented. (Win32, VMS, RISC OS)

syscall LIST

Not implemented. (Mac OS, Win32, VMS, RISC OS, VOS, VM/ESA)

sysopen FILEHANDLE,FILENAME,MODE,PERMS

The traditional "0", "1", and "2" MODEs are implemented with different numeric values on some systems. The flags exported by `Fcntl` (O_RDONLY, O_WRONLY, O_RDWR) should work everywhere though. (Mac OS, OS/390, VM/ESA)

system LIST

Only implemented if ToolServer is installed. (Mac OS)

As an optimization, may not call the command shell specified in `$ENV{PERL5SHELL}`. `system(1, @args)` spawns an external process and immediately returns its process designator, without waiting for it to terminate. Return value may be used subsequently in `wait` or `waitpid`. Failure to `spawn()` a subprocess is indicated by setting `$?` to "255 << 8". `$?` is set in a way compatible with Unix (i.e. the exitstatus of the subprocess is obtained by "`$?` 8", as described in the documentation). (Win32)

There is no shell to process metacharacters, and the native standard is to pass a command line terminated by "\n" "\r" or "\0" to the spawned program. Redirection such as `< foo` is performed (if at all) by the run time library of the spawned program. `system` *list* will call the Unix emulation library's `exec` emulation, which attempts to provide emulation of the stdin, stdout, stderr in force in the parent, providing the child program uses a compatible version of the emulation library. *scalar* will call the native command line direct and no such emulation of a child Unix program will exists. Mileage **will** vary. (RISC OS)

Far from being POSIX compliant. Because there may be no underlying /bin/sh tries to work around the problem by forking and execing the first token in its argument string. Handles basic redirection ("<" or ">") on its own behalf. (MiNT)

Does not automatically flush output handles on some platforms. (SunOS, Solaris, HP-UX)

times Only the first entry returned is nonzero. (Mac OS)

"cumulative" times will be bogus. On anything other than Windows NT or Windows 2000, "system" time will be bogus, and "user" time is actually the time returned by the `clock()` function in the C runtime library. (Win32)

Not useful. (RISC OS)

truncate FILEHANDLE,LENGTH
truncate EXPR,LENGTH

Not implemented. (VMS)

Truncation to zero-length only. (VOS)

If a FILEHANDLE is supplied, it must be writable and opened in append mode (i.e., use `open(FH, 'filename')` or `sysopen(FH,...,O_APPEND|O_RDWR)`. If a filename is

supplied, it should not be held open elsewhere. (Win32)

umask EXPR
umask Returns undef where unavailable, as of version 5.005.

`umask` works but the correct permissions are set only when the file is finally closed. (AmigaOS)

utime LIST

Only the modification time is updated. (Mac OS, VMS, RISC OS)

May not behave as expected. Behavior depends on the C runtime library's implementation of `utime()`, and the filesystem being used. The FAT filesystem typically does not support an "access time" field, and it may limit timestamps to a granularity of two seconds. (Win32)

wait
waitpid PID,FLAGS

Not implemented. (Mac OS, VOS)

Can only be applied to process handles returned for processes spawned using `system(1, ...)` or pseudo processes created with `fork()`. (Win32)

Not useful. (RISC OS)

CHANGES

v1.47, 22 March 2000

Various cleanups from Tom Christiansen, including migration of long platform listings from *perl*.

v1.46, 12 February 2000

Updates for VOS and MPE/iX. (Peter Prymmer) Other small changes.

v1.45, 20 December 1999

Small changes from 5.005_63 distribution, more changes to EBCDIC info.

v1.44, 19 July 1999

A bunch of updates from Peter Prymmer for `$^O` values, endianness, File::Spec, VMS, BS2000, OS/400.

v1.43, 24 May 1999

Added a lot of cleaning up from Tom Christiansen.

v1.42, 22 May 1999

Added notes about tests, sprintf/printf, and epoch offsets.

v1.41, 19 May 1999

Lots more little changes to formatting and content.

Added a bunch of `$^O` and related values for various platforms; fixed mail and web addresses, and added and changed miscellaneous notes. (Peter Prymmer)

v1.40, 11 April 1999

Miscellaneous changes.

v1.39, 11 February 1999

Changes from Jarkko and EMX URL fixes Michael Schwern. Additional note about newlines added.

v1.38, 31 December 1998

More changes from Jarkko.

v1.37, 19 December 1998

More minor changes. Merge two separate version 1.35 documents.

v1.36, 9 September 1998

Updated for Stratus VOS. Also known as version 1.35.

v1.35, 13 August 1998

Integrate more minor changes, plus addition of new sections under *"ISSUES"*: *"Numbers endianness and Width"*, *"Character sets and character encoding"*, *"Internationalisation"*.

v1.33, 06 August 1998

Integrate more minor changes.

v1.32, 05 August 1998

Integrate more minor changes.

v1.30, 03 August 1998

Major update for RISC OS, other minor changes.

v1.23, 10 July 1998

First public release with perl5.005.

Supported Platforms

As of early March 2000 (the Perl release 5.6.0), the following platforms are able to build Perl from the standard source code distribution available at http://www.perl.com/CPAN/src/index.html

```
AIX
DOS DJGPP       1)
EPOC
FreeBSD
HP-UX
IRIX
Linux
LynxOS
MachTen
MPE/iX
NetBSD
OpenBSD
OS/2
QNX
Rhapsody/Darwin 2)
SCO SV
SINIX
Solaris
SVR4
Tru64 UNIX      3)
UNICOS
UNICOS/mk
Unixware
VMS
VOS
Windows 3.1     1)
Windows 95      1) 4)
Windows 98      1) 4)
Windows NT      1) 4)
```

```
1) in DOS mode either the DOS or OS/2 ports can be used
2) new in 5.6.0: the BSD/NeXT-based UNIX of Mac OS X
3) formerly known as Digital UNIX and before that DEC OSF/1
4) compilers: Borland, Cygwin, Mingw32 EGCS/GCC, VC++
```

The following platforms worked for the previous major release (5.005_03 being the latest maintenance release of that, as of early March 2000), but be did not manage to test these in time for the 5.6.0 release of Perl. There is a very good chance that these will work just fine with 5.6.0.

```
A/UX
BeOS
BSD/OS
DG/UX
DYNIX/ptx
DomainOS
Hurd
NextSTEP
OpenSTEP
PowerMAX
SCO ODT/OSR
SunOS
Ultrix
```

The following platform worked for the previous major release (5.005_03 being the latest maintenance release of that, as of early March 2000). However, standardization on UTF−8 as the internal string representation in 5.6.0 has introduced incompatibilities in this EBCDIC platform. Support for this platform may be enabled in a future release:

```
OS390   1)

1) Previously known as MVS, or OpenEdition MVS.
```

Strongly related to the OS390 platform by also being EBCDIC−based mainframe platforms are the following platforms:

```
BS2000
VM/ESA
```

These are also not expected to work under 5.6.0 for the same reasons as OS390. Contact the mailing list perl−mvs@perl.org for more details.

MacOS (Classic, pre−X) is almost 5.6.0−ready; building from the source does work with 5.6.0, but additional MacOS specific source code is needed for a complete port. Contact the mailing list macperl−porters@macperl.org for more information.

The following platforms have been known to build Perl from source in the past, but we haven‘t been able to verify their status for the current release, either because the hardware/software platforms are rare or because we don‘t have an active champion on these platforms—or both:

```
3b1
AmigaOS
ConvexOS
CX/UX
DC/OSx
DDE SMES
DOS EMX
Dynix
EP/IX
ESIX
FPS
```

```
GENIX
Greenhills
ISC
MachTen 68k
MiNT
MPC
NEWS-OS
Opus
Plan 9
PowerUX
RISC/os
Stellar
SVR2
TI1500
TitanOS
Unisys Dynix
Unixware
```

Support for the following platform is planned for a future Perl release:

```
Netware
```

The following platforms have their own source code distributions and binaries available via http://www.perl.com/CPAN/ports/index.html:

	Perl release
AS/400	5.003
Netware	5.003_07
Tandem Guardian	5.004

The following platforms have only binaries available via http://www.perl.com/CPAN/ports/index.html :

	Perl release
Acorn RISCOS	5.005_02
AOS	5.002
LynxOS	5.004_02

Although we do suggest that you always build your own Perl from the source code, both for maximal configurability and for security, in case you are in a hurry you can check http://www.perl.com/CPAN/ports/index.html for binary distributions.

SEE ALSO

perlaix, *perlamiga*, *perlcygwin*, *perldos*, *perlepoc*, *perlebcdic*, *perlhpux*, *perlos2*, *perlos390*, *perlposix-bc*, *perlwin32*, *perlvms*, *perlvos*, and *Win32*.

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VERSION

Version 1.47, last modified 22 March 2000

NAME

perlre – Perl regular expressions

DESCRIPTION

This page describes the syntax of regular expressions in Perl. For a description of how to *use* regular expressions in matching operations, plus various examples of the same, see discussions of `m//`, `s///`, `qr//` and `??` in *Regexp Quote–Like Operators in perlop*.

Matching operations can have various modifiers. Modifiers that relate to the interpretation of the regular expression inside are listed below. Modifiers that alter the way a regular expression is used by Perl are detailed in *Regexp Quote–Like Operators in perlop* and *Gory details of parsing quoted constructs in perlop*.

i Do case–insensitive pattern matching.

If `use locale` is in effect, the case map is taken from the current locale. See *perllocale*.

m Treat string as multiple lines. That is, change "^" and "$" from matching the start or end of the string to matching the start or end of any line anywhere within the string.

s Treat string as single line. That is, change "." to match any character whatsoever, even a newline, which normally it would not match.

The `/s` and `/m` modifiers both override the `$*` setting. That is, no matter what `$*` contains, `/s` without `/m` will force "^" to match only at the beginning of the string and "$" to match only at the end (or just before a newline at the end) of the string. Together, as /ms, they let the "." match any character whatsoever, while yet allowing "^" and "$" to match, respectively, just after and just before newlines within the string.

x Extend your pattern's legibility by permitting whitespace and comments.

These are usually written as "the `/x` modifier", even though the delimiter in question might not really be a slash. Any of these modifiers may also be embedded within the regular expression itself using the `(?...)` construct. See below.

The `/x` modifier itself needs a little more explanation. It tells the regular expression parser to ignore whitespace that is neither backslashed nor within a character class. You can use this to break up your regular expression into (slightly) more readable parts. The # character is also treated as a metacharacter introducing a comment, just as in ordinary Perl code. This also means that if you want real whitespace or # characters in the pattern (outside a character class, where they are unaffected by `/x`), that you'll either have to escape them or encode them using octal or hex escapes. Taken together, these features go a long way towards making Perl's regular expressions more readable. Note that you have to be careful not to include the pattern delimiter in the comment—perl has no way of knowing you did not intend to close the pattern early. See the C–comment deletion code in *perlop*.

Regular Expressions

The patterns used in Perl pattern matching derive from supplied in the Version 8 regex routines. (The routines are derived (distantly) from Henry Spencer's freely redistributable reimplementation of the V8 routines.) See *Version 8 Regular Expressions* for details.

In particular the following metacharacters have their standard *egrep*–ish meanings:

```
\   Quote the next metacharacter
^   Match the beginning of the line
.   Match any character (except newline)
$   Match the end of the line (or before newline at the end)
|   Alternation
()  Grouping
[]  Character class
```

By default, the "^" character is guaranteed to match only the beginning of the string, the "$" character only the end (or before the newline at the end), and Perl does certain optimizations with the assumption that the string contains only one line. Embedded newlines will not be matched by "^" or "$". You may, however, wish to treat a string as a multi-line buffer, such that the "^" will match after any newline within the string, and "$" will match before any newline. At the cost of a little more overhead, you can do this by using the /m modifier on the pattern match operator. (Older programs did this by setting $*, but this practice is now deprecated.)

To simplify multi-line substitutions, the "." character never matches a newline unless you use the /s modifier, which in effect tells Perl to pretend the string is a single line—even if it isn't. The /s modifier also overrides the setting of $*, in case you have some (badly behaved) older code that sets it in another module.

The following standard quantifiers are recognized:

```
*      Match 0 or more times
+      Match 1 or more times
?      Match 1 or 0 times
{n}    Match exactly n times
{n,}   Match at least n times
{n,m}  Match at least n but not more than m times
```

(If a curly bracket occurs in any other context, it is treated as a regular character.) The "*" modifier is equivalent to {0,}, the "+" modifier to {1,}, and the "?" modifier to {0,1}. n and m are limited to integral values less than a preset limit defined when perl is built. This is usually 32766 on the most common platforms. The actual limit can be seen in the error message generated by code such as this:

```
$_ **= $_ , / {$_} / for 2 .. 42;
```

By default, a quantified subpattern is "greedy", that is, it will match as many times as possible (given a particular starting location) while still allowing the rest of the pattern to match. If you want it to match the minimum number of times possible, follow the quantifier with a "?". Note that the meanings don't change, just the "greediness":

```
*?     Match 0 or more times
+?     Match 1 or more times
??     Match 0 or 1 time
{n}?   Match exactly n times
{n,}?  Match at least n times
{n,m}? Match at least n but not more than m times
```

Because patterns are processed as double quoted strings, the following also work:

```
\t          tab                   (HT, TAB)
\n          newline               (LF, NL)
\r          return                (CR)
\f          form feed             (FF)
\a          alarm (bell)          (BEL)
\e          escape (think troff)  (ESC)
\033        octal char (think of a PDP-11)
\x1B        hex char
\x{263a}    wide hex char         (Unicode SMILEY)
\c[         control char
\N{name}    named char
\l          lowercase next char (think vi)
\u          uppercase next char (think vi)
\L          lowercase till \E (think vi)
\U          uppercase till \E (think vi)
\E          end case modification (think vi)
```

```
\Q          quote (disable) pattern metacharacters till \E
```

If `use locale` is in effect, the case map used by `\l`, `\L`, `\u` and `\U` is taken from the current locale. See *perllocale*. For documentation of `\N{name}`, see *charnames*.

You cannot include a literal `$` or `@` within a `\Q` sequence. An unescaped `$` or `@` interpolates the corresponding variable, while escaping will cause the literal string `\$` to be matched. You'll need to write something like `m/\Quser\E\@\Qhost/`.

In addition, Perl defines the following:

```
\w  Match a "word" character (alphanumeric plus "_")
\W  Match a non-"word" character
\s  Match a whitespace character
\S  Match a non-whitespace character
\d  Match a digit character
\D  Match a non-digit character
\pP Match P, named property.  Use \p{Prop} for longer names.
\PP Match non-P
\X  Match eXtended Unicode "combining character sequence",
    equivalent to C<(?:\PM\pM*)>
\C  Match a single C char (octet) even under utf8.
```

A `\w` matches a single alphanumeric character or `_`, not a whole word. Use `\w+` to match a string of Perl-identifier characters (which isn't the same as matching an English word). If `use locale` is in effect, the list of alphabetic characters generated by `\w` is taken from the current locale. See *perllocale*. You may use `\w`, `\W`, `\s`, `\S`, `\d`, and `\D` within character classes, but if you try to use them as endpoints of a range, that's not a range, the "-" is understood literally. See *utf8* for details about `\pP`, `\PP`, and `\X`.

The POSIX character class syntax

```
[:class:]
```

is also available. The available classes and their backslash equivalents (if available) are as follows:

```
alpha
alnum
ascii
blank               [1]
cntrl
digit       \d
graph
lower
print
punct
space       \s      [2]
upper
word        \w      [3]
xdigit
```

```
[1] A GNU extension equivalent to C<[ \t]>, 'all horizontal whitespace'.
[2] Not I<exactly equivalent> to C<\s> since the C<[[:space:]]> includes
    also the (very rare) 'vertical tabulator', "\ck", chr(11).
[3] A Perl extension.
```

For example use `[:upper:]` to match all the uppercase characters. Note that the `[]` are part of the `[::]` construct, not part of the whole character class. For example:

```
[01[:alpha:]%]
```

matches zero, one, any alphabetic character, and the percentage sign.

If the `utf8` pragma is used, the following equivalences to Unicode \p{} constructs hold:

```
alpha       IsAlpha
alnum       IsAlnum
ascii       IsASCII
blank       IsSpace
cntrl       IsCntrl
digit       IsDigit
graph       IsGraph
lower       IsLower
print       IsPrint
punct       IsPunct
space       IsSpace
upper       IsUpper
word        IsWord
xdigit      IsXDigit
```

For example `[:lower:]` and `\p{IsLower}` are equivalent.

If the `utf8` pragma is not used but the `locale` pragma is, the classes correlate with the usual isalpha(3) interface (except for 'word' and 'blank').

The assumedly non−obviously named classes are:

cntrl Any control character. Usually characters that don't produce output as such but instead control the terminal somehow: for example newline and backspace are control characters. All characters with `ord()` less than 32 are most often classified as control characters (assuming ASCII, the ISO Latin character sets, and Unicode).

graph

Any alphanumeric or punctuation (special) character.

print

Any alphanumeric or punctuation (special) character or space.

punct

Any punctuation (special) character.

xdigit

Any hexadecimal digit. Though this may feel silly ([0−9A−Fa−f] would work just fine) it is included for completeness.

You can negate the [::] character classes by prefixing the class name with a '^'. This is a Perl extension. For example:

```
POSIX       trad. Perl  utf8 Perl

[:^digit:]      \D      \P{IsDigit}
[:^space:]      \S      \P{IsSpace}
[:^word:]       \W      \P{IsWord}
```

The POSIX character classes [.cc.] and [=cc=] are recognized but **not** supported and trying to use them will cause an error.

Perl defines the following zero−width assertions:

```
\b  Match a word boundary
\B  Match a non-(word boundary)
\A  Match only at beginning of string
\Z  Match only at end of string, or before newline at the end
```

```
\z  Match only at end of string
\G  Match only at pos() (e.g. at the end-of-match position
    of prior m//g)
```

A word boundary (\b) is a spot between two characters that has a \w on one side of it and a \W on the other side of it (in either order), counting the imaginary characters off the beginning and end of the string as matching a \W. (Within character classes \b represents backspace rather than a word boundary, just as it normally does in any double-quoted string.) The \A and \Z are just like "^" and "$", except that they won't match multiple times when the /m modifier is used, while "^" and "$" will match at every internal line boundary. To match the actual end of the string and not ignore an optional trailing newline, use \z.

The \G assertion can be used to chain global matches (using m//g), as described in *Regexp Quote-Like Operators in perlop*. It is also useful when writing lex-like scanners, when you have several patterns that you want to match against consequent substrings of your string, see the previous reference. The actual location where \G will match can also be influenced by using pos() as an lvalue. See *pos*.

The bracketing construct (...) creates capture buffers. To refer to the digit'th buffer use \<digit within the match. Outside the match use "$" instead of "\". (The \<digit notation works in certain circumstances outside the match. See the warning below about \1 vs $1 for details.) Referring back to another part of the match is called a *backreference*.

There is no limit to the number of captured substrings that you may use. However Perl also uses \10, \11, etc. as aliases for \010, \011, etc. (Recall that 0 means octal, so \011 is the 9'th ASCII character, a tab.) Perl resolves this ambiguity by interpreting \10 as a backreference only if at least 10 left parentheses have opened before it. Likewise \11 is a backreference only if at least 11 left parentheses have opened before it. And so on. \1 through \9 are always interpreted as backreferences."

Examples:

```
s/^([^ ]*) *([^ ]*)/$2 $1/;     # swap first two words

 if (/(.)\1/) {                 # find first doubled char
     print "'$1' is the first doubled character\n";
 }

if (/Time: (..):(..):(..)/) {   # parse out values
    $hours = $1;
    $minutes = $2;
    $seconds = $3;
}
```

Several special variables also refer back to portions of the previous match. $+ returns whatever the last bracket match matched. $& returns the entire matched string. (At one point $0 did also, but now it returns the name of the program.) $` returns everything before the matched string. And $' returns everything after the matched string.

The numbered variables ($1, $2, $3, etc.) and the related punctuation set ($+, $&, $`, and $') are all dynamically scoped until the end of the enclosing block or until the next successful match, whichever comes first. (See *Compound Statements in perlsyn*.)

WARNING: Once Perl sees that you need one of $&, $`, or $' anywhere in the program, it has to provide them for every pattern match. This may substantially slow your program. Perl uses the same mechanism to produce $1, $2, etc, so you also pay a price for each pattern that contains capturing parentheses. (To avoid this cost while retaining the grouping behaviour, use the extended regular expression (?: ...) instead.) But if you never use $&, $` or $', then patterns *without* capturing parentheses will not be penalized. So avoid $&, $', and $` if you can, but if you can't (and some algorithms really appreciate them), once you've used them once, use them at will, because you've already paid the price. As of 5.005, $& is not so costly as the other two.

Backslashed metacharacters in Perl are alphanumeric, such as \b, \w, \n. Unlike some other regular expression languages, there are no backslashed symbols that aren't alphanumeric. So anything that looks like \\, \(, \), \<, \, \{, or \} is always interpreted as a literal character, not a metacharacter. This was once used in a common idiom to disable or quote the special meanings of regular expression metacharacters in a string that you want to use for a pattern. Simply quote all non-"word" characters:

```
$pattern =~ s/(\W)/\\$1/g;
```

(If use locale is set, then this depends on the current locale.) Today it is more common to use the quotemeta() function or the \Q metaquoting escape sequence to disable all metacharacters' special meanings like this:

```
/$unquoted\Q$quoted\E$unquoted/
```

Beware that if you put literal backslashes (those not inside interpolated variables) between \Q and \E, double-quotish backslash interpolation may lead to confusing results. If you *need* to use literal backslashes within \Q...\E, consult *Gory details of parsing quoted constructs in perlop*.

Extended Patterns

Perl also defines a consistent extension syntax for features not found in standard tools like **awk** and **lex**. The syntax is a pair of parentheses with a question mark as the first thing within the parentheses. The character after the question mark indicates the extension.

The stability of these extensions varies widely. Some have been part of the core language for many years. Others are experimental and may change without warning or be completely removed. Check the documentation on an individual feature to verify its current status.

A question mark was chosen for this and for the minimal-matching construct because 1) question marks are rare in older regular expressions, and 2) whenever you see one, you should stop and "question" exactly what is going on. That's psychology...

(?#text) A comment. The text is ignored. If the /x modifier enables whitespace formatting, a simple # will suffice. Note that Perl closes the comment as soon as it sees a), so there is no way to put a literal) in the comment.

(?imsx-imsx)

One or more embedded pattern-match modifiers. This is particularly useful for dynamic patterns, such as those read in from a configuration file, read in as an argument, are specified in a table somewhere, etc. Consider the case that some of which want to be case sensitive and some do not. The case insensitive ones need to include merely (?i) at the front of the pattern. For example:

```
$pattern = "foobar";
if ( /$pattern/i ) { }

# more flexible:

$pattern = "(?i)foobar";
if ( /$pattern/ ) { }
```

Letters after a - turn those modifiers off. These modifiers are localized inside an enclosing group (if any). For example,

```
( (?i) blah ) \s+ \1
```

will match a repeated (*including the case*!) word blah in any case, assuming x modifier, and no i modifier outside this group.

(?:pattern)
(?imsx-imsx:pattern)

This is for clustering, not capturing; it groups subexpressions like "()", but doesn't make backreferences as "()" does. So

```
@fields = split(/\b(?:a|b|c)\b/)
```

is like

```
@fields = split(/\b(a|b|c)\b/)
```

but doesn't spit out extra fields. It's also cheaper not to capture characters if you don't need to.

Any letters between `?` and `:` act as flags modifiers as with `(?imsx-imsx)`. For example,

```
/(?s-i:more.*than).*million/i
```

is equivalent to the more verbose

```
/(?:(?s-i)more.*than).*million/i
```

`(?=pattern)`

A zero-width positive look-ahead assertion. For example, `/\w+(?=\t)/` matches a word followed by a tab, without including the tab in `$&`.

`(?!pattern)`

A zero-width negative look-ahead assertion. For example `/foo(?!bar)/` matches any occurrence of "foo" that isn't followed by "bar". Note however that look-ahead and look-behind are NOT the same thing. You cannot use this for look-behind.

If you are looking for a "bar" that isn't preceded by a "foo", `/(?!foo)bar/` will not do what you want. That's because the `(?!foo)` is just saying that the next thing cannot be "foo"—and it's not, it's a "bar", so "foobar" will match. You would have to do something like `/(?!foo)...bar/` for that. We say "like" because there's the case of your "bar" not having three characters before it. You could cover that this way: `/(?:(?!foo)...|^.{0,2})bar/`. Sometimes it's still easier just to say:

```
if (/bar/ && $` !~ /foo$/)
```

For look-behind see below.

`(?<=pattern)`

A zero-width positive look-behind assertion. For example, `/(?<=\t)\w+/` matches a word that follows a tab, without including the tab in `$&`. Works only for fixed-width look-behind.

`(?<!pattern)`

A zero-width negative look-behind assertion. For example `/(?<!bar)foo/` matches any occurrence of "foo" that does not follow "bar". Works only for fixed-width look-behind.

`(?{ code })`

WARNING: This extended regular expression feature is considered highly experimental, and may be changed or deleted without notice.

This zero-width assertion evaluate any embedded Perl code. It always succeeds, and its `code` is not interpolated. Currently, the rules to determine where the `code` ends are somewhat convoluted.

The `code` is properly scoped in the following sense: If the assertion is backtracked (compare *"Backtracking"*), all changes introduced after `localization` are undone, so that

```
$_ = 'a' x 8;
m<
   (?{ $cnt = 0 })                    # Initialize $cnt.
   (
     a
     (?{
```

```
            local $cnt = $cnt + 1; # Update $cnt, backtracking-safe.
          })
        )*
        aaaa
        (?{ $res = $cnt })          # On success copy to non-localized
                                    # location.
    >x;
```

will set `$res = 4`. Note that after the match, `$cnt` returns to the globally introduced value, because the scopes that restrict `local` operators are unwound.

This assertion may be used as a `(?(condition)yes-pattern|no-pattern)` switch. If *not* used in this way, the result of evaluation of `code` is put into the special variable `$^R`. This happens immediately, so `$^R` can be used from other `(?{ code })` assertions inside the same regular expression.

The assignment to `$^R` above is properly localized, so the old value of `$^R` is restored if the assertion is backtracked; compare *"Backtracking"*.

For reasons of security, this construct is forbidden if the regular expression involves run–time interpolation of variables, unless the perilous `use re 'eval'` pragma has been used (see *re*), or the variables contain results of `qr//` operator (see *qr/STRING/imosx in perlop*).

This restriction is because of the wide–spread and remarkably convenient custom of using run–time determined strings as patterns. For example:

```
$re = <>;
chomp $re;
$string =~ /$re/;
```

Before Perl knew how to execute interpolated code within a pattern, this operation was completely safe from a security point of view, although it could raise an exception from an illegal pattern. If you turn on the `use re 'eval'`, though, it is no longer secure, so you should only do so if you are also using taint checking. Better yet, use the carefully constrained evaluation within a Safe module. See *perlsec* for details about both these mechanisms.

`(??{ code })`

WARNING: This extended regular expression feature is considered highly experimental, and may be changed or deleted without notice. A simplified version of the syntax may be introduced for commonly used idioms.

This is a "postponed" regular subexpression. The `code` is evaluated at run time, at the moment this subexpression may match. The result of evaluation is considered as a regular expression and matched as if it were inserted instead of this construct.

The `code` is not interpolated. As before, the rules to determine where the `code` ends are currently somewhat convoluted.

The following pattern matches a parenthesized group:

```
$re = qr{
           \(
           (?:
              (?> [^()]+ )     # Non-parens without backtracking
            |
              (??{ $re })      # Group with matching parens
           )*
           \)
         }x;
```

< (?pattern)

WARNING: This extended regular expression feature is considered highly experimental, and may be changed or deleted without notice.

An "independent" subexpression, one which matches the substring that a *standalone* `pattern` would match if anchored at the given position, and it matches *nothing other than this substring*. This construct is useful for optimizations of what would otherwise be "eternal" matches, because it will not backtrack (see *"Backtracking"*). It may also be useful in places where the "grab all you can, and do not give anything back" semantic is desirable.

For example: `< ^(?a*)ab` will never match, since `< (?a*)` (anchored at the beginning of string, as above) will match *all* characters `a` at the beginning of string, leaving no `a` for `ab` to match. In contrast, `a*ab` will match the same as `a+b`, since the match of the subgroup `a*` is influenced by the following group `ab` (see *"Backtracking"*). In particular, `a*` inside `a*ab` will match fewer characters than a standalone `a*`, since this makes the tail match.

An effect similar to `< (?pattern)` may be achieved by writing `(?=(pattern))\1`. This matches the same substring as a standalone `a+`, and the following `\1` eats the matched string; it therefore makes a zero-length assertion into an analogue of `< (?...)` . (The difference between these two constructs is that the second one uses a capturing group, thus shifting ordinals of backreferences in the rest of a regular expression.)

Consider this pattern:

```
m{ \(
       (
         [^()]+                 # x+
       |
         \( [^()]* \)
       )+
   \)
 }x
```

That will efficiently match a nonempty group with matching parentheses two levels deep or less. However, if there is no such group, it will take virtually forever on a long string. That's because there are so many different ways to split a long string into several substrings. This is what `(.+)+` is doing, and `(.+)+` is similar to a subpattern of the above pattern. Consider how the pattern above detects no-match on `(((()aaaaaaaaaaaaaaaaa` in several seconds, but that each extra letter doubles this time. This exponential performance will make it appear that your program has hung. However, a tiny change to this pattern

```
m{ \(
       (
         (?> [^()]+ )           # change x+ above to (?> x+ )
       |
         \( [^()]* \)
       )+
   \)
 }x
```

which uses `< (?...)` matches exactly when the one above does (verifying this yourself would be a productive exercise), but finishes in a fourth the time when used on a similar string with 1000000 `a`s. Be aware, however, that this pattern currently triggers a warning message under the `use warnings` pragma or **-w** switch saying it `"matches the null string many times"`):

On simple groups, such as the pattern `< (? [^()]+ )` , a comparable effect may be achieved by negative look-ahead, as in `[^()]+ (?! [^()] )` . This was only 4 times slower on a

string with 1000000 as.

The "grab all you can, and do not give anything back" semantic is desirable in many situations where on the first sight a simple `()*` looks like the correct solution. Suppose we parse text with comments being delimited by # followed by some optional (horizontal) whitespace. Contrary to its appearance, `#[ \t]*` *is not* the correct subexpression to match the comment delimiter, because it may "give up" some whitespace if the remainder of the pattern can be made to match that way. The correct answer is either one of these:

```
(?>#[ \t]*)
#[ \t]*(?![ \t])
```

For example, to grab non-empty comments into `$1`, one should use either one of these:

```
/ (?> \# [ \t]* ) (         .+ ) /x;
/      \# [ \t]*   ( [^ \t] .* ) /x;
```

Which one you pick depends on which of these expressions better reflects the above specification of comments.

`(?(condition)yes-pattern|no-pattern)`
`(?(condition)yes-pattern)`

WARNING: This extended regular expression feature is considered highly experimental, and may be changed or deleted without notice.

Conditional expression. `(condition)` should be either an integer in parentheses (which is valid if the corresponding pair of parentheses matched), or look-ahead/look-behind/evaluate zero-width assertion.

For example:

```
m{ ( \( )?
    [^()]+
    (?(1) \) )
 }x
```

matches a chunk of non-parentheses, possibly included in parentheses themselves.

Backtracking

NOTE: This section presents an abstract approximation of regular expression behavior. For a more rigorous (and complicated) view of the rules involved in selecting a match among possible alternatives, see *Combining pieces together*.

A fundamental feature of regular expression matching involves the notion called *backtracking*, which is currently used (when needed) by all regular expression quantifiers, namely `*`, `*?`, `+`, `+?`, `{n,m}`, and `{n,m}?`. Backtracking is often optimized internally, but the general principle outlined here is valid.

For a regular expression to match, the *entire* regular expression must match, not just part of it. So if the beginning of a pattern containing a quantifier succeeds in a way that causes later parts in the pattern to fail, the matching engine backs up and recalculates the beginning part—that's why it's called backtracking.

Here is an example of backtracking: Let's say you want to find the word following "foo" in the string "Food is on the foo table.":

```
$_ = "Food is on the foo table.";
if ( /\b(foo)\s+(\w+)/i ) {
    print "$2 follows $1.\n";
}
```

When the match runs, the first part of the regular expression (`\b(foo)`) finds a possible match right at the beginning of the string, and loads up `$1` with "Foo". However, as soon as the matching engine sees that there's no whitespace following the "Foo" that it had saved in `$1`, it realizes its mistake and starts over

again one character after where it had the tentative match. This time it goes all the way until the next occurrence of "foo". The complete regular expression matches this time, and you get the expected output of "table follows foo."

Sometimes minimal matching can help a lot. Imagine you'd like to match everything between "foo" and "bar". Initially, you write something like this:

```
$_ =  "The food is under the bar in the barn.";
if ( /foo(.*)bar/ ) {
    print "got <$1>\n";
}
```

Which perhaps unexpectedly yields:

```
got <d is under the bar in the >
```

That's because `.*` was greedy, so you get everything between the *first* "foo" and the *last* "bar". Here it's more effective to use minimal matching to make sure you get the text between a "foo" and the first "bar" thereafter.

```
    if ( /foo(.*?)bar/ ) { print "got <$1>\n" }
got <d is under the >
```

Here's another example: let's say you'd like to match a number at the end of a string, and you also want to keep the preceding part the match. So you write this:

```
$_ = "I have 2 numbers: 53147";
if ( /(.*)(\d*)/ ) {                                    # Wrong!
    print "Beginning is <$1>, number is <$2>.\n";
}
```

That won't work at all, because `.*` was greedy and gobbled up the whole string. As `\d*` can match on an empty string the complete regular expression matched successfully.

```
Beginning is <I have 2 numbers: 53147>, number is <>.
```

Here are some variants, most of which don't work:

```
$_ = "I have 2 numbers: 53147";
@pats = qw{
    (.*)(\d*)
    (.*)(\d+)
    (.*?)(\d*)
    (.*?)(\d+)
    (.*)(\d+)$
    (.*?)(\d+)$
    (.*)\b(\d+)$
    (.*\D)(\d+)$
};

for $pat (@pats) {
    printf "%-12s ", $pat;
    if ( /$pat/ ) {
        print "<$1> <$2>\n";
    } else {
        print "FAIL\n";
    }
}
```

That will print out:

```
(.*)(\d*)    <I have 2 numbers: 53147> <>
(.*)(\d+)    <I have 2 numbers: 5314> <7>
(.*?)(\d*)   <> <>
(.*?)(\d+)   <I have > <2>
(.*)(\d+)$   <I have 2 numbers: 5314> <7>
(.*?)(\d+)$  <I have 2 numbers: > <53147>
(.*)\b(\d+)$ <I have 2 numbers: > <53147>
(.*\D)(\d+)$ <I have 2 numbers: > <53147>
```

As you see, this can be a bit tricky. It's important to realize that a regular expression is merely a set of assertions that gives a definition of success. There may be 0, 1, or several different ways that the definition might succeed against a particular string. And if there are multiple ways it might succeed, you need to understand backtracking to know which variety of success you will achieve.

When using look-ahead assertions and negations, this can all get even tricker. Imagine you'd like to find a sequence of non-digits not followed by "123". You might try to write that as

```
$_ = "ABC123";
if ( /^\D*(?!123)/ ) {              # Wrong!
    print "Yup, no 123 in $_\n";
}
```

But that isn't going to match; at least, not the way you're hoping. It claims that there is no 123 in the string. Here's a clearer picture of why it that pattern matches, contrary to popular expectations:

```
$x = 'ABC123' ;
$y = 'ABC445' ;

print "1: got $1\n" if $x =~ /^(ABC)(?!123)/ ;
print "2: got $1\n" if $y =~ /^(ABC)(?!123)/ ;

print "3: got $1\n" if $x =~ /^(\D*)(?!123)/ ;
print "4: got $1\n" if $y =~ /^(\D*)(?!123)/ ;
```

This prints

```
2: got ABC
3: got AB
4: got ABC
```

You might have expected test 3 to fail because it seems to a more general purpose version of test 1. The important difference between them is that test 3 contains a quantifier (`\D*`) and so can use backtracking, whereas test 1 will not. What's happening is that you've asked "Is it true that at the start of `$x`, following 0 or more non-digits, you have something that's not 123?" If the pattern matcher had let `\D*` expand to "ABC", this would have caused the whole pattern to fail.

The search engine will initially match `\D*` with "ABC". Then it will try to match `(?!123` with "123", which fails. But because a quantifier (`\D*`) has been used in the regular expression, the search engine can backtrack and retry the match differently in the hope of matching the complete regular expression.

The pattern really, *really* wants to succeed, so it uses the standard pattern back-off-and-retry and lets `\D*` expand to just "AB" this time. Now there's indeed something following "AB" that is not "123". It's "C123", which suffices.

We can deal with this by using both an assertion and a negation. We'll say that the first part in `$1` must be followed both by a digit and by something that's not "123". Remember that the look-aheads are zero-width expressions—they only look, but don't consume any of the string in their match. So rewriting this way produces what you'd expect; that is, case 5 will fail, but case 6 succeeds:

```
print "5: got $1\n" if $x =~ /^(\D*)(?=\d)(?!123)/ ;
print "6: got $1\n" if $y =~ /^(\D*)(?=\d)(?!123)/ ;
```

```
6: got ABC
```

In other words, the two zero-width assertions next to each other work as though they're ANDed together, just as you'd use any built-in assertions: `/^$/` matches only if you're at the beginning of the line AND the end of the line simultaneously. The deeper underlying truth is that juxtaposition in regular expressions always means AND, except when you write an explicit OR using the vertical bar. `/ab/` means match "a" AND (then) match "b", although the attempted matches are made at different positions because "a" is not a zero-width assertion, but a one-width assertion.

WARNING: particularly complicated regular expressions can take exponential time to solve because of the immense number of possible ways they can use backtracking to try match. For example, without internal optimizations done by the regular expression engine, this will take a painfully long time to run:

```
'aaaaaaaaaaaa' =~ /((a{0,5}){0,5}){0,5}[c]/
```

And if you used `*`'s instead of limiting it to 0 through 5 matches, then it would take forever—or until you ran out of stack space.

A powerful tool for optimizing such beasts is what is known as an "independent group", which does not backtrack (see *< (?pattern)*). Note also that zero-length look-ahead/look-behind assertions will not backtrack to make the tail match, since they are in "logical" context: only whether they match is considered relevant. For an example where side-effects of look-ahead *might* have influenced the following match, see *< (?pattern)* .

Version 8 Regular Expressions

In case you're not familiar with the "regular" Version 8 regex routines, here are the pattern-matching rules not described above.

Any single character matches itself, unless it is a *metacharacter* with a special meaning described here or above. You can cause characters that normally function as metacharacters to be interpreted literally by prefixing them with a "\" (e.g., "\." matches a ".", not any character; "\\" matches a "\"). A series of characters matches that series of characters in the target string, so the pattern `blurfl` would match "blurfl" in the target string.

You can specify a character class, by enclosing a list of characters in `[]`, which will match any one character from the list. If the first character after the "[" is "^", the class matches any character not in the list. Within a list, the "-" character specifies a range, so that `a-z` represents all characters between "a" and "z", inclusive. If you want either "-" or "]" itself to be a member of a class, put it at the start of the list (possibly after a "^"), or escape it with a backslash. "-" is also taken literally when it is at the end of the list, just before the closing "]". (The following all specify the same class of three characters: `[-az]`, `[az-]`, and `[a\-z]`. All are different from `[a-z]`, which specifies a class containing twenty-six characters.) Also, if you try to use the character classes `\w`, `\W`, `\s`, `\S`, `\d`, or `\D` as endpoints of a range, that's not a range, the "-" is understood literally.

Note also that the whole range idea is rather unportable between character sets—and even within character sets they may cause results you probably didn't expect. A sound principle is to use only ranges that begin from and end at either alphabets of equal case ([a-e], [A-E]), or digits ([0-9]). Anything else is unsafe. If in doubt, spell out the character sets in full.

Characters may be specified using a metacharacter syntax much like that used in C: "\n" matches a newline, "\t" a tab, "\r" a carriage return, "\f" a form feed, etc. More generally, *nnn*, where *nnn* is a string of octal digits, matches the character whose ASCII value is *nnn*. Similarly, \x*nn*, where *nn* are hexadecimal digits, matches the character whose ASCII value is *nn*. The expression \c*x* matches the ASCII character control-*x*. Finally, the "." metacharacter matches any character except "\n" (unless you use `/s`).

You can specify a series of alternatives for a pattern using "|" to separate them, so that `fee|fie|foe` will match any of "fee", "fie", or "foe" in the target string (as would `f(e|i|o)e`). The first alternative includes everything from the last pattern delimiter ("(", "[", or the beginning of the pattern) up to the first "|", and the last alternative contains everything from the last "|" to the next pattern delimiter. That's why it's common practice to include alternatives in parentheses: to minimize confusion about where they start and end.

Alternatives are tried from left to right, so the first alternative found for which the entire expression matches, is the one that is chosen. This means that alternatives are not necessarily greedy. For example: when matching `foo|foot` against "barefoot", only the "foo" part will match, as that is the first alternative tried, and it successfully matches the target string. (This might not seem important, but it is important when you are capturing matched text using parentheses.)

Also remember that "|" is interpreted as a literal within square brackets, so if you write `[fee|fie|foe]` you're really only matching `[feio|]`.

Within a pattern, you may designate subpatterns for later reference by enclosing them in parentheses, and you may refer back to the *n*th subpattern later in the pattern using the metacharacter *n*. Subpatterns are numbered based on the left to right order of their opening parenthesis. A backreference matches whatever actually matched the subpattern in the string being examined, not the rules for that subpattern. Therefore, `(0|0x)\d*\s\1\d*` will match "0x1234 0x4321", but not "0x1234 01234", because subpattern 1 matched "0x", even though the rule `0|0x` could potentially match the leading 0 in the second number.

Warning on \1 vs $1

Some people get too used to writing things like:

```
$pattern =~ s/(\W)/\\\1/g;
```

This is grandfathered for the RHS of a substitute to avoid shocking the **sed** addicts, but it's a dirty habit to get into. That's because in PerlThink, the righthand side of a `s///` is a double-quoted string. `\1` in the usual double-quoted string means a control-A. The customary Unix meaning of `\1` is kludged in for `s///`. However, if you get into the habit of doing that, you get yourself into trouble if you then add an `/e` modifier.

```
s/(\d+)/ \1 + 1 /eg;        # causes warning under -w
```

Or if you try to do

```
s/(\d+)/\1000/;
```

You can't disambiguate that by saying `\{1}000`, whereas you can fix it with `${1}000`. The operation of interpolation should not be confused with the operation of matching a backreference. Certainly they mean two different things on the *left* side of the `s///`.

Repeated patterns matching zero-length substring

WARNING: Difficult material (and prose) ahead. This section needs a rewrite.

Regular expressions provide a terse and powerful programming language. As with most other power tools, power comes together with the ability to wreak havoc.

A common abuse of this power stems from the ability to make infinite loops using regular expressions, with something as innocuous as:

```
'foo' =~ m{ ( o? )* }x;
```

The `o?` can match at the beginning of `'foo'`, and since the position in the string is not moved by the match, `o?` would match again and again because of the `*` modifier. Another common way to create a similar cycle is with the looping modifier `//g`:

```
@matches = ( 'foo' =~ m{ o? }xg );
```

or

```
print "match: <$&>\n" while 'foo' =~ m{ o? }xg;
```

or the loop implied by `split()`.

However, long experience has shown that many programming tasks may be significantly simplified by using repeated subexpressions that may match zero-length substrings. Here's a simple example being:

```
@chars = split //, $string;           # // is not magic in split
```

```
($whitewashed = $string) =~ s/()/ /g; # parens avoid magic s// /
```

Thus Perl allows such constructs, by *forcefully breaking the infinite loop*. The rules for this are different for lower–level loops given by the greedy modifiers `*+{}`, and for higher–level ones like the `/g` modifier or `split()` operator.

The lower–level loops are *interrupted* (that is, the loop is broken) when Perl detects that a repeated expression matched a zero–length substring. Thus

```
m{ (?: NON_ZERO_LENGTH | ZERO_LENGTH )* }x;
```

is made equivalent to

```
m{    (?: NON_ZERO_LENGTH )*
    |
      (?: ZERO_LENGTH )?
 }x;
```

The higher level–loops preserve an additional state between iterations: whether the last match was zero–length. To break the loop, the following match after a zero–length match is prohibited to have a length of zero. This prohibition interacts with backtracking (see *"Backtracking"*), and so the *second best* match is chosen if the *best* match is of zero length.

For example:

```
$_ = 'bar';
s/\w??/<$&>/g;
```

results in `"<<b<<a<<r<"`. At each position of the string the best match given by non–greedy `??` is the zero–length match, and the *second best* match is what is matched by `\w`. Thus zero–length matches alternate with one–character–long matches.

Similarly, for repeated `m/()/g` the second–best match is the match at the position one notch further in the string.

The additional state of being *matched with zero–length* is associated with the matched string, and is reset by each assignment to `pos()`. Zero–length matches at the end of the previous match are ignored during `split`.

Combining pieces together

Each of the elementary pieces of regular expressions which were described before (such as `ab` or `\Z`) could match at most one substring at the given position of the input string. However, in a typical regular expression these elementary pieces are combined into more complicated patterns using combining operators `ST`, `S|T`, `S*` etc (in these examples `S` and `T` are regular subexpressions).

Such combinations can include alternatives, leading to a problem of choice: if we match a regular expression `a|ab` against `"abc"`, will it match substring `"a"` or `"ab"`? One way to describe which substring is actually matched is the concept of backtracking (see *"Backtracking"*). However, this description is too low–level and makes you think in terms of a particular implementation.

Another description starts with notions of "better"/"worse". All the substrings which may be matched by the given regular expression can be sorted from the "best" match to the "worst" match, and it is the "best" match which is chosen. This substitutes the question of "what is chosen?" by the question of "which matches are better, and which are worse?".

Again, for elementary pieces there is no such question, since at most one match at a given position is possible. This section describes the notion of better/worse for combining operators. In the description below `S` and `T` are regular subexpressions.

`ST` Consider two possible matches, `AB` and `A'B'`, `A` and `A'` are substrings which can be matched by `S`, `B` and `B'` are substrings which can be matched by `T`.

If A is better match for S than A', AB is a better match than A'B'.

If A and A' coincide: AB is a better match than AB' if B is better match for T than B'.

S|T When S can match, it is a better match than when only T can match.

Ordering of two matches for S is the same as for S. Similar for two matches for T.

S{REPEAT_COUNT}

Matches as SSS...S (repeated as many times as necessary).

S{min,max}

Matches as S{max}|S{max-1}|...|S{min+1}|S{min}.

S{min,max}?

Matches as S{min}|S{min+1}|...|S{max-1}|S{max}.

S?, S*, S+

Same as S{0,1}, S{0,BIG_NUMBER}, S{1,BIG_NUMBER} respectively.

S??, S*?, S+?

Same as S{0,1}?, S{0,BIG_NUMBER}?, S{1,BIG_NUMBER}? respectively.

< (?S)

Matches the best match for S and only that.

(?=S), (?<=S)

Only the best match for S is considered. (This is important only if S has capturing parentheses, and backreferences are used somewhere else in the whole regular expression.)

(?!S), (?<!S)

For this grouping operator there is no need to describe the ordering, since only whether or not S can match is important.

(??{ EXPR })

The ordering is the same as for the regular expression which is the result of EXPR.

(?(condition)yes-pattern|no-pattern)

Recall that which of yes-pattern or no-pattern actually matches is already determined. The ordering of the matches is the same as for the chosen subexpression.

The above recipes describe the ordering of matches *at a given position*. One more rule is needed to understand how a match is determined for the whole regular expression: a match at an earlier position is always better than a match at a later position.

Creating custom RE engines

Overloaded constants (see *overload*) provide a simple way to extend the functionality of the RE engine.

Suppose that we want to enable a new RE escape–sequence \Y| which matches at boundary between white–space characters and non–whitespace characters. Note that (?=\S)(?<!\S)|(?!\S)(?<=\S) matches exactly at these positions, so we want to have each \Y| in the place of the more complicated version. We can create a module customre to do this:

```
package customre;
use overload;

sub import {
  shift;
  die "No argument to customre::import allowed" if @_;
  overload::constant 'qr' => \&convert;
}
```

```
sub invalid { die "/$_[0]/: invalid escape '\\$_[1]'"}
my %rules = ( '\\' => '\\',
              'Y|' => qr/(?=\S)(?<!\S)|(?!\S)(?<=\S)/ );
sub convert {
  my $re = shift;
  $re =~ s{
            \\ ( \\ | Y . )
          }
          { $rules{$1} or invalid($re,$1) }sgex;
  return $re;
}
```

Now `use customre` enables the new escape in constant regular expressions, i.e., those without any runtime variable interpolations. As documented in *overload*, this conversion will work only over literal parts of regular expressions. For `\Y|$re\Y|` the variable part of this regular expression needs to be converted explicitly (but only if the special meaning of `\Y|` should be enabled inside `$re`):

```
use customre;
$re = <>;
chomp $re;
$re = customre::convert $re;
/\Y|$re\Y|/;
```

BUGS

This document varies from difficult to understand to completely and utterly opaque. The wandering prose riddled with jargon is hard to fathom in several places.

This document needs a rewrite that separates the tutorial content from the reference content.

SEE ALSO

Regexp Quote-Like Operators in perlop.

Gory details of parsing quoted constructs in perlop.

perlfaq6.

pos.

perllocale.

Mastering Regular Expressions by Jeffrey Friedl, published by O'Reilly and Associates.

NAME

perlref – Perl references and nested data structures

NOTE

This is complete documentation about all aspects of references. For a shorter, tutorial introduction to just the essential features, see *perlreftut*.

DESCRIPTION

Before release 5 of Perl it was difficult to represent complex data structures, because all references had to be symbolic—and even then it was difficult to refer to a variable instead of a symbol table entry. Perl now not only makes it easier to use symbolic references to variables, but also lets you have "hard" references to any piece of data or code. Any scalar may hold a hard reference. Because arrays and hashes contain scalars, you can now easily build arrays of arrays, arrays of hashes, hashes of arrays, arrays of hashes of functions, and so on.

Hard references are smart—they keep track of reference counts for you, automatically freeing the thing referred to when its reference count goes to zero. (Reference counts for values in self–referential or cyclic data structures may not go to zero without a little help; see *Two–Phased Garbage Collection in perlobj* for a detailed explanation.) If that thing happens to be an object, the object is destructed. See *perlobj* for more about objects. (In a sense, everything in Perl is an object, but we usually reserve the word for references to objects that have been officially "blessed" into a class package.)

Symbolic references are names of variables or other objects, just as a symbolic link in a Unix filesystem contains merely the name of a file. The `*glob` notation is something of a of symbolic reference. (Symbolic references are sometimes called "soft references", but please don't call them that; references are confusing enough without useless synonyms.)

In contrast, hard references are more like hard links in a Unix file system: They are used to access an underlying object without concern for what its (other) name is. When the word "reference" is used without an adjective, as in the following paragraph, it is usually talking about a hard reference.

References are easy to use in Perl. There is just one overriding principle: Perl does no implicit referencing or dereferencing. When a scalar is holding a reference, it always behaves as a simple scalar. It doesn't magically start being an array or hash or subroutine; you have to tell it explicitly to do so, by dereferencing it.

Making References

References can be created in several ways.

1. By using the backslash operator on a variable, subroutine, or value. (This works much like the `&` (address–of) operator in C.) This typically creates *another* reference to a variable, because there's already a reference to the variable in the symbol table. But the symbol table reference might go away, and you'll still have the reference that the backslash returned. Here are some examples:

```
$scalarref = \$foo;
$arrayref  = \@ARGV;
$hashref   = \%ENV;
$coderef   = \&handler;
$globref   = \*foo;
```

   It isn't possible to create a true reference to an IO handle (filehandle or dirhandle) using the backslash operator. The most you can get is a reference to a typeglob, which is actually a complete symbol table entry. But see the explanation of the `*foo{THING}` syntax below. However, you can still use type globs and globrefs as though they were IO handles.

2. A reference to an anonymous array can be created using square brackets:

```
$arrayref = [1, 2, ['a', 'b', 'c']];
```

Here we've created a reference to an anonymous array of three elements whose final element is itself a reference to another anonymous array of three elements. (The multidimensional syntax described later can be used to access this. For example, after the above, `< $arrayref->[2][1]` would have the value "b".)

Taking a reference to an enumerated list is not the same as using square brackets—instead it's the same as creating a list of references!

```
@list = (\$a, \@b, \%c);
@list = \($a, @b, %c);      # same thing!
```

As a special case, `\(@foo)` returns a list of references to the contents of `@foo`, not a reference to `@foo` itself. Likewise for `%foo`, except that the key references are to copies (since the keys are just strings rather than full-fledged scalars).

3. A reference to an anonymous hash can be created using curly brackets:

```
$hashref = {
    'Adam'  => 'Eve',
    'Clyde' => 'Bonnie',
};
```

Anonymous hash and array composers like these can be intermixed freely to produce as complicated a structure as you want. The multidimensional syntax described below works for these too. The values above are literals, but variables and expressions would work just as well, because assignment operators in Perl (even within `local()` or `my()`) are executable statements, not compile-time declarations.

Because curly brackets (braces) are used for several other things including BLOCKs, you may occasionally have to disambiguate braces at the beginning of a statement by putting a `+` or a `return` in front so that Perl realizes the opening brace isn't starting a BLOCK. The economy and mnemonic value of using curlies is deemed worth this occasional extra hassle.

For example, if you wanted a function to make a new hash and return a reference to it, you have these options:

```
sub hashem {         { @_ } }   # silently wrong
sub hashem {        +{ @_ } }   # ok
sub hashem { return { @_ } }   # ok
```

On the other hand, if you want the other meaning, you can do this:

```
sub showem {         { @_ } }   # ambiguous (currently ok, but may change)
sub showem {        {; @_ } }   # ok
sub showem { { return @_ } }   # ok
```

The leading `+{` and `{;` always serve to disambiguate the expression to mean either the HASH reference, or the BLOCK.

4. A reference to an anonymous subroutine can be created by using `sub` without a subname:

```
$coderef = sub { print "Boink!\n" };
```

Note the semicolon. Except for the code inside not being immediately executed, a `sub {}` is not so much a declaration as it is an operator, like `do{}` or `eval{}`. (However, no matter how many times you execute that particular line (unless you're in an `eval("...")`), `$coderef` will still have a reference to the *same* anonymous subroutine.)

Anonymous subroutines act as closures with respect to `my()` variables, that is, variables lexically visible within the current scope. Closure is a notion out of the Lisp world that says if you define an anonymous function in a particular lexical context, it pretends to run in that context even when it's called outside the context.

In human terms, it's a funny way of passing arguments to a subroutine when you define it as well as when you call it. It's useful for setting up little bits of code to run later, such as callbacks. You can even do object–oriented stuff with it, though Perl already provides a different mechanism to do that—see *perlobj*.

You might also think of closure as a way to write a subroutine template without using `eval()`. Here's a small example of how closures work:

```
sub newprint {
    my $x = shift;
    return sub { my $y = shift; print "$x, $y!\n"; };
}
$h = newprint("Howdy");
$g = newprint("Greetings");

# Time passes...

&$h("world");
&$g("earthlings");
```

This prints

```
Howdy, world!
Greetings, earthlings!
```

Note particularly that `$x` continues to refer to the value passed into `newprint()` *despite* "my `$x`" having gone out of scope by the time the anonymous subroutine runs. That's what a closure is all about.

This applies only to lexical variables, by the way. Dynamic variables continue to work as they have always worked. Closure is not something that most Perl programmers need trouble themselves about to begin with.

5. References are often returned by special subroutines called constructors. Perl objects are just references to a special type of object that happens to know which package it's associated with. Constructors are just special subroutines that know how to create that association. They do so by starting with an ordinary reference, and it remains an ordinary reference even while it's also being an object. Constructors are often named `new()` and called indirectly:

   ```
   $objref = new Doggie (Tail => 'short', Ears => 'long');
   ```

   But don't have to be:

   ```
   $objref   = Doggie->new(Tail => 'short', Ears => 'long');

   use Term::Cap;
   $terminal = Term::Cap->Tgetent( { OSPEED => 9600 });

   use Tk;
   $main    = MainWindow->new();
   $menubar = $main->Frame(-relief              => "raised",
                           -borderwidth         => 2)
   ```

6. References of the appropriate type can spring into existence if you dereference them in a context that assumes they exist. Because we haven't talked about dereferencing yet, we can't show you any examples yet.

7. A reference can be created by using a special syntax, lovingly known as the *foo{THING} syntax. *foo{THING} returns a reference to the THING slot in *foo (which is the symbol table entry which holds everything known as foo).

   ```
   $scalarref = *foo{SCALAR};
   $arrayref  = *ARGV{ARRAY};
   ```

```
$hashref    = *ENV{HASH};
$coderef    = *handler{CODE};
$ioref      = *STDIN{IO};
$globref    = *foo{GLOB};
```

All of these are self–explanatory except for `*foo{IO}`. It returns the IO handle, used for file handles (*open*), sockets (*socket* and *socketpair*), and directory handles (*opendir*). For compatibility with previous versions of Perl, `*foo{FILEHANDLE}` is a synonym for `*foo{IO}`.

`*foo{THING}` returns undef if that particular THING hasn't been used yet, except in the case of scalars. `*foo{SCALAR}` returns a reference to an anonymous scalar if `$foo` hasn't been used yet. This might change in a future release.

`*foo{IO}` is an alternative to the `*HANDLE` mechanism given in *Typeglobs and Filehandles in perldata* for passing filehandles into or out of subroutines, or storing into larger data structures. Its disadvantage is that it won't create a new filehandle for you. Its advantage is that you have less risk of clobbering more than you want to with a typeglob assignment. (It still conflates file and directory handles, though.) However, if you assign the incoming value to a scalar instead of a typeglob as we do in the examples below, there's no risk of that happening.

```
splutter(*STDOUT);          # pass the whole glob
splutter(*STDOUT{IO});      # pass both file and dir handles

sub splutter {
    my $fh = shift;
    print $fh "her um well a hmmm\n";
}

$rec = get_rec(*STDIN);     # pass the whole glob
$rec = get_rec(*STDIN{IO}); # pass both file and dir handles

sub get_rec {
    my $fh = shift;
    return scalar <$fh>;
}
```

Using References

That's it for creating references. By now you're probably dying to know how to use references to get back to your long–lost data. There are several basic methods.

1. Anywhere you'd put an identifier (or chain of identifiers) as part of a variable or subroutine name, you can replace the identifier with a simple scalar variable containing a reference of the correct type:

```
$bar = $$scalarref;
push(@$arrayref, $filename);
$$arrayref[0] = "January";
$$hashref{"KEY"} = "VALUE";
&$coderef(1,2,3);
print $globref "output\n";
```

It's important to understand that we are specifically *not* dereferencing `$arrayref[0]` or `$hashref{"KEY"}` there. The dereference of the scalar variable happens *before* it does any key lookups. Anything more complicated than a simple scalar variable must use methods 2 or 3 below. However, a "simple scalar" includes an identifier that itself uses method 1 recursively. Therefore, the following prints "howdy".

```
$refrefref = \\\"howdy";
print $$$$refrefref;
```

2. Anywhere you'd put an identifier (or chain of identifiers) as part of a variable or subroutine name, you can replace the identifier with a BLOCK returning a reference of the correct type. In other words, the previous examples could be written like this:

```
$bar = ${$scalarref};
push(@{$arrayref}, $filename);
${$arrayref}[0] = "January";
${$hashref}{"KEY"} = "VALUE";
&{$coderef}(1,2,3);
$globref->print("output\n");  # iff IO::Handle is loaded
```

Admittedly, it's a little silly to use the curlies in this case, but the BLOCK can contain any arbitrary expression, in particular, subscripted expressions:

```
&{ $dispatch{$index} }(1,2,3);      # call correct routine
```

Because of being able to omit the curlies for the simple case of `$$x`, people often make the mistake of viewing the dereferencing symbols as proper operators, and wonder about their precedence. If they were, though, you could use parentheses instead of braces. That's not the case. Consider the difference below; case 0 is a short–hand version of case 1, *not* case 2:

```
$$hashref{"KEY"}   = "VALUE";       # CASE 0
${$hashref}{"KEY"} = "VALUE";       # CASE 1
${$hashref{"KEY"}} = "VALUE";       # CASE 2
${$hashref->{"KEY"}} = "VALUE";     # CASE 3
```

Case 2 is also deceptive in that you're accessing a variable called %hashref, not dereferencing through `$hashref` to the hash it's presumably referencing. That would be case 3.

3. Subroutine calls and lookups of individual array elements arise often enough that it gets cumbersome to use method 2. As a form of syntactic sugar, the examples for method 2 may be written:

```
$arrayref->[0] = "January";   # Array element
$hashref->{"KEY"} = "VALUE";  # Hash element
$coderef->(1,2,3);            # Subroutine call
```

The left side of the arrow can be any expression returning a reference, including a previous dereference. Note that `$array[$x]` is *not* the same thing as `$array->[$x]` here:

```
$array[$x]->{"foo"}->[0] = "January";
```

This is one of the cases we mentioned earlier in which references could spring into existence when in an lvalue context. Before this statement, `$array[$x]` may have been undefined. If so, it's automatically defined with a hash reference so that we can look up `{"foo"}` in it. Likewise `$array[$x]->{"foo"}` will automatically get defined with an array reference so that we can look up `[0]` in it. This process is called *autovivification*.

One more thing here. The arrow is optional *between* brackets subscripts, so you can shrink the above down to

```
$array[$x]{"foo"}[0] = "January";
```

Which, in the degenerate case of using only ordinary arrays, gives you multidimensional arrays just like C's:

```
$score[$x][$y][$z] += 42;
```

Well, okay, not entirely like C's arrays, actually. C doesn't know how to grow its arrays on demand. Perl does.

4. If a reference happens to be a reference to an object, then there are probably methods to access the things referred to, and you should probably stick to those methods unless you're in the class package that defines the object's methods. In other words, be nice, and don't violate the object's encapsulation without a very good reason. Perl does not enforce encapsulation. We are not totalitarians here. We do expect some basic civility though.

Using a string or number as a reference produces a symbolic reference, as explained above. Using a reference as a number produces an integer representing its storage location in memory. The only useful thing to be done with this is to compare two references numerically to see whether they refer to the same location.

```
if ($ref1 == $ref2) {  # cheap numeric compare of references
    print "refs 1 and 2 refer to the same thing\n";
}
```

Using a reference as a string produces both its referent's type, including any package blessing as described in *perlobj*, as well as the numeric address expressed in hex. The `ref()` operator returns just the type of thing the reference is pointing to, without the address. See *ref* for details and examples of its use.

The `bless()` operator may be used to associate the object a reference points to with a package functioning as an object class. See *perlobj*.

A typeglob may be dereferenced the same way a reference can, because the dereference syntax always indicates the type of reference desired. So `${*foo}` and `${\$foo}` both indicate the same scalar variable.

Here's a trick for interpolating a subroutine call into a string:

```
print "My sub returned @{[mysub(1,2,3)]} that time.\n";
```

The way it works is that when the `@{...}` is seen in the double–quoted string, it's evaluated as a block. The block creates a reference to an anonymous array containing the results of the call to `mysub(1,2,3)`. So the whole block returns a reference to an array, which is then dereferenced by `@{...}` and stuck into the double–quoted string. This chicanery is also useful for arbitrary expressions:

```
print "That yields @{[$n + 5]} widgets\n";
```

Symbolic references

We said that references spring into existence as necessary if they are undefined, but we didn't say what happens if a value used as a reference is already defined, but *isn't* a hard reference. If you use it as a reference, it'll be treated as a symbolic reference. That is, the value of the scalar is taken to be the *name* of a variable, rather than a direct link to a (possibly) anonymous value.

People frequently expect it to work like this. So it does.

```
$name = "foo";
$$name = 1;                 # Sets $foo
${$name} = 2;               # Sets $foo
${$name x 2} = 3;           # Sets $foofoo
$name->[0] = 4;             # Sets $foo[0]
@$name = ();                # Clears @foo
&$name();                   # Calls &foo() (as in Perl 4)
$pack = "THAT";
${"${pack}::$name"} = 5;    # Sets $THAT::foo without eval
```

This is powerful, and slightly dangerous, in that it's possible to intend (with the utmost sincerity) to use a hard reference, and accidentally use a symbolic reference instead. To protect against that, you can say

```
use strict 'refs';
```

and then only hard references will be allowed for the rest of the enclosing block. An inner block may countermand that with

```
no strict 'refs';
```

Only package variables (globals, even if localized) are visible to symbolic references. Lexical variables (declared with `my()`) aren't in a symbol table, and thus are invisible to this mechanism. For example:

```
local $value = 10;
$ref = "value";
{
    my $value = 20;
    print $$ref;
}
```

This will still print 10, not 20. Remember that `local()` affects package variables, which are all "global" to the package.

Not–so–symbolic references

A new feature contributing to readability in perl version 5.001 is that the brackets around a symbolic reference behave more like quotes, just as they always have within a string. That is,

```
$push = "pop on ";
print "${push}over";
```

has always meant to print "pop on over", even though push is a reserved word. This has been generalized to work the same outside of quotes, so that

```
print ${push} . "over";
```

and even

```
print ${ push } . "over";
```

will have the same effect. (This would have been a syntax error in Perl 5.000, though Perl 4 allowed it in the spaceless form.) This construct is *not* considered to be a symbolic reference when you're using strict refs:

```
use strict 'refs';
${ bareword };      # Okay, means $bareword.
${ "bareword" };    # Error, symbolic reference.
```

Similarly, because of all the subscripting that is done using single words, we've applied the same rule to any bareword that is used for subscripting a hash. So now, instead of writing

```
$array{ "aaa" }{ "bbb" }{ "ccc" }
```

you can write just

```
$array{ aaa }{ bbb }{ ccc }
```

and not worry about whether the subscripts are reserved words. In the rare event that you do wish to do something like

```
$array{ shift }
```

you can force interpretation as a reserved word by adding anything that makes it more than a bareword:

```
$array{ shift() }
$array{ +shift }
$array{ shift @_ }
```

The `use warnings` pragma or the **–w** switch will warn you if it interprets a reserved word as a string. But it will no longer warn you about using lowercase words, because the string is effectively quoted.

Pseudo–hashes: Using an array as a hash

WARNING: This section describes an experimental feature. Details may change without notice in future versions.

Beginning with release 5.005 of Perl, you may use an array reference in some contexts that would normally require a hash reference. This allows you to access array elements using symbolic names, as if they were fields in a structure.

For this to work, the array must contain extra information. The first element of the array has to be a hash reference that maps field names to array indices. Here is an example:

```
$struct = [{foo => 1, bar => 2}, "FOO", "BAR"];

$struct->{foo};  # same as $struct->[1], i.e. "FOO"
$struct->{bar};  # same as $struct->[2], i.e. "BAR"

keys %$struct;   # will return ("foo", "bar") in some order
values %$struct; # will return ("FOO", "BAR") in same some order

while (my($k,$v) = each %$struct) {
   print "$k => $v\n";
}
```

Perl will raise an exception if you try to access nonexistent fields. To avoid inconsistencies, always use the `fields::phash()` function provided by the `fields` pragma.

```
use fields;
$pseudohash = fields::phash(foo => "FOO", bar => "BAR");
```

For better performance, Perl can also do the translation from field names to array indices at compile time for typed object references. See *fields*.

There are two ways to check for the existence of a key in a pseudo–hash. The first is to use `exists()`. This checks to see if the given field has ever been set. It acts this way to match the behavior of a regular hash. For instance:

```
use fields;
$phash = fields::phash([qw(foo bar pants)], ['FOO']);
$phash->{pants} = undef;

print exists $phash->{foo};    # true, 'foo' was set in the declaration
print exists $phash->{bar};    # false, 'bar' has not been used.
print exists $phash->{pants};  # true, your 'pants' have been touched
```

The second is to use `exists()` on the hash reference sitting in the first array element. This checks to see if the given key is a valid field in the pseudo–hash.

```
print exists $phash->[0]{bar};      # true, 'bar' is a valid field
print exists $phash->[0]{shoes};# false, 'shoes' can't be used
```

`delete()` on a pseudo–hash element only deletes the value corresponding to the key, not the key itself. To delete the key, you'll have to explicitly delete it from the first hash element.

```
print delete $phash->{foo};     # prints $phash->[1], "FOO"
print exists $phash->{foo};     # false
print exists $phash->[0]{foo};  # true, key still exists
print delete $phash->[0]{foo};  # now key is gone
print $phash->{foo};            # runtime exception
```

Function Templates

As explained above, a closure is an anonymous function with access to the lexical variables visible when that function was compiled. It retains access to those variables even though it doesn't get run until later, such as in a signal handler or a Tk callback.

Using a closure as a function template allows us to generate many functions that act similarly. Suppose you wanted functions named after the colors that generated HTML font changes for the various colors:

```
print "Be ", red("careful"), "with that ", green("light");
```

The red() and green() functions would be similar. To create these, we'll assign a closure to a typeglob of the name of the function we're trying to build.

```
@colors = qw(red blue green yellow orange purple violet);
for my $name (@colors) {
    no strict 'refs';       # allow symbol table manipulation
    *$name = *{uc $name} = sub { "<FONT COLOR='$name'>@_</FONT>" };
}
```

Now all those different functions appear to exist independently. You can call red(), RED(), blue(), BLUE(), green(), etc. This technique saves on both compile time and memory use, and is less error–prone as well, since syntax checks happen at compile time. It's critical that any variables in the anonymous subroutine be lexicals in order to create a proper closure. That's the reasons for the my on the loop iteration variable.

This is one of the only places where giving a prototype to a closure makes much sense. If you wanted to impose scalar context on the arguments of these functions (probably not a wise idea for this particular example), you could have written it this way instead:

```
*$name = sub ($) { "<FONT COLOR='$name'>$_[0]</FONT>" };
```

However, since prototype checking happens at compile time, the assignment above happens too late to be of much use. You could address this by putting the whole loop of assignments within a BEGIN block, forcing it to occur during compilation.

Access to lexicals that change over type—like those in the for loop above—only works with closures, not general subroutines. In the general case, then, named subroutines do not nest properly, although anonymous ones do. If you are accustomed to using nested subroutines in other programming languages with their own private variables, you'll have to work at it a bit in Perl. The intuitive coding of this type of thing incurs mysterious warnings about ''will not stay shared''. For example, this won't work:

```
sub outer {
    my $x = $_[0] + 35;
    sub inner { return $x * 19 }   # WRONG
    return $x + inner();
}
```

A work–around is the following:

```
sub outer {
    my $x = $_[0] + 35;
    local *inner = sub { return $x * 19 };
    return $x + inner();
}
```

Now inner() can only be called from within outer(), because of the temporary assignments of the closure (anonymous subroutine). But when it does, it has normal access to the lexical variable $x from the scope of outer().

This has the interesting effect of creating a function local to another function, something not normally supported in Perl.

WARNING

You may not (usefully) use a reference as the key to a hash. It will be converted into a string:

```
$x{ \$a } = $a;
```

If you try to dereference the key, it won't do a hard dereference, and you won't accomplish what you're attempting. You might want to do something more like

```
$r = \@a;
$x{ $r } = $r;
```

And then at least you can use the `values()`, which will be real refs, instead of the `keys()`, which won't.

The standard Tie::RefHash module provides a convenient workaround to this.

SEE ALSO

Besides the obvious documents, source code can be instructive. Some pathological examples of the use of references can be found in the ***t/op/ref.t*** regression test in the Perl source directory.

See also *perldsc* and *perllol* for how to use references to create complex data structures, and *perltoot*, *perlobj*, and *perlbot* for how to use them to create objects.

NAME

perlreftut – Mark's very short tutorial about references

DESCRIPTION

One of the most important new features in Perl 5 was the capability to manage complicated data structures like multidimensional arrays and nested hashes. To enable these, Perl 5 introduced a feature called 'references', and using references is the key to managing complicated, structured data in Perl. Unfortunately, there's a lot of funny syntax to learn, and the main manual page can be hard to follow. The manual is quite complete, and sometimes people find that a problem, because it can be hard to tell what is important and what isn't.

Fortunately, you only need to know 10% of what's in the main page to get 90% of the benefit. This page will show you that 10%.

Who Needs Complicated Data Structures?

One problem that came up all the time in Perl 4 was how to represent a hash whose values were lists. Perl 4 had hashes, of course, but the values had to be scalars; they couldn't be lists.

Why would you want a hash of lists? Let's take a simple example: You have a file of city and country names, like this:

```
Chicago, USA
Frankfurt, Germany
Berlin, Germany
Washington, USA
Helsinki, Finland
New York, USA
```

and you want to produce an output like this, with each country mentioned once, and then an alphabetical list of the cities in that country:

```
Finland: Helsinki.
Germany: Berlin, Frankfurt.
USA:  Chicago, New York, Washington.
```

The natural way to do this is to have a hash whose keys are country names. Associated with each country name key is a list of the cities in that country. Each time you read a line of input, split it into a country and a city, look up the list of cities already known to be in that country, and append the new city to the list. When you're done reading the input, iterate over the hash as usual, sorting each list of cities before you print it out.

If hash values can't be lists, you lose. In Perl 4, hash values can't be lists; they can only be strings. You lose. You'd probably have to combine all the cities into a single string somehow, and then when time came to write the output, you'd have to break the string into a list, sort the list, and turn it back into a string. This is messy and error–prone. And it's frustrating, because Perl already has perfectly good lists that would solve the problem if only you could use them.

The Solution

By the time Perl 5 rolled around, we were already stuck with this design: Hash values must be scalars. The solution to this is references.

A reference is a scalar value that *refers to* an entire array or an entire hash (or to just about anything else). Names are one kind of reference that you're already familiar with. Think of the President: a messy, inconvenient bag of blood and bones. But to talk about him, or to represent him in a computer program, all you need is the easy, convenient scalar string "Bill Clinton".

References in Perl are like names for arrays and hashes. They're Perl's private, internal names, so you can be sure they're unambiguous. Unlike "Bill Clinton", a reference only refers to one thing, and you always know what it refers to. If you have a reference to an array, you can recover the entire array from it. If you have a reference to a hash, you can recover the entire hash. But the reference is still an easy, compact scalar

value.

You can't have a hash whose values are arrays; hash values can only be scalars. We're stuck with that. But a single reference can refer to an entire array, and references are scalars, so you can have a hash of references to arrays, and it'll act a lot like a hash of arrays, and it'll be just as useful as a hash of arrays.

We'll come back to this city–country problem later, after we've seen some syntax for managing references.

Syntax

There are just two ways to make a reference, and just two ways to use it once you have it.

Making References

Make Rule 1

If you put a `\` in front of a variable, you get a reference to that variable.

```
$aref = \@array;          # $aref now holds a reference to @array
$href = \%hash;           # $href now holds a reference to %hash
```

Once the reference is stored in a variable like `$aref` or `$href`, you can copy it or store it just the same as any other scalar value:

```
$xy = $aref;              # $xy now holds a reference to @array
$p[3] = $href;            # $p[3] now holds a reference to %hash
$z = $p[3];               # $z now holds a reference to %hash
```

These examples show how to make references to variables with names. Sometimes you want to make an array or a hash that doesn't have a name. This is analogous to the way you like to be able to use the string `"\n"` or the number 80 without having to store it in a named variable first.

Make Rule 2

`[ ITEMS ]` makes a new, anonymous array, and returns a reference to that array. `{ ITEMS }` makes a new, anonymous hash. and returns a reference to that hash.

```
$aref = [ 1, "foo", undef, 13 ];
# $aref now holds a reference to an array

$href = { APR => 4, AUG => 8 };
# $href now holds a reference to a hash
```

The references you get from rule 2 are the same kind of references that you get from rule 1:

```
# This:
$aref = [ 1, 2, 3 ];

# Does the same as this:
@array = (1, 2, 3);
$aref = \@array;
```

The first line is an abbreviation for the following two lines, except that it doesn't create the superfluous array variable `@array`.

Using References

What can you do with a reference once you have it? It's a scalar value, and we've seen that you can store it as a scalar and get it back again just like any scalar. There are just two more ways to use it:

Use Rule 1

If `$aref` contains a reference to an array, then you can put `{$aref}` anywhere you would normally put the name of an array. For example, `@{$aref}` instead of `@array`.

Here are some examples of that:

Arrays:

```
@a              @{$aref}                An array
reverse @a      reverse @{$aref}        Reverse the array
$a[3]           ${$aref}[3]             An element of the array
$a[3] = 17;     ${$aref}[3] = 17        Assigning an element
```

On each line are two expressions that do the same thing. The left-hand versions operate on the array `@a`, and the right-hand versions operate on the array that is referred to by `$aref`, but once they find the array they're operating on, they do the same things to the arrays.

Using a hash reference is *exactly* the same:

```
%h              %{$href}              A hash
keys %h         keys %{$href}         Get the keys from the hash
$h{'red'}       ${$href}{'red'}       An element of the hash
$h{'red'} = 17  ${$href}{'red'} = 17  Assigning an element
```

Use Rule 2

`${$aref}[3]` is too hard to read, so you can write `< $aref->[3]` instead.

`${$href}{red}` is too hard to read, so you can write `< $href->{red}` instead.

Most often, when you have an array or a hash, you want to get or set a single element from it. `${$aref}[3]` and `${$href}{'red'}` have too much punctuation, and Perl lets you abbreviate.

If `$aref` holds a reference to an array, then `< $aref->[3]` is the fourth element of the array. Don't confuse this with `$aref[3]`, which is the fourth element of a totally different array, one deceptively named `@aref`. `$aref` and `@aref` are unrelated the same way that `$item` and `@item` are.

Similarly, `< $href->{'red'}` is part of the hash referred to by the scalar variable `$href`, perhaps even one with no name. `$href{'red'}` is part of the deceptively named `%href` hash. It's easy to forget to leave out the `< ->`, and if you do, you'll get bizarre results when your program gets array and hash elements out of totally unexpected hashes and arrays that weren't the ones you wanted to use.

An Example

Let's see a quick example of how all this is useful.

First, remember that `[1, 2, 3]` makes an anonymous array containing `(1, 2, 3)`, and gives you a reference to that array.

Now think about

```
@a = ( [1, 2, 3],
       [4, 5, 6],
       [7, 8, 9]
     );
```

@a is an array with three elements, and each one is a reference to another array.

`$a[1]` is one of these references. It refers to an array, the array containing `(4, 5, 6)`, and because it is a reference to an array, **USE RULE 2** says that we can write `< $a[1]->[2]` to get the third element from that array. `< $a[1]->[2]` is the 6. Similarly, `< $a[0]->[1]` is the 2. What we have here is like a two-dimensional array; you can write `< $a[ROW]->[COLUMN]` to get or set the element in any row and any column of the array.

The notation still looks a little cumbersome, so there's one more abbreviation:

Arrow Rule

In between two **subscripts**, the arrow is optional.

Instead of `< $a[1]->[2]`, we can write `$a[1][2];` it means the same thing. Instead of `< $a[0]->[1]`, we can write `$a[0][1];` it means the same thing.

Now it really looks like two–dimensional arrays!

You can see why the arrows are important. Without them, we would have had to write `${$a[1]}[2]` instead of `$a[1][2]`. For three–dimensional arrays, they let us write `$x[2][3][5]` instead of the unreadable `${${$x[2]}[3]}[5]`.

Solution

Here's the answer to the problem I posed earlier, of reformatting a file of city and country names.

```
 1   while (<>) {
 2     chomp;
 3     my ($city, $country) = split /, /;
 4     push @{$table{$country}}, $city;
 5   }
 6
 7   foreach $country (sort keys %table) {
 8     print "$country: ";
 9     my @cities = @{$table{$country}};
10     print join ', ', sort @cities;
11     print ".\n";
12   }
```

The program has two pieces: Lines 1—5 read the input and build a data structure, and lines 7—12 analyze the data and print out the report.

In the first part, line 4 is the important one. We're going to have a hash, `%table`, whose keys are country names, and whose values are (references to) arrays of city names. After acquiring a city and country name, the program looks up `$table{$country}`, which holds (a reference to) the list of cities seen in that country so far. Line 4 is totally analogous to

```
push @array, $city;
```

except that the name `array` has been replaced by the reference `{$table{$country}}`. The `push` adds a city name to the end of the referred–to array.

In the second part, line 9 is the important one. Again, `$table{$country}` is (a reference to) the list of cities in the country, so we can recover the original list, and copy it into the array `@cities`, by using `@{$table{$country}}`. Line 9 is totally analogous to

```
@cities = @array;
```

except that the name `array` has been replaced by the reference `{$table{$country}}`. The `@` tells Perl to get the entire array.

The rest of the program is just familiar uses of `chomp`, `split`, `sort`, `print`, and doesn't involve references at all.

There's one fine point I skipped. Suppose the program has just read the first line in its input that happens to mention Greece. Control is at line 4, `$country` is `'Greece'`, and `$city` is `'Athens'`. Since this is the first city in Greece, `$table{$country}` is undefined——in fact there isn't an `'Greece'` key in `%table` at all. What does line 4 do here?

```
4       push @{$table{$country}}, $city;
```

This is Perl, so it does the exact right thing. It sees that you want to push `Athens` onto an array that doesn't exist, so it helpfully makes a new, empty, anonymous array for you, installs it in the table, and then pushes `Athens` onto it. This is called 'autovivification'.

The Rest

I promised to give you 90% of the benefit with 10% of the details, and that means I left out 90% of the details. Now that you have an overview of the important parts, it should be easier to read the *perlref* manual page, which discusses 100% of the details.

Some of the highlights of *perlref*:

- You can make references to anything, including scalars, functions, and other references.
- In **USE RULE 1**, you can omit the curly brackets whenever the thing inside them is an atomic scalar variable like `$aref`. For example, `@$aref` is the same as `@{$aref}`, and `$$aref[1]` is the same as `${$aref}[1]`. If you're just starting out, you may want to adopt the habit of always including the curly brackets.
- To see if a variable contains a reference, use the 'ref' function. It returns true if its argument is a reference. Actually it's a little better than that: It returns HASH for hash references and ARRAY for array references.
- If you try to use a reference like a string, you get strings like

  ```
  ARRAY(0x80f5dec)   or   HASH(0x826afc0)
  ```

  If you ever see a string that looks like this, you'll know you printed out a reference by mistake.

  A side effect of this representation is that you can use `eq` to see if two references refer to the same thing. (But you should usually use == instead because it's much faster.)
- You can use a string as if it were a reference. If you use the string `"foo"` as an array reference, it's taken to be a reference to the array `@foo`. This is called a *soft reference* or *symbolic reference*.

You might prefer to go on to *perllol* instead of *perlref*; it discusses lists of lists and multidimensional arrays in detail. After that, you should move on to *perldsc*; it's a Data Structure Cookbook that shows recipes for using and printing out arrays of hashes, hashes of arrays, and other kinds of data.

Summary

Everyone needs compound data structures, and in Perl the way you get them is with references. There are four important rules for managing references: Two for making references and two for using them. Once you know these rules you can do most of the important things you need to do with references.

Credits

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Distribution Conditions

NAME

perlrequick – Perl regular expressions quick start

DESCRIPTION

This page covers the very basics of understanding, creating and using regular expressions ('regexes') in Perl.

The Guide

Simple word matching

The simplest regex is simply a word, or more generally, a string of characters. A regex consisting of a word matches any string that contains that word:

```
"Hello World" =~ /World/;  # matches
```

In this statement, `World` is a regex and the `//` enclosing `/World/` tells perl to search a string for a match. The operator `=~` associates the string with the regex match and produces a true value if the regex matched, or false if the regex did not match. In our case, `World` matches the second word in `"Hello World"`, so the expression is true. This idea has several variations.

Expressions like this are useful in conditionals:

```
print "It matches\n" if "Hello World" =~ /World/;
```

The sense of the match can be reversed by using `!~` operator:

```
print "It doesn't match\n" if "Hello World" !~ /World/;
```

The literal string in the regex can be replaced by a variable:

```
$greeting = "World";
print "It matches\n" if "Hello World" =~ /$greeting/;
```

If you're matching against `$_`, the `$_ =~` part can be omitted:

```
$_ = "Hello World";
print "It matches\n" if /World/;
```

Finally, the `//` default delimiters for a match can be changed to arbitrary delimiters by putting an `'m'` out front:

```
"Hello World" =~ m!World!;   # matches, delimited by '!'
"Hello World" =~ m{World};   # matches, note the matching '{}'
"/usr/bin/perl" =~ m"/perl"; # matches after '/usr/bin',
                             # '/' becomes an ordinary char
```

Regexes must match a part of the string *exactly* in order for the statement to be true:

```
"Hello World" =~ /world/;  # doesn't match, case sensitive
"Hello World" =~ /o W/;    # matches, ' ' is an ordinary char
"Hello World" =~ /World /; # doesn't match, no ' ' at end
```

perl will always match at the earliest possible point in the string:

```
"Hello World" =~ /o/;       # matches 'o' in 'Hello'
"That hat is red" =~ /hat/; # matches 'hat' in 'That'
```

Not all characters can be used 'as is' in a match. Some characters, called **metacharacters**, are reserved for use in regex notation. The metacharacters are

```
{}[]()^$.|*+?\
```

A metacharacter can be matched by putting a backslash before it:

```
"2+2=4" =~ /2+2/;    # doesn't match, + is a metacharacter
"2+2=4" =~ /2\+2/;   # matches, \+ is treated like an ordinary +
'C:\WIN32' =~ /C:\\WIN/;                      # matches
"/usr/bin/perl" =~ /\/usr\/local\/bin\/perl/;  # matches
```

In the last regex, the forward slash `'/'` is also backslashed, because it is used to delimit the regex.

Non-printable ASCII characters are represented by **escape sequences**. Common examples are `\t` for a tab, `\n` for a newline, and `\r` for a carriage return. Arbitrary bytes are represented by octal escape sequences, e.g., `\033`, or hexadecimal escape sequences, e.g., `\x1B`:

```
"1000\t2000" =~ m(0\t2)        # matches
"cat"        =~ /\143\x61\x74/ # matches, but a weird way to spell cat
```

Regexes are treated mostly as double quoted strings, so variable substitution works:

```
$foo = 'house';
'cathouse' =~ /cat$foo/;   # matches
'housecat' =~ /${foo}cat/; # matches
```

With all of the regexes above, if the regex matched anywhere in the string, it was considered a match. To specify *where* it should match, we would use the **anchor** metacharacters `^` and `$`. The anchor `^` means match at the beginning of the string and the anchor `$` means match at the end of the string, or before a newline at the end of the string. Some examples:

```
"housekeeper" =~ /keeper/;         # matches
"housekeeper" =~ /^keeper/;        # doesn't match
"housekeeper" =~ /keeper$/;        # matches
"housekeeper\n" =~ /keeper$/;      # matches
"housekeeper" =~ /^housekeeper$/;  # matches
```

Using character classes

A **character class** allows a set of possible characters, rather than just a single character, to match at a particular point in a regex. Character classes are denoted by brackets `[...]`, with the set of characters to be possibly matched inside. Here are some examples:

```
/cat/;             # matches 'cat'
/[bcr]at/;         # matches 'bat', 'cat', or 'rat'
"abc" =~ /[cab]/; # matches 'a'
```

In the last statement, even though `'c'` is the first character in the class, the earliest point at which the regex can match is `'a'`.

```
/[yY][eE][sS]/; # match 'yes' in a case-insensitive way
                # 'yes', 'Yes', 'YES', etc.
/yes/i;         # also match 'yes' in a case-insensitive way
```

The last example shows a match with an `'i'` **modifier**, which makes the match case-insensitive.

Character classes also have ordinary and special characters, but the sets of ordinary and special characters inside a character class are different than those outside a character class. The special characters for a character class are `-]\^$` and are matched using an escape:

```
/[\]c]def/; # matches ']def' or 'cdef'
$x = 'bcr';
/[$x]at/;   # matches 'bat, 'cat', or 'rat'
/[\$x]at/;  # matches '$at' or 'xat'
/[\\$x]at/; # matches '\at', 'bat, 'cat', or 'rat'
```

The special character `'-'` acts as a range operator within character classes, so that the unwieldy `[0123456789]` and `[abc...xyz]` become the svelte `[0-9]` and `[a-z]`:

```
/item[0-9]/;  # matches 'item0' or ... or 'item9'
/[0-9a-fA-F]/;  # matches a hexadecimal digit
```

If `'-'` is the first or last character in a character class, it is treated as an ordinary character.

The special character `^` in the first position of a character class denotes a **negated character class**, which matches any character but those in the brackets. Both `[...]` and `[^...]` must match a character, or the match fails. Then

```
/[^a]at/;  # doesn't match 'aat' or 'at', but matches
           # all other 'bat', 'cat, '0at', '%at', etc.
/[^0-9]/;  # matches a non-numeric character
/[a^]at/;  # matches 'aat' or '^at'; here '^' is ordinary
```

Perl has several abbreviations for common character classes:

- \d is a digit and represents [0–9]
- \s is a whitespace character and represents [\ \t\r\n\f]
- \w is a word character (alphanumeric or _) and represents [0–9a–zA–Z_]
- \D is a negated \d; it represents any character but a digit [^0–9]
- \S is a negated \s; it represents any non–whitespace character [^\s]
- \W is a negated \w; it represents any non–word character [^\w]
- The period '.' matches any character but "\n"

The `\d\s\w\D\S\W` abbreviations can be used both inside and outside of character classes. Here are some in use:

```
/\d\d:\d\d:\d\d/; # matches a hh:mm:ss time format
/[\d\s]/;         # matches any digit or whitespace character
/\w\W\w/;         # matches a word char, followed by a
                  # non-word char, followed by a word char
/..rt/;           # matches any two chars, followed by 'rt'
/end\./;          # matches 'end.'
/end[.]/;         # same thing, matches 'end.'
```

The **word anchor** `\b` matches a boundary between a word character and a non–word character `\w\W` or `\W\w`:

```
$x = "Housecat catenates house and cat";
$x =~ /\bcat/;  # matches cat in 'catenates'
$x =~ /cat\b/;  # matches cat in 'housecat'
$x =~ /\bcat\b/;  # matches 'cat' at end of string
```

In the last example, the end of the string is considered a word boundary.

Matching this or that

We can match match different character strings with the **alternation** metacharacter `'|'`. To match `dog` or `cat`, we form the regex `dog|cat`. As before, perl will try to match the regex at the earliest possible point in the string. At each character position, perl will first try to match the the first alternative, `dog`. If `dog` doesn't match, perl will then try the next alternative, `cat`. If `cat` doesn't match either, then the match fails and perl moves to the next position in the string. Some examples:

```
"cats and dogs" =~ /cat|dog|bird/;  # matches "cat"
"cats and dogs" =~ /dog|cat|bird/;  # matches "cat"
```

Even though `dog` is the first alternative in the second regex, `cat` is able to match earlier in the string.

```
"cats"          =~ /c|ca|cat|cats/; # matches "c"
```

```
"cats"          =~ /cats|cat|ca|c/; # matches "cats"
```

At a given character position, the first alternative that allows the regex match to succeed wil be the one that matches. Here, all the alternatives match at the first string position, so th first matches.

Grouping things and hierarchical matching

The **grouping** metacharacters `()` allow a part of a regex to be treated as a single unit. Parts of a regex are grouped by enclosing them in parentheses. The regex `house(cat|keeper)` means match `house` followed by either `cat` or `keeper`. Some more examples are

```
/(a|b)b/;    # matches 'ab' or 'bb'
/(^a|b)c/;   # matches 'ac' at start of string or 'bc' anywhere

/house(cat|)/;  # matches either 'housecat' or 'house'
/house(cat(s|)|)/;  # matches either 'housecats' or 'housecat' or
                    # 'house'.  Note groups can be nested.

"20" =~ /(19|20|)\d\d/;  # matches the null alternative '()\d\d',
                         # because '20\d\d' can't match
```

Extracting matches

The grouping metacharacters `()` also allow the extraction of the parts of a string that matched. For each grouping, the part that matched inside goes into the special variables `$1, $2,` etc. They can be used just as ordinary variables:

```
# extract hours, minutes, seconds
$time =~ /(\d\d):(\d\d):(\d\d)/;  # match hh:mm:ss format
$hours = $1;
$minutes = $2;
$seconds = $3;
```

In list context, a match `/regex/` with groupings will return the list of matched values `($1,$2,...)`. So we could rewrite it as

```
($hours, $minutes, $second) = ($time =~ /(\d\d):(\d\d):(\d\d)/);
```

If the groupings in a regex are nested, `$1` gets the group with the leftmost opening parenthesis, `$2` the next opening parenthesis, etc. For example, here is a complex regex and the matching variables indicated below it:

```
/(ab(cd|ef)((gi)|j))/;
 1  2      34
```

Associated with the matching variables `$1, $2,` ... are the **backreferences** `\1`, `\2`, ... Backreferences are matching variables that can be used *inside* a regex:

```
/(\w\w\w)\s\1/; # find sequences like 'the the' in string
```

`$1, $2,` ... should only be used outside of a regex, and `\1`, `\2`, ... only inside a regex.

Matching repetitions

The **quantifier** metacharacters `?`, `*`, `+`, and `{}` allow us to determine the number of repeats of a portion of a regex we consider to be a match. Quantifiers are put immediately after the character, character class, or grouping that we want to specify. They have the following meanings:

- `a?` = match 'a' 1 or 0 times
- `a*` = match 'a' 0 or more times, i.e., any number of times
- `a+` = match 'a' 1 or more times, i.e., at least once
- `a{n,m}` = match at least `n` times, but not more than `m` times.

- **a{n,} = match at least n or more times**
- a{n} = match exactly n times

Here are some examples:

```
/[a-z]+\s+\d*/;  # match a lowercase word, at least some space, and
                 # any number of digits
/(\w+)\s+\1/;    # match doubled words of arbitrary length
$year =~ /\d{2,4}/;  # make sure year is at least 2 but not more
                     # than 4 digits
$year =~ /\d{4}|\d{2}/;    # better match; throw out 3 digit dates
```

These quantifiers will try to match as much of the string as possible, while still allowing the regex to match. So we have

```
$x = 'the cat in the hat';
$x =~ /^(.*)(at)(.*)$/; # matches,
                        # $1 = 'the cat in the h'
                        # $2 = 'at'
                        # $3 = ''   (0 matches)
```

The first quantifier `.*` grabs as much of the string as possible while still having the regex match. The second quantifier `.*` has no string left to it, so it matches 0 times.

More matching

There are a few more things you might want to know about matching operators. In the code

```
$pattern = 'Seuss';
while (<>) {
    print if /$pattern/;
}
```

perl has to re–evaluate `$pattern` each time through the loop. If `$pattern` won't be changing, use the `//o` modifier, to only perform variable substitutions once. If you don't want any substitutions at all, use the special delimiter `m''`:

```
$pattern = 'Seuss';
m'$pattern'; # matches '$pattern', not 'Seuss'
```

The global modifier `//g` allows the matching operator to match within a string as many times as possible. In scalar context, successive matches against a string will have `//g` jump from match to match, keeping track of position in the string as it goes along. You can get or set the position with the `pos()` function. For example,

```
$x = "cat dog house"; # 3 words
while ($x =~ /(\w+)/g) {
    print "Word is $1, ends at position ", pos $x, "\n";
}
```

prints

```
Word is cat, ends at position 3
Word is dog, ends at position 7
Word is house, ends at position 13
```

A failed match or changing the target string resets the position. If you don't want the position reset after failure to match, add the `//c`, as in `/regex/gc`.

In list context, `//g` returns a list of matched groupings, or if there are no groupings, a list of matches to the whole regex. So

```
@words = ($x =~ /(\w+)/g);  # matches,
                            # $word[0] = 'cat'
                            # $word[1] = 'dog'
                            # $word[2] = 'house'
```

Search and replace

Search and replace is performed using `s/regex/replacement/modifiers`. The `replacement` is a Perl double quoted string that replaces in the string whatever is matched with the `regex`. The operator `=~` is also used here to associate a string with `s///`. If matching against `$_`, the `$_ =~` can be dropped. If there is a match, `s///` returns the number of substitutions made, otherwise it returns false. Here are a few examples:

```
$x = "Time to feed the cat!";
$x =~ s/cat/hacker/;   # $x contains "Time to feed the hacker!"
$y = "'quoted words'";
$y =~ s/^'(.*)'$/$1/;  # strip single quotes,
                       # $y contains "quoted words"
```

With the `s///` operator, the matched variables `$1, $2,` etc. are immediately available for use in the replacement expression. With the global modifier, `s///g` will search and replace all occurrences of the regex in the string:

```
$x = "I batted 4 for 4";
$x =~ s/4/four/;   # $x contains "I batted four for 4"
$x = "I batted 4 for 4";
$x =~ s/4/four/g;  # $x contains "I batted four for four"
```

The evaluation modifier `s///e` wraps an `eval{...}` around the replacement string and the evaluated result is substituted for the matched substring. Some examples:

```
# reverse all the words in a string
$x = "the cat in the hat";
$x =~ s/(\w+)/reverse $1/ge;   # $x contains "eht tac ni eht tah"

# convert percentage to decimal
$x = "A 39% hit rate";
$x =~ s!(\d+)%!$1/100!e;       # $x contains "A 0.39 hit rate"
```

The last example shows that `s///` can use other delimiters, such as `s!!!` and `s{}{}`, and even `s{}//`. If single quotes are used `s''`, then the regex and replacement are treated as single quoted strings.

The split operator

`split /regex/, string` splits `string` into a list of substrings and returns that list. The regex determines the character sequence that `string` is split with respect to. For example, to split a string into words, use

```
$x = "Calvin and Hobbes";
@word = split /\s+/, $x;  # $word[0] = 'Calvin'
                          # $word[1] = 'and'
                          # $word[2] = 'Hobbes'
```

To extract a comma–delimited list of numbers, use

```
$x = "1.618,2.718,   3.142";
@const = split /,\s*/, $x;  # $const[0] = '1.618'
                            # $const[1] = '2.718'
                            # $const[2] = '3.142'
```

If the empty regex `//` is used, the string is split into individual characters. If the regex has groupings, then list produced contains the matched substrings from the groupings as well:

```
$x = "/usr/bin";
@parts = split m!(/)!, $x;  # $parts[0] = ''
                            # $parts[1] = '/'
                            # $parts[2] = 'usr'
                            # $parts[3] = '/'
                            # $parts[4] = 'bin'
```

Since the first character of `$x` matched the regex, `split` prepended an empty initial element to the list.

BUGS

None.

SEE ALSO

This is just a quick start guide. For a more in-depth tutorial on regexes, see *perlretut* and for the reference page, see *perlre*.

AUTHOR AND COPYRIGHT

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NAME

perlretut – Perl regular expressions tutorial

DESCRIPTION

This page provides a basic tutorial on understanding, creating and using regular expressions in Perl. It serves as a complement to the reference page on regular expressions *perlre*. Regular expressions are an integral part of the `m//`, `s///`, `qr//` and `split` operators and so this tutorial also overlaps with *Regexp Quote−Like Operators in perlop* and *split*.

Perl is widely renowned for excellence in text processing, and regular expressions are one of the big factors behind this fame. Perl regular expressions display an efficiency and flexibility unknown in most other computer languages. Mastering even the basics of regular expressions will allow you to manipulate text with surprising ease.

What is a regular expression? A regular expression is simply a string that describes a pattern. Patterns are in common use these days; examples are the patterns typed into a search engine to find web pages and the patterns used to list files in a directory, e.g., `ls *.txt` or `dir *.*`. In Perl, the patterns described by regular expressions are used to search strings, extract desired parts of strings, and to do search and replace operations.

Regular expressions have the undeserved reputation of being abstract and difficult to understand. Regular expressions are constructed using simple concepts like conditionals and loops and are no more difficult to understand than the corresponding `if` conditionals and `while` loops in the Perl language itself. In fact, the main challenge in learning regular expressions is just getting used to the terse notation used to express these concepts.

This tutorial flattens the learning curve by discussing regular expression concepts, along with their notation, one at a time and with many examples. The first part of the tutorial will progress from the simplest word searches to the basic regular expression concepts. If you master the first part, you will have all the tools needed to solve about 98% of your needs. The second part of the tutorial is for those comfortable with the basics and hungry for more power tools. It discusses the more advanced regular expression operators and introduces the latest cutting edge innovations in 5.6.0.

A note: to save time, 'regular expression' is often abbreviated as regexp or regex. Regexp is a more natural abbreviation than regex, but is harder to pronounce. The Perl pod documentation is evenly split on regexp vs regex; in Perl, there is more than one way to abbreviate it. We'll use regexp in this tutorial.

Part 1: The basics

Simple word matching

The simplest regexp is simply a word, or more generally, a string of characters. A regexp consisting of a word matches any string that contains that word:

```
"Hello World" =~ /World/;  # matches
```

What is this perl statement all about? `"Hello World"` is a simple double quoted string. `World` is the regular expression and the `//` enclosing `/World/` tells perl to search a string for a match. The operator `=~` associates the string with the regexp match and produces a true value if the regexp matched, or false if the regexp did not match. In our case, `World` matches the second word in `"Hello World"`, so the expression is true. Expressions like this are useful in conditionals:

```
if ("Hello World" =~ /World/) {
    print "It matches\n";
}
else {
    print "It doesn't match\n";
}
```

There are useful variations on this theme. The sense of the match can be reversed by using `!~` operator:

```
if ("Hello World" !~ /World/) {
    print "It doesn't match\n";
}
else {
    print "It matches\n";
}
```

The literal string in the regexp can be replaced by a variable:

```
$greeting = "World";
if ("Hello World" =~ /$greeting/) {
    print "It matches\n";
}
else {
    print "It doesn't match\n";
}
```

If you're matching against the special default variable `$_`, the `$_ =~` part can be omitted:

```
$_ = "Hello World";
if (/World/) {
    print "It matches\n";
}
else {
    print "It doesn't match\n";
}
```

And finally, the `//` default delimiters for a match can be changed to arbitrary delimiters by putting an `'m'` out front:

```
"Hello World" =~ m!World!;   # matches, delimited by '!'
"Hello World" =~ m{World};   # matches, note the matching '{}'
"/usr/bin/perl" =~ m"/perl"; # matches after '/usr/bin',
                             # '/' becomes an ordinary char
```

`/World/`, `m!World!`, and `m{World}` all represent the same thing. When, e.g., `""` is used as a delimiter, the forward slash `'/'` becomes an ordinary character and can be used in a regexp without trouble.

Let's consider how different regexps would match `"Hello World"`:

```
"Hello World" =~ /world/;  # doesn't match
"Hello World" =~ /o W/;    # matches
"Hello World" =~ /oW/;     # doesn't match
"Hello World" =~ /World /; # doesn't match
```

The first regexp `world` doesn't match because regexps are case-sensitive. The second regexp matches because the substring `'o W'` occurs in the string `"Hello World"`. The space character `' '` is treated like any other character in a regexp and is needed to match in this case. The lack of a space character is the reason the third regexp `'oW'` doesn't match. The fourth regexp `'World '` doesn't match because there is a space at the end of the regexp, but not at the end of the string. The lesson here is that regexps must match a part of the string *exactly* in order for the statement to be true.

If a regexp matches in more than one place in the string, perl will always match at the earliest possible point in the string:

```
"Hello World" =~ /o/;       # matches 'o' in 'Hello'
"That hat is red" =~ /hat/; # matches 'hat' in 'That'
```

With respect to character matching, there are a few more points you need to know about. First of all, not all characters can be used 'as is' in a match. Some characters, called **metacharacters**, are reserved for use in regexp notation. The metacharacters are

```
{}[]()^$.|*+?\
```

The significance of each of these will be explained in the rest of the tutorial, but for now, it is important only to know that a metacharacter can be matched by putting a backslash before it:

```
"2+2=4" =~ /2+2/;    # doesn't match, + is a metacharacter
"2+2=4" =~ /2\+2/;   # matches, \+ is treated like an ordinary +
"The interval is [0,1)." =~ /[0,1)./     # is a syntax error!
"The interval is [0,1)." =~ /\[0,1\)\./  # matches
"/usr/bin/perl" =~ /\/usr\/local\/bin\/perl/;  # matches
```

In the last regexp, the forward slash `'/'` is also backslashed, because it is used to delimit the regexp. This can lead to LTS (leaning toothpick syndrome), however, and it is often more readable to change delimiters.

The backslash character `'\'` is a metacharacter itself and needs to be backslashed:

```
'C:\WIN32' =~ /C:\\WIN/;   # matches
```

In addition to the metacharacters, there are some ASCII characters which don't have printable character equivalents and are instead represented by **escape sequences**. Common examples are `\t` for a tab, `\n` for a newline, `\r` for a carriage return and `\a` for a bell. If your string is better thought of as a sequence of arbitrary bytes, the octal escape sequence, e.g., `\033`, or hexadecimal escape sequence, e.g., `\x1B` may be a more natural representation for your bytes. Here are some examples of escapes:

```
"1000\t2000" =~ m(0\t2)   # matches
"1000\n2000" =~ /0\n20/   # matches
"1000\t2000" =~ /\000\t2/ # doesn't match, "0" ne "\000"
"cat"        =~ /\143\x61\x74/ # matches, but a weird way to spell cat
```

If you've been around Perl a while, all this talk of escape sequences may seem familiar. Similar escape sequences are used in double–quoted strings and in fact the regexps in Perl are mostly treated as double–quoted strings. This means that variables can be used in regexps as well. Just like double–quoted strings, the values of the variables in the regexp will be substituted in before the regexp is evaluated for matching purposes. So we have:

```
$foo = 'house';
'housecat' =~ /$foo/;      # matches
'cathouse' =~ /cat$foo/;   # matches
'housecat' =~ /${foo}cat/; # matches
```

So far, so good. With the knowledge above you can already perform searches with just about any literal string regexp you can dream up. Here is a *very simple* emulation of the Unix grep program:

```
% cat > simple_grep
#!/usr/bin/perl
$regexp = shift;
while (<>) {
    print if /$regexp/;
}
^D

% chmod +x simple_grep

% simple_grep abba /usr/dict/words
Babbage
cabbage
cabbages
sabbath
Sabbathize
Sabbathizes
sabbatical
```

```
scabbard
scabbards
```

This program is easy to understand. `#!/usr/bin/perl` is the standard way to invoke a perl program from the shell. `$regexp = shift;` saves the first command line argument as the regexp to be used, leaving the rest of the command line arguments to be treated as files. `< while (<)` loops over all the lines in all the files. For each line, `print if /$regexp/;` prints the line if the regexp matches the line. In this line, both `print` and `/$regexp/` use the default variable `$_` implicitly.

With all of the regexps above, if the regexp matched anywhere in the string, it was considered a match. Sometimes, however, we'd like to specify *where* in the string the regexp should try to match. To do this, we would use the **anchor** metacharacters `^` and `$`. The anchor `^` means match at the beginning of the string and the anchor `$` means match at the end of the string, or before a newline at the end of the string. Here is how they are used:

```
"housekeeper" =~ /keeper/;    # matches
"housekeeper" =~ /^keeper/;   # doesn't match
"housekeeper" =~ /keeper$/;   # matches
"housekeeper\n" =~ /keeper$/; # matches
```

The second regexp doesn't match because `^` constrains `keeper` to match only at the beginning of the string, but `"housekeeper"` has keeper starting in the middle. The third regexp does match, since the `$` constrains `keeper` to match only at the end of the string.

When both `^` and `$` are used at the same time, the regexp has to match both the beginning and the end of the string, i.e., the regexp matches the whole string. Consider

```
"keeper" =~ /^keep$/;      # doesn't match
"keeper" =~ /^keeper$/;    # matches
""       =~ /^$/;          # ^$ matches an empty string
```

The first regexp doesn't match because the string has more to it than `keep`. Since the second regexp is exactly the string, it matches. Using both `^` and `$` in a regexp forces the complete string to match, so it gives you complete control over which strings match and which don't. Suppose you are looking for a fellow named bert, off in a string by himself:

```
"dogbert" =~ /bert/;   # matches, but not what you want

"dilbert" =~ /^bert/;  # doesn't match, but ..
"bertram" =~ /^bert/;  # matches, so still not good enough

"bertram" =~ /^bert$/; # doesn't match, good
"dilbert" =~ /^bert$/; # doesn't match, good
"bert"    =~ /^bert$/; # matches, perfect
```

Of course, in the case of a literal string, one could just as easily use the string equivalence `$string eq 'bert'` and it would be more efficient. The `^...$` regexp really becomes useful when we add in the more powerful regexp tools below.

Using character classes

Although one can already do quite a lot with the literal string regexps above, we've only scratched the surface of regular expression technology. In this and subsequent sections we will introduce regexp concepts (and associated metacharacter notations) that will allow a regexp to not just represent a single character sequence, but a *whole class* of them.

One such concept is that of a **character class**. A character class allows a set of possible characters, rather than just a single character, to match at a particular point in a regexp. Character classes are denoted by brackets `[...]`, with the set of characters to be possibly matched inside. Here are some examples:

```
/cat/;       # matches 'cat'
/[bcr]at/;   # matches 'bat, 'cat', or 'rat'
```

```
/item[0123456789]/;  # matches 'item0' or ... or 'item9'
"abc" =~ /[cab]/;    # matches 'a'
```

In the last statement, even though `'c'` is the first character in the class, `'a'` matches because the first character position in the string is the earliest point at which the regexp can match.

```
/[yY][eE][sS]/;      # match 'yes' in a case-insensitive way
                     # 'yes', 'Yes', 'YES', etc.
```

This regexp displays a common task: perform a a case–insensitive match. Perl provides away of avoiding all those brackets by simply appending an `'i'` to the end of the match. Then `/[yY][eE][sS]/;` can be rewritten as `/yes/i;`. The `'i'` stands for case–insensitive and is an example of a **modifier** of the matching operation. We will meet other modifiers later in the tutorial.

We saw in the section above that there were ordinary characters, which represented themselves, and special characters, which needed a backslash `\` to represent themselves. The same is true in a character class, but the sets of ordinary and special characters inside a character class are different than those outside a character class. The special characters for a character class are `-]\^$.` `]` is special because it denotes the end of a character class. `$` is special because it denotes a scalar variable. `\` is special because it is used in escape sequences, just like above. Here is how the special characters `]$\` are handled:

```
/[\]c]def/; # matches ']def' or 'cdef'
$x = 'bcr';
/[$x]at/;   # matches 'bat', 'cat', or 'rat'
/[\$x]at/;  # matches '$at' or 'xat'
/[\\$x]at/; # matches '\at', 'bat, 'cat', or 'rat'
```

The last two are a little tricky. in `[\$x]`, the backslash protects the dollar sign, so the character class has two members `$` and `x`. In `[\\$x]`, the backslash is protected, so `$x` is treated as a variable and substituted in double quote fashion.

The special character `'-'` acts as a range operator within character classes, so that a contiguous set of characters can be written as a range. With ranges, the unwieldy `[0123456789]` and `[abc...xyz]` become the svelte `[0-9]` and `[a-z]`. Some examples are

```
/item[0-9]/;  # matches 'item0' or ... or 'item9'
/[0-9bx-z]aa/;  # matches '0aa', ..., '9aa',
                # 'baa', 'xaa', 'yaa', or 'zaa'
/[0-9a-fA-F]/;  # matches a hexadecimal digit
/[0-9a-zA-Z_]/; # matches a "word" character,
                # like those in a perl variable name
```

If `'-'` is the first or last character in a character class, it is treated as an ordinary character; `[-ab]`, `[ab-]` and `[a\-b]` are all equivalent.

The special character `^` in the first position of a character class denotes a **negated character class**, which matches any character but those in the brackets. Both `[...]` and `[^...]` must match a character, or the match fails. Then

```
/[^a]at/;  # doesn't match 'aat' or 'at', but matches
           # all other 'bat', 'cat, '0at', '%at', etc.
/[^0-9]/;  # matches a non-numeric character
/[a^]at/;  # matches 'aat' or '^at'; here '^' is ordinary
```

Now, even `[0-9]` can be a bother the write multiple times, so in the interest of saving keystrokes and making regexps more readable, Perl has several abbreviations for common character classes:

- \d is a digit and represents [0–9]

- \s is a whitespace character and represents [\ \t\r\n\f]
- \w is a word character (alphanumeric or _) and represents [0–9a–zA–Z_]
- \D is a negated \d; it represents any character but a digit [^0–9]
- \S is a negated \s; it represents any non–whitespace character [^\s]
- \W is a negated \w; it represents any non–word character [^\w]
- The period '.' matches any character but "\n"

The `\d\s\w\D\S\W` abbreviations can be used both inside and outside of character classes. Here are some in use:

```
/\d\d:\d\d:\d\d/; # matches a hh:mm:ss time format
/[\d\s]/;         # matches any digit or whitespace character
/\w\W\w/;         # matches a word char, followed by a
                  # non-word char, followed by a word char
/..rt/;           # matches any two chars, followed by 'rt'
/end\./;          # matches 'end.'
/end[.]/;         # same thing, matches 'end.'
```

Because a period is a metacharacter, it needs to be escaped to match as an ordinary period. Because, for example `\d` and `\w` are sets of characters, it is incorrect to think of `[^\d\w]` as `[\D\W]`; in fact `[^\d\w]` is the same as `[^\w]`, which is the same as `[\W]`. Think DeMorgan's laws.

An anchor useful in basic regexps is the **word anchor** `\b`. This matches a boundary between a word character and a non–word character `\w\W` or `\W\w`:

```
$x = "Housecat catenates house and cat";
$x =~ /cat/;    # matches cat in 'housecat'
$x =~ /\bcat/;  # matches cat in 'catenates'
$x =~ /cat\b/;  # matches cat in 'housecat'
$x =~ /\bcat\b/;  # matches 'cat' at end of string
```

Note in the last example, the end of the string is considered a word boundary.

You might wonder why `'.'` matches everything but `"\n"` – why not every character? The reason is that often one is matching against lines and would like to ignore the newline characters. For instance, while the string `"\n"` represents one line, we would like to think of as empty. Then

```
""   =~ /^$/;    # matches
"\n" =~ /^$/;    # matches, "\n" is ignored

""   =~ /./;      # doesn't match; it needs a char
""   =~ /^.$/;    # doesn't match; it needs a char
"\n" =~ /^.$/;    # doesn't match; it needs a char other than "\n"
"a"  =~ /^.$/;    # matches
"a\n"  =~ /^.$/;  # matches, ignores the "\n"
```

This behavior is convenient, because we usually want to ignore newlines when we count and match characters in a line. Sometimes, however, we want to keep track of newlines. We might even want `^` and `$` to anchor at the beginning and end of lines within the string, rather than just the beginning and end of the string. Perl allows us to choose between ignoring and paying attention to newlines by using the `//s` and `//m` modifiers. `//s` and `//m` stand for single line and multi–line and they determine whether a string is to be treated as one continuous string, or as a set of lines. The two modifiers affect two aspects of how the regexp is interpreted: 1) how the `'.'` character class is defined, and 2) where the anchors `^` and `$` are able to match. Here are the four possible combinations:

- no modifiers (//): Default behavior. `'.'` matches any character except `"\n"`. `^` matches only at the beginning of the string and `$` matches only at the end or before a newline at the end.
- s modifier (//s): Treat string as a single long line. `'.'` matches any character, even `"\n"`. `^` matches only at the beginning of the string and `$` matches only at the end or before a newline at the end.
- m modifier (//m): Treat string as a set of multiple lines. `'.'` matches any character except `"\n"`. `^` and `$` are able to match at the start or end of *any* line within the string.
- both s and m modifiers (//sm): Treat string as a single long line, but detect multiple lines. `'.'` matches any character, even `"\n"`. `^` and `$`, however, are able to match at the start or end of *any* line within the string.

Here are examples of `//s` and `//m` in action:

```
$x = "There once was a girl\nWho programmed in Perl\n";

$x =~ /^Who/;   # doesn't match, "Who" not at start of string
$x =~ /^Who/s;  # doesn't match, "Who" not at start of string
$x =~ /^Who/m;  # matches, "Who" at start of second line
$x =~ /^Who/sm; # matches, "Who" at start of second line

$x =~ /girl.Who/;   # doesn't match, "." doesn't match "\n"
$x =~ /girl.Who/s;  # matches, "." matches "\n"
$x =~ /girl.Who/m;  # doesn't match, "." doesn't match "\n"
$x =~ /girl.Who/sm; # matches, "." matches "\n"
```

Most of the time, the default behavior is what is want, but `//s` and `//m` are occasionally very useful. If `//m` is being used, the start of the string can still be matched with `\A` and the end of string can still be matched with the anchors `\Z` (matches both the end and the newline before, like `$)`, and `\z` (matches only the end):

```
$x =~ /^Who/m;   # matches, "Who" at start of second line
$x =~ /\AWho/m;  # doesn't match, "Who" is not at start of string

$x =~ /girl$/m;  # matches, "girl" at end of first line
$x =~ /girl\Z/m; # doesn't match, "girl" is not at end of string

$x =~ /Perl\Z/m; # matches, "Perl" is at newline before end
$x =~ /Perl\z/m; # doesn't match, "Perl" is not at end of string
```

We now know how to create choices among classes of characters in a regexp. What about choices among words or character strings? Such choices are described in the next section.

Matching this or that

Sometimes we would like to our regexp to be able to match different possible words or character strings. This is accomplished by using the **alternation** metacharacter `|`. To match `dog` or `cat`, we form the regexp `dog|cat`. As before, perl will try to match the regexp at the earliest possible point in the string. At each character position, perl will first try to match the first alternative, `dog`. If `dog` doesn't match, perl will then try the next alternative, `cat`. If `cat` doesn't match either, then the match fails and perl moves to the next position in the string. Some examples:

```
"cats and dogs" =~ /cat|dog|bird/;  # matches "cat"
"cats and dogs" =~ /dog|cat|bird/;  # matches "cat"
```

Even though `dog` is the first alternative in the second regexp, `cat` is able to match earlier in the string.

```
"cats"          =~ /c|ca|cat|cats/; # matches "c"
"cats"          =~ /cats|cat|ca|c/; # matches "cats"
```

Here, all the alternatives match at the first string position, so the first alternative is the one that matches. If some of the alternatives are truncations of the others, put the longest ones first to give them a chance to

match.

```
"cab" =~ /a|b|c/ # matches "c"
                 # /a|b|c/ == /[abc]/
```

The last example points out that character classes are like alternations of characters. At a given character position, the first alternative that allows the regexp match to succeed wil be the one that matches.

Grouping things and hierarchical matching

Alternation allows a regexp to choose among alternatives, but by itself it unsatisfying. The reason is that each alternative is a whole regexp, but sometime we want alternatives for just part of a regexp. For instance, suppose we want to search for housecats or housekeepers. The regexp `housecat|housekeeper` fits the bill, but is inefficient because we had to type `house` twice. It would be nice to have parts of the regexp be constant, like `house`, and and some parts have alternatives, like `cat|keeper`.

The **grouping** metacharacters `()` solve this problem. Grouping allows parts of a regexp to be treated as a single unit. Parts of a regexp are grouped by enclosing them in parentheses. Thus we could solve the `housecat|housekeeper` by forming the regexp as `house(cat|keeper)`. The regexp `house(cat|keeper)` means match `house` followed by either `cat` or `keeper`. Some more examples are

```
/(a|b)b/;    # matches 'ab' or 'bb'
/(ac|b)b/;   # matches 'acb' or 'bb'
/(^a|b)c/;   # matches 'ac' at start of string or 'bc' anywhere
/(a|[bc])d/; # matches 'ad', 'bd', or 'cd'

/house(cat|)/;  # matches either 'housecat' or 'house'
/house(cat(s|)|)/;  # matches either 'housecats' or 'housecat' or
                    # 'house'.  Note groups can be nested.

/(19|20|)\d\d/;  # match years 19xx, 20xx, or the Y2K problem, xx
"20" =~ /(19|20|)\d\d/;  # matches the null alternative '()\d\d',
                         # because '20\d\d' can't match
```

Alternations behave the same way in groups as out of them: at a given string position, the leftmost alternative that allows the regexp to match is taken. So in the last example at tth first string position, `"20"` matches the second alternative, but there is nothing left over to match the next two digits `\d\d`. So perl moves on to the next alternative, which is the null alternative and that works, since `"20"` is two digits.

The process of trying one alternative, seeing if it matches, and moving on to the next alternative if it doesn't, is called **backtracking**. The term 'backtracking' comes from the idea that matching a regexp is like a walk in the woods. Successfully matching a regexp is like arriving at a destination. There are many possible trailheads, one for each string position, and each one is tried in order, left to right. From each trailhead there may be many paths, some of which get you there, and some which are dead ends. When you walk along a trail and hit a dead end, you have to backtrack along the trail to an earlier point to try another trail. If you hit your destination, you stop immediately and forget about trying all the other trails. You are persistent, and only if you have tried all the trails from all the trailheads and not arrived at your destination, do you declare failure. To be concrete, here is a step-by-step analysis of what perl does when it tries to match the regexp

```
"abcde" =~ /(abd|abc)(df|d|de)/;
```

0 Start with the first letter in the string 'a'.

1 Try the first alternative in the first group 'abd'.

2 Match 'a' followed by 'b'. So far so good.

3 'd' in the regexp doesn't match 'c' in the string – a dead

end. So backtrack two characters and pick the second alternative in the first group 'abc'.

4 Match 'a' followed by 'b' followed by 'c'. We are on a roll

and have satisfied the first group. Set `$1` to 'abc'.

5 Move on to the second group and pick the first alternative
'df'.

6 Match the 'd'.

7 'f' in the regexp doesn't match 'e' in the string, so a dead
end. Backtrack one character and pick the second alternative in the second group 'd'.

8 'd' matches. The second grouping is satisfied, so set `$2` to
'd'.

9 We are at the end of the regexp, so we are done! We have
matched 'abcd' out of the string "abcde".

There are a couple of things to note about this analysis. First, the third alternative in the second group 'de' also allows a match, but we stopped before we got to it – at a given character position, leftmost wins. Second, we were able to get a match at the first character position of the string 'a'. If there were no matches at the first position, perl would move to the second character position 'b' and attempt the match all over again. Only when all possible paths at all possible character positions have been exhausted does perl give give up and declare `$string =~ /(abd|abc)(df|d|de)/;` to be false.

Even with all this work, regexp matching happens remarkably fast. To speed things up, during compilation stage, perl compiles the regexp into a compact sequence of opcodes that can often fit inside a processor cache. When the code is executed, these opcodes can then run at full throttle and search very quickly.

Extracting matches

The grouping metacharacters `()` also serve another completely different function: they allow the extraction of the parts of a string that matched. This is very useful to find out what matched and for text processing in general. For each grouping, the part that matched inside goes into the special variables `$1, $2,` etc. They can be used just as ordinary variables:

```
# extract hours, minutes, seconds
$time =~ /(\d\d):(\d\d):(\d\d)/;  # match hh:mm:ss format
$hours = $1;
$minutes = $2;
$seconds = $3;
```

Now, we know that in scalar context, `$time =~ /(\d\d):(\d\d):(\d\d)/` returns a true or false value. In list context, however, it returns the list of matched values `($1,$2,$3)`. So we could write the code more compactly as

```
# extract hours, minutes, seconds
($hours, $minutes, $second) = ($time =~ /(\d\d):(\d\d):(\d\d)/);
```

If the groupings in a regexp are nested, `$1` gets the group with the leftmost opening parenthesis, `$2` the next opening parenthesis, etc. For example, here is a complex regexp and the matching variables indicated below it:

```
/(ab(cd|ef)((gi)|j))/;
 1  2      34
```

so that if the regexp matched, e.g., `$2` would contain 'cd' or 'ef'. For convenience, perl sets `$+` to the highest numbered `$1, $2,` ... that got assigned.

Closely associated with the matching variables `$1, $2,` ... are the **backreferences** `\1, \2,` ... . Backreferences are simply matching variables that can be used *inside* a regexp. This is a really nice feature – what matches later in a regexp can depend on what matched earlier in the regexp. Suppose we wanted to look for doubled words in text, like 'the the'. The following regexp finds all 3–letter doubles with a space in between:

```
/(\w\w\w)\s\1/;
```

The grouping assigns a value to \1, so that the same 3 letter sequence is used for both parts. Here are some words with repeated parts:

```
% simple_grep '^(\w\w\w\w|\w\w\w|\w\w|\w)\1$' /usr/dict/words
beriberi
booboo
coco
mama
murmur
papa
```

The regexp has a single grouping which considers 4–letter combinations, then 3–letter combinations, etc. and uses `\1` to look for a repeat. Although `$1` and `\1` represent the same thing, care should be taken to use matched variables `$1`, `$2`, ... only outside a regexp and backreferences `\1`, `\2`, ... only inside a regexp; not doing so may lead to surprising and/or undefined results.

In addition to what was matched, Perl 5.6.0 also provides the positions of what was matched with the `@-` and `@+` arrays. `$-[0]` is the position of the start of the entire match and `$+[0]` is the position of the end. Similarly, `$-[n]` is the position of the start of the `$n` match and `$+[n]` is the position of the end. If `$n` is undefined, so are `$-[n]` and `$+[n]`. Then this code

```
$x = "Mmm...donut, thought Homer";
$x =~ /^(Mmm|Yech)\.\.\.(donut|peas)/; # matches
foreach $expr (1..$#-) {
    print "Match $expr: '${$expr}' at position ($-[$expr],$+[$expr])\n";
}
```

prints

```
Match 1: 'Mmm' at position (0,3)
Match 2: 'donut' at position (6,11)
```

Even if there are no groupings in a regexp, it is still possible to find out what exactly matched in a string. If you use them, perl will set `$`` to the part of the string before the match, will set `$&` to the part of the string that matched, and will set `$'` to the part of the string after the match. An example:

```
$x = "the cat caught the mouse";
$x =~ /cat/;  # $` = 'the ', $& = 'cat', $' = ' caught the mouse'
$x =~ /the/;  # $` = '', $& = 'the', $' = ' cat caught the mouse'
```

In the second match, `$` = ''` because the regexp matched at the first character position in the string and stopped, it never saw the second 'the'. It is important to note that using `$`` and `$'` slows down regexp matching quite a bit, and `$&` slows it down to a lesser extent, because if they are used in one regexp in a program, they are generated for <all regexps in the program. So if raw performance is a goal of your application, they should be avoided. If you need them, use `@-` and `@+` instead:

```
$` is the same as substr( $x, 0, $-[0] )
$& is the same as substr( $x, $-[0], $+[0]-$-[0] )
$' is the same as substr( $x, $+[0] )
```

Matching repetitions

The examples in the previous section display an annoying weakness. We were only matching 3–letter words, or syllables of 4 letters or less. We'd like to be able to match words or syllables of any length, without writing out tedious alternatives like `\w\w\w\w|\w\w\w|\w\w|\w`.

This is exactly the problem the **quantifier** metacharacters `?`, `*`, `+`, and `{}` were created for. They allow us to determine the number of repeats of a portion of a regexp we consider to be a match. Quantifiers are put immediately after the character, character class, or grouping that we want to specify. They have the following meanings:

- **a? = match 'a' 1 or 0 times**
- a* = match 'a' 0 or more times, i.e., any number of times
- a+ = match 'a' 1 or more times, i.e., at least once
- a{n,m} = match at least n times, but not more than m times.
- a{n,} = match at least n or more times
- a{n} = match exactly n times

Here are some examples:

```
/[a-z]+\s+\d*/;  # match a lowercase word, at least some space, and
                 # any number of digits
/(\w+)\s+\1/;    # match doubled words of arbitrary length
/y(es)?/i;       # matches 'y', 'Y', or a case-insensitive 'yes'
$year =~ /\d{2,4}/;  # make sure year is at least 2 but not more
                     # than 4 digits
$year =~ /\d{4}|\d{2}/;    # better match; throw out 3 digit dates
$year =~ /\d{2}(\d{2})?/;  # same thing written differently. However,
                           # this produces $1 and the other does not.

% simple_grep '^(\w+)\1$' /usr/dict/words   # isn't this easier?
beriberi
booboo
coco
mama
murmur
papa
```

For all of these quantifiers, perl will try to match as much of the string as possible, while still allowing the regexp to succeed. Thus with /a?.../, perl will first try to match the regexp with the a present; if that fails, perl will try to match the regexp without the a present. For the quantifier *, we get the following:

```
$x = "the cat in the hat";
$x =~ /^(.*)(cat)(.*)$/; # matches,
                         # $1 = 'the '
                         # $2 = 'cat'
                         # $3 = ' in the hat'
```

Which is what we might expect, the match finds the only cat in the string and locks onto it. Consider, however, this regexp:

```
$x =~ /^(.*)(at)(.*)$/; # matches,
                        # $1 = 'the cat in the h'
                        # $2 = 'at'
                        # $3 = ''   (0 matches)
```

One might initially guess that perl would find the at in cat and stop there, but that wouldn't give the longest possible string to the first quantifier .*. Instead, the first quantifier .* grabs as much of the string as possible while still having the regexp match. In this example, that means having the at sequence with the final at in the string. The other important principle illustrated here is that when there are two or more elements in a regexp, the *leftmost* quantifier, if there is one, gets to grab as much the string as possible, leaving the rest of the regexp to fight over scraps. Thus in our example, the first quantifier .* grabs most of the string, while the second quantifier .* gets the empty string. Quantifiers that grab as much of the string as possible are called **maximal match** or **greedy** quantifiers.

When a regexp can match a string in several different ways, we can use the principles above to predict which way the regexp will match:

- Principle 0: Taken as a whole, any regexp will be matched at the earliest possible position in the string.

- Principle 1: In an alternation `a|b|c...`, the leftmost alternative that allows a match for the whole regexp will be the one used.

- Principle 2: The maximal matching quantifiers `?`, `*`, `+` and `{n,m}` will in general match as much of the string as possible while still allowing the whole regexp to match.

- Principle 3: If there are two or more elements in a regexp, the leftmost greedy quantifier, if any, will match as much of the string as possible while still allowing the whole regexp to match. The next leftmost greedy quantifier, if any, will try to match as much of the string remaining available to it as possible, while still allowing the whole regexp to match. And so on, until all the regexp elements are satisfied.

As we have seen above, Principle 0 overrides the others – the regexp will be matched as early as possible, with the other principles determining how the regexp matches at that earliest character position.

Here is an example of these principles in action:

```
$x = "The programming republic of Perl";
$x =~ /^(.+)(e|r)(.*)$/;  # matches,
                          # $1 = 'The programming republic of Pe'
                          # $2 = 'r'
                          # $3 = 'l'
```

This regexp matches at the earliest string position, `'T'`. One might think that `e`, being leftmost in the alternation, would be matched, but `r` produces the longest string in the first quantifier.

```
$x =~ /(m{1,2})(.*)$/;  # matches,
                        # $1 = 'mm'
                        # $2 = 'ing republic of Perl'
```

Here, The earliest possible match is at the first `'m'` in `programming`. `m{1,2}` is the first quantifier, so it gets to match a maximal `mm`.

```
$x =~ /.*(m{1,2})(.*)$/;  # matches,
                          # $1 = 'm'
                          # $2 = 'ing republic of Perl'
```

Here, the regexp matches at the start of the string. The first quantifier `.*` grabs as much as possible, leaving just a single `'m'` for the second quantifier `m{1,2}`.

```
$x =~ /(.?)(m{1,2})(.*)$/;  # matches,
                            # $1 = 'a'
                            # $2 = 'mm'
                            # $3 = 'ing republic of Perl'
```

Here, `.?` eats its maximal one character at the earliest possible position in the string, `'a'` in `programming`, leaving `m{1,2}` the opportunity to match both `m`'s. Finally,

```
"aXXXb" =~ /(X*)/; # matches with $1 = ''
```

because it can match zero copies of `'X'` at the beginning of the string. If you definitely want to match at least one `'X'`, use `X+`, not `X*`.

Sometimes greed is not good. At times, we would like quantifiers to match a *minimal* piece of string, rather than a maximal piece. For this purpose, Larry Wall created the **minimal match** or **non–greedy** quantifiers `??`,`*?`, `+?`, and `{}?`. These are the usual quantifiers with a `?` appended to them. They have the following meanings:

- **`a??` = match 'a' 0 or 1 times. Try 0 first, then 1.**
- `a*?` = match 'a' 0 or more times, i.e., any number of times, but as few times as possible
- `a+?` = match 'a' 1 or more times, i.e., at least once, but as few times as possible
- `a{n,m}?` = match at least `n` times, not more than `m` times, as few times as possible
- `a{n,}?` = match at least `n` times, but as few times as possible
- `a{n}?` = match exactly `n` times. Because we match exactly `n` times, `a{n}?` is equivalent to `a{n}` and is just there for notational consistency.

Let's look at the example above, but with minimal quantifiers:

```
$x = "The programming republic of Perl";
$x =~ /^(.+?)(e|r)(.*)$/; # matches,
                          # $1 = 'Th'
                          # $2 = 'e'
                          # $3 = ' programming republic of Perl'
```

The minimal string that will allow both the start of the string `^` and the alternation to match is `Th`, with the alternation `e|r` matching `e`. The second quantifier `.*` is free to gobble up the rest of the string.

```
$x =~ /(m{1,2}?)(.*?)$/;  # matches,
                          # $1 = 'm'
                          # $2 = 'ming republic of Perl'
```

The first string position that this regexp can match is at the first `'m'` in `programming`. At this position, the minimal `m{1,2}?` matches just one `'m'`. Although the second quantifier `.*?` would prefer to match no characters, it is constrained by the end-of-string anchor `$` to match the rest of the string.

```
$x =~ /(.*?)(m{1,2}?)(.*)$/;  # matches,
                              # $1 = 'The progra'
                              # $2 = 'm'
                              # $3 = 'ming republic of Perl'
```

In this regexp, you might expect the first minimal quantifier `.*?` to match the empty string, because it is not constrained by a `^` anchor to match the beginning of the word. Principle 0 applies here, however. Because it is possible for the whole regexp to match at the start of the string, it *will* match at the start of the string. Thus the first quantifier has to match everything up to the first `m`. The second minimal quantifier matches just one `m` and the third quantifier matches the rest of the string.

```
$x =~ /(.??)(m{1,2})(.*)$/;  # matches,
                             # $1 = 'a'
                             # $2 = 'mm'
                             # $3 = 'ing republic of Perl'
```

Just as in the previous regexp, the first quantifier `.??` can match earliest at position `'a'`, so it does. The second quantifier is greedy, so it matches `mm`, and the third matches the rest of the string.

We can modify principle 3 above to take into account non-greedy quantifiers:

- Principle 3: If there are two or more elements in a regexp, the leftmost greedy (non-greedy) quantifier, if any, will match as much (little) of the string as possible while still allowing the whole regexp to match. The next leftmost greedy (non-greedy) quantifier, if any, will try to match as much (little) of the string remaining available to it as possible, while still allowing the whole regexp to match. And so on, until all the regexp elements are satisfied.

Just like alternation, quantifiers are also susceptible to backtracking. Here is a step−by−step analysis of the example

```
$x = "the cat in the hat";
$x =~ /^(.*)(at)(.*)$/; # matches,
                        # $1 = 'the cat in the h'
                        # $2 = 'at'
                        # $3 = ''   (0 matches)
```

0 Start with the first letter in the string 't'.

1 The first quantifier '.*' starts out by matching the whole
string 'the cat in the hat'.

2 'a' in the regexp element 'at' doesn't match the end of the
string. Backtrack one character.

3 'a' in the regexp element 'at' still doesn't match the last
letter of the string 't', so backtrack one more character.

4 Now we can match the 'a' and the 't'.

5 Move on to the third element '.*'. Since we are at the end of
the string and '.*' can match 0 times, assign it the empty string.

6 We are done!

Most of the time, all this moving forward and backtracking happens quickly and searching is fast. There are some pathological regexps, however, whose execution time exponentially grows with the size of the string. A typical structure that blows up in your face is of the form

```
/(a|b+)*/;
```

The problem is the nested indeterminate quantifiers. There are many different ways of partitioning a string of length n between the + and *: one repetition with b+ of length n, two repetitions with the first b+ length k and the second with length n−k, m repetitions whose bits add up to length n, etc. In fact there are an exponential number of ways to partition a string as a function of length. A regexp may get lucky and match early in the process, but if there is no match, perl will try *every* possibility before giving up. So be careful with nested *'s, {n,m}'s, and +'s. The book *Mastering regular expressions* by Jeffrey Friedl gives a wonderful discussion of this and other efficiency issues.

Building a regexp

At this point, we have all the basic regexp concepts covered, so let's give a more involved example of a regular expression. We will build a regexp that matches numbers.

The first task in building a regexp is to decide what we want to match and what we want to exclude. In our case, we want to match both integers and floating point numbers and we want to reject any string that isn't a number.

The next task is to break the problem down into smaller problems that are easily converted into a regexp.

The simplest case is integers. These consist of a sequence of digits, with an optional sign in front. The digits we can represent with \d+ and the sign can be matched with [+−]. Thus the integer regexp is

```
/[+−]?\d+/;  # matches integers
```

A floating point number potentially has a sign, an integral part, a decimal point, a fractional part, and an exponent. One or more of these parts is optional, so we need to check out the different possibilities. Floating point numbers which are in proper form include 123., 0.345, .34, −1e6, and 25.4E−72. As with integers, the sign out front is completely optional and can be matched by [+−]?. We can see that if there is no exponent, floating point numbers must have a decimal point, otherwise they are integers. We might be tempted to model these with \d*\.\d*, but this would also match just a single decimal point, which is not a number. So the three cases of floating point number sans exponent are

```
/[+-]?\d+\./;  # 1., 321., etc.
/[+-]?\.\d+/;  # .1, .234, etc.
/[+-]?\d+\.\d+/;  # 1.0, 30.56, etc.
```

These can be combined into a single regexp with a three−way alternation:

```
/[+-]?(\d+\.\d+|\d+\.|\.\d+)/;  # floating point, no exponent
```

In this alternation, it is important to put '`\d+\.\d+`' before '`\d+\.`'. If '`\d+\.`' were first, the regexp would happily match that and ignore the fractional part of the number.

Now consider floating point numbers with exponents. The key observation here is that *both* integers and numbers with decimal points are allowed in front of an exponent. Then exponents, like the overall sign, are independent of whether we are matching numbers with or without decimal points, and can be 'decoupled' from the mantissa. The overall form of the regexp now becomes clear:

```
/^(optional sign)(integer | f.p. mantissa)(optional exponent)$/;
```

The exponent is an `e` or `E`, followed by an integer. So the exponent regexp is

```
/[eE][+-]?\d+/;  # exponent
```

Putting all the parts together, we get a regexp that matches numbers:

```
/^[+-]?(\d+\.\d+|\d+\.|\.\d+|\d+)([eE][+-]?\d+)?$/;  # Ta da!
```

Long regexps like this may impress your friends, but can be hard to decipher. In complex situations like this, the `//x` modifier for a match is invaluable. It allows one to put nearly arbitrary whitespace and comments into a regexp without affecting their meaning. Using it, we can rewrite our 'extended' regexp in the more pleasing form

```
/^
   [+-]?         # first, match an optional sign
   (             # then match integers or f.p. mantissas:
       \d+\.\d+  # mantissa of the form a.b
      |\d+\.     # mantissa of the form a.
      |\.\d+     # mantissa of the form .b
      |\d+       # integer of the form a
   )
   ([eE][+-]?\d+)?  # finally, optionally match an exponent
$/x;
```

If whitespace is mostly irrelevant, how does one include space characters in an extended regexp? The answer is to backslash it '`\ `' or put it in a character class `[ ]`. The same thing goes for pound signs, use `\#` or `[#]`. For instance, Perl allows a space between the sign and the mantissa/integer, and we could add this to our regexp as follows:

```
/^
   [+-]?\ *      # first, match an optional sign *and space*
   (             # then match integers or f.p. mantissas:
       \d+\.\d+  # mantissa of the form a.b
      |\d+\.     # mantissa of the form a.
      |\.\d+     # mantissa of the form .b
      |\d+       # integer of the form a
   )
   ([eE][+-]?\d+)?  # finally, optionally match an exponent
$/x;
```

In this form, it is easier to see a way to simplify the alternation. Alternatives 1, 2, and 4 all start with `\d+`, so it could be factored out:

```
/^
   [+-]?\ *      # first, match an optional sign
   (             # then match integers or f.p. mantissas:
       \d+       # start out with a ...
       (
           \.\d* # mantissa of the form a.b or a.
       )?        # ? takes care of integers of the form a
      |\.\d+     # mantissa of the form .b
   )
   ([eE][+-]?\d+)?  # finally, optionally match an exponent
$/x;
```

or written in the compact form,

```
/^[+-]?\ *(\d+(\.\d*)?|\.\d+)([eE][+-]?\d+)?$/;
```

This is our final regexp. To recap, we built a regexp by

- specifying the task in detail,
- breaking down the problem into smaller parts,
- translating the small parts into regexps,
- combining the regexps,
- and optimizing the final combined regexp.

These are also the typical steps involved in writing a computer program. This makes perfect sense, because regular expressions are essentially programs written a little computer language that specifies patterns.

Using regular expressions in Perl

The last topic of Part 1 briefly covers how regexps are used in Perl programs. Where do they fit into Perl syntax?

We have already introduced the matching operator in its default `/regexp/` and arbitrary delimiter `m!regexp!` forms. We have used the binding operator `=~` and its negation `!~` to test for string matches. Associated with the matching operator, we have discussed the single line `//s`, multi–line `//m`, case–insensitive `//i` and extended `//x` modifiers.

There are a few more things you might want to know about matching operators. First, we pointed out earlier that variables in regexps are substituted before the regexp is evaluated:

```
$pattern = 'Seuss';
while (<>) {
    print if /$pattern/;
}
```

This will print any lines containing the word `Seuss`. It is not as efficient as it could be, however, because perl has to re–evaluate `$pattern` each time through the loop. If `$pattern` won't be changing over the lifetime of the script, we can add the `//o` modifier, which directs perl to only perform variable substitutions once:

```
#!/usr/bin/perl
#    Improved simple_grep
$regexp = shift;
while (<>) {
    print if /$regexp/o;  # a good deal faster
}
```

If you change `$pattern` after the first substitution happens, perl will ignore it. If you don't want any substitutions at all, use the special delimiter `m''`:

```
$pattern = 'Seuss';
while (<>) {
```

```
    print if m'$pattern';  # matches '$pattern', not 'Seuss'
}
```

`m''` acts like single quotes on a regexp; all other `m` delimiters act like double quotes. If the regexp evaluates to the empty string, the regexp in the *last successful match* is used instead. So we have

```
"dog" =~ /d/;  # 'd' matches
"dogbert =~ //;  # this matches the 'd' regexp used before
```

The final two modifiers `//g` and `//c` concern multiple matches. The modifier `//g` stands for global matching and allows the the matching operator to match within a string as many times as possible. In scalar context, successive invocations against a string will have `//g` jump from match to match, keeping track of position in the string as it goes along. You can get or set the position with the `pos()` function.

The use of `//g` is shown in the following example. Suppose we have a string that consists of words separated by spaces. If we know how many words there are in advance, we could extract the words using groupings:

```
$x = "cat dog house"; # 3 words
$x =~ /^\s*(\w+)\s+(\w+)\s+(\w+)\s*$/; # matches,
                                       # $1 = 'cat'
                                       # $2 = 'dog'
                                       # $3 = 'house'
```

But what if we had an indeterminate number of words? This is the sort of task `//g` was made for. To extract all words, form the simple regexp `(\w+)` and loop over all matches with `/(\w+)/g`:

```
while ($x =~ /(\w+)/g) {
    print "Word is $1, ends at position ", pos $x, "\n";
}
```

prints

```
Word is cat, ends at position 3
Word is dog, ends at position 7
Word is house, ends at position 13
```

A failed match or changing the target string resets the position. If you don't want the position reset after failure to match, add the `//c`, as in `/regexp/gc`. The current position in the string is associated with the string, not the regexp. This means that different strings have different positions and their respective positions can be set or read independently.

In list context, `//g` returns a list of matched groupings, or if there are no groupings, a list of matches to the whole regexp. So if we wanted just the words, we could use

```
@words = ($x =~ /(\w+)/g);  # matches,
                            # $word[0] = 'cat'
                            # $word[1] = 'dog'
                            # $word[2] = 'house'
```

Closely associated with the `//g` modifier is the `\G` anchor. The `\G` anchor matches at the point where the previous `//g` match left off. `\G` allows us to easily do context-sensitive matching:

```
$metric = 1;  # use metric units
...
$x = <FILE>;  # read in measurement
$x =~ /^([+-]?\d+)\s*/g;  # get magnitude
$weight = $1;
if ($metric) { # error checking
    print "Units error!" unless $x =~ /\Gkg\./g;
}
```

```
else {
    print "Units error!" unless $x =~ /\Glbs\./g;
}
$x =~ /\G\s+(widget|sprocket)/g;  # continue processing
```

The combination of `//g` and `\G` allows us to process the string a bit at a time and use arbitrary Perl logic to decide what to do next.

`\G` is also invaluable in processing fixed length records with regexps. Suppose we have a snippet of coding region DNA, encoded as base pair letters `ATCGTTGAAT...` and we want to find all the stop codons `TGA`. In a coding region, codons are 3–letter sequences, so we can think of the DNA snippet as a sequence of 3–letter records. The naive regexp

```
# expanded, this is "ATC GTT GAA TGC AAA TGA CAT GAC"
$dna = "ATCGTTGAATGCAAATGACATGAC";
$dna =~ /TGA/;
```

doesn't work; it may match an `TGA`, but there is no guarantee that the match is aligned with codon boundaries, e.g., the substring `GTT GAA` gives a match. A better solution is

```
while ($dna =~ /(\w\w\w)*?TGA/g) {  # note the minimal *?
    print "Got a TGA stop codon at position ", pos $dna, "\n";
}
```

which prints

```
Got a TGA stop codon at position 18
Got a TGA stop codon at position 23
```

Position 18 is good, but position 23 is bogus. What happened?

The answer is that our regexp works well until we get past the last real match. Then the regexp will fail to match a synchronized `TGA` and start stepping ahead one character position at a time, not what we want. The solution is to use `\G` to anchor the match to the codon alignment:

```
while ($dna =~ /\G(\w\w\w)*?TGA/g) {
    print "Got a TGA stop codon at position ", pos $dna, "\n";
}
```

This prints

```
Got a TGA stop codon at position 18
```

which is the correct answer. This example illustrates that it is important not only to match what is desired, but to reject what is not desired.

search and replace

Regular expressions also play a big role in **search and replace** operations in Perl. Search and replace is accomplished with the `s///` operator. The general form is `s/regexp/replacement/modifiers`, with everything we know about regexps and modifiers applying in this case as well. The `replacement` is a Perl double quoted string that replaces in the string whatever is matched with the `regexp`. The operator `=~` is also used here to associate a string with `s///`. If matching against `$_`, the `$_ =~` can be dropped. If there is a match, `s///` returns the number of substitutions made, otherwise it returns false. Here are a few examples:

```
$x = "Time to feed the cat!";
$x =~ s/cat/hacker/;   # $x contains "Time to feed the hacker!"
if ($x =~ s/^(Time.*hacker)!$/$1 now!/) {
    $more_insistent = 1;
}
$y = "'quoted words'";
```

```
$y =~ s/^'(.*)'$/$1/;  # strip single quotes,
                       # $y contains "quoted words"
```

In the last example, the whole string was matched, but only the part inside the single quotes was grouped. With the `s///` operator, the matched variables `$1, $2,` etc. are immediately available for use in the replacement expression, so we use `$1` to replace the quoted string with just what was quoted. With the global modifier, `s///g` will search and replace all occurrences of the regexp in the string:

```
$x = "I batted 4 for 4";
$x =~ s/4/four/;   # doesn't do it all:
                   # $x contains "I batted four for 4"
$x = "I batted 4 for 4";
$x =~ s/4/four/g;  # does it all:
                   # $x contains "I batted four for four"
```

If you prefer 'regex' over 'regexp' in this tutorial, you could use the following program to replace it:

```
% cat > simple_replace
#!/usr/bin/perl
$regexp = shift;
$replacement = shift;
while (<>) {
    s/$regexp/$replacement/go;
    print;
}
^D

% simple_replace regexp regex perlretut.pod
```

In `simple_replace` we used the `s///g` modifier to replace all occurrences of the regexp on each line and the `s///o` modifier to compile the regexp only once. As with `simple_grep`, both the `print` and the `s/$regexp/$replacement/go` use `$_` implicitly.

A modifier available specifically to search and replace is the `s///e` evaluation modifier. `s///e` wraps an `eval{...}` around the replacement string and the evaluated result is substituted for the matched substring. `s///e` is useful if you need to do a bit of computation in the process of replacing text. This example counts character frequencies in a line:

```
$x = "Bill the cat";
$x =~ s/(.)/$chars{$1}++;$1/eg;  # final $1 replaces char with itself
print "frequency of '$_' is $chars{$_}\n"
    foreach (sort {$chars{$b} <=> $chars{$a}} keys %chars);
```

This prints

```
frequency of ' ' is 2
frequency of 't' is 2
frequency of 'l' is 2
frequency of 'B' is 1
frequency of 'c' is 1
frequency of 'e' is 1
frequency of 'h' is 1
frequency of 'i' is 1
frequency of 'a' is 1
```

As with the match `m//` operator, `s///` can use other delimiters, such as `s!!!` and `s{}{}`, and even `s{}//`. If single quotes are used `s''`, then the regexp and replacement are treated as single quoted strings and there are no substitutions. `s///` in list context returns the same thing as in scalar context, i.e., the number of matches.

The split operator

The **split** function can also optionally use a matching operator `m//` to split a string. `split /regexp/, string, limit` splits `string` into a list of substrings and returns that list. The regexp is used to match the character sequence that the `string` is split with respect to. The `limit`, if present, constrains splitting into no more than `limit` number of strings. For example, to split a string into words, use

```
$x = "Calvin and Hobbes";
@words = split /\s+/, $x;  # $word[0] = 'Calvin'
                           # $word[1] = 'and'
                           # $word[2] = 'Hobbes'
```

If the empty regexp `//` is used, the regexp always matches and the string is split into individual characters. If the regexp has groupings, then list produced contains the matched substrings from the groupings as well. For instance,

```
$x = "/usr/bin/perl";
@dirs = split m!/!, $x;  # $dirs[0] = ''
                         # $dirs[1] = 'usr'
                         # $dirs[2] = 'bin'
                         # $dirs[3] = 'perl'
@parts = split m!(/)!, $x;  # $parts[0] = ''
                            # $parts[1] = '/'
                            # $parts[2] = 'usr'
                            # $parts[3] = '/'
                            # $parts[4] = 'bin'
                            # $parts[5] = '/'
                            # $parts[6] = 'perl'
```

Since the first character of `$x` matched the regexp, `split` prepended an empty initial element to the list.

If you have read this far, congratulations! You now have all the basic tools needed to use regular expressions to solve a wide range of text processing problems. If this is your first time through the tutorial, why not stop here and play around with regexps a while... Part 2 concerns the more esoteric aspects of regular expressions and those concepts certainly aren't needed right at the start.

Part 2: Power tools

OK, you know the basics of regexps and you want to know more. If matching regular expressions is analogous to a walk in the woods, then the tools discussed in Part 1 are analogous to topo maps and a compass, basic tools we use all the time. Most of the tools in part 2 are are analogous to flare guns and satellite phones. They aren't used too often on a hike, but when we are stuck, they can be invaluable.

What follows are the more advanced, less used, or sometimes esoteric capabilities of perl regexps. In Part 2, we will assume you are comfortable with the basics and concentrate on the new features.

More on characters, strings, and character classes

There are a number of escape sequences and character classes that we haven't covered yet.

There are several escape sequences that convert characters or strings between upper and lower case. `\l` and `\u` convert the next character to lower or upper case, respectively:

```
$x = "perl";
$string =~ /\u$x/;  # matches 'Perl' in $string
$x = "M(rs?|s)\\."; # note the double backslash
$string =~ /\l$x/;  # matches 'mr.', 'mrs.', and 'ms.',
```

`\L` and `\U` converts a whole substring, delimited by `\L` or `\U` and `\E`, to lower or upper case:

```
$x = "This word is in lower case:\L SHOUT\E";
$x =~ /shout/;       # matches
```

```
$x = "I STILL KEYPUNCH CARDS FOR MY 360"
$x =~ /\Ukeypunch/;  # matches punch card string
```

If there is no \E, case is converted until the end of the string. The regexps \L\u$word or \u\L$word convert the first character of $word to uppercase and the rest of the characters to lowercase.

Control characters can be escaped with \c, so that a control–Z character would be matched with \cZ. The escape sequence \Q...\E quotes, or protects most non–alphabetic characters. For instance,

```
$x = "\QThat !^*&%~& cat!";
$x =~ /\Q!^*&%~&\E/;  # check for rough language
```

It does not protect $ or @, so that variables can still be substituted.

With the advent of 5.6.0, perl regexps can handle more than just the standard ASCII character set. Perl now supports **Unicode**, a standard for encoding the character sets from many of the world's written languages. Unicode does this by allowing characters to be more than one byte wide. Perl uses the UTF–8 encoding, in which ASCII characters are still encoded as one byte, but characters greater than chr(127) may be stored as two or more bytes.

What does this mean for regexps? Well, regexp users don't need to know much about perl's internal representation of strings. But they do need to know 1) how to represent Unicode characters in a regexp and 2) when a matching operation will treat the string to be searched as a sequence of bytes (the old way) or as a sequence of Unicode characters (the new way). The answer to 1) is that Unicode characters greater than chr(127) may be represented using the \x{hex} notation, with hex a hexadecimal integer:

```
use utf8;    # We will be doing Unicode processing
/\x{263a}/;  # match a Unicode smiley face :)
```

Unicode characters in the range of 128–255 use two hexadecimal digits with braces: \x{ab}. Note that this is different than \xab, which is just a hexadecimal byte with no Unicode significance.

Figuring out the hexadecimal sequence of a Unicode character you want or deciphering someone else's hexadecimal Unicode regexp is about as much fun as programming in machine code. So another way to specify Unicode characters is to use the **named character** escape sequence \N{name}. name is a name for the Unicode character, as specified in the Unicode standard. For instance, if we wanted to represent or match the astrological sign for the planet Mercury, we could use

```
use utf8;              # We will be doing Unicode processing
use charnames ":full"; # use named chars with Unicode full names
$x = "abc\N{MERCURY}def";
$x =~ /\N{MERCURY}/;   # matches
```

One can also use short names or restrict names to a certain alphabet:

```
use utf8;              # We will be doing Unicode processing

use charnames ':full';
print "\N{GREEK SMALL LETTER SIGMA} is called sigma.\n";

use charnames ":short";
print "\N{greek:Sigma} is an upper-case sigma.\n";

use charnames qw(greek);
print "\N{sigma} is Greek sigma\n";
```

A list of full names is found in the file Names.txt in the lib/perl5/5.6.0/unicode directory.

The answer to requirement 2), as of 5.6.0, is that if a regexp contains Unicode characters, the string is searched as a sequence of Unicode characters. Otherwise, the string is searched as a sequence of bytes. If the string is being searched as a sequence of Unicode characters, but matching a single byte is required, we can use the \C escape sequence. \C is a character class akin to . except that it matches *any* byte 0–255. So

```
use utf8;              # We will be doing Unicode processing
use charnames ":full"; # use named chars with Unicode full names
$x = "a";
$x =~ /\C/;  # matches 'a', eats one byte
$x = "";
$x =~ /\C/;  # doesn't match, no bytes to match
$x = "\N{MERCURY}";  # two-byte Unicode character
$x =~ /\C/;  # matches, but dangerous!
```

The last regexp matches, but is dangerous because the string *character* position is no longer synchronized to the string *byte* position. This generates the warning 'Malformed UTF–8 character'. `\C` is best used for matching the binary data in strings with binary data intermixed with Unicode characters.

Let us now discuss the rest of the character classes. Just as with Unicode characters, there are named Unicode character classes represented by the `\p{name}` escape sequence. Closely associated is the `\P{name}` character class, which is the negation of the `\p{name}` class. For example, to match lower and uppercase characters,

```
use utf8;              # We will be doing Unicode processing
use charnames ":full"; # use named chars with Unicode full names
$x = "BOB";
$x =~ /^\p{IsUpper}/;   # matches, uppercase char class
$x =~ /^\P{IsUpper}/;   # doesn't match, char class sans uppercase
$x =~ /^\p{IsLower}/;   # doesn't match, lowercase char class
$x =~ /^\P{IsLower}/;   # matches, char class sans lowercase
```

If a `name` is just one letter, the braces can be dropped. For instance, `\pM` is the character class of Unicode 'marks'. Here is the association between some Perl named classes and the traditional Unicode classes:

```
Perl class name  Unicode class name

IsAlpha          Lu, Ll, or Lo
IsAlnum          Lu, Ll, Lo, or Nd
IsASCII          $code le 127
IsCntrl          C
IsDigit          Nd
IsGraph          [^C] and $code ne "0020"
IsLower          Ll
IsPrint          [^C]
IsPunct          P
IsSpace          Z, or ($code lt "0020" and chr(hex $code) is a \s)
IsUpper          Lu
IsWord           Lu, Ll, Lo, Nd or $code eq "005F"
IsXDigit         $code =~ /^00(3[0-9]|[46][1-6])$/
```

For a full list of Perl class names, consult the mktables.PL program in the lib/perl5/5.6.0/unicode directory.

`\X` is an abbreviation for a character class sequence that includes the Unicode 'combining character sequences'. A 'combining character sequence' is a base character followed by any number of combining characters. An example of a combining character is an accent. Using the Unicode full names, e.g., `A + COMBINING RING` is a combining character sequence with base character `A` and combining character `COMBINING RING`, which translates in Danish to A with the circle atop it, as in the word Angstrom. `\X` is equivalent to `\PM\pM*`, i.e., a non–mark followed by one or more marks.

As if all those classes weren't enough, Perl also defines POSIX style character classes. These have the form `[:name:]`, with `name` the name of the POSIX class. The POSIX classes are `alpha`, `alnum`, `ascii`, `cntrl`, `digit`, `graph`, `lower`, `print`, `punct`, `space`, `upper`, and `xdigit`, and two extensions, `word` (a Perl extension to match `\w`), and `blank` (a GNU extension). If `utf8` is being used, then these classes are defined the same as their corresponding perl Unicode classes: `[:upper:]` is the same as

\p{IsUpper}, etc. The POSIX character classes, however, don't require using utf8. The [:digit:], [:word:], and [:space:] correspond to the familiar \d, \w, and \s character classes. To negate a POSIX class, put a ^ in front of the name, so that, e.g., [:^digit:] corresponds to \D and under utf8, \P{IsDigit}. The Unicode and POSIX character classes can be used just like \d, both inside and outside of character classes:

```
/\s+[abc[:digit:]xyz]\s*/;  # match a,b,c,x,y,z, or a digit
/^=item\s[:digit:]/;        # match '=item',
                            # followed by a space and a digit
use utf8;
use charnames ":full";
/\s+[abc\p{IsDigit}xyz]\s+/;  # match a,b,c,x,y,z, or a digit
/^=item\s\p{IsDigit}/;        # match '=item',
                              # followed by a space and a digit
```

Whew! That is all the rest of the characters and character classes.

Compiling and saving regular expressions

In Part 1 we discussed the //o modifier, which compiles a regexp just once. This suggests that a compiled regexp is some data structure that can be stored once and used again and again. The regexp quote qr// does exactly that: qr/string/ compiles the string as a regexp and transforms the result into a form that can be assigned to a variable:

```
$reg = qr/foo+bar?/;  # reg contains a compiled regexp
```

Then $reg can be used as a regexp:

```
$x = "fooooba";
$x =~ $reg;     # matches, just like /foo+bar?/
$x =~ /$reg/;   # same thing, alternate form
```

$reg can also be interpolated into a larger regexp:

```
$x =~ /(abc)?$reg/;  # still matches
```

As with the matching operator, the regexp quote can use different delimiters, e.g., qr!!, qr{} and qr~~. The single quote delimiters qr'' prevent any interpolation from taking place.

Pre–compiled regexps are useful for creating dynamic matches that don't need to be recompiled each time they are encountered. Using pre–compiled regexps, simple_grep program can be expanded into a program that matches multiple patterns:

```
% cat > multi_grep
#!/usr/bin/perl
# multi_grep - match any of <number> regexps
# usage: multi_grep <number> regexp1 regexp2 ... file1 file2 ...

$number = shift;
$regexp[$_] = shift foreach (0..$number-1);
@compiled = map qr/$_/, @regexp;
while ($line = <>) {
    foreach $pattern (@compiled) {
        if ($line =~ /$pattern/) {
            print $line;
            last;  # we matched, so move onto the next line
        }
    }
}
^D
```

```
% multi_grep 2 last for multi_grep
    $regexp[$_] = shift foreach (0..$number-1);
        foreach $pattern (@compiled) {
                last;
```

Storing pre-compiled regexps in an array `@compiled` allows us to simply loop through the regexps without any recompilation, thus gaining flexibility without sacrificing speed.

Embedding comments and modifiers in a regular expression

Starting with this section, we will be discussing Perl's set of **extended patterns**. These are extensions to the traditional regular expression syntax that provide powerful new tools for pattern matching. We have already seen extensions in the form of the minimal matching constructs `??`, `*?`, `+?`, `{n,m}?`, and `{n,}?`. The rest of the extensions below have the form `(?char...)`, where the `char` is a character that determines the type of extension.

The first extension is an embedded comment `(?#text)`. This embeds a comment into the regular expression without affecting its meaning. The comment should not have any closing parentheses in the text. An example is

```
/(?# Match an integer:)[+-]?\d+/;
```

This style of commenting has been largely superseded by the raw, freeform commenting that is allowed with the `//x` modifier.

The modifiers `//i`, `//m`, `//s`, and `//x` can also embedded in a regexp using `(?i)`, `(?m)`, `(?s)`, and `(?x)`. For instance,

```
/(?i)yes/;  # match 'yes' case insensitively
/yes/i;     # same thing
/(?x)(          # freeform version of an integer regexp
         [+-]?  # match an optional sign
         \d+    # match a sequence of digits
     )
/x;
```

Embedded modifiers can have two important advantages over the usual modifiers. Embedded modifiers allow a custom set of modifiers to *each* regexp pattern. This is great for matching an array of regexps that must have different modifiers:

```
$pattern[0] = '(?i)doctor';
$pattern[1] = 'Johnson';
...
while (<>) {
    foreach $patt (@pattern) {
        print if /$patt/;
    }
}
```

The second advantage is that embedded modifiers only affect the regexp inside the group the embedded modifier is contained in. So grouping can be used to localize the modifier's effects:

```
/Answer: ((?i)yes)/;  # matches 'Answer: yes', 'Answer: YES', etc.
```

Embedded modifiers can also turn off any modifiers already present by using, e.g., `(?-i)`. Modifiers can also be combined into a single expression, e.g., `(?s-i)` turns on single line mode and turns off case insensitivity.

Non-capturing groupings

We noted in Part 1 that groupings `()` had two distinct functions: 1) group regexp elements together as a single unit, and 2) extract, or capture, substrings that matched the regexp in the grouping. Non-capturing groupings, denoted by `(?:regexp)`, allow the regexp to be treated as a single unit, but don't extract

substrings or set matching variables $1, etc. Both capturing and non−capturing groupings are allowed to co−exist in the same regexp. Because there is no extraction, non−capturing groupings are faster than capturing groupings. Non−capturing groupings are also handy for choosing exactly which parts of a regexp are to be extracted to matching variables:

```
# match a number, $1-$4 are set, but we only want $1
/([+-]?\ *(\d+(\.\d*)?|\.\d+)([eE][+-]?\d+)?)/;

# match a number faster , only $1 is set
/([+-]?\ *(?:\d+(?:\.\d*)?|\.\d+)(?:[eE][+-]?\d+)?)/;

# match a number, get $1 = whole number, $2 = exponent
/([+-]?\ *(?:\d+(?:\.\d*)?|\.\d+)(?:[eE]([+-]?\d+))?)/;
```

Non−capturing groupings are also useful for removing nuisance elements gathered from a split operation:

```
$x = '12a34b5';
@num = split /(a|b)/, $x;    # @num = ('12','a','34','b','5')
@num = split /(?:a|b)/, $x;  # @num = ('12','34','5')
```

Non−capturing groupings may also have embedded modifiers: (?i-m:regexp) is a non−capturing grouping that matches regexp case insensitively and turns off multi−line mode.

Looking ahead and looking behind

This section concerns the lookahead and lookbehind assertions. First, a little background.

In Perl regular expressions, most regexp elements 'eat up' a certain amount of string when they match. For instance, the regexp element [abc}] eats up one character of the string when it matches, in the sense that perl moves to the next character position in the string after the match. There are some elements, however, that don't eat up characters (advance the character position) if they match. The examples we have seen so far are the anchors. The anchor ^ matches the beginning of the line, but doesn't eat any characters. Similarly, the word boundary anchor \b matches, e.g., if the character to the left is a word character and the character to the right is a non−word character, but it doesn't eat up any characters itself. Anchors are examples of 'zero−width assertions'. Zero−width, because they consume no characters, and assertions, because they test some property of the string. In the context of our walk in the woods analogy to regexp matching, most regexp elements move us along a trail, but anchors have us stop a moment and check our surroundings. If the local environment checks out, we can proceed forward. But if the local environment doesn't satisfy us, we must backtrack.

Checking the environment entails either looking ahead on the trail, looking behind, or both. ^ looks behind, to see that there are no characters before. $ looks ahead, to see that there are no characters after. \b looks both ahead and behind, to see if the characters on either side differ in their 'word'−ness.

The lookahead and lookbehind assertions are generalizations of the anchor concept. Lookahead and lookbehind are zero−width assertions that let us specify which characters we want to test for. The lookahead assertion is denoted by (?=regexp) and the lookbehind assertion is denoted by < (?<=fixed-regexp) . Some examples are

```
$x = "I catch the housecat 'Tom-cat' with catnip";
$x =~ /cat(?=\s+)/;  # matches 'cat' in 'housecat'
@catwords = ($x =~ /(?<=\s)cat\w+/g);  # matches,
                                       # $catwords[0] = 'catch'
                                       # $catwords[1] = 'catnip'
$x =~ /\bcat\b/;  # matches 'cat' in 'Tom-cat'
$x =~ /(?<=\s)cat(?=\s)/; # doesn't match; no isolated 'cat' in
                          # middle of $x
```

Note that the parentheses in (?=regexp) and < (?<=regexp) are non−capturing, since these are zero−width assertions. Thus in the second regexp, the substrings captured are those of the whole regexp itself. Lookahead (?=regexp) can match arbitrary regexps, but lookbehind < (?<=fixed-regexp)

only works for regexps of fixed width, i.e., a fixed number of characters long. Thus `(?<=(ab|bc))` is fine, but `(?<=(ab)*)` is not. The negated versions of the lookahead and lookbehind assertions are denoted by `(?!regexp)` and `(?<!fixed-regexp)` respectively. They evaluate true if the regexps do *not* match:

```
$x = "foobar";
$x =~ /foo(?!bar)/;  # doesn't match, 'bar' follows 'foo'
$x =~ /foo(?!baz)/;  # matches, 'baz' doesn't follow 'foo'
$x =~ /(?<!\s)foo/;  # matches, there is no \s before 'foo'
```

Using independent subexpressions to prevent backtracking

The last few extended patterns in this tutorial are experimental as of 5.6.0. Play with them, use them in some code, but don't rely on them just yet for production code.

Independent subexpressions are regular expressions, in the context of a larger regular expression, that function independently of the larger regular expression. That is, they consume as much or as little of the string as they wish without regard for the ability of the larger regexp to match. Independent subexpressions are represented by `(?regexp)`. We can illustrate their behavior by first considering an ordinary regexp:

```
$x = "ab";
$x =~ /a*ab/;  # matches
```

This obviously matches, but in the process of matching, the subexpression `a*` first grabbed the `a`. Doing so, however, wouldn't allow the whole regexp to match, so after backtracking, `a*` eventually gave back the `a` and matched the empty string. Here, what `a*` matched was *dependent* on what the rest of the regexp matched.

Contrast that with an independent subexpression:

```
$x =~ /(?>a*)ab/;  # doesn't match!
```

The independent subexpression `(?>a*)` doesn't care about the rest of the regexp, so it sees an `a` and grabs it. Then the rest of the regexp `ab` cannot match. Because `(?>a*)` is independent, there is no backtracking and and the independent subexpression does not give up its `a`. Thus the match of the regexp as a whole fails. A similar behavior occurs with completely independent regexps:

```
$x = "ab";
$x =~ /a*/g;   # matches, eats an 'a'
$x =~ /\Gab/g; # doesn't match, no 'a' available
```

Here `//g` and `\G` create a 'tag team' handoff of the string from one regexp to the other. Regexps with an independent subexpression are much like this, with a handoff of the string to the independent subexpression, and a handoff of the string back to the enclosing regexp.

The ability of an independent subexpression to prevent backtracking can be quite useful. Suppose we want to match a non-empty string enclosed in parentheses up to two levels deep. Then the following regexp matches:

```
$x = "abc(de(fg)h";  # unbalanced parentheses
$x =~ /\( ( [^()]+ | \([^()]*\) )+ \)/x;
```

The regexp matches an open parenthesis, one or more copies of an alternation, and a close parenthesis. The alternation is two-way, with the first alternative `[^()]+` matching a substring with no parentheses and the second alternative `\([^()]*\)` matching a substring delimited by parentheses. The problem with this regexp is that it is pathological: it has nested indeterminate quantifiers of the form `(a+|b)+`. We discussed in Part 1 how nested quantifiers like this could take an exponentially long time to execute if there was no match possible. To prevent the exponential blowup, we need to prevent useless backtracking at some point. This can be done by enclosing the inner quantifier as an independent subexpression:

```
$x =~ /\( ( (?>[^()]+) | \([^()]*\) )+ \)/x;
```

Here, `< (?[^()]+)` breaks the degeneracy of string partitioning by gobbling up as much of the string as possible and keeping it. Then match failures fail much more quickly.

Conditional expressions

A **conditional expression** is a form of if-then-else statement that allows one to choose which patterns are to be matched, based on some condition. There are two types of conditional expression: `(?(condition)yes-regexp)` and `(?(condition)yes-regexp|no-regexp)`. `(?(condition)yes-regexp)` is like an 'if () {}' statement in Perl. If the `condition` is true, the `yes-regexp` will be matched. If the condition is false, the `yes-regexp` will be skipped and perl will move onto the next regexp element. The second form is like an 'if () {} else {}' statement in Perl. If the condition is true, the `yes-regexp` will be matched, otherwise the `no-regexp` will be matched.

The `condition` can have two forms. The first form is simply an integer in parentheses `(integer)`. It is true if the corresponding backreference `\integer` matched earlier in the regexp. The second form is a bare zero width assertion `(?...)`, either a lookahead, a lookbehind, or a code assertion (discussed in the next section).

The integer form of the `condition` allows us to choose, with more flexibility, what to match based on what matched earlier in the regexp. This searches for words of the form `"$x$x"` or `"$x$y$y$x"`:

```
% simple_grep '^(\w+)(\w+)?(?(2)\2\1|\1)$' /usr/dict/words
beriberi
coco
couscous
deed
...
toot
toto
tutu
```

The lookbehind `condition` allows, along with backreferences, an earlier part of the match to influence a later part of the match. For instance,

```
/[ATGC]+(?(?<=AA)G|C)$/;
```

matches a DNA sequence such that it either ends in `AAG`, or some other base pair combination and `C`. Note that the form is `< (?(?<=AA)G|C)` and not `< (?((?<=AA))G|C)` ; for the lookahead, lookbehind or code assertions, the parentheses around the conditional are not needed.

A bit of magic: executing Perl code in a regular expression

Normally, regexps are a part of Perl expressions. **Code evaluation** expressions turn that around by allowing arbitrary Perl code to be a part of of a regexp. A code evaluation expression is denoted `(?{code})`, with `code` a string of Perl statements.

Code expressions are zero-width assertions, and the value they return depends on their environment. There are two possibilities: either the code expression is used as a conditional in a conditional expression `(?(condition)...)`, or it is not. If the code expression is a conditional, the code is evaluated and the result (i.e., the result of the last statement) is used to determine truth or falsehood. If the code expression is not used as a conditional, the assertion always evaluates true and the result is put into the special variable `$^R`. The variable `$^R` can then be used in code expressions later in the regexp. Here are some silly examples:

```
$x = "abcdef";
$x =~ /abc(?{print "Hi Mom!";})def/; # matches,
                                     # prints 'Hi Mom!'
$x =~ /aaa(?{print "Hi Mom!";})def/; # doesn't match,
                                     # no 'Hi Mom!'
```

Pay careful attention to the next example:

```
$x =~ /abc(?{print "Hi Mom!";})ddd/; # doesn't match,
                                     # no 'Hi Mom!'
                                     # but why not?
```

At first glance, you'd think that it shouldn't print, because obviously the ddd isn't going to match the target string. But look at this example:

```
$x =~ /abc(?{print "Hi Mom!";})[d]dd/; # doesn't match,
                                       # but _does_ print
```

Hmm. What happened here? If you've been following along, you know that the above pattern should be effectively the same as the last one — enclosing the d in a character class isn't going to change what it matches. So why does the first not print while the second one does?

The answer lies in the optimizations the REx engine makes. In the first case, all the engine sees are plain old characters (aside from the ?{} construct). It's smart enough to realize that the string 'ddd' doesn't occur in our target string before actually running the pattern through. But in the second case, we've tricked it into thinking that our pattern is more complicated than it is. It takes a look, sees our character class, and decides that it will have to actually run the pattern to determine whether or not it matches, and in the process of running it hits the print statement before it discovers that we don't have a match.

To take a closer look at how the engine does optimizations, see the section *"Pragmas and debugging"* below.

More fun with ?{}:

```
$x =~ /(?{print "Hi Mom!";})/;       # matches,
                                     # prints 'Hi Mom!'
$x =~ /(?{$c = 1;})(?{print "$c";})/;  # matches,
                                       # prints '1'
$x =~ /(?{$c = 1;})(?{print "$^R";})/; # matches,
                                       # prints '1'
```

The bit of magic mentioned in the section title occurs when the regexp backtracks in the process of searching for a match. If the regexp backtracks over a code expression and if the variables used within are localized using local, the changes in the variables produced by the code expression are undone! Thus, if we wanted to count how many times a character got matched inside a group, we could use, e.g.,

```
$x = "aaaa";
$count = 0;  # initialize 'a' count
$c = "bob";  # test if $c gets clobbered
$x =~ /(?{local $c = 0;})         # initialize count
       ( a                        # match 'a'
         (?{local $c = $c + 1;})  # increment count
       )*                         # do this any number of times,
       aa                         # but match 'aa' at the end
       (?{$count = $c;})          # copy local $c var into $count
      /x;
print "'a' count is $count, \$c variable is '$c'\n";
```

This prints

```
'a' count is 2, $c variable is 'bob'
```

If we replace the (?{local $c = $c + 1;}) with (?{$c = $c + 1;}) , the variable changes are *not* undone during backtracking, and we get

```
'a' count is 4, $c variable is 'bob'
```

Note that only localized variable changes are undone. Other side effects of code expression execution are permanent. Thus

```
$x = "aaaa";
$x =~ /(a(?{print "Yow\n";}))*aa/;
```

produces

```
Yow
Yow
Yow
Yow
```

The result `$^R` is automatically localized, so that it will behave properly in the presence of backtracking.

This example uses a code expression in a conditional to match the article 'the' in either English or German:

```
$lang = 'DE';  # use German
...
$text = "das";
print "matched\n"
    if $text =~ /(?(?{
                      $lang eq 'EN'; # is the language English?
                    })
                   the |             # if so, then match 'the'
                   (die|das|der)     # else, match 'die|das|der'
                 )
                /xi;
```

Note that the syntax here is `(?(?{...})yes-regexp|no-regexp)`, not `(?((?{...}))yes-regexp|no-regexp)`. In other words, in the case of a code expression, we don't need the extra parentheses around the conditional.

If you try to use code expressions with interpolating variables, perl may surprise you:

```
$bar = 5;
$pat = '(?{ 1 })';
/foo(?{ $bar })bar/; # compiles ok, $bar not interpolated
/foo(?{ 1 })$bar/;   # compile error!
/foo${pat}bar/;      # compile error!

$pat = qr/(?{ $foo = 1 })/;  # precompile code regexp
/foo${pat}bar/;      # compiles ok
```

If a regexp has (1) code expressions and interpolating variables,or (2) a variable that interpolates a code expression, perl treats the regexp as an error. If the code expression is precompiled into a variable, however, interpolating is ok. The question is, why is this an error?

The reason is that variable interpolation and code expressions together pose a security risk. The combination is dangerous because many programmers who write search engines often take user input and plug it directly into a regexp:

```
$regexp = <>;       # read user-supplied regexp
$chomp $regexp;     # get rid of possible newline
$text =~ /$regexp/; # search $text for the $regexp
```

If the `$regexp` variable contains a code expression, the user could then execute arbitrary Perl code. For instance, some joker could search for `system('rm -rf *');` to erase your files. In this sense, the combination of interpolation and code expressions **taints** your regexp. So by default, using both interpolation and code expressions in the same regexp is not allowed. If you're not concerned about malicious users, it is possible to bypass this security check by invoking `use re 'eval'`:

```
use re 'eval';       # throw caution out the door
$bar = 5;
$pat = '(?{ 1 })';
/foo(?{ 1 })$bar/;   # compiles ok
/foo${pat}bar/;      # compiles ok
```

Another form of code expression is the **pattern code expression** . The pattern code expression is like a regular code expression, except that the result of the code evaluation is treated as a regular expression and matched immediately. A simple example is

```
$length = 5;
$char = 'a';
$x = 'aaaaabb';
$x =~ /(??{$char x $length})/x; # matches, there are 5 of 'a'
```

This final example contains both ordinary and pattern code expressions. It detects if a binary string `1101010010001...` has a Fibonacci spacing 0,1,1,2,3,5,... of the `1`'s:

```
$s0 = 0; $s1 = 1; # initial conditions
$x = "1101010010001000001";
print "It is a Fibonacci sequence\n"
    if $x =~ /^1         # match an initial '1'
                (
                   (??{'0' x $s0}) # match $s0 of '0'
                   1               # and then a '1'
                   (?{
                      $largest = $s0;   # largest seq so far
                      $s2 = $s1 + $s0;  # compute next term
                      $s0 = $s1;        # in Fibonacci sequence
                      $s1 = $s2;
                     })
                  )+   # repeat as needed
               $       # that is all there is
              /x;
print "Largest sequence matched was $largest\n";
```

This prints

```
It is a Fibonacci sequence
Largest sequence matched was 5
```

Ha! Try that with your garden variety regexp package...

Note that the variables `$s0` and `$s1` are not substituted when the regexp is compiled, as happens for ordinary variables outside a code expression. Rather, the code expressions are evaluated when perl encounters them during the search for a match.

The regexp without the `//x` modifier is

```
/^1((??{'0'x$s0})1(?{$largest=$s0;$s2=$s1+$s0$s0=$s1;$s1=$s2;}))+$/;
```

and is a great start on an Obfuscated Perl entry :–) When working with code and conditional expressions, the extended form of regexps is almost necessary in creating and debugging regexps.

Pragmas and debugging

Speaking of debugging, there are several pragmas available to control and debug regexps in Perl. We have already encountered one pragma in the previous section, `use re 'eval';`, that allows variable interpolation and code expressions to coexist in a regexp. The other pragmas are

```
use re 'taint';
$tainted = <>;
```

```
@parts = ($tainted =~ /(\w+)\s+(\w+)/; # @parts is now tainted
```

The `taint` pragma causes any substrings from a match with a tainted variable to be tainted as well. This is not normally the case, as regexps are often used to extract the safe bits from a tainted variable. Use `taint` when you are not extracting safe bits, but are performing some other processing. Both `taint` and `eval` pragmas are lexically scoped, which means they are in effect only until the end of the block enclosing the pragmas.

```
use re 'debug';
/^(.*)$/s;       # output debugging info

use re 'debugcolor';
/^(.*)$/s;       # output debugging info in living color
```

The global `debug` and `debugcolor` pragmas allow one to get detailed debugging info about regexp compilation and execution. `debugcolor` is the same as debug, except the debugging information is displayed in color on terminals that can display termcap color sequences. Here is example output:

```
% perl -e 'use re "debug"; "abc" =~ /a*b+c/;'
Compiling REx `a*b+c'
size 9 first at 1
   1: STAR(4)
   2:   EXACT <a>(0)
   4: PLUS(7)
   5:   EXACT <b>(0)
   7: EXACT <c>(9)
   9: END(0)
floating `bc' at 0..2147483647 (checking floating) minlen 2
Guessing start of match, REx `a*b+c' against `abc'...
Found floating substr `bc' at offset 1...
Guessed: match at offset 0
Matching REx `a*b+c' against `abc'
  Setting an EVAL scope, savestack=3
   0 <> <abc>             |  1:  STAR
                           EXACT <a> can match 1 times out of 32767...
  Setting an EVAL scope, savestack=3
   1 <a> <bc>             |  4:    PLUS
                           EXACT <b> can match 1 times out of 32767...
  Setting an EVAL scope, savestack=3
   2 <ab> <c>             |  7:      EXACT <c>
   3 <abc> <>             |  9:      END
Match successful!
Freeing REx: `a*b+c'
```

If you have gotten this far into the tutorial, you can probably guess what the different parts of the debugging output tell you. The first part

```
Compiling REx `a*b+c'
size 9 first at 1
   1: STAR(4)
   2:   EXACT <a>(0)
   4: PLUS(7)
   5:   EXACT <b>(0)
   7: EXACT <c>(9)
   9: END(0)
```

describes the compilation stage. `STAR(4)` means that there is a starred object, in this case `'a'`, and if it matches, goto line 4, i.e., `PLUS(7)`. The middle lines describe some heuristics and optimizations performed

before a match:

```
floating 'bc' at 0..2147483647 (checking floating) minlen 2
Guessing start of match, REx 'a*b+c' against 'abc'...
Found floating substr 'bc' at offset 1...
Guessed: match at offset 0
```

Then the match is executed and the remaining lines describe the process:

```
Matching REx 'a*b+c' against 'abc'
  Setting an EVAL scope, savestack=3
   0 <> <abc>              |  1:  STAR
                            EXACT <a> can match 1 times out of 32767...
  Setting an EVAL scope, savestack=3
   1 <a> <bc>              |  4:    PLUS
                            EXACT <b> can match 1 times out of 32767...
  Setting an EVAL scope, savestack=3
   2 <ab> <c>              |  7:      EXACT <c>
   3 <abc> <>              |  9:      END
Match successful!
Freeing REx: 'a*b+c'
```

Each step is of the form `< n <x <y` , with `< <x` the part of the string matched and `< <y` the part not yet matched. The `< | 1: STAR` says that perl is at line number 1 n the compilation list above. See *Debugging regular expressions in perldebguts* for much more detail.

An alternative method of debugging regexps is to embed `print` statements within the regexp. This provides a blow–by–blow account of the backtracking in an alternation:

```
"that this" =~ m@(?{print "Start at position ", pos, "\n";})
                 t(?{print "t1\n";})
                 h(?{print "h1\n";})
                 i(?{print "i1\n";})
                 s(?{print "s1\n";})
                     |
                 t(?{print "t2\n";})
                 h(?{print "h2\n";})
                 a(?{print "a2\n";})
                 t(?{print "t2\n";})
                 (?{print "Done at position ", pos, "\n";})
                @x;
```

prints

```
Start at position 0
t1
h1
t2
h2
a2
t2
Done at position 4
```

BUGS

Code expressions, conditional expressions, and independent expressions are **experimental**. Don't use them in production code. Yet.

SEE ALSO

This is just a tutorial. For the full story on perl regular expressions, see the *perlre* regular expressions reference page.

For more information on the matching `m//` and substitution `s///` operators, see *Regexp Quote−Like Operators in perlop*. For information on the `split` operation, see *split*.

For an excellent all−around resource on the care and feeding of regular expressions, see the book *Mastering Regular Expressions* by Jeffrey Friedl (published by O'Reilly, ISBN 1556592−257−3).

AUTHOR AND COPYRIGHT

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NAME

perlrun – how to execute the Perl interpreter

SYNOPSIS

perl [**–CsTuUWX**]
[**–hv**] [**–V**[:*configvar*]]
[**–cw**] [**–d**[:*debugger*]] [**–D**[*number/list*]]
[**–pna**] [**–F***pattern*] [**–l**[*octal*]] [**–0**[*octal*]]
[**–I***dir*] [**–m**[**–**]*module*] [**–M**[**–**]*'module...'*]
[**–P**]
[**–S**]
[**–x**[*dir*]]
[**–i**[*extension*]]
[**–e** *'command'*] [**—**] [*programfile*] [*argument*]...

DESCRIPTION

The normal way to run a Perl program is by making it directly executable, or else by passing the name of the source file as an argument on the command line. (An interactive Perl environment is also possible—see *perldebug* for details on how to do that.) Upon startup, Perl looks for your program in one of the following places:

1. Specified line by line via **–e** switches on the command line.
2. Contained in the file specified by the first filename on the command line. (Note that systems supporting the #! notation invoke interpreters this way. See *Location of Perl*.)
3. Passed in implicitly via standard input. This works only if there are no filename arguments—to pass arguments to a STDIN–read program you must explicitly specify a "–" for the program name.

With methods 2 and 3, Perl starts parsing the input file from the beginning, unless you've specified a **–x** switch, in which case it scans for the first line starting with #! and containing the word "perl", and starts there instead. This is useful for running a program embedded in a larger message. (In this case you would indicate the end of the program using the `__END__` token.)

The #! line is always examined for switches as the line is being parsed. Thus, if you're on a machine that allows only one argument with the #! line, or worse, doesn't even recognize the #! line, you still can get consistent switch behavior regardless of how Perl was invoked, even if **–x** was used to find the beginning of the program.

Because historically some operating systems silently chopped off kernel interpretation of the #! line after 32 characters, some switches may be passed in on the command line, and some may not; you could even get a "–" without its letter, if you're not careful. You probably want to make sure that all your switches fall either before or after that 32–character boundary. Most switches don't actually care if they're processed redundantly, but getting a "–" instead of a complete switch could cause Perl to try to execute standard input instead of your program. And a partial **–I** switch could also cause odd results.

Some switches do care if they are processed twice, for instance combinations of **–l** and **–0**. Either put all the switches after the 32–character boundary (if applicable), or replace the use of **–0***digits* by `BEGIN{ $/ = "\0digits"; }`.

Parsing of the #! switches starts wherever "perl" is mentioned in the line. The sequences "–*" and "– " are specifically ignored so that you could, if you were so inclined, say

```
#!/bin/sh -- # -*- perl -*- -p
eval 'exec perl -wS $0 ${1+"$@"}'
    if $running_under_some_shell;
```

to let Perl see the **–p** switch.

A similar trick involves the **env** program, if you have it.

```
#!/usr/bin/env perl
```

The examples above use a relative path to the perl interpreter, getting whatever version is first in the user's path. If you want a specific version of Perl, say, perl5.005_57, you should place that directly in the #! line's path.

If the #! line does not contain the word "perl", the program named after the #! is executed instead of the Perl interpreter. This is slightly bizarre, but it helps people on machines that don't do #!, because they can tell a program that their SHELL is ***/usr/bin/perl***, and Perl will then dispatch the program to the correct interpreter for them.

After locating your program, Perl compiles the entire program to an internal form. If there are any compilation errors, execution of the program is not attempted. (This is unlike the typical shell script, which might run part–way through before finding a syntax error.)

If the program is syntactically correct, it is executed. If the program runs off the end without hitting an `exit()` or `die()` operator, an implicit `exit(0)` is provided to indicate successful completion.

#! and quoting on non–Unix systems

Unix's #! technique can be simulated on other systems:

OS/2

Put

```
extproc perl -S -your_switches
```

as the first line in `*.cmd` file (**–S** due to a bug in cmd.exe's 'extproc' handling).

MS–DOS

Create a batch file to run your program, and codify it in `ALTERNATIVE_SHEBANG` (see the ***dosish.h*** file in the source distribution for more information).

Win95/NT

The Win95/NT installation, when using the ActiveState installer for Perl, will modify the Registry to associate the ***.pl*** extension with the perl interpreter. If you install Perl by other means (including building from the sources), you may have to modify the Registry yourself. Note that this means you can no longer tell the difference between an executable Perl program and a Perl library file.

Macintosh

A Macintosh perl program will have the appropriate Creator and Type, so that double–clicking them will invoke the perl application.

VMS

Put

```
$ perl -mysw 'f$env("procedure")' 'p1' 'p2' 'p3' 'p4' 'p5' 'p6' 'p7' 'p8' !
$ exit++ + ++$status != 0 and $exit = $status = undef;
```

at the top of your program, where **–mysw** are any command line switches you want to pass to Perl. You can now invoke the program directly, by saying `perl program`, or as a DCL procedure, by saying `@program` (or implicitly via ***DCL$PATH*** by just using the name of the program).

This incantation is a bit much to remember, but Perl will display it for you if you say `perl "-V:startperl"`.

Command–interpreters on non–Unix systems have rather different ideas on quoting than Unix shells. You'll need to learn the special characters in your command–interpreter (`*`, `\` and `"` are common) and how to protect whitespace and these characters to run one–liners (see **–e** below).

On some systems, you may have to change single–quotes to double ones, which you must *not* do on Unix or

Plan9 systems. You might also have to change a single % to a %%.

For example:

```
# Unix
perl -e 'print "Hello world\n"'

# MS-DOS, etc.
perl -e "print \"Hello world\n\""

# Macintosh
print "Hello world\n"
 (then Run "Myscript" or Shift-Command-R)

# VMS
perl -e "print ""Hello world\n"""
```

The problem is that none of this is reliable: it depends on the command and it is entirely possible neither works. If **4DOS** were the command shell, this would probably work better:

```
perl -e "print <Ctrl-x>"Hello world\n<Ctrl-x>""
```

CMD.EXE in Windows NT slipped a lot of standard Unix functionality in when nobody was looking, but just try to find documentation for its quoting rules.

Under the Macintosh, it depends which environment you are using. The MacPerl shell, or MPW, is much like Unix shells in its support for several quoting variants, except that it makes free use of the Macintosh's non-ASCII characters as control characters.

There is no general solution to all of this. It's just a mess.

Location of Perl

It may seem obvious to say, but Perl is useful only when users can easily find it. When possible, it's good for both ***/usr/bin/perl*** and ***/usr/local/bin/perl*** to be symlinks to the actual binary. If that can't be done, system administrators are strongly encouraged to put (symlinks to) perl and its accompanying utilities into a directory typically found along a user's PATH, or in some other obvious and convenient place.

In this documentation, `#!/usr/bin/perl` on the first line of the program will stand in for whatever method works on your system. You are advised to use a specific path if you care about a specific version.

```
#!/usr/local/bin/perl5.00554
```

or if you just want to be running at least version, place a statement like this at the top of your program:

```
use 5.005_54;
```

Command Switches

As with all standard commands, a single-character switch may be clustered with the following switch, if any.

```
#!/usr/bin/perl -spi.orig   # same as -s -p -i.orig
```

Switches include:

-0[*digits*]

specifies the input record separator (`$/`) as an octal number. If there are no digits, the null character is the separator. Other switches may precede or follow the digits. For example, if you have a version of **find** which can print filenames terminated by the null character, you can say this:

```
find . -name '*.orig' -print0 | perl -n0e unlink
```

The special value 00 will cause Perl to slurp files in paragraph mode. The value 0777 will cause Perl to slurp files whole because there is no legal character with that value.

–a turns on autosplit mode when used with a **–n** or **–p**. An implicit split command to the @F array is done as the first thing inside the implicit while loop produced by the **–n** or **–p**.

```
perl -ane 'print pop(@F), "\n";'
```

is equivalent to

```
while (<>) {
    @F = split(' ');
    print pop(@F), "\n";
}
```

An alternate delimiter may be specified using **–F**.

–C enables Perl to use the native wide character APIs on the target system. The magic variable ${^WIDE_SYSTEM_CALLS} reflects the state of this switch. See *${^WIDE_SYSTEM_CALLS} in perlvar*.

This feature is currently only implemented on the Win32 platform.

–c causes Perl to check the syntax of the program and then exit without executing it. Actually, it *will* execute BEGIN, CHECK, and use blocks, because these are considered as occurring outside the execution of your program. INIT and END blocks, however, will be skipped.

–d runs the program under the Perl debugger. See *perldebug*.

–d:*foo[=bar,baz]*

runs the program under the control of a debugging, profiling, or tracing module installed as Devel::foo. E.g., **–d:DProf** executes the program using the Devel::DProf profiler. As with the **–M** flag, options may be passed to the Devel::foo package where they will be received and interpreted by the Devel::foo::import routine. The comma–separated list of options must follow a = character. See *perldebug*.

–D*letters*
–D*number*

sets debugging flags. To watch how it executes your program, use **–Dtls**. (This works only if debugging is compiled into your Perl.) Another nice value is **–Dx**, which lists your compiled syntax tree. And **–Dr** displays compiled regular expressions. As an alternative, specify a number instead of list of letters (e.g., **–D14** is equivalent to **–Dtls**):

```
    1  p  Tokenizing and parsing
    2  s  Stack snapshots
    4  l  Context (loop) stack processing
    8  t  Trace execution
   16  o  Method and overloading resolution
   32  c  String/numeric conversions
   64  P  Print preprocessor command for -P, source file input state
  128  m  Memory allocation
  256  f  Format processing
  512  r  Regular expression parsing and execution
 1024  x  Syntax tree dump
 2048  u  Tainting checks
 4096  L  Memory leaks (needs -DLEAKTEST when compiling Perl)
 8192  H  Hash dump -- usurps values()
16384  X  Scratchpad allocation
32768  D  Cleaning up
65536  S  Thread synchronization
```

All these flags require **–DDEBUGGING** when you compile the Perl executable. See the ***INSTALL*** file in the Perl source distribution for how to do this. This flag is automatically set if you include **–g**

option when `Configure` asks you about optimizer/debugger flags.

If you're just trying to get a print out of each line of Perl code as it executes, the way that `sh -x` provides for shell scripts, you can't use Perl's **-D** switch. Instead do this

```
# Bourne shell syntax
$ PERLDB_OPTS="NonStop=1 AutoTrace=1 frame=2" perl -dS program

# csh syntax
% (setenv PERLDB_OPTS "NonStop=1 AutoTrace=1 frame=2"; perl -dS program)
```

See *perldebug* for details and variations.

-e *commandline*

may be used to enter one line of program. If **-e** is given, Perl will not look for a filename in the argument list. Multiple **-e** commands may be given to build up a multi-line script. Make sure to use semicolons where you would in a normal program.

-F*pattern*

specifies the pattern to split on if **-a** is also in effect. The pattern may be surrounded by `//`, `""`, or `''`, otherwise it will be put in single quotes.

-h prints a summary of the options.

-i[*extension*]

specifies that files processed by the `<>` construct are to be edited in-place. It does this by renaming the input file, opening the output file by the original name, and selecting that output file as the default for `print()` statements. The extension, if supplied, is used to modify the name of the old file to make a backup copy, following these rules:

If no extension is supplied, no backup is made and the current file is overwritten.

If the extension doesn't contain a `*`, then it is appended to the end of the current filename as a suffix. If the extension does contain one or more `*` characters, then each `*` is replaced with the current filename. In Perl terms, you could think of this as:

```
($backup = $extension) =~ s/\*/$file_name/g;
```

This allows you to add a prefix to the backup file, instead of (or in addition to) a suffix:

```
$ perl -pi 'orig_*' -e 's/bar/baz/' fileA   # backup to 'orig_fileA'
```

Or even to place backup copies of the original files into another directory (provided the directory already exists):

```
$ perl -pi 'old/*.orig' -e 's/bar/baz/' fileA # backup to 'old/fileA.orig'
```

These sets of one-liners are equivalent:

```
$ perl -pi -e 's/bar/baz/' fileA            # overwrite current file
$ perl -pi '*' -e 's/bar/baz/' fileA        # overwrite current file

$ perl -pi '.orig' -e 's/bar/baz/' fileA    # backup to 'fileA.orig'
$ perl -pi '*.orig' -e 's/bar/baz/' fileA   # backup to 'fileA.orig'
```

From the shell, saying

```
$ perl -p -i.orig -e "s/foo/bar/; ... "
```

is the same as using the program:

```
#!/usr/bin/perl -pi.orig
s/foo/bar/;
```

which is equivalent to

```
#!/usr/bin/perl
$extension = '.orig';
LINE: while (<>) {
    if ($ARGV ne $oldargv) {
        if ($extension !~ /\*/) {
            $backup = $ARGV . $extension;
        }
        else {
            ($backup = $extension) =~ s/\*/$ARGV/g;
        }
        rename($ARGV, $backup);
        open(ARGVOUT, ">$ARGV");
        select(ARGVOUT);
        $oldargv = $ARGV;
    }
    s/foo/bar/;
}
continue {
    print;  # this prints to original filename
}
select(STDOUT);
```

except that the **–i** form doesn't need to compare `$ARGV` to `$oldargv` to know when the filename has changed. It does, however, use ARGVOUT for the selected filehandle. Note that STDOUT is restored as the default output filehandle after the loop.

As shown above, Perl creates the backup file whether or not any output is actually changed. So this is just a fancy way to copy files:

```
$ perl -p -i '/some/file/path/*' -e 1 file1 file2 file3...
```

or

```
$ perl –p –i '.orig' –e 1 file1 file2 file3...
```

You can use `eof` without parentheses to locate the end of each input file, in case you want to append to each file, or reset line numbering (see example in *eof*).

If, for a given file, Perl is unable to create the backup file as specified in the extension then it will skip that file and continue on with the next one (if it exists).

For a discussion of issues surrounding file permissions and **–i**, see *Why does Perl let me delete read–only files? Why does –i clobber protected files? Isn't this a bug in Perl?*.

You cannot use **–i** to create directories or to strip extensions from files.

Perl does not expand ~ in filenames, which is good, since some folks use it for their backup files:

```
$ perl -pi~ -e 's/foo/bar/' file1 file2 file3...
```

Finally, the **–i** switch does not impede execution when no files are given on the command line. In this case, no backup is made (the original file cannot, of course, be determined) and processing proceeds from STDIN to STDOUT as might be expected.

–I*directory*

Directories specified by **–I** are prepended to the search path for modules (`@INC`), and also tells the C preprocessor where to search for include files. The C preprocessor is invoked with **–P**; by default it searches /usr/include and /usr/lib/perl.

–l[*octnum*]

enables automatic line–ending processing. It has two separate effects. First, it automatically chomps `$/` (the input record separator) when used with **–n** or **–p**. Second, it assigns `$\` (the output record separator) to have the value of *octnum* so that any print statements will have that separator added back on. If *octnum* is omitted, sets `$\` to the current value of `$/`. For instance, to trim lines to 80 columns:

```
perl -lpe 'substr($_, 80) = ""'
```

Note that the assignment `$\ = $/` is done when the switch is processed, so the input record separator can be different than the output record separator if the **–l** switch is followed by a **–0** switch:

```
gnufind / -print0 | perl -ln0e 'print "found $_" if -p'
```

This sets `$\` to newline and then sets `$/` to the null character.

–m[**–**]*module*
–M[**–**]*module*
–M[**–**]*'module ...'*
–[mM][**–**]*module=arg[,arg]...*

–m*module* executes `use` *module* `();` before executing your program.

–M*module* executes `use` *module* `;` before executing your program. You can use quotes to add extra code after the module name, e.g., `'-Mmodule qw(foo bar)'`.

If the first character after the **–M** or **–m** is a dash (`-`) then the 'use' is replaced with 'no'.

A little builtin syntactic sugar means you can also say **–mmodule=foo,bar** or **–Mmodule=foo,bar** as a shortcut for `'-Mmodule qw(foo bar)'`. This avoids the need to use quotes when importing symbols. The actual code generated by **–Mmodule=foo,bar** is `use module split(/,/,q{foo,bar})`. Note that the = form removes the distinction between **–m** and **–M**.

–n causes Perl to assume the following loop around your program, which makes it iterate over filename arguments somewhat like **sed –n** or **awk**:

```
LINE:
  while (<>) {
      ...             # your program goes here
  }
```

Note that the lines are not printed by default. See **–p** to have lines printed. If a file named by an argument cannot be opened for some reason, Perl warns you about it and moves on to the next file.

Here is an efficient way to delete all files older than a week:

```
find . -mtime +7 -print | perl -nle unlink
```

This is faster than using the **–exec** switch of **find** because you don't have to start a process on every filename found. It does suffer from the bug of mishandling newlines in pathnames, which you can fix if you

`BEGIN` and `END` blocks may be used to capture control before or after the implicit program loop, just as in **awk**.

–p causes Perl to assume the following loop around your program, which makes it iterate over filename arguments somewhat like **sed**:

```
LINE:
  while (<>) {
      ...             # your program goes here
  } continue {
```

```
        print or die "-p destination: $!\n";
    }
```

If a file named by an argument cannot be opened for some reason, Perl warns you about it, and moves on to the next file. Note that the lines are printed automatically. An error occurring during printing is treated as fatal. To suppress printing use the **–n** switch. A **–p** overrides a **–n** switch.

`BEGIN` and `END` blocks may be used to capture control before or after the implicit loop, just as in **awk**.

–P causes your program to be run through the C preprocessor before compilation by Perl. Because both comments and **cpp** directives begin with the # character, you should avoid starting comments with any words recognized by the C preprocessor such as `"if"`, `"else"`, or `"define"`. Also, in some platforms the C preprocessor knows too much: it knows about the C++ –style until–end–of–line comments starting with `"//"`. This will cause problems with common Perl constructs like

```
s/foo//;
```

because after –P this will became illegal code

```
s/foo
```

The workaround is to use some other quoting separator than `"/"`, like for example `"!"`:

```
s!foo!!;
```

–s enables rudimentary switch parsing for switches on the command line after the program name but before any filename arguments (or before an argument of **—**). This means you can have switches with two leading dashes (**—help**). Any switch found there is removed from @ARGV and sets the corresponding variable in the Perl program. The following program prints "1" if the program is invoked with a **–xyz** switch, and "abc" if it is invoked with **–xyz=abc**.

```
#!/usr/bin/perl -s
if ($xyz) { print "$xyz\n" }
```

Do note that **—help** creates the variable `${-help}`, which is not compliant with `strict refs`.

–S makes Perl use the PATH environment variable to search for the program (unless the name of the program contains directory separators).

On some platforms, this also makes Perl append suffixes to the filename while searching for it. For example, on Win32 platforms, the ".bat" and ".cmd" suffixes are appended if a lookup for the original name fails, and if the name does not already end in one of those suffixes. If your Perl was compiled with DEBUGGING turned on, using the –Dp switch to Perl shows how the search progresses.

Typically this is used to emulate #! startup on platforms that don't support #!. This example works on many platforms that have a shell compatible with Bourne shell:

```
#!/usr/bin/perl
eval 'exec /usr/bin/perl -wS $0 ${1+"$@"}'
        if $running_under_some_shell;
```

The system ignores the first line and feeds the program to ***/bin/sh***, which proceeds to try to execute the Perl program as a shell script. The shell executes the second line as a normal shell command, and thus starts up the Perl interpreter. On some systems `$0` doesn't always contain the full pathname, so the **–S** tells Perl to search for the program if necessary. After Perl locates the program, it parses the lines and ignores them because the variable `$running_under_some_shell` is never true. If the program will be interpreted by csh, you will need to replace `${1+"$@"}` with `$*`, even though that doesn't understand embedded spaces (and such) in the argument list. To start up sh rather than csh, some systems may have to replace the #! line with a line containing just a colon, which will be politely ignored by Perl. Other systems can't control that, and need a totally devious construct that will work under any of **csh**, **sh**, or Perl, such as the following:

```
eval '(exit $?0)' && eval 'exec perl -wS $0 ${1+"$@"}'
& eval 'exec /usr/bin/perl -wS $0 $argv:q'
        if $running_under_some_shell;
```

If the filename supplied contains directory separators (i.e., is an absolute or relative pathname), and if that file is not found, platforms that append file extensions will do so and try to look for the file with those extensions added, one by one.

On DOS-like platforms, if the program does not contain directory separators, it will first be searched for in the current directory before being searched for on the PATH. On Unix platforms, the program will be searched for strictly on the PATH.

-T forces "taint" checks to be turned on so you can test them. Ordinarily these checks are done only when running setuid or setgid. It's a good idea to turn them on explicitly for programs that run on behalf of someone else whom you might not necessarily trust, such as CGI programs or any internet servers you might write in Perl. See *perlsec* for details. For security reasons, this option must be seen by Perl quite early; usually this means it must appear early on the command line or in the #! line for systems which support that construct.

-u This obsolete switch causes Perl to dump core after compiling your program. You can then in theory take this core dump and turn it into an executable file by using the **undump** program (not supplied). This speeds startup at the expense of some disk space (which you can minimize by stripping the executable). (Still, a "hello world" executable comes out to about 200K on my machine.) If you want to execute a portion of your program before dumping, use the `dump()` operator instead. Note: availability of **undump** is platform specific and may not be available for a specific port of Perl.

This switch has been superseded in favor of the new Perl code generator backends to the compiler. See *B* and *B::Bytecode* for details.

-U allows Perl to do unsafe operations. Currently the only "unsafe" operations are the unlinking of directories while running as superuser, and running setuid programs with fatal taint checks turned into warnings. Note that the **-w** switch (or the `$^W` variable) must be used along with this option to actually *generate* the taint-check warnings.

-v prints the version and patchlevel of your perl executable.

-V prints summary of the major perl configuration values and the current values of @INC.

-V:*name*

Prints to STDOUT the value of the named configuration variable. For example,

```
$ perl -V:man.dir
```

will provide strong clues about what your MANPATH variable should be set to in order to access the Perl documentation.

-w prints warnings about dubious constructs, such as variable names that are mentioned only once and scalar variables that are used before being set, redefined subroutines, references to undefined filehandles or filehandles opened read-only that you are attempting to write on, values used as a number that doesn't look like numbers, using an array as though it were a scalar, if your subroutines recurse more than 100 deep, and innumerable other things.

This switch really just enables the internal `^$W` variable. You can disable or promote into fatal errors specific warnings using `__WARN__` hooks, as described in *perlvar* and *warn*. See also *perldiag* and *perltrap*. A new, fine-grained warning facility is also available if you want to manipulate entire classes of warnings; see *warnings* or *perllexwarn*.

-W Enables all warnings regardless of `no warnings` or `$^W`. See *perllexwarn*.

-X Disables all warnings regardless of `use warnings` or `$^W`. See *perllexwarn*.

–x *directory*

tells Perl that the program is embedded in a larger chunk of unrelated ASCII text, such as in a mail message. Leading garbage will be discarded until the first line that starts with #! and contains the string "perl". Any meaningful switches on that line will be applied. If a directory name is specified, Perl will switch to that directory before running the program. The **–x** switch controls only the disposal of leading garbage. The program must be terminated with `__END__` if there is trailing garbage to be ignored (the program can process any or all of the trailing garbage via the DATA filehandle if desired).

ENVIRONMENT

HOME Used if chdir has no argument.

LOGDIR Used if chdir has no argument and HOME is not set.

PATH Used in executing subprocesses, and in finding the program if **–S** is used.

PERL5LIB A colon–separated list of directories in which to look for Perl library files before looking in the standard library and the current directory. Any architecture–specific directories under the specified locations are automatically included if they exist. If PERL5LIB is not defined, PERLLIB is used.

When running taint checks (either because the program was running setuid or setgid, or the **–T** switch was used), neither variable is used. The program should instead say:

```
use lib "/my/directory";
```

PERL5OPT Command–line options (switches). Switches in this variable are taken as if they were on every Perl command line. Only the **–[DIMUdmw]** switches are allowed. When running taint checks (because the program was running setuid or setgid, or the **–T** switch was used), this variable is ignored. If PERL5OPT begins with **–T**, tainting will be enabled, and any subsequent options ignored.

PERLLIB A colon–separated list of directories in which to look for Perl library files before looking in the standard library and the current directory. If PERL5LIB is defined, PERLLIB is not used.

PERL5DB The command used to load the debugger code. The default is:

```
BEGIN { require 'perl5db.pl' }
```

PERL5SHELL (specific to the Win32 port)

May be set to an alternative shell that perl must use internally for executing "backtick" commands or `system()`. Default is `cmd.exe /x/c` on WindowsNT and `command.com /c` on Windows95. The value is considered to be space–separated. Precede any character that needs to be protected (like a space or backslash) with a backslash.

Note that Perl doesn't use COMSPEC for this purpose because COMSPEC has a high degree of variability among users, leading to portability concerns. Besides, perl can use a shell that may not be fit for interactive use, and setting COMSPEC to such a shell may interfere with the proper functioning of other programs (which usually look in COMSPEC to find a shell fit for interactive use).

PERL_DEBUG_MSTATS

Relevant only if perl is compiled with the malloc included with the perl distribution (that is, if `perl -V:d_mymalloc` is 'define'). If set, this causes memory statistics to be dumped after execution. If set to an integer greater than one, also causes memory statistics to be dumped after compilation.

PERL_DESTRUCT_LEVEL

Relevant only if your perl executable was built with **–DDEBUGGING**, this controls the behavior of global destruction of objects and other references.

PERL_ROOT (specific to the VMS port)

A translation concealed rooted logical name that contains perl and the logical device for the @INC path on VMS only. Other logical names that affect perl on VMS include PERLSHR, PERL_ENV_TABLES, and SYS$TIMEZONE_DIFFERENTIAL but are optional and discussed further in *perlvms* and in ***README.vms*** in the Perl source distribution.

SYS$LOGIN (specific to the VMS port)

Used if chdir has no argument and HOME and LOGDIR are not set.

Perl also has environment variables that control how Perl handles data specific to particular natural languages. See *perllocale*.

Apart from these, Perl uses no other environment variables, except to make them available to the program being executed, and to child processes. However, programs running setuid would do well to execute the following lines before doing anything else, just to keep people honest:

```
$ENV{PATH}  = '/bin:/usr/bin';    # or whatever you need
$ENV{SHELL} = '/bin/sh' if exists $ENV{SHELL};
delete @ENV{qw(IFS CDPATH ENV BASH_ENV)};
```

NAME

perlsec – Perl security

DESCRIPTION

Perl is designed to make it easy to program securely even when running with extra privileges, like setuid or setgid programs. Unlike most command line shells, which are based on multiple substitution passes on each line of the script, Perl uses a more conventional evaluation scheme with fewer hidden snags. Additionally, because the language has more builtin functionality, it can rely less upon external (and possibly untrustworthy) programs to accomplish its purposes.

Perl automatically enables a set of special security checks, called *taint mode*, when it detects its program running with differing real and effective user or group IDs. The setuid bit in Unix permissions is mode 04000, the setgid bit mode 02000; either or both may be set. You can also enable taint mode explicitly by using the **–T** command line flag. This flag is *strongly* suggested for server programs and any program run on behalf of someone else, such as a CGI script. Once taint mode is on, it's on for the remainder of your script.

While in this mode, Perl takes special precautions called *taint checks* to prevent both obvious and subtle traps. Some of these checks are reasonably simple, such as verifying that path directories aren't writable by others; careful programmers have always used checks like these. Other checks, however, are best supported by the language itself, and it is these checks especially that contribute to making a set–id Perl program more secure than the corresponding C program.

You may not use data derived from outside your program to affect something else outside your program—at least, not by accident. All command line arguments, environment variables, locale information (see *perllocale*), results of certain system calls `(readdir()`, `readlink()`, the variable of `shmread()`, the messages returned by `msgrcv()`, the password, gcos and shell fields returned by the `getpwxxx()` calls), and all file input are marked as "tainted". Tainted data may not be used directly or indirectly in any command that invokes a sub–shell, nor in any command that modifies files, directories, or processes, **with the following exceptions**:

- If you pass a list of arguments to either `system` or `exec`, the elements of that list are **not** checked for taintedness.
- Arguments to `print` and `syswrite` are **not** checked for taintedness.

Any variable set to a value derived from tainted data will itself be tainted, even if it is logically impossible for the tainted data to alter the variable. Because taintedness is associated with each scalar value, some elements of an array can be tainted and others not.

For example:

```
$arg = shift;               # $arg is tainted
$hid = $arg, 'bar';         # $hid is also tainted
$line = <>;                 # Tainted
$line = <STDIN>;            # Also tainted
open FOO, "/home/me/bar" or die $!;
$line = <FOO>;              # Still tainted
$path = $ENV{'PATH'};       # Tainted, but see below
$data = 'abc';              # Not tainted

system "echo $arg";         # Insecure
system "/bin/echo", $arg;   # Secure (doesn't use sh)
system "echo $hid";         # Insecure
system "echo $data";        # Insecure until PATH set

$path = $ENV{'PATH'};       # $path now tainted

$ENV{'PATH'} = '/bin:/usr/bin';
delete @ENV{'IFS', 'CDPATH', 'ENV', 'BASH_ENV'};
```

```
$path = $ENV{'PATH'}# $path now NOT tainted
system "echo $data";# Is secure now!

open(FOO, "< $arg");        # OK - read-only file
open(FOO, "> $arg");        # Not OK - trying to write

open(FOO,"echo $arg|");     # Not OK, but...
open(FOO,"-|")
    or exec 'echo', $arg;   # OK

$shout = `echo $arg`;       # Insecure, $shout now tainted

unlink $data, $arg;         # Insecure
umask $arg;                 # Insecure

exec "echo $arg";           # Insecure
exec "echo", $arg;          # Secure (doesn't use the shell)
exec "sh", '-c', $arg;      # Considered secure, alas!

@files = <*.c>;             # insecure (uses readdir() or similar)
@files = glob('*.c');       # insecure (uses readdir() or similar)
```

If you try to do something insecure, you will get a fatal error saying something like "Insecure dependency" or "Insecure `$ENV{PATH}`". Note that you can still write an insecure **system** or **exec**, but only by explicitly doing something like the "considered secure" example above.

Laundering and Detecting Tainted Data

To test whether a variable contains tainted data, and whose use would thus trigger an "Insecure dependency" message, check your nearby CPAN mirror for the ***Taint.pm*** module, which should become available around November 1997. Or you may be able to use the following *`is_tainted()`* function.

```
sub is_tainted {
    return ! eval {
        join('',@_), kill 0;
        1;
    };
}
```

This function makes use of the fact that the presence of tainted data anywhere within an expression renders the entire expression tainted. It would be inefficient for every operator to test every argument for taintedness. Instead, the slightly more efficient and conservative approach is used that if any tainted value has been accessed within the same expression, the whole expression is considered tainted.

But testing for taintedness gets you only so far. Sometimes you have just to clear your data's taintedness. The only way to bypass the tainting mechanism is by referencing subpatterns from a regular expression match. Perl presumes that if you reference a substring using `$1, $2,` etc., that you knew what you were doing when you wrote the pattern. That means using a bit of thought—don't just blindly untaint anything, or you defeat the entire mechanism. It's better to verify that the variable has only good characters (for certain values of "good") rather than checking whether it has any bad characters. That's because it's far too easy to miss bad characters that you never thought of.

Here's a test to make sure that the data contains nothing but "word" characters (alphabetics, numerics, and underscores), a hyphen, an at sign, or a dot.

```
if ($data =~ /^([-\@\w.]+)$/) {
    $data = $1;                     # $data now untainted
} else {
    die "Bad data in $data";        # log this somewhere
}
```

This is fairly secure because `/\w+/` doesn't normally match shell metacharacters, nor are dot, dash, or at

going to mean something special to the shell. Use of `/.+/` would have been insecure in theory because it lets everything through, but Perl doesn't check for that. The lesson is that when untainting, you must be exceedingly careful with your patterns. Laundering data using regular expression is the *only* mechanism for untainting dirty data, unless you use the strategy detailed below to fork a child of lesser privilege.

The example does not untaint `$data` if `use locale` is in effect, because the characters matched by `\w` are determined by the locale. Perl considers that locale definitions are untrustworthy because they contain data from outside the program. If you are writing a locale-aware program, and want to launder data with a regular expression containing `\w`, put `no locale` ahead of the expression in the same block. See *SECURITY* for further discussion and examples.

Switches On the "#!" Line

When you make a script executable, in order to make it usable as a command, the system will pass switches to perl from the script's #! line. Perl checks that any command line switches given to a setuid (or setgid) script actually match the ones set on the #! line. Some Unix and Unix-like environments impose a one-switch limit on the #! line, so you may need to use something like `-wU` instead of `-w -U` under such systems. (This issue should arise only in Unix or Unix-like environments that support #! and setuid or setgid scripts.)

Cleaning Up Your Path

For "Insecure `$ENV{PATH}`" messages, you need to set `$ENV{'PATH'}` to a known value, and each directory in the path must be non-writable by others than its owner and group. You may be surprised to get this message even if the pathname to your executable is fully qualified. This is *not* generated because you didn't supply a full path to the program; instead, it's generated because you never set your PATH environment variable, or you didn't set it to something that was safe. Because Perl can't guarantee that the executable in question isn't itself going to turn around and execute some other program that is dependent on your PATH, it makes sure you set the PATH.

The PATH isn't the only environment variable which can cause problems. Because some shells may use the variables IFS, CDPATH, ENV, and BASH_ENV, Perl checks that those are either empty or untainted when starting subprocesses. You may wish to add something like this to your setid and taint-checking scripts.

```
delete @ENV{qw(IFS CDPATH ENV BASH_ENV)};   # Make %ENV safer
```

It's also possible to get into trouble with other operations that don't care whether they use tainted values. Make judicious use of the file tests in dealing with any user-supplied filenames. When possible, do opens and such **after** properly dropping any special user (or group!) privileges. Perl doesn't prevent you from opening tainted filenames for reading, so be careful what you print out. The tainting mechanism is intended to prevent stupid mistakes, not to remove the need for thought.

Perl does not call the shell to expand wild cards when you pass **system** and **exec** explicit parameter lists instead of strings with possible shell wildcards in them. Unfortunately, the **open**, **glob**, and backtick functions provide no such alternate calling convention, so more subterfuge will be required.

Perl provides a reasonably safe way to open a file or pipe from a setuid or setgid program: just create a child process with reduced privilege who does the dirty work for you. First, fork a child using the special **open** syntax that connects the parent and child by a pipe. Now the child resets its ID set and any other per-process attributes, like environment variables, umasks, current working directories, back to the originals or known safe values. Then the child process, which no longer has any special permissions, does the **open** or other system call. Finally, the child passes the data it managed to access back to the parent. Because the file or pipe was opened in the child while running under less privilege than the parent, it's not apt to be tricked into doing something it shouldn't.

Here's a way to do backticks reasonably safely. Notice how the **exec** is not called with a string that the shell could expand. This is by far the best way to call something that might be subjected to shell escapes: just never call the shell at all.

```
use English;
die "Can't fork: $!" unless defined($pid = open(KID, "-|"));
```

```
if ($pid) {           # parent
    while (<KID>) {
        # do something
    }
    close KID;
} else {
    my @temp     = ($EUID, $EGID);
    my $orig_uid = $UID;
    my $orig_gid = $GID;
    $EUID = $UID;
    $EGID = $GID;
    # Drop privileges
    $UID  = $orig_uid;
    $GID  = $orig_gid;
    # Make sure privs are really gone
    ($EUID, $EGID) = @temp;
    die "Can't drop privileges"
        unless $UID == $EUID  && $GID eq $EGID;
    $ENV{PATH} = "/bin:/usr/bin"; # Minimal PATH.
    # Consider sanitizing the environment even more.
    exec 'myprog', 'arg1', 'arg2'
        or die "can't exec myprog: $!";
}
```

A similar strategy would work for wildcard expansion via `glob`, although you can use `readdir` instead.

Taint checking is most useful when although you trust yourself not to have written a program to give away the farm, you don't necessarily trust those who end up using it not to try to trick it into doing something bad. This is the kind of security checking that's useful for set–id programs and programs launched on someone else's behalf, like CGI programs.

This is quite different, however, from not even trusting the writer of the code not to try to do something evil. That's the kind of trust needed when someone hands you a program you've never seen before and says, "Here, run this." For that kind of safety, check out the Safe module, included standard in the Perl distribution. This module allows the programmer to set up special compartments in which all system operations are trapped and namespace access is carefully controlled.

Security Bugs

Beyond the obvious problems that stem from giving special privileges to systems as flexible as scripts, on many versions of Unix, set–id scripts are inherently insecure right from the start. The problem is a race condition in the kernel. Between the time the kernel opens the file to see which interpreter to run and when the (now–set–id) interpreter turns around and reopens the file to interpret it, the file in question may have changed, especially if you have symbolic links on your system.

Fortunately, sometimes this kernel "feature" can be disabled. Unfortunately, there are two ways to disable it. The system can simply outlaw scripts with any set–id bit set, which doesn't help much. Alternately, it can simply ignore the set–id bits on scripts. If the latter is true, Perl can emulate the setuid and setgid mechanism when it notices the otherwise useless setuid/gid bits on Perl scripts. It does this via a special executable called **suidperl** that is automatically invoked for you if it's needed.

However, if the kernel set–id script feature isn't disabled, Perl will complain loudly that your set–id script is insecure. You'll need to either disable the kernel set–id script feature, or put a C wrapper around the script. A C wrapper is just a compiled program that does nothing except call your Perl program. Compiled programs are not subject to the kernel bug that plagues set–id scripts. Here's a simple wrapper, written in C:

```
#define REAL_PATH "/path/to/script"
main(ac, av)
```

```
    char **av;
{
    execv(REAL_PATH, av);
}
```

Compile this wrapper into a binary executable and then make *it* rather than your script setuid or setgid.

In recent years, vendors have begun to supply systems free of this inherent security bug. On such systems, when the kernel passes the name of the set–id script to open to the interpreter, rather than using a pathname subject to meddling, it instead passes */dev/fd/3*. This is a special file already opened on the script, so that there can be no race condition for evil scripts to exploit. On these systems, Perl should be compiled with `-DSETUID_SCRIPTS_ARE_SECURE_NOW`. The **Configure** program that builds Perl tries to figure this out for itself, so you should never have to specify this yourself. Most modern releases of SysVr4 and BSD 4.4 use this approach to avoid the kernel race condition.

Prior to release 5.6.1 of Perl, bugs in the code of **suidperl** could introduce a security hole.

Protecting Your Programs

There are a number of ways to hide the source to your Perl programs, with varying levels of "security".

First of all, however, you *can't* take away read permission, because the source code has to be readable in order to be compiled and interpreted. (That doesn't mean that a CGI script's source is readable by people on the web, though.) So you have to leave the permissions at the socially friendly 0755 level. This lets people on your local system only see your source.

Some people mistakenly regard this as a security problem. If your program does insecure things, and relies on people not knowing how to exploit those insecurities, it is not secure. It is often possible for someone to determine the insecure things and exploit them without viewing the source. Security through obscurity, the name for hiding your bugs instead of fixing them, is little security indeed.

You can try using encryption via source filters (Filter::* from CPAN). But crackers might be able to decrypt it. You can try using the byte code compiler and interpreter described below, but crackers might be able to de–compile it. You can try using the native–code compiler described below, but crackers might be able to disassemble it. These pose varying degrees of difficulty to people wanting to get at your code, but none can definitively conceal it (this is true of every language, not just Perl).

If you're concerned about people profiting from your code, then the bottom line is that nothing but a restrictive licence will give you legal security. License your software and pepper it with threatening statements like "This is unpublished proprietary software of XYZ Corp. Your access to it does not give you permission to use it blah blah blah." You should see a lawyer to be sure your licence's wording will stand up in court.

SEE ALSO

perlrun for its description of cleaning up environment variables.

NAME

perlstyle – Perl style guide

DESCRIPTION

Each programmer will, of course, have his or her own preferences in regards to formatting, but there are some general guidelines that will make your programs easier to read, understand, and maintain.

The most important thing is to run your programs under the **–w** flag at all times. You may turn it off explicitly for particular portions of code via the `use warnings` pragma or the `$^W` variable if you must. You should also always run under `use strict` or know the reason why not. The `use sigtrap` and even `use diagnostics` pragmas may also prove useful.

Regarding aesthetics of code lay out, about the only thing Larry cares strongly about is that the closing curly bracket of a multi–line BLOCK should line up with the keyword that started the construct. Beyond that, he has other preferences that aren't so strong:

- 4–column indent.
- Opening curly on same line as keyword, if possible, otherwise line up.
- Space before the opening curly of a multi–line BLOCK.
- One–line BLOCK may be put on one line, including curlies.
- No space before the semicolon.
- Semicolon omitted in "short" one–line BLOCK.
- Space around most operators.
- Space around a "complex" subscript (inside brackets).
- Blank lines between chunks that do different things.
- Uncuddled elses.
- No space between function name and its opening parenthesis.
- Space after each comma.
- Long lines broken after an operator (except "and" and "or").
- Space after last parenthesis matching on current line.
- Line up corresponding items vertically.
- Omit redundant punctuation as long as clarity doesn't suffer.

Larry has his reasons for each of these things, but he doesn't claim that everyone else's mind works the same as his does.

Here are some other more substantive style issues to think about:

- Just because you *CAN* do something a particular way doesn't mean that you *SHOULD* do it that way. Perl is designed to give you several ways to do anything, so consider picking the most readable one. For instance

  ```
  open(FOO,$foo) || die "Can't open $foo: $!";
  ```

  is better than

  ```
  die "Can't open $foo: $!" unless open(FOO,$foo);
  ```

  because the second way hides the main point of the statement in a modifier. On the other hand

  ```
  print "Starting analysis\n" if $verbose;
  ```

is better than

```
$verbose && print "Starting analysis\n";
```

because the main point isn't whether the user typed **-v** or not.

Similarly, just because an operator lets you assume default arguments doesn't mean that you have to make use of the defaults. The defaults are there for lazy systems programmers writing one-shot programs. If you want your program to be readable, consider supplying the argument.

Along the same lines, just because you *CAN* omit parentheses in many places doesn't mean that you ought to:

```
return print reverse sort num values %array;
return print(reverse(sort num (values(%array))));
```

When in doubt, parenthesize. At the very least it will let some poor schmuck bounce on the % key in **vi**.

Even if you aren't in doubt, consider the mental welfare of the person who has to maintain the code after you, and who will probably put parentheses in the wrong place.

- Don't go through silly contortions to exit a loop at the top or the bottom, when Perl provides the `last` operator so you can exit in the middle. Just "outdent" it a little to make it more visible:

```
LINE:
    for (;;) {
        statements;
      last LINE if $foo;
        next LINE if /^#/;
        statements;
    }
```

- Don't be afraid to use loop labels—they're there to enhance readability as well as to allow multilevel loop breaks. See the previous example.

- Avoid using `grep()` (or `map()`) or 'backticks' in a void context, that is, when you just throw away their return values. Those functions all have return values, so use them. Otherwise use a `foreach()` loop or the `system()` function instead.

- For portability, when using features that may not be implemented on every machine, test the construct in an eval to see if it fails. If you know what version or patchlevel a particular feature was implemented, you can test `$]` (`$PERL_VERSION` in `English`) to see if it will be there. The `Config` module will also let you interrogate values determined by the **Configure** program when Perl was installed.

- Choose mnemonic identifiers. If you can't remember what mnemonic means, you've got a problem.

- While short identifiers like `$gotit` are probably ok, use underscores to separate words. It is generally easier to read `$var_names_like_this` than `$VarNamesLikeThis`, especially for non-native speakers of English. It's also a simple rule that works consistently with VAR_NAMES_LIKE_THIS.

  Package names are sometimes an exception to this rule. Perl informally reserves lowercase module names for "pragma" modules like `integer` and `strict`. Other modules should begin with a capital letter and use mixed case, but probably without underscores due to limitations in primitive file systems' representations of module names as files that must fit into a few sparse bytes.

- You may find it helpful to use letter case to indicate the scope or nature of a variable. For example:

```
$ALL_CAPS_HERE   constants only (beware clashes with perl vars!)
$Some_Caps_Here  package-wide global/static
$no_caps_here    function scope my() or local() variables
```

Function and method names seem to work best as all lowercase. E.g., `$obj->as_string()`.

You can use a leading underscore to indicate that a variable or function should not be used outside the package that defined it.

- If you have a really hairy regular expression, use the `/x` modifier and put in some whitespace to make it look a little less like line noise. Don't use slash as a delimiter when your regexp has slashes or backslashes.
- Use the new "and" and "or" operators to avoid having to parenthesize list operators so much, and to reduce the incidence of punctuation operators like `&&` and `||`. Call your subroutines as if they were functions or list operators to avoid excessive ampersands and parentheses.
- Use here documents instead of repeated `print()` statements.
- Line up corresponding things vertically, especially if it'd be too long to fit on one line anyway.

```
$IDX = $ST_MTIME;
$IDX = $ST_ATIME       if $opt_u;
$IDX = $ST_CTIME       if $opt_c;
$IDX = $ST_SIZE        if $opt_s;

mkdir $tmpdir, 0700 or die "can't mkdir $tmpdir: $!";
chdir($tmpdir)      or die "can't chdir $tmpdir: $!";
mkdir 'tmp',   0777 or die "can't mkdir $tmpdir/tmp: $!";
```

- Always check the return codes of system calls. Good error messages should go to STDERR, include which program caused the problem, what the failed system call and arguments were, and (VERY IMPORTANT) should contain the standard system error message for what went wrong. Here's a simple but sufficient example:

```
opendir(D, $dir)     or die "can't opendir $dir: $!";
```

- Line up your transliterations when it makes sense:

```
tr [abc]
   [xyz];
```

- Think about reusability. Why waste brainpower on a one-shot when you might want to do something like it again? Consider generalizing your code. Consider writing a module or object class. Consider making your code run cleanly with `use strict` and `use warnings` (or **-w**) in effect Consider giving away your code. Consider changing your whole world view. Consider... oh, never mind.
- Be consistent.
- Be nice.

NAME

perlsub – Perl subroutines

SYNOPSIS

To declare subroutines:

```
sub NAME;                       # A "forward" declaration.
sub NAME(PROTO);                #  ditto, but with prototypes
sub NAME : ATTRS;               #  with attributes
sub NAME(PROTO) : ATTRS;        #  with attributes and prototypes

sub NAME BLOCK                  # A declaration and a definition.
sub NAME(PROTO) BLOCK           #  ditto, but with prototypes
sub NAME : ATTRS BLOCK          #  with attributes
sub NAME(PROTO) : ATTRS BLOCK #  with prototypes and attributes
```

To define an anonymous subroutine at runtime:

```
$subref = sub BLOCK;                  # no proto
$subref = sub (PROTO) BLOCK;          # with proto
$subref = sub : ATTRS BLOCK;          # with attributes
$subref = sub (PROTO) : ATTRS BLOCK; # with proto and attributes
```

To import subroutines:

```
use MODULE qw(NAME1 NAME2 NAME3);
```

To call subroutines:

```
NAME(LIST);    # & is optional with parentheses.
NAME LIST;     # Parentheses optional if predeclared/imported.
&NAME(LIST);   # Circumvent prototypes.
&NAME;         # Makes current @_ visible to called subroutine.
```

DESCRIPTION

Like many languages, Perl provides for user–defined subroutines. These may be located anywhere in the main program, loaded in from other files via the `do`, `require`, or `use` keywords, or generated on the fly using `eval` or anonymous subroutines. You can even call a function indirectly using a variable containing its name or a CODE reference.

The Perl model for function call and return values is simple: all functions are passed as parameters one single flat list of scalars, and all functions likewise return to their caller one single flat list of scalars. Any arrays or hashes in these call and return lists will collapse, losing their identities—but you may always use pass–by–reference instead to avoid this. Both call and return lists may contain as many or as few scalar elements as you'd like. (Often a function without an explicit return statement is called a subroutine, but there's really no difference from Perl's perspective.)

Any arguments passed in show up in the array `@_`. Therefore, if you called a function with two arguments, those would be stored in `$_[0]` and `$_[1]`. The array `@_` is a local array, but its elements are aliases for the actual scalar parameters. In particular, if an element `$_[0]` is updated, the corresponding argument is updated (or an error occurs if it is not updatable). If an argument is an array or hash element which did not exist when the function was called, that element is created only when (and if) it is modified or a reference to it is taken. (Some earlier versions of Perl created the element whether or not the element was assigned to.) Assigning to the whole array `@_` removes that aliasing, and does not update any arguments.

The return value of a subroutine is the value of the last expression evaluated. More explicitly, a `return` statement may be used to exit the subroutine, optionally specifying the returned value, which will be evaluated in the appropriate context (list, scalar, or void) depending on the context of the subroutine call. If you specify no return value, the subroutine returns an empty list in list context, the undefined value in scalar context, or nothing in void context. If you return one or more aggregates (arrays and hashes), these will be

flattened together into one large indistinguishable list.

Perl does not have named formal parameters. In practice all you do is assign to a `my()` list of these. Variables that aren't declared to be private are global variables. For gory details on creating private variables, see *"Private Variables via `my()`"* and *"Temporary Values via `local()`"*. To create protected environments for a set of functions in a separate package (and probably a separate file), see *Packages in perlmod*.

Example:

```
sub max {
    my $max = shift(@_);
    foreach $foo (@_) {
        $max = $foo if $max < $foo;
    }
    return $max;
}
$bestday = max($mon,$tue,$wed,$thu,$fri);
```

Example:

```
# get a line, combining continuation lines
#  that start with whitespace

sub get_line {
    $thisline = $lookahead;  # global variables!
    LINE: while (defined($lookahead = <STDIN>)) {
        if ($lookahead =~ /^[ \t]/) {
            $thisline .= $lookahead;
        }
        else {
            last LINE;
        }
    }
    return $thisline;
}

$lookahead = <STDIN>;       # get first line
while (defined($line = get_line())) {
    ...
}
```

Assigning to a list of private variables to name your arguments:

```
sub maybeset {
    my($key, $value) = @_;
    $Foo{$key} = $value unless $Foo{$key};
}
```

Because the assignment copies the values, this also has the effect of turning call–by–reference into call–by–value. Otherwise a function is free to do in–place modifications of `@_` and change its caller's values.

```
upcase_in($v1, $v2);  # this changes $v1 and $v2
sub upcase_in {
    for (@_) { tr/a-z/A-Z/ }
}
```

You aren't allowed to modify constants in this way, of course. If an argument were actually literal and you tried to change it, you'd take a (presumably fatal) exception. For example, this won't work:

```
upcase_in("frederick");
```

It would be much safer if the `upcase_in()` function were written to return a copy of its parameters instead of changing them in place:

```
($v3, $v4) = upcase($v1, $v2);  # this doesn't change $v1 and $v2
sub upcase {
    return unless defined wantarray;  # void context, do nothing
    my @parms = @_;
    for (@parms) { tr/a-z/A-Z/ }
    return wantarray ? @parms : $parms[0];
}
```

Notice how this (unprototyped) function doesn't care whether it was passed real scalars or arrays. Perl sees all arguments as one big, long, flat parameter list in `@_`. This is one area where Perl's simple argument-passing style shines. The `upcase()` function would work perfectly well without changing the `upcase()` definition even if we fed it things like this:

```
@newlist   = upcase(@list1, @list2);
@newlist   = upcase( split /:/, $var );
```

Do not, however, be tempted to do this:

```
(@a, @b)   = upcase(@list1, @list2);
```

Like the flattened incoming parameter list, the return list is also flattened on return. So all you have managed to do here is stored everything in `@a` and made `@b` an empty list. See *Pass by Reference* for alternatives.

A subroutine may be called using an explicit `&` prefix. The `&` is optional in modern Perl, as are parentheses if the subroutine has been predeclared. The `&` is *not* optional when just naming the subroutine, such as when it's used as an argument to `defined()` or `undef()`. Nor is it optional when you want to do an indirect subroutine call with a subroutine name or reference using the `&$subref()` or `&{$subref}()` constructs, although the `< $subref->()` notation solves that problem. See *perlref* for more about all that.

Subroutines may be called recursively. If a subroutine is called using the `&` form, the argument list is optional, and if omitted, no `@_` array is set up for the subroutine: the `@_` array at the time of the call is visible to subroutine instead. This is an efficiency mechanism that new users may wish to avoid.

```
&foo(1,2,3);          # pass three arguments
foo(1,2,3);           # the same

foo();                # pass a null list
&foo();               # the same

&foo;                 # foo() get current args, like foo(@_) !!
foo;                  # like foo() IFF sub foo predeclared, else "foo"
```

Not only does the `&` form make the argument list optional, it also disables any prototype checking on arguments you do provide. This is partly for historical reasons, and partly for having a convenient way to cheat if you know what you're doing. See *Prototypes* below.

Functions whose names are in all upper case are reserved to the Perl core, as are modules whose names are in all lower case. A function in all capitals is a loosely-held convention meaning it will be called indirectly by the run-time system itself, usually due to a triggered event. Functions that do special, pre-defined things include `BEGIN`, `CHECK`, `INIT`, `END`, `AUTOLOAD`, and `DESTROY`—plus all functions mentioned in *perltie*.

Private Variables via `my()`

Synopsis:

```
my $foo;            # declare $foo lexically local
my (@wid, %get);    # declare list of variables local
```

```
    my $foo = "f#ude";  declare $foo lexical, and init it
    my @oof = @bar;     declare @oof lexical, and init it
    my $x : Foo # $y;   similar, with an attribute applied
```

WARNING: The use of attribute lists on my declarations is experimental. This feature should not be relied upon. It may change or disappear in future releases of Perl. See *attributes*.

The my operator declares the listed variables to be lexically confined to the enclosing block, conditional (if/unless/elsif/else), loop (for/foreach/while/until/continue), subroutine, eval, or do/require/use'd file. If more than one value is listed, the list must be placed in parentheses. All listed elements must be legal lvalues. Only alphanumeric identifiers may be lexically scoped—magical built–ins like $/ must currently be localize with local instead.

Unlike dynamic variables created by the local operator, lexical variables declared with my are totally hidden from the outside world, including any called subroutines. This is true if it's the same subroutine called from itself or elsewhere—every call gets its own copy.

This doesn't mean that a my variable declared in a statically enclosing lexical scope would be invisible. Only dynamic scopes are cut off. For example, the bumpx() function below has access to the lexical $x variable because both the my and the sub occurred at the same scope, presumably file scope.

```
    my $x = 10;
    sub bumpx { $x++ }
```

An eval(), however, can see lexical variables of the scope it is being evaluated in, so long as the names aren't hidden by declarations within the eval() itself. See *perlref*.

The parameter list to my() may be assigned to if desired, which allows you to initialize your variables. (If no initializer is given for a particular variable, it is created with the undefined value.) Commonly this is used to name input parameters to a subroutine. Examples:

```
    $arg = "fred";        # "global" variable
    $n = cube_root(27);
    print "$arg thinks the root is $n\n";
 fred thinks the root is 3

    sub cube_root {
        my $arg = shift;  # name doesn't matter
        $arg **= 1/3;
        return $arg;
    }
```

The my is simply a modifier on something you might assign to. So when you do assign to variables in its argument list, my doesn't change whether those variables are viewed as a scalar or an array. So

```
    my ($foo) = <STDIN>;                # WRONG?
    my @FOO = <STDIN>;
```

both supply a list context to the right–hand side, while

```
    my $foo = <STDIN>;
```

supplies a scalar context. But the following declares only one variable:

```
    my $foo, $bar = 1;                  # WRONG
```

That has the same effect as

```
    my $foo;
    $bar = 1;
```

The declared variable is not introduced (is not visible) until after the current statement. Thus,

```
my $x = $x;
```

can be used to initialize a new $x with the value of the old $x, and the expression

```
my $x = 123 and $x == 123
```

is false unless the old $x happened to have the value 123.

Lexical scopes of control structures are not bounded precisely by the braces that delimit their controlled blocks; control expressions are part of that scope, too. Thus in the loop

```
while (my $line = <>) {
    $line = lc $line;
} continue {
    print $line;
}
```

the scope of $line extends from its declaration throughout the rest of the loop construct (including the continue clause), but not beyond it. Similarly, in the conditional

```
if ((my $answer = <STDIN>) =~ /^yes$/i) {
    user_agrees();
} elsif ($answer =~ /^no$/i) {
    user_disagrees();
} else {
    chomp $answer;
    die "'$answer' is neither 'yes' nor 'no'";
}
```

the scope of $answer extends from its declaration through the rest of that conditional, including any elsif and else clauses, but not beyond it.

None of the foregoing text applies to if/unless or while/until modifiers appended to simple statements. Such modifiers are not control structures and have no effect on scoping.

The foreach loop defaults to scoping its index variable dynamically in the manner of local. However, if the index variable is prefixed with the keyword my, or if there is already a lexical by that name in scope, then a new lexical is created instead. Thus in the loop

```
for my $i (1, 2, 3) {
    some_function();
}
```

the scope of $i extends to the end of the loop, but not beyond it, rendering the value of $i inaccessible within some_function().

Some users may wish to encourage the use of lexically scoped variables. As an aid to catching implicit uses to package variables, which are always global, if you say

```
use strict 'vars';
```

then any variable mentioned from there to the end of the enclosing block must either refer to a lexical variable, be predeclared via our or use vars, or else must be fully qualified with the package name. A compilation error results otherwise. An inner block may countermand this with no strict 'vars'.

A my has both a compile–time and a run–time effect. At compile time, the compiler takes notice of it. The principal usefulness of this is to quiet use strict 'vars', but it is also essential for generation of closures as detailed in *perlref*. Actual initialization is delayed until run time, though, so it gets executed at the appropriate time, such as each time through a loop, for example.

Variables declared with my are not part of any package and are therefore never fully qualified with the package name. In particular, you're not allowed to try to make a package variable (or other global) lexical:

```
my $pack::va#;ERROR!  Illegal syntax
my $_;      # also illegal (currently)
```

In fact, a dynamic variable (also known as package or global variables) are still accessible using the fully qualified `::` notation even while a lexical of the same name is also visible:

```
package main;
local $x = 10;
my    $x = 20;
print "$x and $::x\n";
```

That will print out `20` and `10`.

You may declare `my` variables at the outermost scope of a file to hide any such identifiers from the world outside that file. This is similar in spirit to C‘s static variables when they are used at the file level. To do this with a subroutine requires the use of a closure (an anonymous function that accesses enclosing lexicals). If you want to create a private subroutine that cannot be called from outside that block, it can declare a lexical variable containing an anonymous sub reference:

```
my $secret_version = '1.001-beta';
my $secret_sub = sub { print $secret_version };
&$secret_sub();
```

As long as the reference is never returned by any function within the module, no outside module can see the subroutine, because its name is not in any package‘s symbol table. Remember that it‘s not *REALLY* called `$some_pack::secret_version` or anything; it‘s just `$secret_version`, unqualified and unqualifiable.

This does not work with object methods, however; all object methods have to be in the symbol table of some package to be found. See *Function Templates in perlref* for something of a work–around to this.

Persistent Private Variables

Just because a lexical variable is lexically (also called statically) scoped to its enclosing block, `eval`, or `do` FILE, this doesn‘t mean that within a function it works like a C static. It normally works more like a C auto, but with implicit garbage collection.

Unlike local variables in C or C++, Perl‘s lexical variables don‘t necessarily get recycled just because their scope has exited. If something more permanent is still aware of the lexical, it will stick around. So long as something else references a lexical, that lexical won‘t be freed—which is as it should be. You wouldn‘t want memory being free until you were done using it, or kept around once you were done. Automatic garbage collection takes care of this for you.

This means that you can pass back or save away references to lexical variables, whereas to return a pointer to a C auto is a grave error. It also gives us a way to simulate C‘s function statics. Here‘s a mechanism for giving a function private variables with both lexical scoping and a static lifetime. If you do want to create something like C‘s static variables, just enclose the whole function in an extra block, and put the static variable outside the function but in the block.

```
{
    my $secret_val = 0;
    sub gimme_another {
        return ++$secret_val;
    }
}
# $secret_val now becomes unreachable by the outside
# world, but retains its value between calls to gimme_another
```

If this function is being sourced in from a separate file via `require` or `use`, then this is probably just fine. If it‘s all in the main program, you‘ll need to arrange for the `my` to be executed early, either by putting the whole block above your main program, or more likely, placing merely a `BEGIN` sub around it to make sure it

gets executed before your program starts to run:

```
sub BEGIN {
    my $secret_val = 0;
    sub gimme_another {
        return ++$secret_val;
    }
}
```

See *Package Constructors and Destructors in perlmod* about the special triggered functions, BEGIN, CHECK, INIT and END.

If declared at the outermost scope (the file scope), then lexicals work somewhat like C's file statics. They are available to all functions in that same file declared below them, but are inaccessible from outside that file. This strategy is sometimes used in modules to create private variables that the whole module can see.

Temporary Values via local()

WARNING: In general, you should be using my instead of local, because it's faster and safer. Exceptions to this include the global punctuation variables, filehandles and formats, and direct manipulation of the Perl symbol table itself. Format variables often use local though, as do other variables whose current value must be visible to called subroutines.

Synopsis:

```
local $foo;                 # declare $foo dynamically local
local (@wid, %get);         # declare list of variables local
local $foo = "flurp";       # declare $foo dynamic, and init it
local @oof = @bar;          # declare @oof dynamic, and init it

local *FH;                  # localize $FH, @FH, %FH, &FH  ...
local *merlyn = *randal;    # now $merlyn is really $randal, plus
                            #     @merlyn is really @randal, etc
local *merlyn = 'randal';   # SAME THING: promote 'randal' to *randal
local *merlyn = \$randal;   # just alias $merlyn, not @merlyn etc
```

A local modifies its listed variables to be "local" to the enclosing block, eval, or do FILE—and to *any subroutine called from within that block*. A local just gives temporary values to global (meaning package) variables. It does *not* create a local variable. This is known as dynamic scoping. Lexical scoping is done with my, which works more like C's auto declarations.

If more than one variable is given to local, they must be placed in parentheses. All listed elements must be legal lvalues. This operator works by saving the current values of those variables in its argument list on a hidden stack and restoring them upon exiting the block, subroutine, or eval. This means that called subroutines can also reference the local variable, but not the global one. The argument list may be assigned to if desired, which allows you to initialize your local variables. (If no initializer is given for a particular variable, it is created with an undefined value.) Commonly this is used to name the parameters to a subroutine. Examples:

```
for $i ( 0 .. 9 ) {
    $digits{$i} = $i;
}
# assume this function uses global %digits hash
parse_num();

# now temporarily add to %digits hash
if ($base12) {
    # (NOTE: not claiming this is efficient!)
    local %digits  = (%digits, 't' => 10, 'e' => 11);
    parse_num();  # parse_num gets this new %digits!
}
```

```
    # old %digits restored here
```

Because `local` is a run–time operator, it gets executed each time through a loop. In releases of Perl previous to 5.0, this used more stack storage each time until the loop was exited. Perl now reclaims the space each time through, but it's still more efficient to declare your variables outside the loop.

A `local` is simply a modifier on an lvalue expression. When you assign to a `local`ized variable, the `local` doesn't change whether its list is viewed as a scalar or an array. So

```
    local($foo) = <STDIN>;
    local @FOO = <STDIN>;
```

both supply a list context to the right–hand side, while

```
    local $foo = <STDIN>;
```

supplies a scalar context.

A note about `local()` and composite types is in order. Something like `local(%foo)` works by temporarily placing a brand new hash in the symbol table. The old hash is left alone, but is hidden "behind" the new one.

This means the old variable is completely invisible via the symbol table (i.e. the hash entry in the `*foo` typeglob) for the duration of the dynamic scope within which the `local()` was seen. This has the effect of allowing one to temporarily occlude any magic on composite types. For instance, this will briefly alter a tied hash to some other implementation:

```
    tie %ahash, 'APackage';
    [...]
    {
       local %ahash;
       tie %ahash, 'BPackage';
       [..called code will see %ahash tied to 'BPackage'..]
       {
          local %ahash;
          [..%ahash is a normal (untied) hash here..]
       }
    }
    [..%ahash back to its initial tied self again..]
```

As another example, a custom implementation of `%ENV` might look like this:

```
    {
        local %ENV;
        tie %ENV, 'MyOwnEnv';
        [..do your own fancy %ENV manipulation here..]
    }
    [..normal %ENV behavior here..]
```

It's also worth taking a moment to explain what happens when you `local`ize a member of a composite type (i.e. an array or hash element). In this case, the element is `local`ized *by name*. This means that when the scope of the `local()` ends, the saved value will be restored to the hash element whose key was named in the `local()`, or the array element whose index was named in the `local()`. If that element was deleted while the `local()` was in effect (e.g. by a `delete()` from a hash or a `shift()` of an array), it will spring back into existence, possibly extending an array and filling in the skipped elements with `undef`. For instance, if you say

```
    %hash = ( 'This' => 'is', 'a' => 'test' );
    @ary  = ( 0..5 );
    {
         local($ary[5]) = 6;
```

```
        local($hash{'a'}) = 'drill';
        while (my $e = pop(@ary)) {
            print "$e . . .\n";
            last unless $e > 3;
        }
        if (@ary) {
            $hash{'only a'} = 'test';
            delete $hash{'a'};
        }
    }
    print join(' ', map { "$_ $hash{$_}" } sort keys %hash),".\n";
    print "The array has ",scalar(@ary)," elements: ",
          join(', ', map { defined $_ ? $_ : 'undef' } @ary),"\n";
```

Perl will print

```
6 . . .
4 . . .
3 . . .
This is a test only a test.
The array has 6 elements: 0, 1, 2, undef, undef, 5
```

The behavior of `local()` on non−existent members of composite types is subject to change in future.

Lvalue subroutines

WARNING: Lvalue subroutines are still experimental and the implementation may change in future versions of Perl.

It is possible to return a modifiable value from a subroutine. To do this, you have to declare the subroutine to return an lvalue.

```
my $val;
sub canmod : lvalue {
    $val;
}
sub nomod {
    $val;
}

canmod() = 5;   # assigns to $val
nomod()  = 5;   # ERROR
```

The scalar/list context for the subroutine and for the right−hand side of assignment is determined as if the subroutine call is replaced by a scalar. For example, consider:

```
data(2,3) = get_data(3,4);
```

Both subroutines here are called in a scalar context, while in:

```
(data(2,3)) = get_data(3,4);
```

and in:

```
(data(2),data(3)) = get_data(3,4);
```

all the subroutines are called in a list context.

The current implementation does not allow arrays and hashes to be returned from lvalue subroutines directly. You may return a reference instead. This restriction may be lifted in future.

Passing Symbol Table Entries (typeglobs)

WARNING: The mechanism described in this section was originally the only way to simulate pass−by−reference in older versions of Perl. While it still works fine in modern versions, the new reference mechanism is generally easier to work with. See below.

Sometimes you don't want to pass the value of an array to a subroutine but rather the name of it, so that the subroutine can modify the global copy of it rather than working with a local copy. In perl you can refer to all objects of a particular name by prefixing the name with a star: `*foo`. This is often known as a "typeglob", because the star on the front can be thought of as a wildcard match for all the funny prefix characters on variables and subroutines and such.

When evaluated, the typeglob produces a scalar value that represents all the objects of that name, including any filehandle, format, or subroutine. When assigned to, it causes the name mentioned to refer to whatever `*` value was assigned to it. Example:

```
sub doubleary {
    local(*someary) = @_;
    foreach $elem (@someary) {
        $elem *= 2;
    }
}
doubleary(*foo);
doubleary(*bar);
```

Scalars are already passed by reference, so you can modify scalar arguments without using this mechanism by referring explicitly to `$_[0]` etc. You can modify all the elements of an array by passing all the elements as scalars, but you have to use the `*` mechanism (or the equivalent reference mechanism) to `push`, `pop`, or change the size of an array. It will certainly be faster to pass the typeglob (or reference).

Even if you don't want to modify an array, this mechanism is useful for passing multiple arrays in a single LIST, because normally the LIST mechanism will merge all the array values so that you can't extract out the individual arrays. For more on typeglobs, see *Typeglobs and Filehandles in perldata*.

When to Still Use `local()`

Despite the existence of `my`, there are still three places where the `local` operator still shines. In fact, in these three places, you *must* use `local` instead of `my`.

1. You need to give a global variable a temporary value, especially `$_`.

   The global variables, like `@ARGV` or the punctuation variables, must be `local`ized with `local()`. This block reads in ***/etc/motd***, and splits it up into chunks separated by lines of equal signs, which are placed in `@Fields`.

   ```
   {
       local @ARGV = ("/etc/motd");
       local $/ = undef;
       local $_ = <>;
       @Fields = split /^\s*=+\s*$/;
   }
   ```

   It particular, it's important to `local`ize `$_` in any routine that assigns to it. Look out for implicit assignments in `while` conditionals.

2. You need to create a local file or directory handle or a local function.

   A function that needs a filehandle of its own must use `local()` on a complete typeglob. This can be used to create new symbol table entries:

   ```
   sub ioqueue {
       local  (*READER, *WRITER);    # not my!
       pipe    (READER,  WRITER);    or die "pipe: $!";
   ```

```
        return (*READER, *WRITER);
    }
    ($head, $tail) = ioqueue();
```

See the Symbol module for a way to create anonymous symbol table entries.

Because assignment of a reference to a typeglob creates an alias, this can be used to create what is effectively a local function, or at least, a local alias.

```
    {
        local *grow = \&shrink; # only until this block exists
        grow();                 # really calls shrink()
        move();                 # if move() grow()s, it shrink()s too
    }
    grow();                     # get the real grow() again
```

See *Function Templates in perlref* for more about manipulating functions by name in this way.

3. You want to temporarily change just one element of an array or hash.

You can `localize` just one element of an aggregate. Usually this is done on dynamics:

```
    {
        local $SIG{INT} = 'IGNORE';
        funct();                            # uninterruptible
    }
    # interruptibility automatically restored here
```

But it also works on lexically declared aggregates. Prior to 5.005, this operation could on occasion misbehave.

Pass by Reference

If you want to pass more than one array or hash into a function—or return them from it—and have them maintain their integrity, then you're going to have to use an explicit pass–by–reference. Before you do that, you need to understand references as detailed in *perlref*. This section may not make much sense to you otherwise.

Here are a few simple examples. First, let's pass in several arrays to a function and have it `pop` all of then, returning a new list of all their former last elements:

```
@tailings = popmany ( \@a, \@b, \@c, \@d );

sub popmany {
    my $aref;
    my @retlist = ();
    foreach $aref ( @_ ) {
        push @retlist, pop @$aref;
    }
    return @retlist;
}
```

Here's how you might write a function that returns a list of keys occurring in all the hashes passed to it:

```
@common = inter( \%foo, \%bar, \%joe );
sub inter {
    my ($k, $href, %seen); # locals
    foreach $href (@_) {
        while ( $k = each %$href ) {
            $seen{$k}++;
        }
    }
    return grep { $seen{$_} == @_ } keys %seen;
```

```
}
```

So far, we're using just the normal list return mechanism. What happens if you want to pass or return a hash? Well, if you're using only one of them, or you don't mind them concatenating, then the normal calling convention is ok, although a little expensive.

Where people get into trouble is here:

```
(@a, @b) = func(@c, @d);
```

or

```
(%a, %b) = func(%c, %d);
```

That syntax simply won't work. It sets just `@a` or `%a` and clears the `@b` or `%b`. Plus the function didn't get passed into two separate arrays or hashes: it got one long list in `@_`, as always.

If you can arrange for everyone to deal with this through references, it's cleaner code, although not so nice to look at. Here's a function that takes two array references as arguments, returning the two array elements in order of how many elements they have in them:

```
($aref, $bref) = func(\@c, \@d);
print "@$aref has more than @$bref\n";
sub func {
    my ($cref, $dref) = @_;
    if (@$cref > @$dref) {
        return ($cref, $dref);
    } else {
        return ($dref, $cref);
    }
}
```

It turns out that you can actually do this also:

```
(*a, *b) = func(\@c, \@d);
print "@a has more than @b\n";
sub func {
    local (*c, *d) = @_;
    if (@c > @d) {
        return (\@c, \@d);
    } else {
        return (\@d, \@c);
    }
}
```

Here we're using the typeglobs to do symbol table aliasing. It's a tad subtle, though, and also won't work if you're using `my` variables, because only globals (even in disguise as `locals`) are in the symbol table.

If you're passing around filehandles, you could usually just use the bare typeglob, like `*STDOUT`, but typeglobs references work, too. For example:

```
splutter(\*STDOUT);
sub splutter {
    my $fh = shift;
    print $fh "her um well a hmmm\n";
}

$rec = get_rec(\*STDIN);
sub get_rec {
    my $fh = shift;
    return scalar <$fh>;
}
```

If you're planning on generating new filehandles, you could do this. Notice to pass back just the bare *FH, not its reference.

```
sub openit {
    my $path = shift;
    local *FH;
    return open (FH, $path) ? *FH : undef;
}
```

Prototypes

Perl supports a very limited kind of compile−time argument checking using function prototyping. If you declare

```
sub mypush (\@@)
```

then `mypush()` takes arguments exactly like `push()` does. The function declaration must be visible at compile time. The prototype affects only interpretation of new−style calls to the function, where new−style is defined as not using the `&` character. In other words, if you call it like a built−in function, then it behaves like a built−in function. If you call it like an old−fashioned subroutine, then it behaves like an old−fashioned subroutine. It naturally falls out from this rule that prototypes have no influence on subroutine references like `\&foo` or on indirect subroutine calls like `&{$subref}` or `< $subref-() .`

Method calls are not influenced by prototypes either, because the function to be called is indeterminate at compile time, since the exact code called depends on inheritance.

Because the intent of this feature is primarily to let you define subroutines that work like built−in functions, here are prototypes for some other functions that parse almost exactly like the corresponding built−in.

```
Declared as                 Called as

sub mylink ($$)           mylink $old, $new
sub myvec ($$$)           myvec $var, $offset, 1
sub myindex ($$;$)        myindex &getstring, "substr"
sub mysyswrite ($$$;$)    mysyswrite $buf, 0, length($buf) - $off, $off
sub myreverse (@)         myreverse $a, $b, $c
sub myjoin ($@)           myjoin ":", $a, $b, $c
sub mypop (\@)            mypop @array
sub mysplice (\@$$@)      mysplice @array, @array, 0, @pushme
sub mykeys (\%)           mykeys %{$hashref}
sub myopen (*;$)          myopen HANDLE, $name
sub mypipe (**)           mypipe READHANDLE, WRITEHANDLE
sub mygrep (&@)           mygrep { /foo/ } $a, $b, $c
sub myrand ($)            myrand 42
sub mytime ()             mytime
```

Any backslashed prototype character represents an actual argument that absolutely must start with that character. The value passed as part of `@_` will be a reference to the actual argument given in the subroutine call, obtained by applying `\` to that argument.

Unbackslashed prototype characters have special meanings. Any unbackslashed `@` or `%` eats all remaining arguments, and forces list context. An argument represented by `$` forces scalar context. An `&` requires an anonymous subroutine, which, if passed as the first argument, does not require the `sub` keyword or a subsequent comma.

A `*` allows the subroutine to accept a bareword, constant, scalar expression, typeglob, or a reference to a typeglob in that slot. The value will be available to the subroutine either as a simple scalar, or (in the latter two cases) as a reference to the typeglob. If you wish to always convert such arguments to a typeglob reference, use `Symbol::qualify_to_ref()` as follows:

```
use Symbol 'qualify_to_ref';
```

```
sub foo (*) {
    my $fh = qualify_to_ref(shift, caller);
    ...
}
```

A semicolon separates mandatory arguments from optional arguments. It is redundant before `@` or `%`, which gobble up everything else.

Note how the last three examples in the table above are treated specially by the parser. `mygrep()` is parsed as a true list operator, `myrand()` is parsed as a true unary operator with unary precedence the same as `rand()`, and `mytime()` is truly without arguments, just like `time()`. That is, if you say

```
mytime +2;
```

you'll get `mytime() + 2`, not `mytime(2)`, which is how it would be parsed without a prototype.

The interesting thing about `&` is that you can generate new syntax with it, provided it's in the initial position:

```
sub try (&@) {
    my($try,$catch) = @_;
    eval { &$try };
    if ($@) {
        local $_ = $@;
        &$catch;
    }
}
sub catch (&) { $_[0] }

try {
    die "phooey";
} catch {
    /phooey/ and print "unphooey\n";
};
```

That prints `"unphooey"`. (Yes, there are still unresolved issues having to do with visibility of `@_`. I'm ignoring that question for the moment. (But note that if we make `@_` lexically scoped, those anonymous subroutines can act like closures... (Gee, is this sounding a little Lispish? (Never mind.))))

And here's a reimplementation of the Perl `grep` operator:

```
sub mygrep (&@) {
    my $code = shift;
    my @result;
    foreach $_ (@_) {
        push(@result, $_) if &$code;
    }
    @result;
}
```

Some folks would prefer full alphanumeric prototypes. Alphanumerics have been intentionally left out of prototypes for the express purpose of someday in the future adding named, formal parameters. The current mechanism's main goal is to let module writers provide better diagnostics for module users. Larry feels the notation quite understandable to Perl programmers, and that it will not intrude greatly upon the meat of the module, nor make it harder to read. The line noise is visually encapsulated into a small pill that's easy to swallow.

It's probably best to prototype new functions, not retrofit prototyping into older ones. That's because you must be especially careful about silent impositions of differing list versus scalar contexts. For example, if you decide that a function should take just one parameter, like this:

```
sub func ($) {
    my $n = shift;
    print "you gave me $n\n";
}
```

and someone has been calling it with an array or expression returning a list:

```
func(@foo);
func( split /:/ );
```

Then you've just supplied an automatic `scalar` in front of their argument, which can be more than a bit surprising. The old `@foo` which used to hold one thing doesn't get passed in. Instead, `func()` now gets passed in a `1`; that is, the number of elements in `@foo`. And the `split` gets called in scalar context so it starts scribbling on your `@_` parameter list. Ouch!

This is all very powerful, of course, and should be used only in moderation to make the world a better place.

Constant Functions

Functions with a prototype of `()` are potential candidates for inlining. If the result after optimization and constant folding is either a constant or a lexically–scoped scalar which has no other references, then it will be used in place of function calls made without `&`. Calls made using `&` are never inlined. (See ***constant.pm*** for an easy way to declare most constants.)

The following functions would all be inlined:

```
sub pi ()           { 3.14159 }             # Not exact, but close.
sub PI ()           { 4 * atan2 1, 1 }      # As good as it gets,
                                            # and it's inlined, too!
sub ST_DEV ()       { 0 }
sub ST_INO ()       { 1 }

sub FLAG_FOO ()     { 1 << 8 }
sub FLAG_BAR ()     { 1 << 9 }
sub FLAG_MASK ()    { FLAG_FOO | FLAG_BAR }

sub OPT_BAZ ()      { not (0x1B58 & FLAG_MASK) }
sub BAZ_VAL () {
    if (OPT_BAZ) {
        return 23;
    }
    else {
        return 42;
    }
}

sub N () { int(BAZ_VAL) / 3 }
BEGIN {
    my $prod = 1;
    for (1..N) { $prod *= $_ }
    sub N_FACTORIAL () { $prod }
}
```

If you redefine a subroutine that was eligible for inlining, you'll get a mandatory warning. (You can use this warning to tell whether or not a particular subroutine is considered constant.) The warning is considered severe enough not to be optional because previously compiled invocations of the function will still be using the old value of the function. If you need to be able to redefine the subroutine, you need to ensure that it isn't inlined, either by dropping the `()` prototype (which changes calling semantics, so beware) or by thwarting the inlining mechanism in some other way, such as

```
sub not_inlined () {
```

```
    23 if $];
}
```

Overriding Built–in Functions

Many built–in functions may be overridden, though this should be tried only occasionally and for good reason. Typically this might be done by a package attempting to emulate missing built–in functionality on a non–Unix system.

Overriding may be done only by importing the name from a module—ordinary predeclaration isn't good enough. However, the `use subs` pragma lets you, in effect, predeclare subs via the import syntax, and these names may then override built–in ones:

```
use subs 'chdir', 'chroot', 'chmod', 'chown';
chdir $somewhere;
sub chdir { ... }
```

To unambiguously refer to the built–in form, precede the built–in name with the special package qualifier `CORE::`. For example, saying `CORE::open()` always refers to the built–in `open()`, even if the current package has imported some other subroutine called `&open()` from elsewhere. Even though it looks like a regular function call, it isn't: you can't take a reference to it, such as the incorrect `\&CORE::open` might appear to produce.

Library modules should not in general export built–in names like `open` or `chdir` as part of their default `@EXPORT` list, because these may sneak into someone else's namespace and change the semantics unexpectedly. Instead, if the module adds that name to `@EXPORT_OK`, then it's possible for a user to import the name explicitly, but not implicitly. That is, they could say

```
use Module 'open';
```

and it would import the `open` override. But if they said

```
use Module;
```

they would get the default imports without overrides.

The foregoing mechanism for overriding built–in is restricted, quite deliberately, to the package that requests the import. There is a second method that is sometimes applicable when you wish to override a built–in everywhere, without regard to namespace boundaries. This is achieved by importing a sub into the special namespace `CORE::GLOBAL::`. Here is an example that quite brazenly replaces the `glob` operator with something that understands regular expressions.

```
package REGlob;
require Exporter;
@ISA = 'Exporter';
@EXPORT_OK = 'glob';

sub import {
    my $pkg = shift;
    return unless @_;
    my $sym = shift;
    my $where = ($sym =~ s/^GLOBAL_// ? 'CORE::GLOBAL' : caller(0));
    $pkg->export($where, $sym, @_);
}

sub glob {
    my $pat = shift;
    my @got;
    local *D;
    if (opendir D, '.') {
        @got = grep /$pat/, readdir D;
        closedir D;
```

```
    }
    return @got;
}
1;
```

And here's how it could be (ab)used:

```
#use REGlob 'GLOBAL_glob';      # override glob() in ALL namespaces
package Foo;
use REGlob 'glob';              # override glob() in Foo:: only
print for <^[a-z_]+\.pm\$>;     # show all pragmatic modules
```

The initial comment shows a contrived, even dangerous example. By overriding `glob` globally, you would be forcing the new (and subversive) behavior for the `glob` operator for *every* namespace, without the complete cognizance or cooperation of the modules that own those namespaces. Naturally, this should be done with extreme caution—if it must be done at all.

The `REGlob` example above does not implement all the support needed to cleanly override perl's `glob` operator. The built–in `glob` has different behaviors depending on whether it appears in a scalar or list context, but our `REGlob` doesn't. Indeed, many perl built–in have such context sensitive behaviors, and these must be adequately supported by a properly written override. For a fully functional example of overriding `glob`, study the implementation of `File::DosGlob` in the standard library.

Autoloading

If you call a subroutine that is undefined, you would ordinarily get an immediate, fatal error complaining that the subroutine doesn't exist. (Likewise for subroutines being used as methods, when the method doesn't exist in any base class of the class's package.) However, if an `AUTOLOAD` subroutine is defined in the package or packages used to locate the original subroutine, then that `AUTOLOAD` subroutine is called with the arguments that would have been passed to the original subroutine. The fully qualified name of the original subroutine magically appears in the global `$AUTOLOAD` variable of the same package as the `AUTOLOAD` routine. The name is not passed as an ordinary argument because, er, well, just because, that's why...

Many `AUTOLOAD` routines load in a definition for the requested subroutine using `eval()`, then execute that subroutine using a special form of `goto()` that erases the stack frame of the `AUTOLOAD` routine without a trace. (See the source to the standard module documented in *AutoLoader*, for example.) But an `AUTOLOAD` routine can also just emulate the routine and never define it. For example, let's pretend that a function that wasn't defined should just invoke `system` with those arguments. All you'd do is:

```
sub AUTOLOAD {
    my $program = $AUTOLOAD;
    $program =~ s/.*::/;
    system($program, @_);
}
date();
who('am', 'i');
ls('-l');
```

In fact, if you predeclare functions you want to call that way, you don't even need parentheses:

```
use subs qw(date who ls);
date;
who "am", "i";
ls -l;
```

A more complete example of this is the standard Shell module, which can treat undefined subroutine calls as calls to external programs.

Mechanisms are available to help modules writers split their modules into autoloadable files. See the standard AutoLoader module described in *AutoLoader* and in *AutoSplit*, the standard SelfLoader modules in

SelfLoader, and the document on adding C functions to Perl code in *perlxs*.

Subroutine Attributes

A subroutine declaration or definition may have a list of attributes associated with it. If such an attribute list is present, it is broken up at space or colon boundaries and treated as though a `use attributes` had been seen. See *attributes* for details about what attributes are currently supported. Unlike the limitation with the obsolescent `use attrs`, the `sub : ATTRLIST` syntax works to associate the attributes with a pre−declaration, and not just with a subroutine definition.

The attributes must be valid as simple identifier names (without any punctuation other than the '_' character). They may have a parameter list appended, which is only checked for whether its parentheses ('(',')') nest properly.

Examples of valid syntax (even though the attributes are unknown):

```
sub fnord (&\%) : switch(10,foo(7,3))  :  expensive ;
sub plugh () : Ugly('\(") :Bad ;
sub xyzzy : _5x5 { ... }
```

Examples of invalid syntax:

```
sub fnord : switch(10,foo() ; # ()-string not balanced
sub snoid : Ugly('(') ;       # ()-string not balanced
sub xyzzy : 5x5 ;             # "5x5" not a valid identifier
sub plugh : Y2::north ;       # "Y2::north" not a simple identifier
sub snurt : foo + bar ;       # "+" not a colon or space
```

The attribute list is passed as a list of constant strings to the code which associates them with the subroutine. In particular, the second example of valid syntax above currently looks like this in terms of how it's parsed and invoked:

```
use attributes __PACKAGE__, \&plugh, q[Ugly('\(")], 'Bad';
```

For further details on attribute lists and their manipulation, see *attributes*.

SEE ALSO

See *Function Templates in perlref* for more about references and closures. See *perlxs* if you'd like to learn about calling C subroutines from Perl. See *perlembed* if you'd like to learn about calling Perl subroutines from C. See *perlmod* to learn about bundling up your functions in separate files. See *perlmodlib* to learn what library modules come standard on your system. See *perltoot* to learn how to make object method calls.

NAME

perlsyn – Perl syntax

DESCRIPTION

A Perl script consists of a sequence of declarations and statements. The sequence of statements is executed just once, unlike in **sed** and **awk** scripts, where the sequence of statements is executed for each input line. While this means that you must explicitly loop over the lines of your input file (or files), it also means you have much more control over which files and which lines you look at. (Actually, I'm lying—it is possible to do an implicit loop with either the **-n** or **-p** switch. It's just not the mandatory default like it is in **sed** and **awk**.)

Perl is, for the most part, a free-form language. (The only exception to this is format declarations, for obvious reasons.) Text from a `"#"` character until the end of the line is a comment, and is ignored. If you attempt to use `/* */` C-style comments, it will be interpreted either as division or pattern matching, depending on the context, and C++ `//` comments just look like a null regular expression, so don't do that.

Declarations

The only things you need to declare in Perl are report formats and subroutines—and even undefined subroutines can be handled through AUTOLOAD. A variable holds the undefined value (`undef`) until it has been assigned a defined value, which is anything other than `undef`. When used as a number, `undef` is treated as ; when used as a string, it is treated the empty string, `""`; and when used as a reference that isn't being assigned to, it is treated as an error. If you enable warnings, you'll be notified of an uninitialized value whenever you treat `undef` as a string or a number. Well, usually. Boolean ("don't-care") contexts and operators such as `++`, `--`, `+=`, `-=`, and `.=` are always exempt from such warnings.

A declaration can be put anywhere a statement can, but has no effect on the execution of the primary sequence of statements—declarations all take effect at compile time. Typically all the declarations are put at the beginning or the end of the script. However, if you're using lexically-scoped private variables created with `my()`, you'll have to make sure your format or subroutine definition is within the same block scope as the my if you expect to be able to access those private variables.

Declaring a subroutine allows a subroutine name to be used as if it were a list operator from that point forward in the program. You can declare a subroutine without defining it by saying `sub name`, thus:

```
sub myname;
$me = myname $0             or die "can't get myname";
```

Note that `myname()` functions as a list operator, not as a unary operator; so be careful to use `or` instead of `||` in this case. However, if you were to declare the subroutine as `sub myname ($)`, then `myname` would function as a unary operator, so either `or` or `||` would work.

Subroutines declarations can also be loaded up with the `require` statement or both loaded and imported into your namespace with a `use` statement. See *perlmod* for details on this.

A statement sequence may contain declarations of lexically-scoped variables, but apart from declaring a variable name, the declaration acts like an ordinary statement, and is elaborated within the sequence of statements as if it were an ordinary statement. That means it actually has both compile-time and run-time effects.

Simple statements

The only kind of simple statement is an expression evaluated for its side effects. Every simple statement must be terminated with a semicolon, unless it is the final statement in a block, in which case the semicolon is optional. (A semicolon is still encouraged there if the block takes up more than one line, because you may eventually add another line.) Note that there are some operators like `eval {}` and `do {}` that look like compound statements, but aren't (they're just TERMs in an expression), and thus need an explicit termination if used as the last item in a statement.

Any simple statement may optionally be followed by a *SINGLE* modifier, just before the terminating semicolon (or block ending). The possible modifiers are:

```
if EXPR
unless EXPR
while EXPR
until EXPR
foreach EXPR
```

The `if` and `unless` modifiers have the expected semantics, presuming you're a speaker of English. The `foreach` modifier is an iterator: For each value in EXPR, it aliases `$_` to the value and executes the statement. The `while` and `until` modifiers have the usual "`while` loop" semantics (conditional evaluated first), except when applied to a `do`-BLOCK (or to the deprecated `do`-SUBROUTINE statement), in which case the block executes once before the conditional is evaluated. This is so that you can write loops like:

```
do {
    $line = <STDIN>;
    ...
} until $line  eq ".\n";
```

See *do*. Note also that the loop control statements described later will *NOT* work in this construct, because modifiers don't take loop labels. Sorry. You can always put another block inside of it (for `next`) or around it (for `last`) to do that sort of thing. For `next`, just double the braces:

```
do {{
    next if $x == $y;
    # do something here
}} until $x++ > $z;
```

For `last`, you have to be more elaborate:

```
LOOP: {
        do {
            last if $x = $y**2;
            # do something here
        } while $x++ <= $z;
}
```

Compound statements

In Perl, a sequence of statements that defines a scope is called a block. Sometimes a block is delimited by the file containing it (in the case of a required file, or the program as a whole), and sometimes a block is delimited by the extent of a string (in the case of an eval).

But generally, a block is delimited by curly brackets, also known as braces. We will call this syntactic construct a BLOCK.

The following compound statements may be used to control flow:

```
if (EXPR) BLOCK
if (EXPR) BLOCK else BLOCK
if (EXPR) BLOCK elsif (EXPR) BLOCK ... else BLOCK
LABEL while (EXPR) BLOCK
LABEL while (EXPR) BLOCK continue BLOCK
LABEL for (EXPR; EXPR; EXPR) BLOCK
LABEL foreach VAR (LIST) BLOCK
LABEL foreach VAR (LIST) BLOCK continue BLOCK
LABEL BLOCK continue BLOCK
```

Note that, unlike C and Pascal, these are defined in terms of BLOCKs, not statements. This means that the curly brackets are *required*—no dangling statements allowed. If you want to write conditionals without curly brackets there are several other ways to do it. The following all do the same thing:

```
if (!open(FOO)) { die "Can't open $FOO: $!"; }
die "Can't open $FOO: $!" unless open(FOO);
open(FOO) or die "Can't open $FOO: $#"FOO or bust!
open(FOO) ? 'hi mom' : die "Can't open $FOO: $!";
                    # a bit exotic, that last one
```

The `if` statement is straightforward. Because BLOCKs are always bounded by curly brackets, there is never any ambiguity about which `if` an `else` goes with. If you use `unless` in place of `if`, the sense of the test is reversed.

The `while` statement executes the block as long as the expression is true (does not evaluate to the null string `""` or or `"0"`). The LABEL is optional, and if present, consists of an identifier followed by a colon. The LABEL identifies the loop for the loop control statements `next`, `last`, and `redo`. If the LABEL is omitted, the loop control statement refers to the innermost enclosing loop. This may include dynamically looking back your call–stack at run time to find the LABEL. Such desperate behavior triggers a warning if you use the `use warnings` pragma or the **–w** flag. Unlike a `foreach` statement, a `while` statement never implicitly localises any variables.

If there is a `continue` BLOCK, it is always executed just before the conditional is about to be evaluated again, just like the third part of a `for` loop in C. Thus it can be used to increment a loop variable, even when the loop has been continued via the `next` statement (which is similar to the C `continue` statement).

Loop Control

The `next` command is like the `continue` statement in C; it starts the next iteration of the loop:

```
LINE: while (<STDIN>) {
    next LINE if /^#/;      # discard comments
    ...
}
```

The `last` command is like the `break` statement in C (as used in loops); it immediately exits the loop in question. The `continue` block, if any, is not executed:

```
LINE: while (<STDIN>) {
    last LINE if /^$/;      # exit when done with header
    ...
}
```

The `redo` command restarts the loop block without evaluating the conditional again. The `continue` block, if any, is *not* executed. This command is normally used by programs that want to lie to themselves about what was just input.

For example, when processing a file like ***/etc/termcap***. If your input lines might end in backslashes to indicate continuation, you want to skip ahead and get the next record.

```
while (<>) {
    chomp;
    if (s/\\$//) {
        $_ .= <>;
        redo unless eof();
    }
    # now process $_
}
```

which is Perl short–hand for the more explicitly written version:

```
LINE: while (defined($line = <ARGV>)) {
    chomp($line);
    if ($line =~ s/\\$//) {
        $line .= <ARGV>;
```

```
        redo LINE unless eof(); # not eof(ARGV)!
    }
    # now process $line
}
```

Note that if there were a `continue` block on the above code, it would get executed even on discarded lines. This is often used to reset line counters or `?pat?` one–time matches.

```
# inspired by :1,$g/fred/s//WILMA/
while (<>) {
    ?(fred)?    && s//WILMA $1 WILMA/;
    ?(barney)?  && s//BETTY $1 BETTY/;
    ?(homer)?   && s//MARGE $1 MARGE/;
} continue {
    print "$ARGV $.: $_";
    close ARGV  if eof();           # reset $.
    reset       if eof();           # reset ?pat?
}
```

If the word `while` is replaced by the word `until`, the sense of the test is reversed, but the conditional is still tested before the first iteration.

The loop control statements don't work in an `if` or `unless`, since they aren't loops. You can double the braces to make them such, though.

```
if (/pattern/) {{
    next if /fred/;
    next if /barney/;
    # so something here
}}
```

The form `while/if BLOCK BLOCK`, available in Perl 4, is no longer available. Replace any occurrence of `if BLOCK` by `if (do BLOCK)`.

For Loops

Perl's C–style `for` loop works exactly like the corresponding `while` loop; that means that this:

```
for ($i = 1; $i < 10; $i++) {
    ...
}
```

is the same as this:

```
$i = 1;
while ($i < 10) {
    ...
} continue {
    $i++;
}
```

(There is one minor difference: The first form implies a lexical scope for variables declared with `my` in the initialization expression.)

Besides the normal array index looping, `for` can lend itself to many other interesting applications. Here's one that avoids the problem you get into if you explicitly test for end–of–file on an interactive file descriptor causing your program to appear to hang.

```
$on_a_tty = -t STDIN && -t STDOUT;
sub prompt { print "yes? " if $on_a_tty }
for ( prompt(); <STDIN>; prompt() ) {
    # do something
```

```
}
```

Foreach Loops

The `foreach` loop iterates over a normal list value and sets the variable VAR to be each element of the list in turn. If the variable is preceded with the keyword `my`, then it is lexically scoped, and is therefore visible only within the loop. Otherwise, the variable is implicitly local to the loop and regains its former value upon exiting the loop. If the variable was previously declared with `my`, it uses that variable instead of the global one, but it's still localized to the loop.

The `foreach` keyword is actually a synonym for the `for` keyword, so you can use `foreach` for readability or `for` for brevity. (Or because the Bourne shell is more familiar to you than *csh*, so writing `for` comes more naturally.) If VAR is omitted, `$_` is set to each value.

If any element of LIST is an lvalue, you can modify it by modifying VAR inside the loop. Conversely, if any element of LIST is NOT an lvalue, any attempt to modify that element will fail. In other words, the `foreach` loop index variable is an implicit alias for each item in the list that you're looping over.

If any part of LIST is an array, `foreach` will get very confused if you add or remove elements within the loop body, for example with `splice`. So don't do that.

`foreach` probably won't do what you expect if VAR is a tied or other special variable. Don't do that either.

Examples:

```
for (@ary) { s/foo/bar/ }

for my $elem (@elements) {
    $elem *= 2;
}

for $count (10,9,8,7,6,5,4,3,2,1,'BOOM') {
    print $count, "\n"; sleep(1);
}

for (1..15) { print "Merry Christmas\n"; }

foreach $item (split(/:[\\\n:]*/, $ENV{TERMCAP})) {
    print "Item: $item\n";
}
```

Here's how a C programmer might code up a particular algorithm in Perl:

```
for (my $i = 0; $i < @ary1; $i++) {
    for (my $j = 0; $j < @ary2; $j++) {
        if ($ary1[$i] > $ary2[$j]) {
            last; # can't go to outer :-(
        }
        $ary1[$i] += $ary2[$j];
    }
    # this is where that last takes me
}
```

Whereas here's how a Perl programmer more comfortable with the idiom might do it:

```
OUTER: for my $wid (@ary1) {
INNER:   for my $jet (@ary2) {
            next OUTER if $wid > $jet;
            $wid += $jet;
         }
       }
```

See how much easier this is? It's cleaner, safer, and faster. It's cleaner because it's less noisy. It's safer because if code gets added between the inner and outer loops later on, the new code won't be accidentally executed. The `next` explicitly iterates the other loop rather than merely terminating the inner one. And it's faster because Perl executes a `foreach` statement more rapidly than it would the equivalent `for` loop.

Basic BLOCKs and Switch Statements

A BLOCK by itself (labeled or not) is semantically equivalent to a loop that executes once. Thus you can use any of the loop control statements in it to leave or restart the block. (Note that this is *NOT* true in `eval{}`, `sub{}`, or contrary to popular belief `do{}` blocks, which do *NOT* count as loops.) The `continue` block is optional.

The BLOCK construct is particularly nice for doing case structures.

```
SWITCH: {
    if (/^abc/) { $abc = 1; last SWITCH; }
    if (/^def/) { $def = 1; last SWITCH; }
    if (/^xyz/) { $xyz = 1; last SWITCH; }
    $nothing = 1;
}
```

There is no official `switch` statement in Perl, because there are already several ways to write the equivalent. In addition to the above, you could write

```
SWITCH: {
    $abc = 1, last SWITCH  if /^abc/;
    $def = 1, last SWITCH  if /^def/;
    $xyz = 1, last SWITCH  if /^xyz/;
    $nothing = 1;
}
```

(That's actually not as strange as it looks once you realize that you can use loop control "operators" within an expression, That's just the normal C comma operator.)

or

```
SWITCH: {
    /^abc/ && do { $abc = 1; last SWITCH; };
    /^def/ && do { $def = 1; last SWITCH; };
    /^xyz/ && do { $xyz = 1; last SWITCH; };
    $nothing = 1;
}
```

or formatted so it stands out more as a "proper" `switch` statement:

```
SWITCH: {
    /^abc/      && do {
                        $abc = 1;
                        last SWITCH;
                   };
    /^def/      && do {
                        $def = 1;
                        last SWITCH;
                   };
    /^xyz/      && do {
                        $xyz = 1;
                        last SWITCH;
                    };
    $nothing = 1;
```

```
    }
```

or

```
    SWITCH: {
        /^abc/ and $abc = 1, last SWITCH;
        /^def/ and $def = 1, last SWITCH;
        /^xyz/ and $xyz = 1, last SWITCH;
        $nothing = 1;
    }
```

or even, horrors,

```
    if (/^abc/)
        { $abc = 1 }
    elsif (/^def/)
        { $def = 1 }
    elsif (/^xyz/)
        { $xyz = 1 }
    else
        { $nothing = 1 }
```

A common idiom for a `switch` statement is to use `foreach`'s aliasing to make a temporary assignment to `$_` for convenient matching:

```
    SWITCH: for ($where) {
                /In Card Names/     && do { push @flags, '-e'; last; };
                /Anywhere/          && do { push @flags, '-h'; last; };
                /In Rulings/        && do {                    last; };
                die "unknown value for form variable where: `$where'";
            }
```

Another interesting approach to a switch statement is arrange for a `do` block to return the proper value:

```
    $amode = do {
        if     ($flag & O_RDONLY) { "r" }       # XXX: isn't this 0?
        elsif  ($flag & O_WRONLY) { ($flag & O_APPEND) ? "a" : "w" }
        elsif  ($flag & O_RDWR)   {
            if ($flag & O_CREAT)  { "w+" }
            else                  { ($flag & O_APPEND) ? "a+" : "r+" }
        }
    };
```

Or

```
        print do {
            ($flags & O_WRONLY) ? "write-only"          :
            ($flags & O_RDWR)   ? "read-write"          :
                                  "read-only";
        };
```

Or if you are certainly that all the `&&` clauses are true, you can use something like this, which "switches" on the value of the `HTTP_USER_AGENT` environment variable.

```
    #!/usr/bin/perl
    # pick out jargon file page based on browser
    $dir = 'http://www.wins.uva.nl/~mes/jargon';
    for ($ENV{HTTP_USER_AGENT}) {
        $page  =    /Mac/            && 'm/Macintrash.html'
                 || /Win(dows )?NT/  && 'e/evilandrude.html'
```

```
                || /Win|MSIE|WebTV/ && 'm/MicroslothWindows.html'
                || /Linux/          && 'l/Linux.html'
                || /HP-UX/          && 'h/HP-SUX.html'
                || /SunOS/          && 's/ScumOS.html'
                ||                     'a/AppendixB.html';
}
print "Location: $dir/$page\015\012\015\012";
```

That kind of switch statement only works when you know the `&&` clauses will be true. If you don't, the previous `?:` example should be used.

You might also consider writing a hash of subroutine references instead of synthesizing a `switch` statement.

Goto

Although not for the faint of heart, Perl does support a `goto` statement. There are three forms: `goto`-LABEL, `goto`-EXPR, and `goto`-`&NAME`. A loop's LABEL is not actually a valid target for a `goto`; it's just the name of the loop.

The `goto`-LABEL form finds the statement labeled with LABEL and resumes execution there. It may not be used to go into any construct that requires initialization, such as a subroutine or a `foreach` loop. It also can't be used to go into a construct that is optimized away. It can be used to go almost anywhere else within the dynamic scope, including out of subroutines, but it's usually better to use some other construct such as `last` or `die`. The author of Perl has never felt the need to use this form of `goto` (in Perl, that is—C is another matter).

The `goto`-EXPR form expects a label name, whose scope will be resolved dynamically. This allows for computed `goto`s per FORTRAN, but isn't necessarily recommended if you're optimizing for maintainability:

```
goto(("FOO", "BAR", "GLARCH")[$i]);
```

The `goto`-`&NAME` form is highly magical, and substitutes a call to the named subroutine for the currently running subroutine. This is used by `AUTOLOAD()` subroutines that wish to load another subroutine and then pretend that the other subroutine had been called in the first place (except that any modifications to `@_` in the current subroutine are propagated to the other subroutine.) After the `goto`, not even `caller()` will be able to tell that this routine was called first.

In almost all cases like this, it's usually a far, far better idea to use the structured control flow mechanisms of `next`, `last`, or `redo` instead of resorting to a `goto`. For certain applications, the catch and throw pair of `eval{}` and `die()` for exception processing can also be a prudent approach.

PODs: Embedded Documentation

Perl has a mechanism for intermixing documentation with source code. While it's expecting the beginning of a new statement, if the compiler encounters a line that begins with an equal sign and a word, like this

```
=head1 Here There Be Pods!
```

Then that text and all remaining text up through and including a line beginning with `=cut` will be ignored. The format of the intervening text is described in *perlpod*.

This allows you to intermix your source code and your documentation text freely, as in

```
=item snazzle($)

The snazzle() function will behave in the most spectacular
form that you can possibly imagine, not even excepting
cybernetic pyrotechnics.

=cut back to the compiler, nuff of this pod stuff!

sub snazzle($) {
```

```
    my $thingie = shift;
    .........
}
```

Note that pod translators should look at only paragraphs beginning with a pod directive (it makes parsing easier), whereas the compiler actually knows to look for pod escapes even in the middle of a paragraph. This means that the following secret stuff will be ignored by both the compiler and the translators.

```
$a=3;
=secret stuff
 warn "Neither POD nor CODE!?"
=cut back
print "got $a\n";
```

You probably shouldn't rely upon the `warn()` being podded out forever. Not all pod translators are well-behaved in this regard, and perhaps the compiler will become pickier.

One may also use pod directives to quickly comment out a section of code.

Plain Old Comments (Not!)

Much like the C preprocessor, Perl can process line directives. Using this, one can control Perl's idea of filenames and line numbers in error or warning messages (especially for strings that are processed with `eval()`). The syntax for this mechanism is the same as for most C preprocessors: it matches the regular expression `/^#\s*line\s+(\d+)\s*(?:\s"([^"]+)")?\s*$/` with `$1` being the line number for the next line, and `$2` being the optional filename (specified within quotes).

There is a fairly obvious gotcha included with the line directive: Debuggers and profilers will only show the last source line to appear at a particular line number in a given file. Care should be taken not to cause line number collisions in code you'd like to debug later.

Here are some examples that you should be able to type into your command shell:

```
% perl
# line 200 "bzzzt"
# the '#' on the previous line must be the first char on line
die 'foo';
__END__
foo at bzzzt line 201.

% perl
# line 200 "bzzzt"
eval qq[\n#line 2001 ""\ndie 'foo']; print $@;
__END__
foo at - line 2001.

% perl
eval qq[\n#line 200 "foo bar"\ndie 'foo']; print $@;
__END__
foo at foo bar line 200.

% perl
# line 345 "goop"
eval "\n#line " . __LINE__ . ' "' . __FILE__ ."\"\ndie 'foo'";
print $@;
__END__
foo at goop line 345.
```

NAME

perlthrtut – tutorial on threads in Perl

DESCRIPTION

```
WARNING: Threading is an experimental feature.  Both the interface
and implementation are subject to change drastically.  In fact, this
documentation describes the flavor of threads that was in version
5.005.  Perl 5.6.0 and later have the beginnings of support for
interpreter threads, which (when finished) is expected to be
significantly different from what is described here.  The information
contained here may therefore soon be obsolete.  Use at your own risk!
```

One of the most prominent new features of Perl 5.005 is the inclusion of threads. Threads make a number of things a lot easier, and are a very useful addition to your bag of programming tricks.

What Is A Thread Anyway?

A thread is a flow of control through a program with a single execution point.

Sounds an awful lot like a process, doesn't it? Well, it should. Threads are one of the pieces of a process. Every process has at least one thread and, up until now, every process running Perl had only one thread. With 5.005, though, you can create extra threads. We're going to show you how, when, and why.

Threaded Program Models

There are three basic ways that you can structure a threaded program. Which model you choose depends on what you need your program to do. For many non–trivial threaded programs you'll need to choose different models for different pieces of your program.

Boss/Worker

The boss/worker model usually has one 'boss' thread and one or more 'worker' threads. The boss thread gathers or generates tasks that need to be done, then parcels those tasks out to the appropriate worker thread.

This model is common in GUI and server programs, where a main thread waits for some event and then passes that event to the appropriate worker threads for processing. Once the event has been passed on, the boss thread goes back to waiting for another event.

The boss thread does relatively little work. While tasks aren't necessarily performed faster than with any other method, it tends to have the best user–response times.

Work Crew

In the work crew model, several threads are created that do essentially the same thing to different pieces of data. It closely mirrors classical parallel processing and vector processors, where a large array of processors do the exact same thing to many pieces of data.

This model is particularly useful if the system running the program will distribute multiple threads across different processors. It can also be useful in ray tracing or rendering engines, where the individual threads can pass on interim results to give the user visual feedback.

Pipeline

The pipeline model divides up a task into a series of steps, and passes the results of one step on to the thread processing the next. Each thread does one thing to each piece of data and passes the results to the next thread in line.

This model makes the most sense if you have multiple processors so two or more threads will be executing in parallel, though it can often make sense in other contexts as well. It tends to keep the individual tasks small and simple, as well as allowing some parts of the pipeline to block (on I/O or system calls, for example) while other parts keep going. If you're running different parts of the pipeline on different processors you may also take advantage of the caches on each processor.

This model is also handy for a form of recursive programming where, rather than having a subroutine call

itself, it instead creates another thread. Prime and Fibonacci generators both map well to this form of the pipeline model. (A version of a prime number generator is presented later on.)

Native threads

There are several different ways to implement threads on a system. How threads are implemented depends both on the vendor and, in some cases, the version of the operating system. Often the first implementation will be relatively simple, but later versions of the OS will be more sophisticated.

While the information in this section is useful, it's not necessary, so you can skip it if you don't feel up to it.

There are three basic categories of threads–user–mode threads, kernel threads, and multiprocessor kernel threads.

User–mode threads are threads that live entirely within a program and its libraries. In this model, the OS knows nothing about threads. As far as it's concerned, your process is just a process.

This is the easiest way to implement threads, and the way most OSes start. The big disadvantage is that, since the OS knows nothing about threads, if one thread blocks they all do. Typical blocking activities include most system calls, most I/O, and things like `sleep()`.

Kernel threads are the next step in thread evolution. The OS knows about kernel threads, and makes allowances for them. The main difference between a kernel thread and a user–mode thread is blocking. With kernel threads, things that block a single thread don't block other threads. This is not the case with user–mode threads, where the kernel blocks at the process level and not the thread level.

This is a big step forward, and can give a threaded program quite a performance boost over non–threaded programs. Threads that block performing I/O, for example, won't block threads that are doing other things. Each process still has only one thread running at once, though, regardless of how many CPUs a system might have.

Since kernel threading can interrupt a thread at any time, they will uncover some of the implicit locking assumptions you may make in your program. For example, something as simple as `$a = $a + 2` can behave unpredictably with kernel threads if `$a` is visible to other threads, as another thread may have changed `$a` between the time it was fetched on the right hand side and the time the new value is stored.

Multiprocessor Kernel Threads are the final step in thread support. With multiprocessor kernel threads on a machine with multiple CPUs, the OS may schedule two or more threads to run simultaneously on different CPUs.

This can give a serious performance boost to your threaded program, since more than one thread will be executing at the same time. As a tradeoff, though, any of those nagging synchronization issues that might not have shown with basic kernel threads will appear with a vengeance.

In addition to the different levels of OS involvement in threads, different OSes (and different thread implementations for a particular OS) allocate CPU cycles to threads in different ways.

Cooperative multitasking systems have running threads give up control if one of two things happen. If a thread calls a yield function, it gives up control. It also gives up control if the thread does something that would cause it to block, such as perform I/O. In a cooperative multitasking implementation, one thread can starve all the others for CPU time if it so chooses.

Preemptive multitasking systems interrupt threads at regular intervals while the system decides which thread should run next. In a preemptive multitasking system, one thread usually won't monopolize the CPU.

On some systems, there can be cooperative and preemptive threads running simultaneously. (Threads running with realtime priorities often behave cooperatively, for example, while threads running at normal priorities behave preemptively.)

What kind of threads are perl threads?

If you have experience with other thread implementations, you might find that things aren't quite what you expect. It's very important to remember when dealing with Perl threads that Perl Threads Are Not X Threads, for all values of X. They aren't POSIX threads, or DecThreads, or Java's Green threads, or Win32

threads. There are similarities, and the broad concepts are the same, but if you start looking for implementation details you're going to be either disappointed or confused. Possibly both.

This is not to say that Perl threads are completely different from everything that's ever come before—they're not. Perl's threading model owes a lot to other thread models, especially POSIX. Just as Perl is not C, though, Perl threads are not POSIX threads. So if you find yourself looking for mutexes, or thread priorities, it's time to step back a bit and think about what you want to do and how Perl can do it.

Threadsafe Modules

The addition of threads has changed Perl's internals substantially. There are implications for people who write modules—especially modules with XS code or external libraries. While most modules won't encounter any problems, modules that aren't explicitly tagged as thread-safe should be tested before being used in production code.

Not all modules that you might use are thread-safe, and you should always assume a module is unsafe unless the documentation says otherwise. This includes modules that are distributed as part of the core. Threads are a beta feature, and even some of the standard modules aren't thread-safe.

If you're using a module that's not thread-safe for some reason, you can protect yourself by using semaphores and lots of programming discipline to control access to the module. Semaphores are covered later in the article. Perl Threads Are Different

Thread Basics

The core Thread module provides the basic functions you need to write threaded programs. In the following sections we'll cover the basics, showing you what you need to do to create a threaded program. After that, we'll go over some of the features of the Thread module that make threaded programming easier.

Basic Thread Support

Thread support is a Perl compile-time option-it's something that's turned on or off when Perl is built at your site, rather than when your programs are compiled. If your Perl wasn't compiled with thread support enabled, then any attempt to use threads will fail.

Remember that the threading support in 5.005 is in beta release, and should be treated as such. You should expect that it may not function entirely properly, and the thread interface may well change some before it is a fully supported, production release. The beta version shouldn't be used for mission-critical projects. Having said that, threaded Perl is pretty nifty, and worth a look.

Your programs can use the Config module to check whether threads are enabled. If your program can't run without them, you can say something like:

```
$Config{usethreads} or die "Recompile Perl with threads to run this program.";
```

A possibly-threaded program using a possibly-threaded module might have code like this:

```
use Config;
use MyMod;

if ($Config{usethreads}) {
    # We have threads
    require MyMod_threaded;
    import MyMod_threaded;
} else {
    require MyMod_unthreaded;
    import MyMod_unthreaded;
}
```

Since code that runs both with and without threads is usually pretty messy, it's best to isolate the thread-specific code in its own module. In our example above, that's what MyMod_threaded is, and it's only imported if we're running on a threaded Perl.

Creating Threads

The Thread package provides the tools you need to create new threads. Like any other module, you need to tell Perl you want to use it; use Thread imports all the pieces you need to create basic threads.

The simplest, straightforward way to create a thread is with `new()`:

```
use Thread;

$thr = new Thread \&sub1;

sub sub1 {
    print "In the thread\n";
}
```

The `new()` method takes a reference to a subroutine and creates a new thread, which starts executing in the referenced subroutine. Control then passes both to the subroutine and the caller.

If you need to, your program can pass parameters to the subroutine as part of the thread startup. Just include the list of parameters as part of the `Thread::new` call, like this:

```
use Thread;
$Param3 = "foo";
$thr = new Thread \&sub1, "Param 1", "Param 2", $Param3;
$thr = new Thread \&sub1, @ParamList;
$thr = new Thread \&sub1, qw(Param1 Param2 $Param3);

sub sub1 {
    my @InboundParameters = @_;
    print "In the thread\n";
    print "got parameters >", join("<>", @InboundParameters), "<\n";
}
```

The subroutine runs like a normal Perl subroutine, and the call to new Thread returns whatever the subroutine returns.

The last example illustrates another feature of threads. You can spawn off several threads using the same subroutine. Each thread executes the same subroutine, but in a separate thread with a separate environment and potentially separate arguments.

The other way to spawn a new thread is with `async()`, which is a way to spin off a chunk of code like `eval()`, but into its own thread:

```
use Thread qw(async);

$LineCount = 0;

$thr = async {
    while(<>) {$LineCount++}
    print "Got $LineCount lines\n";
};

print "Waiting for the linecount to end\n";
$thr->join;
print "All done\n";
```

You'll notice we did a use Thread qw(async) in that example. async is not exported by default, so if you want it, you'll either need to import it before you use it or fully qualify it as Thread::async. You'll also note that there's a semicolon after the closing brace. That's because `async()` treats the following block as an anonymous subroutine, so the semicolon is necessary.

Like `eval()`, the code executes in the same context as it would if it weren't spun off. Since both the code inside and after the async start executing, you need to be careful with any shared resources. Locking and

other synchronization techniques are covered later.

Giving up control

There are times when you may find it useful to have a thread explicitly give up the CPU to another thread. Your threading package might not support preemptive multitasking for threads, for example, or you may be doing something compute–intensive and want to make sure that the user–interface thread gets called frequently. Regardless, there are times that you might want a thread to give up the processor.

Perl's threading package provides the `yield()` function that does this. `yield()` is pretty straightforward, and works like this:

```
use Thread qw(yield async);
async {
    my $foo = 50;
    while ($foo--) { print "first async\n" }
    yield;
    $foo = 50;
    while ($foo--) { print "first async\n" }
};
async {
    my $foo = 50;
    while ($foo--) { print "second async\n" }
    yield;
    $foo = 50;
    while ($foo--) { print "second async\n" }
};
```

Waiting For A Thread To Exit

Since threads are also subroutines, they can return values. To wait for a thread to exit and extract any scalars it might return, you can use the `join()` method.

```
use Thread;
$thr = new Thread \&sub1;

@ReturnData = $thr->join;
print "Thread returned @ReturnData";

sub sub1 { return "Fifty-six", "foo", 2; }
```

In the example above, the `join()` method returns as soon as the thread ends. In addition to waiting for a thread to finish and gathering up any values that the thread might have returned, `join()` also performs any OS cleanup necessary for the thread. That cleanup might be important, especially for long–running programs that spawn lots of threads. If you don't want the return values and don't want to wait for the thread to finish, you should call the `detach()` method instead. `detach()` is covered later in the article.

Errors In Threads

So what happens when an error occurs in a thread? Any errors that could be caught with `eval()` are postponed until the thread is joined. If your program never joins, the errors appear when your program exits.

Errors deferred until a `join()` can be caught with `eval()`:

```
use Thread qw(async);
$thr = async {$b = 3/0};   # Divide by zero error
$foo = eval {$thr->join};
if ($@) {
    print "died with error $@\n";
} else {
    print "Hey, why aren't you dead?\n";
```

```
}
```

`eval()` passes any results from the joined thread back unmodified, so if you want the return value of the thread, this is your only chance to get them.

Ignoring A Thread

`join()` does three things: it waits for a thread to exit, cleans up after it, and returns any data the thread may have produced. But what if you're not interested in the thread's return values, and you don't really care when the thread finishes? All you want is for the thread to get cleaned up after when it's done.

In this case, you use the `detach()` method. Once a thread is detached, it'll run until it's finished, then Perl will clean up after it automatically.

```
use Thread;
$thr = new Thread \&sub1; # Spawn the thread

$thr->detach; # Now we officially don't care any more

sub sub1 {
    $a = 0;
    while (1) {
        $a++;
        print "\$a is $a\n";
        sleep 1;
    }
}
```

Once a thread is detached, it may not be joined, and any output that it might have produced (if it was done and waiting for a join) is lost.

Threads And Data

Now that we've covered the basics of threads, it's time for our next topic: data. Threading introduces a couple of complications to data access that non–threaded programs never need to worry about.

Shared And Unshared Data

The single most important thing to remember when using threads is that all threads potentially have access to all the data anywhere in your program. While this is true with a nonthreaded Perl program as well, it's especially important to remember with a threaded program, since more than one thread can be accessing this data at once.

Perl's scoping rules don't change because you're using threads. If a subroutine (or block, in the case of `async()`) could see a variable if you weren't running with threads, it can see it if you are. This is especially important for the subroutines that create, and makes `my` variables even more important. Remember—if your variables aren't lexically scoped (declared with `my`) you're probably sharing them between threads.

Thread Pitfall: Races

While threads bring a new set of useful tools, they also bring a number of pitfalls. One pitfall is the race condition:

```
use Thread;
$a = 1;
$thr1 = Thread->new(\&sub1);
$thr2 = Thread->new(\&sub2);

sleep 10;
print "$a\n";

sub sub1 { $foo = $a; $a = $foo + 1; }
sub sub2 { $bar = $a; $a = $bar + 1; }
```

What do you think `$a` will be? The answer, unfortunately, is "it depends." Both `sub1()` and `sub2()` access the global variable `$a`, once to read and once to write. Depending on factors ranging from your thread implementation's scheduling algorithm to the phase of the moon, `$a` can be 2 or 3.

Race conditions are caused by unsynchronized access to shared data. Without explicit synchronization, there's no way to be sure that nothing has happened to the shared data between the time you access it and the time you update it. Even this simple code fragment has the possibility of error:

```
use Thread qw(async);
$a = 2;
async{ $b = $a; $a = $b + 1; };
async{ $c = $a; $a = $c + 1; };
```

Two threads both access `$a`. Each thread can potentially be interrupted at any point, or be executed in any order. At the end, `$a` could be 3 or 4, and both `$b` and `$c` could be 2 or 3.

Whenever your program accesses data or resources that can be accessed by other threads, you must take steps to coordinate access or risk data corruption and race conditions.

Controlling access: `lock()`

The `lock()` function takes a variable (or subroutine, but we'll get to that later) and puts a lock on it. No other thread may lock the variable until the locking thread exits the innermost block containing the lock. Using `lock()` is straightforward:

```
use Thread qw(async);
$a = 4;
$thr1 = async {
    $foo = 12;
    {
        lock ($a); # Block until we get access to $a
        $b = $a;
        $a = $b * $foo;
    }
    print "\$foo was $foo\n";
};
$thr2 = async {
    $bar = 7;
    {
        lock ($a); # Block until we can get access to $a
        $c = $a;
        $a = $c * $bar;
    }
    print "\$bar was $bar\n";
};
$thr1->join;
$thr2->join;
print "\$a is $a\n";
```

`lock()` blocks the thread until the variable being locked is available. When `lock()` returns, your thread can be sure that no other thread can lock that variable until the innermost block containing the lock exits.

It's important to note that locks don't prevent access to the variable in question, only lock attempts. This is in keeping with Perl's longstanding tradition of courteous programming, and the advisory file locking that `flock()` gives you. Locked subroutines behave differently, however. We'll cover that later in the article.

You may lock arrays and hashes as well as scalars. Locking an array, though, will not block subsequent locks on array elements, just lock attempts on the array itself.

Finally, locks are recursive, which means it's okay for a thread to lock a variable more than once. The lock

will last until the outermost `lock()` on the variable goes out of scope.

Thread Pitfall: Deadlocks

Locks are a handy tool to synchronize access to data. Using them properly is the key to safe shared data. Unfortunately, locks aren't without their dangers. Consider the following code:

```
use Thread qw(async yield);
$a = 4;
$b = "foo";
async {
    lock($a);
    yield;
    sleep 20;
    lock ($b);
};
async {
    lock($b);
    yield;
    sleep 20;
    lock ($a);
};
```

This program will probably hang until you kill it. The only way it won't hang is if one of the two `async()` routines acquires both locks first. A guaranteed–to–hang version is more complicated, but the principle is the same.

The first thread spawned by `async()` will grab a lock on `$a` then, a second or two later, try to grab a lock on `$b`. Meanwhile, the second thread grabs a lock on `$b`, then later tries to grab a lock on `$a`. The second lock attempt for both threads will block, each waiting for the other to release its lock.

This condition is called a deadlock, and it occurs whenever two or more threads are trying to get locks on resources that the others own. Each thread will block, waiting for the other to release a lock on a resource. That never happens, though, since the thread with the resource is itself waiting for a lock to be released.

There are a number of ways to handle this sort of problem. The best way is to always have all threads acquire locks in the exact same order. If, for example, you lock variables `$a`, `$b`, and `$c`, always lock `$a` before `$b`, and `$b` before `$c`. It's also best to hold on to locks for as short a period of time to minimize the risks of deadlock.

Queues: Passing Data Around

A queue is a special thread–safe object that lets you put data in one end and take it out the other without having to worry about synchronization issues. They're pretty straightforward, and look like this:

```
use Thread qw(async);
use Thread::Queue;

my $DataQueue = new Thread::Queue;
$thr = async {
    while ($DataElement = $DataQueue->dequeue) {
        print "Popped $DataElement off the queue\n";
    }
};

$DataQueue->enqueue(12);
$DataQueue->enqueue("A", "B", "C");
$DataQueue->enqueue(\$thr);
sleep 10;
$DataQueue->enqueue(undef);
```

You create the queue with new Thread::Queue. Then you can add lists of scalars onto the end with `enqueue()`, and pop scalars off the front of it with `dequeue()`. A queue has no fixed size, and can grow as needed to hold everything pushed on to it.

If a queue is empty, `dequeue()` blocks until another thread enqueues something. This makes queues ideal for event loops and other communications between threads.

Threads And Code

In addition to providing thread–safe access to data via locks and queues, threaded Perl also provides general–purpose semaphores for coarser synchronization than locks provide and thread–safe access to entire subroutines.

Semaphores: Synchronizing Data Access

Semaphores are a kind of generic locking mechanism. Unlike lock, which gets a lock on a particular scalar, Perl doesn't associate any particular thing with a semaphore so you can use them to control access to anything you like. In addition, semaphores can allow more than one thread to access a resource at once, though by default semaphores only allow one thread access at a time.

Basic semaphores

Semaphores have two methods, down and up. down decrements the resource count, while up increments it. down calls will block if the semaphore's current count would decrement below zero. This program gives a quick demonstration:

```
use Thread qw(yield);
use Thread::Semaphore;
my $semaphore = new Thread::Semaphore;
$GlobalVariable = 0;

$thr1 = new Thread \&sample_sub, 1;
$thr2 = new Thread \&sample_sub, 2;
$thr3 = new Thread \&sample_sub, 3;

sub sample_sub {
    my $SubNumber = shift @_;
    my $TryCount = 10;
    my $LocalCopy;
    sleep 1;
    while ($TryCount--) {
        $semaphore->down;
        $LocalCopy = $GlobalVariable;
        print "$TryCount tries left for sub $SubNumber (\$GlobalVariable is $
        yield;
        sleep 2;
        $LocalCopy++;
        $GlobalVariable = $LocalCopy;
        $semaphore->up;
    }
}
```

The three invocations of the subroutine all operate in sync. The semaphore, though, makes sure that only one thread is accessing the global variable at once.

Advanced Semaphores

By default, semaphores behave like locks, letting only one thread `down()` them at a time. However, there are other uses for semaphores.

Each semaphore has a counter attached to it. `down()` decrements the counter and `up()` increments the counter. By default, semaphores are created with the counter set to one, `down()` decrements by one, and `up()` increments by one. If `down()` attempts to decrement the counter below zero, it blocks

until the counter is large enough. Note that while a semaphore can be created with a starting count of zero, any `up()` or `down()` always changes the counter by at least one. `$semaphore-down(0)` is the same as `$semaphore-down(1)`.

The question, of course, is why would you do something like this? Why create a semaphore with a starting count that's not one, or why decrement/increment it by more than one? The answer is resource availability. Many resources that you want to manage access for can be safely used by more than one thread at once.

For example, let's take a GUI driven program. It has a semaphore that it uses to synchronize access to the display, so only one thread is ever drawing at once. Handy, but of course you don't want any thread to start drawing until things are properly set up. In this case, you can create a semaphore with a counter set to zero, and up it when things are ready for drawing.

Semaphores with counters greater than one are also useful for establishing quotas. Say, for example, that you have a number of threads that can do I/O at once. You don't want all the threads reading or writing at once though, since that can potentially swamp your I/O channels, or deplete your process' quota of filehandles. You can use a semaphore initialized to the number of concurrent I/O requests (or open files) that you want at any one time, and have your threads quietly block and unblock themselves.

Larger increments or decrements are handy in those cases where a thread needs to check out or return a number of resources at once.

Attributes: Restricting Access To Subroutines

In addition to synchronizing access to data or resources, you might find it useful to synchronize access to subroutines. You may be accessing a singular machine resource (perhaps a vector processor), or find it easier to serialize calls to a particular subroutine than to have a set of locks and semaphores.

One of the additions to Perl 5.005 is subroutine attributes. The Thread package uses these to provide several flavors of serialization. It's important to remember that these attributes are used in the compilation phase of your program so you can't change a subroutine's behavior while your program is actually running.

Subroutine Locks

The basic subroutine lock looks like this:

```
sub test_sub :locked {
}
```

This ensures that only one thread will be executing this subroutine at any one time. Once a thread calls this subroutine, any other thread that calls it will block until the thread in the subroutine exits it. A more elaborate example looks like this:

```
use Thread qw(yield);

new Thread \&thread_sub, 1;
new Thread \&thread_sub, 2;
new Thread \&thread_sub, 3;
new Thread \&thread_sub, 4;

sub sync_sub :locked {
    my $CallingThread = shift @_;
    print "In sync_sub for thread $CallingThread\n";
    yield;
    sleep 3;
    print "Leaving sync_sub for thread $CallingThread\n";
}

sub thread_sub {
    my $ThreadID = shift @_;
    print "Thread $ThreadID calling sync_sub\n";
```

```
    sync_sub($ThreadID);
    print "$ThreadID is done with sync_sub\n";
}
```

The `locked` attribute tells perl to lock `sync_sub()`, and if you run this, you can see that only one thread is in it at any one time.

Methods

Locking an entire subroutine can sometimes be overkill, especially when dealing with Perl objects. When calling a method for an object, for example, you want to serialize calls to a method, so that only one thread will be in the subroutine for a particular object, but threads calling that subroutine for a different object aren't blocked. The method attribute indicates whether the subroutine is really a method.

```
use Thread;

sub tester {
    my $thrnum = shift @_;
    my $bar = new Foo;
    foreach (1..10) {
        print "$thrnum calling per_object\n";
        $bar->per_object($thrnum);
        print "$thrnum out of per_object\n";
        yield;
        print "$thrnum calling one_at_a_time\n";
        $bar->one_at_a_time($thrnum);
        print "$thrnum out of one_at_a_time\n";
        yield;
    }
}

foreach my $thrnum (1..10) {
    new Thread \&tester, $thrnum;
}

package Foo;
sub new {
    my $class = shift @_;
    return bless [@_], $class;
}

sub per_object :locked :method {
    my ($class, $thrnum) = @_;
    print "In per_object for thread $thrnum\n";
    yield;
    sleep 2;
    print "Exiting per_object for thread $thrnum\n";
}

sub one_at_a_time :locked {
    my ($class, $thrnum) = @_;
    print "In one_at_a_time for thread $thrnum\n";
    yield;
    sleep 2;
    print "Exiting one_at_a_time for thread $thrnum\n";
}
```

As you can see from the output (omitted for brevity; it's 800 lines) all the threads can be in `per_object()` simultaneously, but only one thread is ever in `one_at_a_time()` at once.

Locking A Subroutine

You can lock a subroutine as you would lock a variable. Subroutine locks work the same as specifying a `locked` attribute for the subroutine, and block all access to the subroutine for other threads until the lock goes out of scope. When the subroutine isn't locked, any number of threads can be in it at once, and getting a lock on a subroutine doesn't affect threads already in the subroutine. Getting a lock on a subroutine looks like this:

```
lock(\&sub_to_lock);
```

Simple enough. Unlike the `locked` attribute, which is a compile time option, locking and unlocking a subroutine can be done at runtime at your discretion. There is some runtime penalty to using `lock(\&sub)` instead of the `locked` attribute, so make sure you're choosing the proper method to do the locking.

You'd choose `lock(\&sub)` when writing modules and code to run on both threaded and unthreaded Perl, especially for code that will run on 5.004 or earlier Perls. In that case, it's useful to have subroutines that should be serialized lock themselves if they're running threaded, like so:

```
package Foo;
use Config;
$Running_Threaded = 0;

BEGIN { $Running_Threaded = $Config{'usethreads'} }

sub sub1 { lock(\&sub1) if $Running_Threaded }
```

This way you can ensure single-threadedness regardless of which version of Perl you're running.

General Thread Utility Routines

We've covered the workhorse parts of Perl's threading package, and with these tools you should be well on your way to writing threaded code and packages. There are a few useful little pieces that didn't really fit in anyplace else.

What Thread Am I In?

The Thread->self method provides your program with a way to get an object representing the thread it's currently in. You can use this object in the same way as the ones returned from the thread creation.

Thread IDs

`tid()` is a thread object method that returns the thread ID of the thread the object represents. Thread IDs are integers, with the main thread in a program being 0. Currently Perl assigns a unique tid to every thread ever created in your program, assigning the first thread to be created a tid of 1, and increasing the tid by 1 for each new thread that's created.

Are These Threads The Same?

The `equal()` method takes two thread objects and returns true if the objects represent the same thread, and false if they don't.

What Threads Are Running?

Thread->list returns a list of thread objects, one for each thread that's currently running. Handy for a number of things, including cleaning up at the end of your program:

```
# Loop through all the threads
foreach $thr (Thread->list) {
    # Don't join the main thread or ourselves
    if ($thr->tid && !Thread::equal($thr, Thread->self)) {
        $thr->join;
    }
}
```

The example above is just for illustration. It isn't strictly necessary to join all the threads you create, since Perl detaches all the threads before it exits.

A Complete Example

Confused yet? It's time for an example program to show some of the things we've covered. This program finds prime numbers using threads.

```
1  #!/usr/bin/perl -w
2  # prime-pthread, courtesy of Tom Christiansen
3
4  use strict;
5
6  use Thread;
7  use Thread::Queue;
8
9  my $stream = new Thread::Queue;
10 my $kid    = new Thread(\&check_num, $stream, 2);
11
12 for my $i ( 3 .. 1000 ) {
13     $stream->enqueue($i);
14 }
15
16 $stream->enqueue(undef);
17 $kid->join();
18
19 sub check_num {
20     my ($upstream, $cur_prime) = @_;
21     my $kid;
22     my $downstream = new Thread::Queue;
23     while (my $num = $upstream->dequeue) {
24         next unless $num % $cur_prime;
25         if ($kid) {
26            $downstream->enqueue($num);
27                   } else {
28            print "Found prime $num\n";
29                $kid = new Thread(\&check_num, $downstream, $num);
30         }
31     }
32     $downstream->enqueue(undef) if $kid;
33     $kid->join()         if $kid;
34 }
```

This program uses the pipeline model to generate prime numbers. Each thread in the pipeline has an input queue that feeds numbers to be checked, a prime number that it's responsible for, and an output queue that it funnels numbers that have failed the check into. If the thread has a number that's failed its check and there's no child thread, then the thread must have found a new prime number. In that case, a new child thread is created for that prime and stuck on the end of the pipeline.

This probably sounds a bit more confusing than it really is, so lets go through this program piece by piece and see what it does. (For those of you who might be trying to remember exactly what a prime number is, it's a number that's only evenly divisible by itself and 1)

The bulk of the work is done by the `check_num()` subroutine, which takes a reference to its input queue and a prime number that it's responsible for. After pulling in the input queue and the prime that the subroutine's checking (line 20), we create a new queue (line 22) and reserve a scalar for the thread that we're likely to create later (line 21).

The while loop from lines 23 to line 31 grabs a scalar off the input queue and checks against the prime this thread is responsible for. Line 24 checks to see if there's a remainder when we modulo the number to be

checked against our prime. If there is one, the number must not be evenly divisible by our prime, so we need to either pass it on to the next thread if we've created one (line 26) or create a new thread if we haven't.

The new thread creation is line 29. We pass on to it a reference to the queue we've created, and the prime number we've found.

Finally, once the loop terminates (because we got a 0 or undef in the queue, which serves as a note to die), we pass on the notice to our child and wait for it to exit if we've created a child (Lines 32 and 37).

Meanwhile, back in the main thread, we create a queue (line 9) and the initial child thread (line 10), and pre-seed it with the first prime: 2. Then we queue all the numbers from 3 to 1000 for checking (lines 12-14), then queue a die notice (line 16) and wait for the first child thread to terminate (line 17). Because a child won't die until its child has died, we know that we're done once we return from the join.

That's how it works. It's pretty simple; as with many Perl programs, the explanation is much longer than the program.

Conclusion

A complete thread tutorial could fill a book (and has, many times), but this should get you well on your way. The final authority on how Perl's threads behave is the documentation bundled with the Perl distribution, but with what we've covered in this article, you should be well on your way to becoming a threaded Perl expert.

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Acknowledgements

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NAME

perltie – how to hide an object class in a simple variable

SYNOPSIS

```
tie VARIABLE, CLASSNAME, LIST

$object = tied VARIABLE

untie VARIABLE
```

DESCRIPTION

Prior to release 5.0 of Perl, a programmer could use `dbmopen()` to connect an on–disk database in the standard Unix dbm(3x) format magically to a %HASH in their program. However, their Perl was either built with one particular dbm library or another, but not both, and you couldn't extend this mechanism to other packages or types of variables.

Now you can.

The `tie()` function binds a variable to a class (package) that will provide the implementation for access methods for that variable. Once this magic has been performed, accessing a tied variable automatically triggers method calls in the proper class. The complexity of the class is hidden behind magic methods calls. The method names are in ALL CAPS, which is a convention that Perl uses to indicate that they're called implicitly rather than explicitly—just like the `BEGIN()` and `END()` functions.

In the `tie()` call, `VARIABLE` is the name of the variable to be enchanted. `CLASSNAME` is the name of a class implementing objects of the correct type. Any additional arguments in the `LIST` are passed to the appropriate constructor method for that class—meaning `TIESCALAR()`, `TIEARRAY()`, `TIEHASH()`, or `TIEHANDLE()`. (Typically these are arguments such as might be passed to the `dbminit()` function of C.) The object returned by the "new" method is also returned by the `tie()` function, which would be useful if you wanted to access other methods in `CLASSNAME`. (You don't actually have to return a reference to a right "type" (e.g., HASH or `CLASSNAME`) so long as it's a properly blessed object.) You can also retrieve a reference to the underlying object using the `tied()` function.

Unlike `dbmopen()`, the `tie()` function will not `use` or `require` a module for you—you need to do that explicitly yourself.

Tying Scalars

A class implementing a tied scalar should define the following methods: TIESCALAR, FETCH, STORE, and possibly UNTIE and/or DESTROY.

Let's look at each in turn, using as an example a tie class for scalars that allows the user to do something like:

```
tie $his_speed, 'Nice', getppid();
tie $my_speed,  'Nice', $$;
```

And now whenever either of those variables is accessed, its current system priority is retrieved and returned. If those variables are set, then the process's priority is changed!

We'll use Jarkko Hietaniemi *<jhi@iki.fi>*'s BSD::Resource class (not included) to access the PRIO_PROCESS, PRIO_MIN, and PRIO_MAX constants from your system, as well as the `getpriority()` and `setpriority()` system calls. Here's the preamble of the class.

```
package Nice;
use Carp;
use BSD::Resource;
use strict;
$Nice::DEBUG = 0 unless defined $Nice::DEBUG;
```

TIESCALAR classname, LIST

This is the constructor for the class. That means it is expected to return a blessed reference to a new scalar (probably anonymous) that it's creating. For example:

```
sub TIESCALAR {
    my $class = shift;
    my $pid = shift || $$; # 0 means me

    if ($pid !~ /^\d+$/) {
        carp "Nice::Tie::Scalar got non-numeric pid $pid" if $^W;
        return undef;
    }

    unless (kill 0, $pid) { # EPERM or ERSCH, no doubt
        carp "Nice::Tie::Scalar got bad pid $pid: $!" if $^W;
        return undef;
    }

    return bless \$pid, $class;
}
```

This tie class has chosen to return an error rather than raising an exception if its constructor should fail. While this is how `dbmopen()` works, other classes may well not wish to be so forgiving. It checks the global variable `$^W` to see whether to emit a bit of noise anyway.

FETCH this

This method will be triggered every time the tied variable is accessed (read). It takes no arguments beyond its self reference, which is the object representing the scalar we're dealing with. Because in this case we're using just a SCALAR ref for the tied scalar object, a simple `$$self` allows the method to get at the real value stored there. In our example below, that real value is the process ID to which we've tied our variable.

```
sub FETCH {
    my $self = shift;
    confess "wrong type" unless ref $self;
    croak "usage error" if @_;
    my $nicety;
    local($!) = 0;
    $nicety = getpriority(PRIO_PROCESS, $$self);
    if ($!) { croak "getpriority failed: $!" }
    return $nicety;
}
```

This time we've decided to blow up (raise an exception) if the renice fails—there's no place for us to return an error otherwise, and it's probably the right thing to do.

STORE this, value

This method will be triggered every time the tied variable is set (assigned). Beyond its self reference, it also expects one (and only one) argument—the new value the user is trying to assign.

```
sub STORE {
    my $self = shift;
    confess "wrong type" unless ref $self;
    my $new_nicety = shift;
    croak "usage error" if @_;

    if ($new_nicety < PRIO_MIN) {
        carp sprintf
          "WARNING: priority %d less than minimum system priority %d",
```

```
                $new_nicety, PRIO_MIN if $^W;
            $new_nicety = PRIO_MIN;
        }

        if ($new_nicety > PRIO_MAX) {
            carp sprintf
              "WARNING: priority %d greater than maximum system priority %d",
                $new_nicety, PRIO_MAX if $^W;
            $new_nicety = PRIO_MAX;
        }

        unless (defined setpriority(PRIO_PROCESS, $$self, $new_nicety)) {
            confess "setpriority failed: $!";
        }
        return $new_nicety;
    }
```

UNTIE this

This method will be triggered when the `untie` occurs. This can be useful if the class needs to know when no further calls will be made. (Except DESTROY of course.) See below for more details.

DESTROY this

This method will be triggered when the tied variable needs to be destructed. As with other object classes, such a method is seldom necessary, because Perl deallocates its moribund object's memory for you automatically—this isn't C++, you know. We'll use a DESTROY method here for debugging purposes only.

```
sub DESTROY {
    my $self = shift;
    confess "wrong type" unless ref $self;
    carp "[ Nice::DESTROY pid $$self ]" if $Nice::DEBUG;
}
```

That's about all there is to it. Actually, it's more than all there is to it, because we've done a few nice things here for the sake of completeness, robustness, and general aesthetics. Simpler TIESCALAR classes are certainly possible.

Tying Arrays

A class implementing a tied ordinary array should define the following methods: TIEARRAY, FETCH, STORE, FETCHSIZE, STORESIZE and perhaps UNTIE and/or DESTROY.

FETCHSIZE and STORESIZE are used to provide `$#array` and equivalent `scalar(@array)` access.

The methods POP, PUSH, SHIFT, UNSHIFT, SPLICE, DELETE, and EXISTS are required if the perl operator with the corresponding (but lowercase) name is to operate on the tied array. The **Tie::Array** class can be used as a base class to implement the first five of these in terms of the basic methods above. The default implementations of DELETE and EXISTS in **Tie::Array** simply `croak`.

In addition EXTEND will be called when perl would have pre–extended allocation in a real array.

This means that tied arrays are now *complete*. The example below needs upgrading to illustrate this. (The documentation in **Tie::Array** is more complete.)

For this discussion, we'll implement an array whose indices are fixed at its creation. If you try to access anything beyond those bounds, you'll take an exception. For example:

```
require Bounded_Array;
tie @ary, 'Bounded_Array', 2;
$| = 1;
for $i (0 .. 10) {
```

```
    print "setting index $i: ";
    $ary[$i] = 10 * $i;
    $ary[$i] = 10 * $i;
    print "value of elt $i now $ary[$i]\n";
}
```

The preamble code for the class is as follows:

```
package Bounded_Array;
use Carp;
use strict;
```

TIEARRAY classname, LIST

This is the constructor for the class. That means it is expected to return a blessed reference through which the new array (probably an anonymous ARRAY ref) will be accessed.

In our example, just to show you that you don't *really* have to return an ARRAY reference, we'll choose a HASH reference to represent our object. A HASH works out well as a generic record type: the {BOUND} field will store the maximum bound allowed, and the {ARRAY} field will hold the true ARRAY ref. If someone outside the class tries to dereference the object returned (doubtless thinking it an ARRAY ref), they'll blow up. This just goes to show you that you should respect an object's privacy.

```
sub TIEARRAY {
    my $class = shift;
    my $bound = shift;
    confess "usage: tie(\@ary, 'Bounded_Array', max_subscript)"
        if @_ || $bound =~ /\D/;
    return bless {
        BOUND => $bound,
        ARRAY => [],
    }, $class;
}
```

FETCH this, index

This method will be triggered every time an individual element the tied array is accessed (read). It takes one argument beyond its self reference: the index whose value we're trying to fetch.

```
sub FETCH {
  my($self,$idx) = @_;
  if ($idx > $self->{BOUND}) {
    confess "Array OOB: $idx > $self->{BOUND}";
  }
  return $self->{ARRAY}[$idx];
}
```

If a negative array index is used to read from an array, the index will be translated to a positive one internally by calling FETCHSIZE before being passed to FETCH.

As you may have noticed, the name of the FETCH method (et al.) is the same for all accesses, even though the constructors differ in names (TIESCALAR vs TIEARRAY). While in theory you could have the same class servicing several tied types, in practice this becomes cumbersome, and it's easiest to keep them at simply one tie type per class.

STORE this, index, value

This method will be triggered every time an element in the tied array is set (written). It takes two arguments beyond its self reference: the index at which we're trying to store something and the value we're trying to put there. For example:

```
sub STORE {
  my($self, $idx, $value) = @_;
  print "[STORE $value at $idx]\n" if _debug;
  if ($idx > $self->{BOUND} ) {
    confess "Array OOB: $idx > $self->{BOUND}";
  }
  return $self->{ARRAY}[$idx] = $value;
}
```

Negative indexes are treated the same as with FETCH.

UNTIE this

Will be called when `untie` happens. (See below.)

DESTROY this

This method will be triggered when the tied variable needs to be destructed. As with the scalar tie class, this is almost never needed in a language that does its own garbage collection, so this time we'll just leave it out.

The code we presented at the top of the tied array class accesses many elements of the array, far more than we've set the bounds to. Therefore, it will blow up once they try to access beyond the 2nd element of @ary, as the following output demonstrates:

```
setting index 0: value of elt 0 now 0
setting index 1: value of elt 1 now 10
setting index 2: value of elt 2 now 20
setting index 3: Array OOB: 3 > 2 at Bounded_Array.pm line 39
        Bounded_Array::FETCH called at testba line 12
```

Tying Hashes

Hashes were the first Perl data type to be tied (see `dbmopen()`). A class implementing a tied hash should define the following methods: TIEHASH is the constructor. FETCH and STORE access the key and value pairs. EXISTS reports whether a key is present in the hash, and DELETE deletes one. CLEAR empties the hash by deleting all the key and value pairs. FIRSTKEY and NEXTKEY implement the `keys()` and `each()` functions to iterate over all the keys. UNTIE is called when `untie` happens, and DESTROY is called when the tied variable is garbage collected.

If this seems like a lot, then feel free to inherit from merely the standard Tie::Hash module for most of your methods, redefining only the interesting ones. See *Tie::Hash* for details.

Remember that Perl distinguishes between a key not existing in the hash, and the key existing in the hash but having a corresponding value of `undef`. The two possibilities can be tested with the `exists()` and `defined()` functions.

Here's an example of a somewhat interesting tied hash class: it gives you a hash representing a particular user's dot files. You index into the hash with the name of the file (minus the dot) and you get back that dot file's contents. For example:

```
use DotFiles;
tie %dot, 'DotFiles';
if ( $dot{profile} =~ /MANPATH/ ||
     $dot{login}   =~ /MANPATH/ ||
     $dot{cshrc}   =~ /MANPATH/    )
{
    print "you seem to set your MANPATH\n";
}
```

Or here's another sample of using our tied class:

```
tie %him, 'DotFiles', 'daemon';
foreach $f ( keys %him ) {
    printf "daemon dot file %s is size %d\n",
        $f, length $him{$f};
}
```

In our tied hash DotFiles example, we use a regular hash for the object containing several important fields, of which only the {LIST} field will be what the user thinks of as the real hash.

USER
: whose dot files this object represents

HOME
: where those dot files live

CLOBBER
: whether we should try to change or remove those dot files

LIST
: the hash of dot file names and content mappings

Here's the start of ***Dotfiles.pm***:

```
package DotFiles;
use Carp;
sub whowasi { (caller(1))[3] . '()' }
my $DEBUG = 0;
sub debug { $DEBUG = @_ ? shift : 1 }
```

For our example, we want to be able to emit debugging info to help in tracing during development. We keep also one convenience function around internally to help print out warnings; whowasi() returns the function name that calls it.

Here are the methods for the DotFiles tied hash.

TIEHASH classname, LIST
: This is the constructor for the class. That means it is expected to return a blessed reference through which the new object (probably but not necessarily an anonymous hash) will be accessed.

  Here's the constructor:

```
sub TIEHASH {
    my $self = shift;
    my $user = shift || $>;
    my $dotdir = shift || '';
    croak "usage: @{[&whowasi]} [USER [DOTDIR]]" if @_;
    $user = getpwuid($user) if $user =~ /^\d+$/;
    my $dir = (getpwnam($user))[7]
            || croak "@{[&whowasi]}: no user $user";
    $dir .= "/$dotdir" if $dotdir;

    my $node = {
        USER    => $user,
        HOME    => $dir,
        LIST    => {},
        CLOBBER => 0,
    };

    opendir(DIR, $dir)
            || croak "@{[&whowasi]}: can't opendir $dir: $!";
    foreach $dot ( grep /^\./ && -f "$dir/$_", readdir(DIR)) {
        $dot =~ s/^\.//;
```

```
            $node->{LIST}{$dot} = undef;
        }
        closedir DIR;
        return bless $node, $self;
    }
```

It's probably worth mentioning that if you're going to filetest the return values out of a readdir, you'd better prepend the directory in question. Otherwise, because we didn't `chdir()` there, it would have been testing the wrong file.

FETCH this, key

This method will be triggered every time an element in the tied hash is accessed (read). It takes one argument beyond its self reference: the key whose value we're trying to fetch.

Here's the fetch for our DotFiles example.

```
sub FETCH {
    carp &whowasi if $DEBUG;
    my $self = shift;
    my $dot = shift;
    my $dir = $self->{HOME};
    my $file = "$dir/.$dot";

    unless (exists $self->{LIST}->{$dot} || -f $file) {
        carp "@{[&whowasi]}: no $dot file" if $DEBUG;
        return undef;
    }

    if (defined $self->{LIST}->{$dot}) {
        return $self->{LIST}->{$dot};
    } else {
        return $self->{LIST}->{$dot} = `cat $dir/.$dot`;
    }
}
```

It was easy to write by having it call the Unix cat(1) command, but it would probably be more portable to open the file manually (and somewhat more efficient). Of course, because dot files are a Unixy concept, we're not that concerned.

STORE this, key, value

This method will be triggered every time an element in the tied hash is set (written). It takes two arguments beyond its self reference: the index at which we're trying to store something, and the value we're trying to put there.

Here in our DotFiles example, we'll be careful not to let them try to overwrite the file unless they've called the `clobber()` method on the original object reference returned by `tie()`.

```
sub STORE {
    carp &whowasi if $DEBUG;
    my $self = shift;
    my $dot = shift;
    my $value = shift;
    my $file = $self->{HOME} . "/.$dot";
    my $user = $self->{USER};

    croak "@{[&whowasi]}: $file not clobberable"
        unless $self->{CLOBBER};

    open(F, "> $file") || croak "can't open $file: $!";
    print F $value;
```

```
    close(F);
}
```

If they wanted to clobber something, they might say:

```
$ob = tie %daemon_dots, 'daemon';
$ob->clobber(1);
$daemon_dots{signature} = "A true daemon\n";
```

Another way to lay hands on a reference to the underlying object is to use the `tied()` function, so they might alternately have set clobber using:

```
tie %daemon_dots, 'daemon';
tied(%daemon_dots)->clobber(1);
```

The clobber method is simply:

```
sub clobber {
    my $self = shift;
    $self->{CLOBBER} = @_ ? shift : 1;
}
```

DELETE this, key

This method is triggered when we remove an element from the hash, typically by using the `delete()` function. Again, we'll be careful to check whether they really want to clobber files.

```
sub DELETE   {
    carp &whowasi if $DEBUG;

    my $self = shift;
    my $dot = shift;
    my $file = $self->{HOME} . "/.$dot";
    croak "@{[&whowasi]}: won't remove file $file"
        unless $self->{CLOBBER};
    delete $self->{LIST}->{$dot};
    my $success = unlink($file);
    carp "@{[&whowasi]}: can't unlink $file: $!" unless $success;
    $success;
}
```

The value returned by DELETE becomes the return value of the call to `delete()`. If you want to emulate the normal behavior of `delete()`, you should return whatever FETCH would have returned for this key. In this example, we have chosen instead to return a value which tells the caller whether the file was successfully deleted.

CLEAR this

This method is triggered when the whole hash is to be cleared, usually by assigning the empty list to it.

In our example, that would remove all the user's dot files! It's such a dangerous thing that they'll have to set CLOBBER to something higher than 1 to make it happen.

```
sub CLEAR    {
    carp &whowasi if $DEBUG;
    my $self = shift;
    croak "@{[&whowasi]}: won't remove all dot files for $self->{USER}"
        unless $self->{CLOBBER} > 1;
    my $dot;
    foreach $dot ( keys %{$self->{LIST}}) {
        $self->DELETE($dot);
    }
```

```
}
```

EXISTS this, key

This method is triggered when the user uses the `exists()` function on a particular hash. In our example, we'll look at the `{LIST}` hash element for this:

```
sub EXISTS   {
    carp &whowasi if $DEBUG;
    my $self = shift;
    my $dot = shift;
    return exists $self->{LIST}->{$dot};
}
```

FIRSTKEY this

This method will be triggered when the user is going to iterate through the hash, such as via a `keys()` or `each()` call.

```
sub FIRSTKEY {
    carp &whowasi if $DEBUG;
    my $self = shift;
    my $a = keys %{$self->{LIST}};          # reset each() iterator
    each %{$self->{LIST}}
}
```

NEXTKEY this, lastkey

This method gets triggered during a `keys()` or `each()` iteration. It has a second argument which is the last key that had been accessed. This is useful if you're carrying about ordering or calling the iterator from more than one sequence, or not really storing things in a hash anywhere.

For our example, we're using a real hash so we'll do just the simple thing, but we'll have to go through the LIST field indirectly.

```
sub NEXTKEY  {
    carp &whowasi if $DEBUG;
    my $self = shift;
    return each %{ $self->{LIST} }
}
```

UNTIE this

This is called when `untie` occurs.

DESTROY this

This method is triggered when a tied hash is about to go out of scope. You don't really need it unless you're trying to add debugging or have auxiliary state to clean up. Here's a very simple function:

```
sub DESTROY  {
    carp &whowasi if $DEBUG;
}
```

Note that functions such as `keys()` and `values()` may return huge lists when used on large objects, like DBM files. You may prefer to use the `each()` function to iterate over such. Example:

```
# print out history file offsets
use NDBM_File;
tie(%HIST, 'NDBM_File', '/usr/lib/news/history', 1, 0);
while (($key,$val) = each %HIST) {
    print $key, ' = ', unpack('L',$val), "\n";
}
untie(%HIST);
```

Tying FileHandles

This is partially implemented now.

A class implementing a tied filehandle should define the following methods: TIEHANDLE, at least one of PRINT, PRINTF, WRITE, READLINE, GETC, READ, and possibly CLOSE, UNTIE and DESTROY. The class can also provide: BINMODE, OPEN, EOF, FILENO, SEEK, TELL – if the corresponding perl operators are used on the handle.

It is especially useful when perl is embedded in some other program, where output to STDOUT and STDERR may have to be redirected in some special way. See nvi and the Apache module for examples.

In our example we're going to create a shouting handle.

```
package Shout;
```

TIEHANDLE classname, LIST

This is the constructor for the class. That means it is expected to return a blessed reference of some sort. The reference can be used to hold some internal information.

```
sub TIEHANDLE { print "<shout>\n"; my $i; bless \$i, shift }
```

WRITE this, LIST

This method will be called when the handle is written to via the `syswrite` function.

```
sub WRITE {
    $r = shift;
    my($buf,$len,$offset) = @_;
    print "WRITE called, \$buf=$buf, \$len=$len, \$offset=$offset";
}
```

PRINT this, LIST

This method will be triggered every time the tied handle is printed to with the `print()` function. Beyond its self reference it also expects the list that was passed to the print function.

```
sub PRINT { $r = shift; $$r++; print join($,,map(uc($_),@_)),$\ }
```

PRINTF this, LIST

This method will be triggered every time the tied handle is printed to with the `printf()` function. Beyond its self reference it also expects the format and list that was passed to the printf function.

```
sub PRINTF {
    shift;
    my $fmt = shift;
    print sprintf($fmt, @_)."\n";
}
```

READ this, LIST

This method will be called when the handle is read from via the `read` or `sysread` functions.

```
sub READ {
    my $self = shift;
    my $$bufref = \$_[0];
    my(undef,$len,$offset) = @_;
    print "READ called, \$buf=$bufref, \$len=$len, \$offset=$offset";
    # add to $$bufref, set $len to number of characters read
    $len;
}
```

READLINE this

This method will be called when the handle is read from via <HANDLE. The method should return undef when there is no more data.

```
sub READLINE { $r = shift; "READLINE called $$r times\n"; }
```

GETC this

This method will be called when the `getc` function is called.

```
sub GETC { print "Don't GETC, Get Perl"; return "a"; }
```

CLOSE this

This method will be called when the handle is closed via the `close` function.

```
sub CLOSE { print "CLOSE called.\n" }
```

UNTIE this

As with the other types of ties, this method will be called when `untie` happens. It may be appropriate to "auto CLOSE" when this occurs.

DESTROY this

As with the other types of ties, this method will be called when the tied handle is about to be destroyed. This is useful for debugging and possibly cleaning up.

```
sub DESTROY { print "</shout>\n" }
```

Here's how to use our little example:

```
tie(*FOO,'Shout');
print FOO "hello\n";
$a = 4; $b = 6;
print FOO $a, " plus ", $b, " equals ", $a + $b, "\n";
print <FOO>;
```

UNTIE this

You can define for all tie types an UNTIE method that will be called at `untie()`.

The `untie` Gotcha

If you intend making use of the object returned from either `tie()` or `tied()`, and if the tie's target class defines a destructor, there is a subtle gotcha you *must* guard against.

As setup, consider this (admittedly rather contrived) example of a tie; all it does is use a file to keep a log of the values assigned to a scalar.

```
package Remember;

use strict;
use warnings;
use IO::File;

sub TIESCALAR {
    my $class = shift;
    my $filename = shift;
    my $handle = new IO::File "> $filename"
                     or die "Cannot open $filename: $!\n";

    print $handle "The Start\n";
    bless {FH => $handle, Value => 0}, $class;
}

sub FETCH {
    my $self = shift;
```

```
    return $self->{Value};
}

sub STORE {
    my $self = shift;
    my $value = shift;
    my $handle = $self->{FH};
    print $handle "$value\n";
    $self->{Value} = $value;
}

sub DESTROY {
    my $self = shift;
    my $handle = $self->{FH};
    print $handle "The End\n";
    close $handle;
}

1;
```

Here is an example that makes use of this tie:

```
use strict;
use Remember;

my $fred;
tie $fred, 'Remember', 'myfile.txt';
$fred = 1;
$fred = 4;
$fred = 5;
untie $fred;
system "cat myfile.txt";
```

This is the output when it is executed:

```
The Start
1
4
5
The End
```

So far so good. Those of you who have been paying attention will have spotted that the tied object hasn't been used so far. So lets add an extra method to the Remember class to allow comments to be included in the file — say, something like this:

```
sub comment {
    my $self = shift;
    my $text = shift;
    my $handle = $self->{FH};
    print $handle $text, "\n";
}
```

And here is the previous example modified to use the `comment` method (which requires the tied object):

```
use strict;
use Remember;

my ($fred, $x);
$x = tie $fred, 'Remember', 'myfile.txt';
$fred = 1;
$fred = 4;
```

```
comment $x "changing...";
$fred = 5;
untie $fred;
system "cat myfile.txt";
```

When this code is executed there is no output. Here's why:

When a variable is tied, it is associated with the object which is the return value of the TIESCALAR, TIEARRAY, or TIEHASH function. This object normally has only one reference, namely, the implicit reference from the tied variable. When `untie()` is called, that reference is destroyed. Then, as in the first example above, the object's destructor (DESTROY) is called, which is normal for objects that have no more valid references; and thus the file is closed.

In the second example, however, we have stored another reference to the tied object in `$x`. That means that when `untie()` gets called there will still be a valid reference to the object in existence, so the destructor is not called at that time, and thus the file is not closed. The reason there is no output is because the file buffers have not been flushed to disk.

Now that you know what the problem is, what can you do to avoid it? Prior to the introduction of the optional UNTIE method the only way was the good old `-w` flag. Which will spot any instances where you call `untie()` and there are still valid references to the tied object. If the second script above this near the top `use warnings 'untie'` or was run with the `-w` flag, Perl prints this warning message:

```
untie attempted while 1 inner references still exist
```

To get the script to work properly and silence the warning make sure there are no valid references to the tied object *before* `untie()` is called:

```
undef $x;
untie $fred;
```

Now that UNTIE exists the class designer can decide which parts of the class functionality are really associated with `untie` and which with the object being destroyed. What makes sense for a given class depends on whether the inner references are being kept so that non-tie-related methods can be called on the object. But in most cases it probably makes sense to move the functionality that would have been in DESTROY to the UNTIE method.

If the UNTIE method exists then the warning above does not occur. Instead the UNTIE method is passed the count of "extra" references and can issue its own warning if appropriate. e.g. to replicate the no UNTIE case this method can be used:

```
sub UNTIE
{
 my ($obj,$count) = @_;
 carp "untie attempted while $count inner references still exist" if $count;
}
```

SEE ALSO

See *DB_File* or *Config* for some interesting `tie()` implementations. A good starting point for many `tie()` implementations is with one of the modules *Tie::Scalar*, *Tie::Array*, *Tie::Hash*, or *Tie::Handle*.

BUGS

You cannot easily tie a multilevel data structure (such as a hash of hashes) to a dbm file. The first problem is that all but GDBM and Berkeley DB have size limitations, but beyond that, you also have problems with how references are to be represented on disk. One experimental module that does attempt to address this need partially is the MLDBM module. Check your nearest CPAN site as described in *perlmodlib* for source code to MLDBM.

Tied filehandles are still incomplete. `sysopen()`, `truncate()`, `flock()`, `fcntl()`, `stat()` and -X can't currently be trapped.

AUTHOR

Tom Christiansen

TIEHANDLE by Sven Verdoolaege *<skimo@dns.ufsia.ac.be* and Doug MacEachern *<dougm@osf.org*

UNTIE by Nick Ing−Simmons *<nick@ing−simmons.net*

NAME

perltoc − perl documentation table of contents

DESCRIPTION

This page provides a brief table of contents for the rest of the Perl documentation set. It is meant to be scanned quickly or grepped through to locate the proper section you're looking for.

BASIC DOCUMENTATION

perl − Practical Extraction and Report Language

SYNOPSIS
DESCRIPTION

modularity and reusability using innumerable modules, embeddable and extensible, roll−your−own magic variables (including multiple simultaneous DBM implementations), subroutines can now be overridden, autoloaded, and prototyped, arbitrarily nested data structures and anonymous functions, object−oriented programming, compilability into C code or Perl bytecode, support for light−weight processes (threads), support for internationalization, localization, and Unicode, lexical scoping, regular expression enhancements, enhanced debugger and interactive Perl environment, with integrated editor support, POSIX 1003.1 compliant library

AVAILABILITY
ENVIRONMENT
AUTHOR
FILES
SEE ALSO
DIAGNOSTICS
BUGS
NOTES

perlfaq − frequently asked questions about Perl (`$Date: 1999/05/23`

20:38:02 $)

DESCRIPTION

perlfaq: Structural overview of the FAQ, *perlfaq1*: General Questions About Perl, What is Perl?, Who supports Perl? Who develops it? Why is it free?, Which version of Perl should I use?, What are perl4 and perl5?, What is perl6?, How stable is Perl?, Is Perl difficult to learn?, How does Perl compare with other languages like Java, Python, REXX, Scheme, or Tcl?, Can I do [task] in Perl?, When shouldn't I program in Perl?, What's the difference between "perl" and "Perl"?, Is it a Perl program or a Perl script?, What is a JAPH?, Where can I get a list of Larry Wall witticisms?, How can I convince my sysadmin/supervisor/employees to use (version 5/5.005/Perl) instead of some other language?, *perlfaq2*: Obtaining and Learning about Perl, What machines support Perl? Where do I get it?, How can I get a binary version of Perl?, I don't have a C compiler on my system. How can I compile perl?, I copied the Perl binary from one machine to another, but scripts don't work, I grabbed the sources and tried to compile but gdbm/dynamic loading/malloc/linking/... failed. How do I make it work?, What modules and extensions are available for Perl? What is CPAN? What does CPAN/src/... mean?, Is there an ISO or ANSI certified version of Perl?, Where can I get information on Perl?, What are the Perl newsgroups on USENET? Where do I post questions?, Where should I post source code?, Perl Books, Perl in Magazines, Perl on the Net: FTP and WWW Access, What mailing lists are there for perl?, Archives of comp.lang.perl.misc, Where can I buy a commercial version of Perl?, Where do I send bug reports?, What is perl.com?, *perlfaq3*: Programming Tools, How do I do (anything)?, How can I use Perl interactively?, Is there a Perl shell?, How do I debug my Perl programs?, How do I profile my Perl programs?, How do I cross−reference my Perl programs?, Is there a pretty−printer (formatter) for Perl?, Is there a ctags for Perl?, Is there an IDE or Windows Perl Editor?, Where can I get Perl macros for vi?, Where can I get perl−mode for emacs?, How can I use curses with Perl?, How can I use X or Tk with Perl?, How can I generate simple menus without using CGI or Tk?, What is undump?, How can I make my Perl program run faster?, How can I make my Perl program take less

perltoc – perl documentation table of contents

perlreftut – Mark's very short tutorial about references

perldsc – Perl Data Structures Cookbook

perlfaq8 – System Interaction (`$Revision: 1.39 $, $Date: 1999/05/23` 18:37:57 `$`)

perlfaq9 – Networking (`$Revision: 1.26 $, $Date: 1999/05/23 16:08:30 $`)

perlposix−bc, README.posix−bc − building and installing Perl for

perlsolaris, README.solaris − Perl version 5 on Solaris systems

B – The Perl Compiler

d_flexfnam, d_flock, d_fork, d_fpathconf, d_fpos64_t, d_frexpl, d_fs_data_s, d_fseeko, d_fsetpos, d_fstatfs, d_fstatvfs, d_ftello, d_ftime, d_Gconvert, d_getcwd, d_getespwnam, d_getfsstat, d_getgrent, d_getgrps, d_gethbyaddr, d_gethbyname, d_gethent, d_gethname, d_gethostprotos, d_getlogin, d_getmnt, d_getmntent, d_getnbyaddr, d_getnbyname, d_getnent, d_getnetprotos, d_getpbyname, d_getpbynumber, d_getpent, d_getpgid, d_getpgrp2, d_getpgrp, d_getppid, d_getprior, d_getprotoprotos, d_getprpwnam, d_getpwent, d_getsbyname, d_getsbyport, d_getsent, d_getservprotos, d_getspnam, d_gettimeod, d_gnulibc, d_grpasswd, d_hasmntopt, d_htonl, d_iconv, d_index, d_inetaton, d_int64_t, d_isascii, d_isnan, d_isnanl, d_killpg, d_lchown, d_ldbl_dig, d_link, d_locconv, d_lockf, d_longdbl, d_longlong, d_lseekproto, d_lstat, d_madvise, d_mblen, d_mbstowcs, d_mbtowc, d_memchr, d_memcmp, d_memcpy, d_memmove, d_memset, d_mkdir, d_mkdtemp, d_mkfifo, d_mkstemp, d_mkstemps, d_mktime, d_mmap, d_modfl, d_mprotect, d_msg, d_msg_ctrunc, d_msg_dontroute, d_msg_oob, d_msg_peek, d_msg_proxy, d_msgctl, d_msgget, d_msgrcv, d_msgsnd, d_msync, d_munmap, d_mymalloc, d_nice, d_nv_preserves_uv, d_nv_preserves_uv_bits, d_off64_t, d_old_pthread_create_joinable, d_oldpthreads, d_oldsock, d_open3, d_pathconf, d_pause, d_perl_otherlibdirs, d_phostname, d_pipe, d_poll, d_portable, d_PRId64, d_PRIeldbl, d_PRIEUldbl, d_PRIfldbl, d_PRIFUldbl, d_PRIgldbl, d_PRIGUldbl, d_PRIi64, d_PRIo64, d_PRIu64, d_PRIx64, d_PRIXU64, d_pthread_yield, d_pwage, d_pwchange, d_pwclass, d_pwcomment, d_pwexpire, d_pwgecos, d_pwpasswd, d_pwquota, d_qgcvt, d_quad, d_readdir, d_readlink, d_rename, d_rewinddir, d_rmdir, d_safebcpy, d_safemcpy, d_sanemcmp, d_sched_yield, d_scm_rights, d_SCNfldbl, d_seekdir, d_select, d_sem, d_semctl, d_semctl_semid_ds, d_semctl_semun, d_semget, d_semop, d_setegid, d_seteuid, d_setgrent, d_setgrps, d_sethent, d_setlinebuf, d_setlocale, d_setnent, d_setpent, d_setpgid, d_setpgrp2, d_setpgrp, d_setprior, d_setproctitle, d_setpwent, d_setregid, d_setresgid, d_setresuid, d_setreuid, d_setrgid, d_setruid, d_setsent, d_setsid, d_setvbuf, d_sfio, d_shm, d_shmat, d_shmatprototype, d_shmctl, d_shmdt, d_shmget, d_sigaction, d_sigsetjmp, d_socket, d_socklen_t, d_sockpair, d_socks5_init, d_sqrtl, d_statblks, d_statfs_f_flags, d_statfs_s, d_statvfs, d_stdio_cnt_lval, d_stdio_ptr_lval, d_stdio_ptr_lval_nochange_cnt, d_stdio_ptr_lval_sets_cnt, d_stdio_stream_array, d_stdiobase, d_stdstdio, d_strchr, d_strcoll, d_strctcpy, d_strerrm, d_strerror, d_strtod, d_strtol, d_strtold, d_strtoll, d_strtoul, d_strtoull, d_strtouq, d_strxfrm, d_suidsafe, d_symlink, d_syscall, d_sysconf, d_sysernlst, d_syserrlst, d_system, d_tcgetpgrp, d_tcsetpgrp, d_telldir, d_telldirproto, d_time, d_times, d_truncate, d_tzname, d_umask, d_uname, d_union_semun, d_ustat, d_vendorarch, d_vendorbin, d_vendorlib, d_vfork, d_void_closedir, d_voidsig, d_voidtty, d_volatile, d_vprintf, d_wait4, d_waitpid, d_wcstombs, d_wctomb, d_xenix, date, db_hashtype, db_prefixtype, defvoidused, direntrytype, dlext, dlsrc, doublesize, drand01, dynamic_ext

e eagain, ebcdic, echo, egrep, emacs, eunicefix, exe_ext, expr, extensions

f fflushall, fflushNULL, find, firstmakefile, flex, fpossize, fpostype, freetype, full_ar, full_csh, full_sed

g gccosandvers, gccversion, gidformat, gidsign, gidsize, gidtype, glibpth, grep, groupcat, groupstype, gzip

h h_fcntl, h_sysfile, hint, hostcat

i i16size, i16type, i32size, i32type, i64size, i64type, i8size, i8type, i_arpainet, i_bsdioctl, i_db, i_dbm, i_dirent, i_dld, i_dlfcn, i_fcntl, i_float, i_gdbm, i_grp, i_iconv, i_ieeefp, i_inttypes, i_libutil, i_limits, i_locale, i_machcthr, i_malloc, i_math, i_memory, i_mntent, i_ndbm, i_netdb, i_neterrno, i_netinettcp, i_niin, i_poll, i_prot, i_pthread, i_pwd, i_rpcsvcdbm, i_sfio, i_sgtty, i_shadow, i_socks, i_stdarg, i_stddef, i_stdlib, i_string, i_sunmath, i_sysaccess, i_sysdir, i_sysfile, i_sysfilio, i_sysin, i_sysioctl, i_syslog, i_sysmman, i_sysmode, i_sysmount, i_sysndir, i_sysparam, i_sysresrc, i_syssecrt, i_sysselct, i_syssockio, i_sysstat, i_sysstatfs, i_sysstatvfs, i_systime, i_systimek, i_systimes, i_systypes, i_sysuio, i_sysun, i_sysutsname, i_sysvfs, i_syswait, i_termio, i_termios, i_time, i_unistd, i_ustat, i_utime, i_values, i_varargs, i_varhdr, i_vfork, ignore_versioned_solibs, inc_version_list, inc_version_list_init, incpath, inews, installarchlib, installbin, installman1dir, installman3dir, installprefix, installprefixexp, installprivlib, installscript, installsitearch, installsitebin, installsitelib, installstyle, installusrbinperl, installvendorarch, installvendorbin, installvendorlib, intsize, ivdformat, ivsize, ivtype

k known_extensions, ksh

l ld, lddlflags, ldflags, ldflags_uselargefiles, ldlibpthname, less, lib_ext, libc, libperl, libpth, libs, libsdirs, libsfiles, libsfound, libspath, libswanted, libswanted_uselargefiles, line, lint, lkflags, ln, lns, locincpth, loclibpth, longdblsize, longlongsize, longsize, lp, lpr, ls, lseeksize, lseektype

m mail, mailx, make, make_set_make, mallocobj, mallocsrc, malloctype, man1dir, man1direxp, man1ext, man3dir, man3direxp, man3ext

M Mcc, mips_type, mkdir, mmaptype, modetype, more, multiarch, mv, myarchname, mydomain, myhostname, myuname

n n, netdb_hlen_type, netdb_host_type, netdb_name_type, netdb_net_type, nm, nm_opt, nm_so_opt, nonxs_ext, nroff, nveformat, nvEUformat, nvfformat, nvFUformat, nvgformat, nvGUformat, nvsize, nvtype

o o_nonblock, obj_ext, old_pthread_create_joinable, optimize, orderlib, osname, osvers, otherlibdirs

p package, pager, passcat, patchlevel, path_sep, perl5, perl

P PERL_REVISION, PERL_SUBVERSION, PERL_VERSION, perladmin, perllibs, perlpath, pg, phostname, pidtype, plibpth, pm_apiversion, pmake, pr, prefix, prefixexp, privlib, privlibexp, prototype, ptrsize

q quadkind, quadtype

r randbits, randfunc, randseedtype, ranlib, rd_nodata, revision, rm, rmail, runnm

s sched_yield, scriptdir, scriptdirexp, sed, seedfunc, selectminbits, selecttype, sendmail, sh, shar, sharpbang, shmattype, shortsize, shrpenv, shsharp, sig_count, sig_name, sig_name_init, sig_num, sig_num_init, signal_t, sitearch, sitearchexp, sitebin, sitebinexp, sitelib, sitelib_stem, sitelibexp, siteprefix, siteprefixexp, sizesize, sizetype, sleep, smail, so, sockethdr, socketlib, socksizetype, sort,

without previous =over, No argument for =begin, =end without =begin, Nested =begin's, =for without formatter specification, unresolved internal link *NAME*, Unknown command "*CMD*", Unknown interior-sequence "*SEQ*", nested commands *CMD*<...*CMD*<...>...>, garbled entity *STRING*, Entity number out of range, malformed link L<>, nonempty Z<>, empty X<>, Spurious text after =pod / =cut, Spurious character(s) after =back

Warnings

multiple occurence of link target *name*, line containing nothing but whitespace in paragraph, file does not start with =head, No numeric argument for =over, previous =item has no contents, preceding non-item paragraph(s), =item type mismatch (*one* vs. *two*), *N* unescaped <> in paragraph, Unknown entity, No items in =over, No argument for =item, empty section in previous paragraph, Verbatim paragraph in NAME section

Hyperlinks

collapsing newlines to blanks, ignoring leading/trailing whitespace in link, (section) in '`$page`' deprecated, alternative text/node '%s' contains non-escaped | or /

RETURN VALUE
EXAMPLES
INTERFACE

```
Pod::Checker->new( %options )
```

```
$checker->poderror( @args ),$checker->poderror( {%opts}, @args )
```

```
$checker->num_errors()
```

```
$checker->name()
```

```
$checker->node()
```

```
$checker->idx()
```

```
$checker->hyperlink()
```

AUTHOR

Pod::Find – find POD documents in directory trees

SYNOPSIS
DESCRIPTION

```
pod_find( { %opts } , @directories )
    -verbose => 1,-perl => 1,-script => 1,-inc => 1
```

```
simplify_name( $str )
pod_where( { %opts }, $pod )
    -inc => 1,-dirs => [ $dir1, $dir2, ... ],-verbose => 1
```

```
contains_pod( $file , $verbose )
```

AUTHOR
SEE ALSO

Pod::Html – module to convert pod files to HTML

SYNOPSIS
DESCRIPTION
ARGUMENTS

backlink, css, flush, header, help, htmldir, htmlroot, index, infile, libpods, netscape, outfile, podpath, podroot, quiet, recurse, title, verbose

Pod::LaTeX – Convert Pod data to formatted Latex

Here should be listed all the extra programs' documentation, but they don't all have manual pages yet:

a2p
s2p
find2perl
h2ph
c2ph
h2xs
xsubpp
pod2man
wrapsuid

AUTHOR

Larry Wall *<larry@wall.org*, with the help of oodles of other folks.

NAME

perltodo − Perl TO−DO List

DESCRIPTION

This is a list of wishes for Perl. It is maintained by Nathan Torkington for the Perl porters. Send updates to *perl5−porters@perl.org*. If you want to work on any of these projects, be sure to check the perl5−porters archives for past ideas, flames, and propaganda. This will save you time and also prevent you from implementing something that Larry has already vetoed. One set of archives may be found at:

```
http://www.xray.mpe.mpg.de/mailing-lists/perl5-porters/
```

Infrastructure

Mailing list archives

Chaim suggests contacting egroup and asking them to archive the other perl.org mailing lists. Probably not advocacy, but definitely perl6−porters, etc.

Bug tracking system

Richard Foley *richard@perl.org* is writing one. We looked at several, like gnats and the Debian system, but at the time we investigated them, none met our needs. Since then, Jitterbug has matured, and may be worth reinvestigation.

The system we've developed is the recipient of perlbug mail, and any followups it generates from perl5−porters. New bugs are entered into a mysql database, and sent on to perl5−porters with the subject line rewritten to include a "ticket number" (unique ID for the new bug). If the incoming message already had a ticket number in the subject line, then the message is logged against that bug. There is a separate email interface (not forwarding to p5p) that permits porters to claim, categorize, and close tickets.

There is also a web interface to the system at http://bugs.perl.org.

The current delay in implementation is caused by perl.org lockups. One suspect is the mail handling system, possibly going into loops.

We still desperately need a bugmaster, someone who will look at every new "bug" and kill those that we already know about, those that are not bugs at all, etc.

Regression Tests

The test suite for Perl serves two needs: ensuring features work, and ensuring old bugs have not been reintroduced. Both need work.

Brent LaVelle (lavelle@metronet.com) has stepped forward to work on performance tests and improving the size of the test suite.

Coverage

Do the tests that come with Perl exercise every line (or every block, or ...) of the Perl interpreter, and if not then how can we make them do so?

Regression

No bug fixes should be made without a corresponding testsuite addition. This needs a dedicated enforcer, as the current pumpking is either too lazy or too stupid or both and lets enforcement wander all over the map. :−)

__DIE__

Tests that fail need to be of a form that can be readily mailed to perlbug and diagnosed with minimal back−and−forth's to determine which test failed, due to what cause, etc.

suidperl

We need regression/sanity tests for suidperl

The 25% slowdown from perl4 to perl5

This value may or may not be accurate, but it certainly is eye−catching. For some things perl5 is faster than perl4, but often the reliability and extensibility have come at a cost of speed. The benchmark suite that Gisle released earlier has been hailed as both a fantastic solution and as a source of entirely meaningless figures. Do we need to test "real applications"? Can you do so? Anyone have machines to dedicate to the task? Identify the things that have grown slower, and see if there's a way to make them faster.

Configure

Andy Dougherty maintain(edls) a list of "todo" items for the configure that comes with Perl. See Porting/pumpkin.pod in the latest source release.

Install HTML

Have "make install" give you the option to install HTML as well. This would be part of Configure. Andy Wardley (certified Perl studmuffin) will look into the current problems of HTML installation—is 'installhtml' preventing this from happening cleanly, or is pod2html the problem? If the latter, Brad Appleton's pod work may fix the problem for free.

Perl Language

64−bit Perl

Verify complete 64 bit support so that the value of sysseek, or `-s`, or `stat()`, or tell can fit into a perl number without losing precision. Work with the perl−64bit mailing list on perl.org.

Prototypes

Named prototypes

Add proper named prototypes that actually work usefully.

Indirect objects

Fix prototype bug that forgets indirect objects.

Method calls

Prototypes for method calls.

Context

Return context prototype declarations.

Scoped subs

lexically−scoped subs, e.g. my sub

Perl Internals

magic_setisa

`magic_setisa` should be made to update %FIELDS [???]

Garbage Collection

There was talk of a mark−and−sweep garbage collector at TPC2, but the (to users) unpredictable nature of its behaviour put some off. Sarathy, I believe, did the work. Here's what he has to say:

Yeah, I hope to implement it someday too. The points that were raised in TPC2 were all to do with calling `DESTROY()` methods, but I think we can accommodate that by extending `bless()` to stash extra information for objects so we track their lifetime accurately for those that want their `DESTROY()` to be predictable (this will be a speed hit, naturally, and will therefore be optional, naturally. :)

[N.B. Don't even ask me about this now! When I have the time to write a cogent summary, I'll post it.]

Reliable signals

Sarathy and Dan Sugalski are working on this. Chip posted a patch earlier, but it was not accepted into 5.005. The issue is tricky, because it has the potential to greatly slow down the core.

There are at least three things to consider:

Alternate `runops()` for signal despatch

Sarathy and Dan are discussed this on perl5–porters.

Figure out how to `die()` in delayed sighandler
Add tests for Thread::Signal
Automatic tests against CPAN

Is there some way to automatically build all/most of CPAN with the new Perl and check that the modules there pass all the tests?

Interpolated regex performance bugs

```
while (<>) {
  $found = 0;
  foreach $pat (@patterns) {
    $found++ if /$pat/o;
  }
  print if $found;
}
```

The qr// syntax added in 5.005 has solved this problem, but it needs more thorough documentation.

Memory leaks from failed eval/regcomp

The only known memory leaks in Perl are in failed code or regexp compilation. Fix this. Hugo Van Der Sanden will attempt this but won't have tuits until January 1999.

Make XS easier to use

There was interest in SWIG from porters, but nothing has happened lately.

Make embedded Perl easier to use

This is probably difficult for the same reasons that "XS For Dummies" will be difficult.

Namespace cleanup

```
CPP-space:    restrict CPP symbols exported from headers
header-space: move into CORE/perl/
API-space:    begin list of things that constitute public api
env-space:    Configure should use PERL_CONFIG instead of CONFIG etc.
```

MULTIPLICITY

Complete work on safe recursive interpreters `Perl->new()`. Sarathy says that a reference implementation exists.

MacPerl

Chris Nandor and Matthias Neeracher are working on better integrating MacPerl into the Perl distribution.

Documentation

There's a lot of documentation that comes with Perl. The quantity of documentation makes it difficult for users to know which section of which manpage to read in order to solve their problem. Tom Christiansen has done much of the documentation work in the past.

A clear division into tutorial and reference

Some manpages (e.g., perltoot and perlreftut) clearly set out to educate the reader about a subject. Other manpages (e.g., perlsub) are references for which there is no tutorial, or are references with a slight tutorial bent. If things are either tutorial or reference, then the reader knows which manpage to read to learn about a

subject, and which manpage to read to learn all about an aspect of that subject. Part of the solution to this is:

Remove the artificial distinction between operators and functions

History shows us that users, and often porters, aren't clear on the operator–function distinction. The present split in reference material between perlfunc and perlop hinders user navigation. Given that perlfunc is by far the larger of the two, move operator reference into perlfunc.

More tutorials

More documents of a tutorial nature could help. Here are some candidates:

Regular expressions

Robin Berjon (r.berjon@ltconsulting.net) has volunteered.

I/O

Mark–Jason Dominus (mjd@plover.com) has an outline for perliotut.

pack/unpack

This is badly needed. There has been some discussion on the subject on perl5–porters.

Debugging

Ronald Kimball (rjk@linguist.dartmouth.edu) has volunteered.

Include a search tool

perldoc should be able to 'grep' fulltext indices of installed POD files. This would let people say:

```
perldoc -find printing numbers with commas
```

and get back the perlfaq entry on 'commify'.

This solution, however, requires documentation to contain the keywords the user is searching for. Even when the users know what they're looking for, often they can't spell it.

Include a locate tool

perldoc should be able to help people find the manpages on a particular high–level subject:

```
perldoc -find web
```

would tell them manpages, web pages, and books with material on web programming. Similarly `perldoc -find databases`, `perldoc -find references` and so on.

We need something in the vicinity of:

```
% perl -help random stuff
No documentation for perl function 'random stuff' found
The following entry in perlfunc.pod matches /random/a:
  =item rand EXPR

  =item rand

  Returns a random fractional number greater than or equal to C<0> and less
  than the value of EXPR.  (EXPR should be positive.)  If EXPR is
  omitted, the value C<1> is used.  Automatically calls C<srand()> unless
  C<srand()> has already been called.  See also C<srand()>.

  (Note: If your rand function consistently returns numbers that are too
  large or too small, then your version of Perl was probably compiled
  with the wrong number of RANDBITS.)
The following pod pages seem to have /stuff/a:
  perlfunc.pod        (7 hits)
  perlfaq7.pod        (6 hits)
  perlmod.pod         (4 hits)
  perlsyn.pod         (3 hits)
  perlfaq8.pod        (2 hits)
```

```
  perlipc.pod         (2 hits)
  perl5004delta.pod   (1 hit)
  perl5005delta.pod   (1 hit)
  perlcall.pod(1 hit)
  perldelta.pod(1 hit)
  perlfaq3.pod(1 hit)
  perlfaq5.pod(1 hit)
  perlhist.pod(1 hit)
  perlref.pod         (1 hit)
  perltoc.pod         (1 hit)
  perltrap.pod(1 hit)
Proceed to open perlfunc.pod? [y] n
Do you want to speak perl interactively? [y] n
Should I dial 911? [y] n
Do you need psychiatric help? [y] y
<PELIZA> Hi, what bothers you today?
         A Python programmer in the next cubby is driving me nuts!
<PELIZA> Hmm, thats fixable.  Just [rest censored]
```

Separate function manpages by default

Perl should install 'manpages' for every function/operator into the 3pl or 3p manual section. By default. The splitman program in the Perl source distribution does the work of turning big perlfunc into little 3p pages.

Users can't find the manpages

Make `perldoc` tell users what they need to add to their .login or .cshrc to set their MANPATH correctly.

Install ALL Documentation

Make the standard documentation kit include the VMS, OS/2, Win32, Threads, etc information. installperl and pod/Makefile should know enough to copy README.foo to perlfoo.pod before building everything, when appropriate.

Outstanding issues to be documented

Tom has a list of 5.005_5* features or changes that require documentation.

Create one document that coherently explains the delta between the last camel release and the current release. perldelta was supposed to be that, but no longer. The things in perldelta never seemed to get placed in the right places in the real manpages, either. This needs work.

Adapt www.linuxhq.com for Perl

This should help glorify documentation and get more people involved in perl development.

Replace man with a perl program

Can we reimplement man in Perl? Tom has a start. I believe some of the Linux systems distribute a manalike. Alternatively, build on perldoc to remove the unfeatures like "is slow" and "has no apropos".

Unicode tutorial

We could use more work on helping people understand Perl's new Unicode support that Larry has created.

Modules

Update the POSIX extension to conform with the POSIX 1003.1 Edition 2

The current state of the POSIX extension is as of Edition 1, 1991, whereas the Edition 2 came out in 1996. ISO/IEC 9945:1−1996(E), ANSI/IEEE Std 1003.1, 1996 Edition. ISBN 1−55937−573−6. The updates were legion: threads, IPC, and real time extensions.

Module versions

Automate the checking of versions in the standard distribution so it's easy for a pumpking to check whether CPAN has a newer version that we should be including?

New modules

Which modules should be added to the standard distribution? This ties in with the SDK discussed on the perl-sdk list at perl.org.

Profiler

Make the profiler (Devel::DProf) part of the standard release, and document it well.

Tie Modules

VecArray

Implement array using `vec()`. Nathan Torkington has working code to do this.

SubstrArray

Implement array using `substr()`

VirtualArray

Implement array using a file

ShiftSplice

Defines shift et al in terms of splice method

Procedural options

Support procedural interfaces for the common cases of Perl's gratuitously OOO modules. Tom objects to "use IO::File" reading many thousands of lines of code.

RPC

Write a module for transparent, portable remote procedure calls. (Not core). This touches on the CORBA and ILU work.

y2k localtime/gmtime

Write a module, Y2k::Catch, which overloads localtime and gmtime's returned year value and catches "bad" attempts to use it.

Export File::Find variables

Make File::Find export `$name` etc manually, at least if asked to.

Ioctl

Finish a proper Ioctl module.

Debugger attach/detach

Permit a user to debug an already-running program.

Regular Expression debugger

Create a visual profiler/debugger tool that stepped you through the execution of a regular expression point by point. Ilya has a module to color-code and display regular expression parses and executions. There's something at http://tkworld.org/ that might be a good start, it's a Tk/Tcl RE wizard, that builds regexen of many flavours.

Alternative RE Syntax

Make an alternative regular expression syntax that is accessed through a module. For instance,

```
use RE;
$re = start_of_line()
    ->literal("1998/10/08")
    ->optional( whitespace() )
```

```
    ->literal("[")
    ->remember( many( or( "-", digit() ) ) );

if (/$re/) {
  print "time is $1\n";
}
```

Newbies to regular expressions typically only use a subset of the full language. Perhaps you wouldn't have to implement the full feature set.

Bundled modules

Nicholas Clark (nick@flirble.org) had a patch for storing modules in zipped format. This needs exploring and concluding.

Expect

Adopt IO::Tty, make it as portable as Don Libes' "expect" (can we link against expect code?), and perfect a Perl version of expect. IO::Tty and expect could then be distributed as part of the core distribution, replacing Comm.pl and other hacks.

GUI::Native

A simple−to−use interface to native graphical abilities would be welcomed. Oh, Perl's access Tk is nice enough, and reasonably portable, but it's not particularly as fast as one would like. Simple access to the mouse's cut buffer or mouse−presses shouldn't required loading a few terabytes of Tk code.

Update semibroken auxiliary tools; h2ph, a2p, etc.

Kurt Starsinic is working on h2ph. mjd has fixed bugs in a2p in the past. a2p apparently doesn't work on nawk and gawk extensions. Graham Barr has an Include module that does h2ph work at runtime.

pod2html

A short−term fix: pod2html generates absolute HTML links. Make it generate relative links.

Podchecker

Something like lint for Pod would be good. Something that catches common errors as well as gross ones. Brad Appleton is putting together something as part of his PodParser work.

Tom's Wishes

Webperl

Design a webperl environment that's as tightly integrated and as easy−to−use as Perl's current command−line environment.

Mobile agents

More work on a safe and secure execution environment for mobile agents would be neat; the Safe.pm module is a start, but there's a still a lot to be done in that area. Adopt Penguin?

POSIX on non−POSIX

Standard programming constructs for non−POSIX systems would help a lot of programmers stuck on primitive, legacy systems. For example, Microsoft still hasn't made a usable POSIX interface on their clunky systems, which means that standard operations such as `alarm()` and `fork()`, both critical for sophisticated client−server programming, must both be kludged around.

I'm unsure whether Tom means to emulate alarm( )and `fork()`, or merely to provide a document like perlport.pod to say which features are portable and which are not.

Portable installations

Figure out a portable semi−gelled installation, that is, one without full paths. Larry has said that he's thinking about this. Ilya pointed out that `perllib_mangle()` is good for this.

Win32 Stuff

Rename new headers to be consistent with the rest

Sort out the `spawnvp()` mess

Work out DLL versioning

Style–check

Would be nice to have

`pack "(stuff)*"`
Contiguous bitfields in pack/unpack
lexperl
Bundled perl preprocessor
Use posix calls internally where possible
format BOTTOM
–i rename file only when successfully changed
All ARGV input should act like <
report HANDLE [formats].
support in perlmain to rerun debugger
lvalue functions

Tuomas Lukka, on behalf of the PDL project, greatly desires this and Ilya has a patch for it (probably against an older version of Perl). Tuomas points out that what PDL really wants is lvalue *methods*, not just subs.

Possible pragmas

'less'

(use less memory, CPU)

Optimizations

constant function cache

foreach(reverse...)

Cache eval tree

Unless lexical outer scope used (mark in `&compiling?`).

rcatmaybe

Shrink opcode tables

Via multiple implementations selected in peep.

Cache hash value

Not a win, according to Guido.

Optimize away @_ where possible

Optimize sort by { `$a <= $b` }

Greg Bacon added several more sort optimizations. These have made it into 5.005_55, thanks to Hans Mulder.

Rewrite regexp parser for better integrated optimization

The regexp parser was rewritten for 5.005. Ilya's the regexp guru.

Vague possibilities

ref function in list context

This seems impossible to do without substantially breaking code.

make tr/// return histogram in list context?
Loop control on do{} et al
Explicit switch statements

Nobody has yet managed to come up with a switch syntax that would allow for mixed hash, constant, regexp checks. Submit implementation with syntax, please.

compile to real threaded code
structured types
Modifiable `$1` et al

The intent is for this to be a means of editing the matched portions of the target string.

To Do Or Not To Do

These are things that have been discussed in the past and roundly criticized for being of questionable value.

Making `my()` work on "package" variables

Being able to say `my($Foo::Bar)`, something that sounds ludicrous and the 5.6 pumpking has mocked.

"or" testing defined not truth

We tell people that `||` can be used to give a default value to a variable:

```
$children = shift || 5;             # default is 5 children
```

which is almost (but not):

```
$children = shift;
$children = 5 unless $children;
```

but if the first argument was given and is "0", then it will be considered false by `||` and `5` used instead. Really we want an `||`–like operator that behaves like:

```
$children = shift;
$children = 5 unless defined $children;
```

Namely, a `||` that tests defined–ness rather than truth. One was discussed, and a patch submitted, but the objections were many. While there were objections, many still feel the need. At least it was decided that `??` is the best name for the operator.

"dynamic" lexicals

```
my $x;
sub foo {
  local $x;
}
```

Localizing, as Tim Bunce points out, is a separate concept from whether the variable is global or lexical. Chip Salzenberg had an implementation once, but Larry thought it had potential to confuse.

"class"–based, rather than package–based "lexicals"

This is like what the Alias module provides, but the variables would be lexicals reserved by perl at compile–time, which really are indices pointing into the pseudo–hash object visible inside every method so declared.

Threading

Modules

Which of the standard modules are thread–safe? Which CPAN modules? How easy is it to fix those non–safe modules?

Testing

Threading is still experimental. Every reproducible bug identifies something else for us to fix. Find and submit more of these problems.

`$AUTOLOAD`

exit/die

Consistent semantics for exit/die in threads.

External threads

Better support for externally created threads.

Thread::Pool

thread−safety

Spot−check globals like statcache and global GVs for thread−safety. "**Part done**", says Sarathy.

Per−thread GVs

According to Sarathy, this would make @_ be the same in threaded and non−threaded, as well as helping solve problems like filehandles (the same filehandle currently cannot be used in two threads).

Compiler

Optimization

The compiler's back−end code−generators for creating bytecode or compilable C code could use optimization work.

Byteperl

Figure out how and where byteperl will be built for the various platforms.

Precompiled modules

Save byte−compiled modules on disk.

Executables

Auto−produce executable.

Typed lexicals

Typed lexicals should affect B::CC::load_pad.

Win32

Workarounds to help Win32 dynamic loading.

END blocks

END blocks need saving in compiled output, now that CHECK blocks are available.

_AUTOLOAD

_AUTOLOAD prodding.

comppadlist

Fix comppadlist (names in comppad_name can have fake SvCUR from where newASSIGNOP steals the field).

Cached compilation

Can we install modules as bytecode?

Recently Finished Tasks

Figure a way out of `$^(capital` letter)

Figure out a clean way to extend `$^(capital` letter) beyond the 26 alphabets. (`${^WORD}` maybe?)

Mark−Jason Dominus sent a patch which went into 5.005_56.

Filenames

Keep filenames in the distribution and in the standard module set be 8.3 friendly where feasible. Good luck changing the standard modules, though.

Foreign lines

Perl should be more generous in accepting foreign line terminations. Mostly **done** in 5.005.

Namespace cleanup

```
symbol-space: "pl_" prefix for all global vars
              "Perl_" prefix for all functions

CPP-space:    stop malloc()/free() pollution unless asked
```

ISA.pm

Rename and alter ISA.pm. **Done**. It is now base.pm.

gettimeofday

See Time::HiRes.

autocroak?

This is the Fatal.pm module, so any builtin that does not return success automatically `die()`s. If you're feeling brave, tie this in with the unified exceptions scheme.

NAME

perltoot − Tom's object−oriented tutorial for perl

DESCRIPTION

Object−oriented programming is a big seller these days. Some managers would rather have objects than sliced bread. Why is that? What's so special about an object? Just what *is* an object anyway?

An object is nothing but a way of tucking away complex behaviours into a neat little easy−to−use bundle. (This is what professors call abstraction.) Smart people who have nothing to do but sit around for weeks on end figuring out really hard problems make these nifty objects that even regular people can use. (This is what professors call software reuse.) Users (well, programmers) can play with this little bundle all they want, but they aren't to open it up and mess with the insides. Just like an expensive piece of hardware, the contract says that you void the warranty if you muck with the cover. So don't do that.

The heart of objects is the class, a protected little private namespace full of data and functions. A class is a set of related routines that addresses some problem area. You can think of it as a user−defined type. The Perl package mechanism, also used for more traditional modules, is used for class modules as well. Objects "live" in a class, meaning that they belong to some package.

More often than not, the class provides the user with little bundles. These bundles are objects. They know whose class they belong to, and how to behave. Users ask the class to do something, like "give me an object." Or they can ask one of these objects to do something. Asking a class to do something for you is calling a *class method*. Asking an object to do something for you is calling an *object method*. Asking either a class (usually) or an object (sometimes) to give you back an object is calling a *constructor*, which is just a kind of method.

That's all well and good, but how is an object different from any other Perl data type? Just what is an object *really*; that is, what's its fundamental type? The answer to the first question is easy. An object is different from any other data type in Perl in one and only one way: you may dereference it using not merely string or numeric subscripts as with simple arrays and hashes, but with named subroutine calls. In a word, with *methods*.

The answer to the second question is that it's a reference, and not just any reference, mind you, but one whose referent has been `bless()`ed into a particular class (read: package). What kind of reference? Well, the answer to that one is a bit less concrete. That's because in Perl the designer of the class can employ any sort of reference they'd like as the underlying intrinsic data type. It could be a scalar, an array, or a hash reference. It could even be a code reference. But because of its inherent flexibility, an object is usually a hash reference.

Creating a Class

Before you create a class, you need to decide what to name it. That's because the class (package) name governs the name of the file used to house it, just as with regular modules. Then, that class (package) should provide one or more ways to generate objects. Finally, it should provide mechanisms to allow users of its objects to indirectly manipulate these objects from a distance.

For example, let's make a simple Person class module. It gets stored in the file Person.pm. If it were called a Happy::Person class, it would be stored in the file Happy/Person.pm, and its package would become Happy::Person instead of just Person. (On a personal computer not running Unix or Plan 9, but something like MacOS or VMS, the directory separator may be different, but the principle is the same.) Do not assume any formal relationship between modules based on their directory names. This is merely a grouping convenience, and has no effect on inheritance, variable accessibility, or anything else.

For this module we aren't going to use Exporter, because we're a well−behaved class module that doesn't export anything at all. In order to manufacture objects, a class needs to have a *constructor method*. A constructor gives you back not just a regular data type, but a brand−new object in that class. This magic is taken care of by the `bless()` function, whose sole purpose is to enable its referent to be used as an object. Remember: being an object really means nothing more than that methods may now be called against it.

While a constructor may be named anything you'd like, most Perl programmers seem to like to call theirs `new()`. However, `new()` is not a reserved word, and a class is under no obligation to supply such. Some programmers have also been known to use a function with the same name as the class as the constructor.

Object Representation

By far the most common mechanism used in Perl to represent a Pascal record, a C struct, or a C++ class is an anonymous hash. That's because a hash has an arbitrary number of data fields, each conveniently accessed by an arbitrary name of your own devising.

If you were just doing a simple struct–like emulation, you would likely go about it something like this:

```
$rec = {
    name  => "Jason",
    age   => 23,
    peers => [ "Norbert", "Rhys", "Phineas"],
};
```

If you felt like it, you could add a bit of visual distinction by up–casing the hash keys:

```
$rec = {
    NAME  => "Jason",
    AGE   => 23,
    PEERS => [ "Norbert", "Rhys", "Phineas"],
};
```

And so you could get at `< $rec–{NAME} >` to find "Jason", or `< @{ $rec–{PEERS} } >` to get at "Norbert", "Rhys", and "Phineas". (Have you ever noticed how many 23–year–old programmers seem to be named "Jason" these days? :–)

This same model is often used for classes, although it is not considered the pinnacle of programming propriety for folks from outside the class to come waltzing into an object, brazenly accessing its data members directly. Generally speaking, an object should be considered an opaque cookie that you use *object methods* to access. Visually, methods look like you're dereffing a reference using a function name instead of brackets or braces.

Class Interface

Some languages provide a formal syntactic interface to a class's methods, but Perl does not. It relies on you to read the documentation of each class. If you try to call an undefined method on an object, Perl won't complain, but the program will trigger an exception while it's running. Likewise, if you call a method expecting a prime number as its argument with a non–prime one instead, you can't expect the compiler to catch this. (Well, you can expect it all you like, but it's not going to happen.)

Let's suppose you have a well–educated user of your Person class, someone who has read the docs that explain the prescribed interface. Here's how they might use the Person class:

```
use Person;

$him = Person–>new();
$him–>name("Jason");
$him–>age(23);
$him–>peers( "Norbert", "Rhys", "Phineas" );

push @All_Recs, $him;  # save object in array for later

printf "%s is %d years old.\n", $him–>name, $him–>age;
print "His peers are: ", join(", ", $him–>peers), "\n";

printf "Last rec's name is %s\n", $All_Recs[–1]–>name;
```

As you can see, the user of the class doesn't know (or at least, has no business paying attention to the fact) that the object has one particular implementation or another. The interface to the class and its objects is exclusively via methods, and that's all the user of the class should ever play with.

Constructors and Instance Methods

Still, *someone* has to know what's in the object. And that someone is the class. It implements methods that the programmer uses to access the object. Here's how to implement the Person class using the standard hash–ref–as–an–object idiom. We'll make a class method called `new()` to act as the constructor, and three object methods called `name()`, `age()`, and `peers()` to get at per–object data hidden away in our anonymous hash.

```
package Person;
use strict;

##################################################
## the object constructor (simplistic version)  ##
##################################################
sub new {
    my $self  = {};
    $self->{NAME}   = undef;
    $self->{AGE}    = undef;
    $self->{PEERS}  = [];
    bless($self);           # but see below
    return $self;
}

##############################################
## methods to access per-object data        ##
##                                          ##
## With args, they set the value.  Without  ##
## any, they only retrieve it/them.         ##
##############################################

sub name {
    my $self = shift;
    if (@_) { $self->{NAME} = shift }
    return $self->{NAME};
}

sub age {
    my $self = shift;
    if (@_) { $self->{AGE} = shift }
    return $self->{AGE};
}

sub peers {
    my $self = shift;
    if (@_) { @{ $self->{PEERS} } = @_ }
    return @{ $self->{PEERS} };
}

1;  # so the require or use succeeds
```

We've created three methods to access an object's data, `name()`, `age()`, and `peers()`. These are all substantially similar. If called with an argument, they set the appropriate field; otherwise they return the value held by that field, meaning the value of that hash key.

Planning for the Future: Better Constructors

Even though at this point you may not even know what it means, someday you're going to worry about inheritance. (You can safely ignore this for now and worry about it later if you'd like.) To ensure that this all works out smoothly, you must use the double–argument form of `bless()`. The second argument is the class into which the referent will be blessed. By not assuming our own class as the default second argument

and instead using the class passed into us, we make our constructor inheritable.

While we're at it, let's make our constructor a bit more flexible. Rather than being uniquely a class method, we'll set it up so that it can be called as either a class method *or* an object method. That way you can say:

```
$me  = Person->new();
$him = $me->new();
```

To do this, all we have to do is check whether what was passed in was a reference or not. If so, we were invoked as an object method, and we need to extract the package (class) using the `ref()` function. If not, we just use the string passed in as the package name for blessing our referent.

```
sub new {
    my $proto = shift;
    my $class = ref($proto) || $proto;
    my $self  = {};
    $self->{NAME}   = undef;
    $self->{AGE}    = undef;
    $self->{PEERS}  = [];
    bless ($self, $class);
    return $self;
}
```

That's about all there is for constructors. These methods bring objects to life, returning neat little opaque bundles to the user to be used in subsequent method calls.

Destructors

Every story has a beginning and an end. The beginning of the object's story is its constructor, explicitly called when the object comes into existence. But the ending of its story is the *destructor*, a method implicitly called when an object leaves this life. Any per–object clean–up code is placed in the destructor, which must (in Perl) be called DESTROY.

If constructors can have arbitrary names, then why not destructors? Because while a constructor is explicitly called, a destructor is not. Destruction happens automatically via Perl's garbage collection (GC) system, which is a quick but somewhat lazy reference–based GC system. To know what to call, Perl insists that the destructor be named DESTROY. Perl's notion of the right time to call a destructor is not well–defined currently, which is why your destructors should not rely on when they are called.

Why is DESTROY in all caps? Perl on occasion uses purely uppercase function names as a convention to indicate that the function will be automatically called by Perl in some way. Others that are called implicitly include BEGIN, END, AUTOLOAD, plus all methods used by tied objects, described in *perltie*.

In really good object–oriented programming languages, the user doesn't care when the destructor is called. It just happens when it's supposed to. In low–level languages without any GC at all, there's no way to depend on this happening at the right time, so the programmer must explicitly call the destructor to clean up memory and state, crossing their fingers that it's the right time to do so. Unlike C++, an object destructor is nearly never needed in Perl, and even when it is, explicit invocation is uncalled for. In the case of our Person class, we don't need a destructor because Perl takes care of simple matters like memory deallocation.

The only situation where Perl's reference–based GC won't work is when there's a circularity in the data structure, such as:

```
$this->{WHATEVER} = $this;
```

In that case, you must delete the self–reference manually if you expect your program not to leak memory. While admittedly error–prone, this is the best we can do right now. Nonetheless, rest assured that when your program is finished, its objects' destructors are all duly called. So you are guaranteed that an object *eventually* gets properly destroyed, except in the unique case of a program that never exits. (If you're running Perl embedded in another application, this full GC pass happens a bit more frequently—whenever a thread shuts down.)

Other Object Methods

The methods we've talked about so far have either been constructors or else simple "data methods", interfaces to data stored in the object. These are a bit like an object's data members in the C++ world, except that strangers don't access them as data. Instead, they should only access the object's data indirectly via its methods. This is an important rule: in Perl, access to an object's data should *only* be made through methods.

Perl doesn't impose restrictions on who gets to use which methods. The public–versus–private distinction is by convention, not syntax. (Well, unless you use the Alias module described below in *Data Members as Variables*.) Occasionally you'll see method names beginning or ending with an underscore or two. This marking is a convention indicating that the methods are private to that class alone and sometimes to its closest acquaintances, its immediate subclasses. But this distinction is not enforced by Perl itself. It's up to the programmer to behave.

There's no reason to limit methods to those that simply access data. Methods can do anything at all. The key point is that they're invoked against an object or a class. Let's say we'd like object methods that do more than fetch or set one particular field.

```
sub exclaim {
    my $self = shift;
    return sprintf "Hi, I'm %s, age %d, working with %s",
        $self->{NAME}, $self->{AGE}, join(", ", @{$self->{PEERS}});
}
```

Or maybe even one like this:

```
sub happy_birthday {
    my $self = shift;
    return ++$self->{AGE};
}
```

Some might argue that one should go at these this way:

```
sub exclaim {
    my $self = shift;
    return sprintf "Hi, I'm %s, age %d, working with %s",
        $self->name, $self->age, join(", ", $self->peers);
}

sub happy_birthday {
    my $self = shift;
    return $self->age( $self->age() + 1 );
}
```

But since these methods are all executing in the class itself, this may not be critical. There are tradeoffs to be made. Using direct hash access is faster (about an order of magnitude faster, in fact), and it's more convenient when you want to interpolate in strings. But using methods (the external interface) internally shields not just the users of your class but even you yourself from changes in your data representation.

Class Data

What about "class data", data items common to each object in a class? What would you want that for? Well, in your Person class, you might like to keep track of the total people alive. How do you implement that?

You *could* make it a global variable called `$Person::Census`. But about only reason you'd do that would be if you *wanted* people to be able to get at your class data directly. They could just say `$Person::Census` and play around with it. Maybe this is ok in your design scheme. You might even conceivably want to make it an exported variable. To be exportable, a variable must be a (package) global. If this were a traditional module rather than an object–oriented one, you might do that.

While this approach is expected in most traditional modules, it's generally considered rather poor form in most object modules. In an object module, you should set up a protective veil to separate interface from

implementation. So provide a class method to access class data just as you provide object methods to access object data.

So, you *could* still keep `$Census` as a package global and rely upon others to honor the contract of the module and therefore not play around with its implementation. You could even be supertricky and make `$Census` a tied object as described in *perltie*, thereby intercepting all accesses.

But more often than not, you just want to make your class data a file−scoped lexical. To do so, simply put this at the top of the file:

```
my $Census = 0;
```

Even though the scope of a `my()` normally expires when the block in which it was declared is done (in this case the whole file being required or used), Perl's deep binding of lexical variables guarantees that the variable will not be deallocated, remaining accessible to functions declared within that scope. This doesn't work with global variables given temporary values via `local()`, though.

Irrespective of whether you leave `$Census` a package global or make it instead a file−scoped lexical, you should make these changes to your `Person::new()` constructor:

```
sub new {
    my $proto = shift;
    my $class = ref($proto) || $proto;
    my $self  = {};
    $Census++;
    $self->{NAME}   = undef;
    $self->{AGE}    = undef;
    $self->{PEERS}  = [];
    bless ($self, $class);
    return $self;
}

sub population {
    return $Census;
}
```

Now that we've done this, we certainly do need a destructor so that when Person is destroyed, the `$Census` goes down. Here's how this could be done:

```
sub DESTROY { --$Census }
```

Notice how there's no memory to deallocate in the destructor? That's something that Perl takes care of for you all by itself.

Accessing Class Data

It turns out that this is not really a good way to go about handling class data. A good scalable rule is that *you must never reference class data directly from an object method*. Otherwise you aren't building a scalable, inheritable class. The object must be the rendezvous point for all operations, especially from an object method. The globals (class data) would in some sense be in the "wrong" package in your derived classes. In Perl, methods execute in the context of the class they were defined in, *not* that of the object that triggered them. Therefore, namespace visibility of package globals in methods is unrelated to inheritance.

Got that? Maybe not. Ok, let's say that some other class "borrowed" (well, inherited) the DESTROY method as it was defined above. When those objects are destroyed, the original `$Census` variable will be altered, not the one in the new class's package namespace. Perhaps this is what you want, but probably it isn't.

Here's how to fix this. We'll store a reference to the data in the value accessed by the hash key "_CENSUS". Why the underscore? Well, mostly because an initial underscore already conveys strong feelings of magicalness to a C programmer. It's really just a mnemonic device to remind ourselves that this field is special and not to be used as a public data member in the same way that NAME, AGE, and PEERS

are. (Because we've been developing this code under the strict pragma, prior to perl version 5.004 we'll have to quote the field name.)

```
sub new {
    my $proto = shift;
    my $class = ref($proto) || $proto;
    my $self  = {};
    $self->{NAME}     = undef;
    $self->{AGE}      = undef;
    $self->{PEERS}    = [];
    # "private" data
    $self->{"_CENSUS"} = \$Census;
    bless ($self, $class);
    ++ ${ $self->{"_CENSUS"} };
    return $self;
}

sub population {
    my $self = shift;
    if (ref $self) {
        return ${ $self->{"_CENSUS"} };
    } else {
        return $Census;
    }
}

sub DESTROY {
    my $self = shift;
    -- ${ $self->{"_CENSUS"} };
}
```

Debugging Methods

It's common for a class to have a debugging mechanism. For example, you might want to see when objects are created or destroyed. To do that, add a debugging variable as a file-scoped lexical. For this, we'll pull in the standard Carp module to emit our warnings and fatal messages. That way messages will come out with the caller's filename and line number instead of our own; if we wanted them to be from our own perspective, we'd just use `die()` and `warn()` directly instead of `croak()` and `carp()` respectively.

```
use Carp;
my $Debugging = 0;
```

Now add a new class method to access the variable.

```
sub debug {
    my $class = shift;
    if (ref $class)  { confess "Class method called as object method" }
    unless (@_ == 1) { confess "usage: CLASSNAME->debug(level)" }
    $Debugging = shift;
}
```

Now fix up DESTROY to murmur a bit as the moribund object expires:

```
sub DESTROY {
    my $self = shift;
    if ($Debugging) { carp "Destroying $self " . $self->name }
    -- ${ $self->{"_CENSUS"} };
}
```

One could conceivably make a per-object debug state. That way you could call both of these:

```
Person->debug(1);   # entire class
$him->debug(1);     # just this object
```

To do so, we need our debugging method to be a "bimodal" one, one that works on both classes *and* objects. Therefore, adjust the `debug()` and DESTROY methods as follows:

```
sub debug {
    my $self = shift;
    confess "usage: thing->debug(level)"    unless @_ == 1;
    my $level = shift;
    if (ref($self))  {
        $self->{"_DEBUG"} = $level;         # just myself
    } else {
        $Debugging        = $level;         # whole class
    }
}

sub DESTROY {
    my $self = shift;
    if ($Debugging || $self->{"_DEBUG"}) {
        carp "Destroying $self " . $self->name;
    }
    -- ${ $self->{"_CENSUS"} };
}
```

What happens if a derived class (which we'll call Employee) inherits methods from this Person base class? Then `< Employee->debug()` , when called as a class method, manipulates `$Person::Debugging` not `$Employee::Debugging`.

Class Destructors

The object destructor handles the death of each distinct object. But sometimes you want a bit of cleanup when the entire class is shut down, which currently only happens when the program exits. To make such a *class destructor*, create a function in that class's package named END. This works just like the END function in traditional modules, meaning that it gets called whenever your program exits unless it execs or dies of an uncaught signal. For example,

```
sub END {
    if ($Debugging) {
        print "All persons are going away now.\n";
    }
}
```

When the program exits, all the class destructors (END functions) are be called in the opposite order that they were loaded in (LIFO order).

Documenting the Interface

And there you have it: we've just shown you the *implementation* of this Person class. Its *interface* would be its documentation. Usually this means putting it in pod ("plain old documentation") format right there in the same file. In our Person example, we would place the following docs anywhere in the Person.pm file. Even though it looks mostly like code, it's not. It's embedded documentation such as would be used by the pod2man, pod2html, or pod2text programs. The Perl compiler ignores pods entirely, just as the translators ignore code. Here's an example of some pods describing the informal interface:

```
=head1 NAME

Person - class to implement people

=head1 SYNOPSIS

 use Person;
```

```
 #################
 # class methods #
 #################
 $ob    = Person->new;
 $count = Person->population;

 ########################
 # object data methods #
 ########################

 ### get versions ###
     $who   = $ob->name;
     $years = $ob->age;
     @pals  = $ob->peers;

 ### set versions ###
     $ob->name("Jason");
     $ob->age(23);
     $ob->peers( "Norbert", "Rhys", "Phineas" );

 ########################
 # other object methods #
 ########################

 $phrase = $ob->exclaim;
 $ob->happy_birthday;

=head1 DESCRIPTION

The Person class implements dah dee dah dee dah....
```

That's all there is to the matter of interface versus implementation. A programmer who opens up the module and plays around with all the private little shiny bits that were safely locked up behind the interface contract has voided the warranty, and you shouldn't worry about their fate.

Aggregation

Suppose you later want to change the class to implement better names. Perhaps you'd like to support both given names (called Christian names, irrespective of one's religion) and family names (called surnames), plus nicknames and titles. If users of your Person class have been properly accessing it through its documented interface, then you can easily change the underlying implementation. If they haven't, then they lose and it's their fault for breaking the contract and voiding their warranty.

To do this, we'll make another class, this one called Fullname. What's the Fullname class look like? To answer that question, you have to first figure out how you want to use it. How about we use it this way:

```
$him = Person->new();
$him->fullname->title("St");
$him->fullname->christian("Thomas");
$him->fullname->surname("Aquinas");
$him->fullname->nickname("Tommy");
printf "His normal name is %s\n", $him->name;
printf "But his real name is %s\n", $him->fullname->as_string;
```

Ok. To do this, we'll change `Person::new()` so that it supports a full name field this way:

```
sub new {
    my $proto = shift;
    my $class = ref($proto) || $proto;
    my $self  = {};
    $self->{FULLNAME} = Fullname->new();
    $self->{AGE}      = undef;
```

```
    $self->{PEERS}    = [];
    $self->{"_CENSUS"} = \$Census;
    bless ($self, $class);
    ++ ${ $self->{"_CENSUS"} };
    return $self;
}

sub fullname {
    my $self = shift;
    return $self->{FULLNAME};
}
```

Then to support old code, define `Person::name()` this way:

```
sub name {
    my $self = shift;
    return $self->{FULLNAME}->nickname(@_)
      ||   $self->{FULLNAME}->christian(@_);
}
```

Here's the Fullname class. We'll use the same technique of using a hash reference to hold data fields, and methods by the appropriate name to access them:

```
package Fullname;
use strict;

sub new {
    my $proto = shift;
    my $class = ref($proto) || $proto;
    my $self  = {
        TITLE       => undef,
        CHRISTIAN   => undef,
        SURNAME     => undef,
        NICK        => undef,
    };
    bless ($self, $class);
    return $self;
}

sub christian {
    my $self = shift;
    if (@_) { $self->{CHRISTIAN} = shift }
    return $self->{CHRISTIAN};
}

sub surname {
    my $self = shift;
    if (@_) { $self->{SURNAME} = shift }
    return $self->{SURNAME};
}

sub nickname {
    my $self = shift;
    if (@_) { $self->{NICK} = shift }
    return $self->{NICK};
}

sub title {
    my $self = shift;
```

```
    if (@_) { $self->{TITLE} = shift }
    return $self->{TITLE};
}

sub as_string {
    my $self = shift;
    my $name = join(" ", @$self{'CHRISTIAN', 'SURNAME'});
    if ($self->{TITLE}) {
        $name = $self->{TITLE} . " " . $name;
    }
    return $name;
}

1;
```

Finally, here's the test program:

```
#!/usr/bin/perl -w
use strict;
use Person;
sub END { show_census() }

sub show_census ()  {
    printf "Current population: %d\n", Person->population;
}

Person->debug(1);

show_census();

my $him = Person->new();

$him->fullname->christian("Thomas");
$him->fullname->surname("Aquinas");
$him->fullname->nickname("Tommy");
$him->fullname->title("St");
$him->age(1);

printf "%s is really %s.\n", $him->name, $him->fullname;
printf "%s's age: %d.\n", $him->name, $him->age;
$him->happy_birthday;
printf "%s's age: %d.\n", $him->name, $him->age;

show_census();
```

Inheritance

Object-oriented programming systems all support some notion of inheritance. Inheritance means allowing one class to piggy-back on top of another one so you don't have to write the same code again and again. It's about software reuse, and therefore related to Laziness, the principal virtue of a programmer. (The import/export mechanisms in traditional modules are also a form of code reuse, but a simpler one than the true inheritance that you find in object modules.)

Sometimes the syntax of inheritance is built into the core of the language, and sometimes it's not. Perl has no special syntax for specifying the class (or classes) to inherit from. Instead, it's all strictly in the semantics. Each package can have a variable called @ISA, which governs (method) inheritance. If you try to call a method on an object or class, and that method is not found in that object's package, Perl then looks to @ISA for other packages to go looking through in search of the missing method.

Like the special per-package variables recognized by Exporter (such as @EXPORT, @EXPORT_OK, @EXPORT_FAIL, %EXPORT_TAGS, and `$VERSION`), the @ISA array *must* be a package-scoped global and not a file-scoped lexical created via `my()`. Most classes have just one item in their @ISA array.

In this case, we have what's called "single inheritance", or SI for short.

Consider this class:

```
package Employee;
use Person;
@ISA = ("Person");
1;
```

Not a lot to it, eh? All it's doing so far is loading in another class and stating that this one will inherit methods from that other class if need be. We have given it none of its own methods. We rely upon an Employee to behave just like a Person.

Setting up an empty class like this is called the "empty subclass test"; that is, making a derived class that does nothing but inherit from a base class. If the original base class has been designed properly, then the new derived class can be used as a drop-in replacement for the old one. This means you should be able to write a program like this:

```
use Employee;
my $empl = Employee->new();
$empl->name("Jason");
$empl->age(23);
printf "%s is age %d.\n", $empl->name, $empl->age;
```

By proper design, we mean always using the two-argument form of `bless()`, avoiding direct access of global data, and not exporting anything. If you look back at the `Person::new()` function we defined above, we were careful to do that. There's a bit of package data used in the constructor, but the reference to this is stored on the object itself and all other methods access package data via that reference, so we should be ok.

What do we mean by the `Person::new()` function — isn't that actually a method? Well, in principle, yes. A method is just a function that expects as its first argument a class name (package) or object (blessed reference). `Person::new()` is the function that both the `< Person-new()` method and the `< Employee-new()` method end up calling. Understand that while a method call looks a lot like a function call, they aren't really quite the same, and if you treat them as the same, you'll very soon be left with nothing but broken programs. First, the actual underlying calling conventions are different: method calls get an extra argument. Second, function calls don't do inheritance, but methods do.

```
Method Call             Resulting Function Call
-----------             -----------------------
Person->new()           Person::new("Person")
Employee->new()         Person::new("Employee")
```

So don't use function calls when you mean to call a method.

If an employee is just a Person, that's not all too very interesting. So let's add some other methods. We'll give our employee data fields to access their salary, their employee ID, and their start date.

If you're getting a little tired of creating all these nearly identical methods just to get at the object's data, do not despair. Later, we'll describe several different convenience mechanisms for shortening this up. Meanwhile, here's the straight-forward way:

```
sub salary {
    my $self = shift;
    if (@_) { $self->{SALARY} = shift }
    return $self->{SALARY};
}

sub id_number {
    my $self = shift;
    if (@_) { $self->{ID} = shift }
```

```
    return $self->{ID};
}

sub start_date {
    my $self = shift;
    if (@_) { $self->{START_DATE} = shift }
    return $self->{START_DATE};
}
```

Overridden Methods

What happens when both a derived class and its base class have the same method defined? Well, then you get the derived class's version of that method. For example, let's say that we want the `peers()` method called on an employee to act a bit differently. Instead of just returning the list of peer names, let's return slightly different strings. So doing this:

```
$empl->peers("Peter", "Paul", "Mary");
printf "His peers are: %s\n", join(", ", $empl->peers);
```

will produce:

```
His peers are: PEON=PETER, PEON=PAUL, PEON=MARY
```

To do this, merely add this definition into the Employee.pm file:

```
sub peers {
    my $self = shift;
    if (@_) { @{ $self->{PEERS} } = @_ }
    return map { "PEON=\U$_" } @{ $self->{PEERS} };
}
```

There, we've just demonstrated the high−falutin' concept known in certain circles as *polymorphism*. We've taken on the form and behaviour of an existing object, and then we've altered it to suit our own purposes. This is a form of Laziness. (Getting polymorphed is also what happens when the wizard decides you'd look better as a frog.)

Every now and then you'll want to have a method call trigger both its derived class (also known as "subclass") version as well as its base class (also known as "superclass") version. In practice, constructors and destructors are likely to want to do this, and it probably also makes sense in the `debug()` method we showed previously.

To do this, add this to Employee.pm:

```
use Carp;
my $Debugging = 0;

sub debug {
    my $self = shift;
    confess "usage: thing->debug(level)"    unless @_ == 1;
    my $level = shift;
    if (ref($self))  {
        $self->{"_DEBUG"} = $level;
    } else {
        $Debugging = $level;            # whole class
    }
    Person::debug($self, $Debugging);   # don't really do this
}
```

As you see, we turn around and call the Person package's `debug()` function. But this is far too fragile for good design. What if Person doesn't have a `debug()` function, but is inheriting *its* `debug()` method from elsewhere? It would have been slightly better to say

```
Person->debug($Debugging);
```

But even that's got too much hard-coded. It's somewhat better to say

```
$self->Person::debug($Debugging);
```

Which is a funny way to say to start looking for a `debug()` method up in Person. This strategy is more often seen on overridden object methods than on overridden class methods.

There is still something a bit off here. We've hard-coded our superclass's name. This in particular is bad if you change which classes you inherit from, or add others. Fortunately, the pseudoclass SUPER comes to the rescue here.

```
$self->SUPER::debug($Debugging);
```

This way it starts looking in my class's @ISA. This only makes sense from *within* a method call, though. Don't try to access anything in SUPER:: from anywhere else, because it doesn't exist outside an overridden method call.

Things are getting a bit complicated here. Have we done anything we shouldn't? As before, one way to test whether we're designing a decent class is via the empty subclass test. Since we already have an Employee class that we're trying to check, we'd better get a new empty subclass that can derive from Employee. Here's one:

```
package Boss;
use Employee;        # :-)
@ISA = qw(Employee);
```

And here's the test program:

```
#!/usr/bin/perl -w
use strict;
use Boss;
Boss->debug(1);

my $boss = Boss->new();

$boss->fullname->title("Don");
$boss->fullname->surname("Pichon Alvarez");
$boss->fullname->christian("Federico Jesus");
$boss->fullname->nickname("Fred");

$boss->age(47);
$boss->peers("Frank", "Felipe", "Faust");

printf "%s is age %d.\n", $boss->fullname, $boss->age;
printf "His peers are: %s\n", join(", ", $boss->peers);
```

Running it, we see that we're still ok. If you'd like to dump out your object in a nice format, somewhat like the way the 'x' command works in the debugger, you could use the Data::Dumper module from CPAN this way:

```
use Data::Dumper;
print "Here's the boss:\n";
print Dumper($boss);
```

Which shows us something like this:

```
Here's the boss:
$VAR1 = bless( {
     _CENSUS => \1,
     FULLNAME => bless( {
                          TITLE => 'Don',
```

```
                            SURNAME => 'Pichon Alvarez',
                            NICK => 'Fred',
                            CHRISTIAN => 'Federico Jesus'
                          }, 'Fullname' ),
      AGE => 47,
      PEERS => [
                  'Frank',
                  'Felipe',
                  'Faust'
                ]
    }, 'Boss' );
```

Hm.... something's missing there. What about the salary, start date, and ID fields? Well, we never set them to anything, even undef, so they don't show up in the hash's keys. The Employee class has no `new()` method of its own, and the `new()` method in Person doesn't know about Employees. (Nor should it: proper OO design dictates that a subclass be allowed to know about its immediate superclass, but never vice-versa.) So let's fix up `Employee::new()` this way:

```
sub new {
    my $proto = shift;
    my $class = ref($proto) || $proto;
    my $self  = $class->SUPER::new();
    $self->{SALARY}        = undef;
    $self->{ID}            = undef;
    $self->{START_DATE}    = undef;
    bless ($self, $class);          # reconsecrate
    return $self;
}
```

Now if you dump out an Employee or Boss object, you'll find that new fields show up there now.

Multiple Inheritance

Ok, at the risk of confusing beginners and annoying OO gurus, it's time to confess that Perl's object system includes that controversial notion known as multiple inheritance, or MI for short. All this means is that rather than having just one parent class who in turn might itself have a parent class, etc., that you can directly inherit from two or more parents. It's true that some uses of MI can get you into trouble, although hopefully not quite so much trouble with Perl as with dubiously-OO languages like C++.

The way it works is actually pretty simple: just put more than one package name in your @ISA array. When it comes time for Perl to go finding methods for your object, it looks at each of these packages in order. Well, kinda. It's actually a fully recursive, depth-first order. Consider a bunch of @ISA arrays like this:

```
@First::ISA    = qw( Alpha );
@Second::ISA   = qw( Beta );
@Third::ISA    = qw( First Second );
```

If you have an object of class Third:

```
my $ob = Third->new();
$ob->spin();
```

How do we find a `spin()` method (or a `new()` method for that matter)? Because the search is depth-first, classes will be looked up in the following order: Third, First, Alpha, Second, and Beta.

In practice, few class modules have been seen that actually make use of MI. One nearly always chooses simple containership of one class within another over MI. That's why our Person object *contained* a Fullname object. That doesn't mean it *was* one.

However, there is one particular area where MI in Perl is rampant: borrowing another class's class methods. This is rather common, especially with some bundled "objectless" classes, like Exporter, DynaLoader,

AutoLoader, and SelfLoader. These classes do not provide constructors; they exist only so you may inherit their class methods. (It's not entirely clear why inheritance was done here rather than traditional module importation.)

For example, here is the POSIX module's @ISA:

```
package POSIX;
@ISA = qw(Exporter DynaLoader);
```

The POSIX module isn't really an object module, but then, neither are Exporter or DynaLoader. They're just lending their classes' behaviours to POSIX.

Why don't people use MI for object methods much? One reason is that it can have complicated side–effects. For one thing, your inheritance graph (no longer a tree) might converge back to the same base class. Although Perl guards against recursive inheritance, merely having parents who are related to each other via a common ancestor, incestuous though it sounds, is not forbidden. What if in our Third class shown above we wanted its `new()` method to also call both overridden constructors in its two parent classes? The SUPER notation would only find the first one. Also, what about if the Alpha and Beta classes both had a common ancestor, like Nought? If you kept climbing up the inheritance tree calling overridden methods, you'd end up calling `Nought::new()` twice, which might well be a bad idea.

UNIVERSAL: The Root of All Objects

Wouldn't it be convenient if all objects were rooted at some ultimate base class? That way you could give every object common methods without having to go and add it to each and every @ISA. Well, it turns out that you can. You don't see it, but Perl tacitly and irrevocably assumes that there's an extra element at the end of @ISA: the class UNIVERSAL. In version 5.003, there were no predefined methods there, but you could put whatever you felt like into it.

However, as of version 5.004 (or some subversive releases, like 5.003_08), UNIVERSAL has some methods in it already. These are builtin to your Perl binary, so they don't take any extra time to load. Predefined methods include `isa()`, `can()`, and `VERSION()`. `isa()` tells you whether an object or class "is" another one without having to traverse the hierarchy yourself:

```
$has_io = $fd->isa("IO::Handle");
$itza_handle = IO::Socket->isa("IO::Handle");
```

The `can()` method, called against that object or class, reports back whether its string argument is a callable method name in that class. In fact, it gives you back a function reference to that method:

```
$his_print_method = $obj->can('as_string');
```

Finally, the VERSION method checks whether the class (or the object's class) has a package global called `$VERSION` that's high enough, as in:

```
Some_Module->VERSION(3.0);
$his_vers = $ob->VERSION();
```

However, we don't usually call VERSION ourselves. (Remember that an all uppercase function name is a Perl convention that indicates that the function will be automatically used by Perl in some way.) In this case, it happens when you say

```
use Some_Module 3.0;
```

If you wanted to add version checking to your Person class explained above, just add this to Person.pm:

```
our $VERSION = '1.1';
```

and then in Employee.pm could you can say

```
use Employee 1.1;
```

And it would make sure that you have at least that version number or higher available. This is not the same as loading in that exact version number. No mechanism currently exists for concurrent installation of

multiple versions of a module. Lamentably.

Alternate Object Representations

Nothing requires objects to be implemented as hash references. An object can be any sort of reference so long as its referent has been suitably blessed. That means scalar, array, and code references are also fair game.

A scalar would work if the object has only one datum to hold. An array would work for most cases, but makes inheritance a bit dodgy because you have to invent new indices for the derived classes.

Arrays as Objects

If the user of your class honors the contract and sticks to the advertised interface, then you can change its underlying interface if you feel like it. Here's another implementation that conforms to the same interface specification. This time we'll use an array reference instead of a hash reference to represent the object.

```
package Person;
use strict;

my($NAME, $AGE, $PEERS) = ( 0 .. 2 );

############################################
## the object constructor (array version) ##
############################################
sub new {
    my $self = [];
    $self->[$NAME]   = undef;  # this is unnecessary
    $self->[$AGE]    = undef;  # as is this
    $self->[$PEERS]  = [];     # but this isn't, really
    bless($self);
    return $self;
}

sub name {
    my $self = shift;
    if (@_) { $self->[$NAME] = shift }
    return $self->[$NAME];
}

sub age {
    my $self = shift;
    if (@_) { $self->[$AGE] = shift }
    return $self->[$AGE];
}

sub peers {
    my $self = shift;
    if (@_) { @{ $self->[$PEERS] } = @_ }
    return @{ $self->[$PEERS] };
}

1;  # so the require or use succeeds
```

You might guess that the array access would be a lot faster than the hash access, but they're actually comparable. The array is a *little* bit faster, but not more than ten or fifteen percent, even when you replace the variables above like `$AGE` with literal numbers, like 1. A bigger difference between the two approaches can be found in memory use. A hash representation takes up more memory than an array representation because you have to allocate memory for the keys as well as for the values. However, it really isn't that bad, especially since as of version 5.004, memory is only allocated once for a given hash key, no matter how many hashes have that key. It's expected that sometime in the future, even these differences will fade into obscurity as more efficient underlying representations are devised.

Still, the tiny edge in speed (and somewhat larger one in memory) is enough to make some programmers choose an array representation for simple classes. There's still a little problem with scalability, though, because later in life when you feel like creating subclasses, you'll find that hashes just work out better.

Closures as Objects

Using a code reference to represent an object offers some fascinating possibilities. We can create a new anonymous function (closure) who alone in all the world can see the object's data. This is because we put the data into an anonymous hash that's lexically visible only to the closure we create, bless, and return as the object. This object's methods turn around and call the closure as a regular subroutine call, passing it the field we want to affect. (Yes, the double–function call is slow, but if you wanted fast, you wouldn't be using objects at all, eh? :–)

Use would be similar to before:

```
use Person;
$him = Person->new();
$him->name("Jason");
$him->age(23);
$him->peers( [ "Norbert", "Rhys", "Phineas" ] );
printf "%s is %d years old.\n", $him->name, $him->age;
print "His peers are: ", join(", ", @{$him->peers}), "\n";
```

but the implementation would be radically, perhaps even sublimely different:

```
package Person;

sub new {
     my $that  = shift;
     my $class = ref($that) || $that;
     my $self = {
        NAME  => undef,
        AGE   => undef,
        PEERS => [],
     };
     my $closure = sub {
        my $field = shift;
        if (@_) { $self->{$field} = shift }
        return    $self->{$field};
    };
    bless($closure, $class);
    return $closure;
}

sub name   { &{ $_[0] }("NAME",  @_[ 1 .. $#_ ] ) }
sub age    { &{ $_[0] }("AGE",   @_[ 1 .. $#_ ] ) }
sub peers  { &{ $_[0] }("PEERS", @_[ 1 .. $#_ ] ) }

1;
```

Because this object is hidden behind a code reference, it's probably a bit mysterious to those whose background is more firmly rooted in standard procedural or object–based programming languages than in functional programming languages whence closures derive. The object created and returned by the `new()` method is itself not a data reference as we've seen before. It's an anonymous code reference that has within it access to a specific version (lexical binding and instantiation) of the object's data, which are stored in the private variable `$self`. Although this is the same function each time, it contains a different version of `$self`.

When a method like `$him->name("Jason")` is called, its implicit zeroth argument is the invoking object—just as it is with all method calls. But in this case, it's our code reference (something like a function

pointer in C++, but with deep binding of lexical variables). There's not a lot to be done with a code reference beyond calling it, so that's just what we do when we say `&{$_[0]}`. This is just a regular function call, not a method call. The initial argument is the string "NAME", and any remaining arguments are whatever had been passed to the method itself.

Once we're executing inside the closure that had been created in `new()`, the `$self` hash reference suddenly becomes visible. The closure grabs its first argument ("NAME" in this case because that's what the `name()` method passed it), and uses that string to subscript into the private hash hidden in its unique version of `$self`.

Nothing under the sun will allow anyone outside the executing method to be able to get at this hidden data. Well, nearly nothing. You *could* single step through the program using the debugger and find out the pieces while you're in the method, but everyone else is out of luck.

There, if that doesn't excite the Scheme folks, then I just don't know what will. Translation of this technique into C++, Java, or any other braindead−static language is left as a futile exercise for aficionados of those camps.

You could even add a bit of nosiness via the `caller()` function and make the closure refuse to operate unless called via its own package. This would no doubt satisfy certain fastidious concerns of programming police and related puritans.

If you were wondering when Hubris, the third principle virtue of a programmer, would come into play, here you have it. (More seriously, Hubris is just the pride in craftsmanship that comes from having written a sound bit of well−designed code.)

AUTOLOAD: Proxy Methods

Autoloading is a way to intercept calls to undefined methods. An autoload routine may choose to create a new function on the fly, either loaded from disk or perhaps just `eval()`ed right there. This define−on−the−fly strategy is why it's called autoloading.

But that's only one possible approach. Another one is to just have the autoloaded method itself directly provide the requested service. When used in this way, you may think of autoloaded methods as "proxy" methods.

When Perl tries to call an undefined function in a particular package and that function is not defined, it looks for a function in that same package called AUTOLOAD. If one exists, it's called with the same arguments as the original function would have had. The fully−qualified name of the function is stored in that package's global variable `$AUTOLOAD`. Once called, the function can do anything it would like, including defining a new function by the right name, and then doing a really fancy kind of `goto` right to it, erasing itself from the call stack.

What does this have to do with objects? After all, we keep talking about functions, not methods. Well, since a method is just a function with an extra argument and some fancier semantics about where it's found, we can use autoloading for methods, too. Perl doesn't start looking for an AUTOLOAD method until it has exhausted the recursive hunt up through @ISA, though. Some programmers have even been known to define a UNIVERSAL::AUTOLOAD method to trap unresolved method calls to any kind of object.

Autoloaded Data Methods

You probably began to get a little suspicious about the duplicated code way back earlier when we first showed you the Person class, and then later the Employee class. Each method used to access the hash fields looked virtually identical. This should have tickled that great programming virtue, Impatience, but for the time, we let Laziness win out, and so did nothing. Proxy methods can cure this.

Instead of writing a new function every time we want a new data field, we'll use the autoload mechanism to generate (actually, mimic) methods on the fly. To verify that we're accessing a valid member, we will check against an `_permitted` (pronounced "under−permitted") field, which is a reference to a file−scoped lexical (like a C file static) hash of permitted fields in this record called %fields. Why the underscore? For the same reason as the _CENSUS field we once used: as a marker that means "for internal use only".

Here's what the module initialization code and class constructor will look like when taking this approach:

```
package Person;
use Carp;
our $AUTOLOAD;  # it's a package global

my %fields = (
    name        => undef,
    age         => undef,
    peers       => undef,
);

sub new {
    my $that  = shift;
    my $class = ref($that) || $that;
    my $self  = {
        _permitted => \%fields,
        %fields,
    };
    bless $self, $class;
    return $self;
}
```

If we wanted our record to have default values, we could fill those in where current we have `undef` in the %fields hash.

Notice how we saved a reference to our class data on the object itself? Remember that it's important to access class data through the object itself instead of having any method reference %fields directly, or else you won't have a decent inheritance.

The real magic, though, is going to reside in our proxy method, which will handle all calls to undefined methods for objects of class Person (or subclasses of Person). It has to be called AUTOLOAD. Again, it's all caps because it's called for us implicitly by Perl itself, not by a user directly.

```
sub AUTOLOAD {
    my $self = shift;
    my $type = ref($self)
                or croak "$self is not an object";

    my $name = $AUTOLOAD;
    $name =~ s/.*://;   # strip fully-qualified portion

    unless (exists $self->{_permitted}->{$name} ) {
        croak "Can't access `$name' field in class $type";
    }

    if (@_) {
        return $self->{$name} = shift;
    } else {
        return $self->{$name};
    }
}
```

Pretty nifty, eh? All we have to do to add new data fields is modify %fields. No new functions need be written.

I could have avoided the `_permitted` field entirely, but I wanted to demonstrate how to store a reference to class data on the object so you wouldn't have to access that class data directly from an object method.

Inherited Autoloaded Data Methods

But what about inheritance? Can we define our Employee class similarly? Yes, so long as we're careful enough.

Here's how to be careful:

```
package Employee;
use Person;
use strict;
our @ISA = qw(Person);

my %fields = (
    id          => undef,
    salary      => undef,
);

sub new {
    my $that  = shift;
    my $class = ref($that) || $that;
    my $self = bless $that->SUPER::new(), $class;
    my($element);
    foreach $element (keys %fields) {
        $self->{_permitted}->{$element} = $fields{$element};
    }
    @{$self}{keys %fields} = values %fields;
    return $self;
}
```

Once we've done this, we don't even need to have an AUTOLOAD function in the Employee package, because we'll grab Person's version of that via inheritance, and it will all work out just fine.

Metaclassical Tools

Even though proxy methods can provide a more convenient approach to making more struct–like classes than tediously coding up data methods as functions, it still leaves a bit to be desired. For one thing, it means you have to handle bogus calls that you don't mean to trap via your proxy. It also means you have to be quite careful when dealing with inheritance, as detailed above.

Perl programmers have responded to this by creating several different class construction classes. These metaclasses are classes that create other classes. A couple worth looking at are Class::Struct and Alias. These and other related metaclasses can be found in the modules directory on CPAN.

Class::Struct

One of the older ones is Class::Struct. In fact, its syntax and interface were sketched out long before perl5 even solidified into a real thing. What it does is provide you a way to "declare" a class as having objects whose fields are of a specific type. The function that does this is called, not surprisingly enough, `struct()`. Because structures or records are not base types in Perl, each time you want to create a class to provide a record–like data object, you yourself have to define a `new()` method, plus separate data–access methods for each of that record's fields. You'll quickly become bored with this process. The `Class::Struct::struct()` function alleviates this tedium.

Here's a simple example of using it:

```
use Class::Struct qw(struct);
use Jobbie;  # user-defined; see below

struct 'Fred' => {
    one        => '$',
    many       => '@',
    profession => Jobbie,  # calls Jobbie->new()
```

```
};

$ob = Fred->new;
$ob->one("hmmmm");

$ob->many(0, "here");
$ob->many(1, "you");
$ob->many(2, "go");
print "Just set: ", $ob->many(2), "\n";

$ob->profession->salary(10_000);
```

You can declare types in the struct to be basic Perl types, or user–defined types (classes). User types will be initialized by calling that class's `new()` method.

Here's a real–world example of using struct generation. Let's say you wanted to override Perl's idea of `gethostbyname()` and `gethostbyaddr()` so that they would return objects that acted like C structures. We don't care about high–falutin' OO gunk. All we want is for these objects to act like structs in the C sense.

```
use Socket;
use Net::hostent;
$h = gethostbyname("perl.com");  # object return
printf "perl.com's real name is %s, address %s\n",
    $h->name, inet_ntoa($h->addr);
```

Here's how to do this using the Class::Struct module. The crux is going to be this call:

```
struct 'Net::hostent' => [          # note bracket
    name       => '$',
    aliases    => '@',
    addrtype   => '$',
    'length'   => '$',
    addr_list  => '@',
 ];
```

Which creates object methods of those names and types. It even creates a `new()` method for us.

We could also have implemented our object this way:

```
struct 'Net::hostent' => {          # note brace
    name       => '$',
    aliases    => '@',
    addrtype   => '$',
    'length'   => '$',
    addr_list  => '@',
 };
```

and then Class::Struct would have used an anonymous hash as the object type, instead of an anonymous array. The array is faster and smaller, but the hash works out better if you eventually want to do inheritance. Since for this struct–like object we aren't planning on inheritance, this time we'll opt for better speed and size over better flexibility.

Here's the whole implementation:

```
package Net::hostent;
use strict;

BEGIN {
    use Exporter   ();
    our @EXPORT      = qw(gethostbyname gethostbyaddr gethost);
    our @EXPORT_OK   = qw(
```

```
                            $h_name         @h_aliases
                            $h_addrtype     $h_length
                            @h_addr_list    $h_addr
                          );
    our %EXPORT_TAGS = ( FIELDS => [ @EXPORT_OK, @EXPORT ] );
}
our @EXPORT_OK;

# Class::Struct forbids use of @ISA
sub import { goto &Exporter::import }

use Class::Struct qw(struct);
struct 'Net::hostent' => [
   name        => '$',
   aliases     => '@',
   addrtype    => '$',
   'length'    => '$',
   addr_list   => '@',
];

sub addr { shift->addr_list->[0] }

sub populate (@) {
    return unless @_;
    my $hob = new();  # Class::Struct made this!
    $h_name     =    $hob->[0]               = $_[0];
    @h_aliases  = @{ $hob->[1] } = split ' ', $_[1];
    $h_addrtype =    $hob->[2]               = $_[2];
    $h_length   =    $hob->[3]               = $_[3];
    $h_addr     =                              $_[4];
    @h_addr_list = @{ $hob->[4] } =         @_[ (4 .. $#_) ];
    return $hob;
}

sub gethostbyname ($)  { populate(CORE::gethostbyname(shift)) }

sub gethostbyaddr ($;$) {
    my ($addr, $addrtype);
    $addr = shift;
    require Socket unless @_;
    $addrtype = @_ ? shift : Socket::AF_INET();
    populate(CORE::gethostbyaddr($addr, $addrtype))
}

sub gethost($) {
    if ($_[0] =~ /^\d+(?:\.\d+(?:\.\d+(?:\.\d+)?)?)?$/) {
       require Socket;
       &gethostbyaddr(Socket::inet_aton(shift));
    } else {
       &gethostbyname;
    }
}

1;
```

We've snuck in quite a fair bit of other concepts besides just dynamic class creation, like overriding core functions, import/export bits, function prototyping, short–cut function call via `&whatever`, and function replacement with `goto &whatever`. These all mostly make sense from the perspective of a traditional module, but as you can see, we can also use them in an object module.

You can look at other object−based, struct−like overrides of core functions in the 5.004 release of Perl in File::stat, Net::hostent, Net::netent, Net::protoent, Net::servent, Time::gmtime, Time::localtime, User::grent, and User::pwent. These modules have a final component that's all lowercase, by convention reserved for compiler pragmas, because they affect the compilation and change a builtin function. They also have the type names that a C programmer would most expect.

Data Members as Variables

If you're used to C++ objects, then you're accustomed to being able to get at an object's data members as simple variables from within a method. The Alias module provides for this, as well as a good bit more, such as the possibility of private methods that the object can call but folks outside the class cannot.

Here's an example of creating a Person using the Alias module. When you update these magical instance variables, you automatically update value fields in the hash. Convenient, eh?

```
package Person;

# this is the same as before...
sub new {
     my $that  = shift;
     my $class = ref($that) || $that;
     my $self = {
        NAME  => undef,
        AGE   => undef,
        PEERS => [],
    };
    bless($self, $class);
    return $self;
}

use Alias qw(attr);
our ($NAME, $AGE, $PEERS);

sub name {
    my $self = attr shift;
    if (@_) { $NAME = shift; }
    return    $NAME;
}

sub age {
    my $self = attr shift;
    if (@_) { $AGE = shift; }
    return    $AGE;
}

sub peers {
    my $self = attr shift;
    if (@_) { @PEERS = @_; }
    return    @PEERS;
}

sub exclaim {
    my $self = attr shift;
    return sprintf "Hi, I'm %s, age %d, working with %s",
        $NAME, $AGE, join(", ", @PEERS);
}

sub happy_birthday {
    my $self = attr shift;
    return ++$AGE;
```

```
}
```

The need for the `our` declaration is because what Alias does is play with package globals with the same name as the fields. To use globals while `use strict` is in effect, you have to predeclare them. These package variables are localized to the block enclosing the `attr()` call just as if you'd used a `local()` on them. However, that means that they're still considered global variables with temporary values, just as with any other `local()`.

It would be nice to combine Alias with something like Class::Struct or Class::MethodMaker.

NOTES

Object Terminology

In the various OO literature, it seems that a lot of different words are used to describe only a few different concepts. If you're not already an object programmer, then you don't need to worry about all these fancy words. But if you are, then you might like to know how to get at the same concepts in Perl.

For example, it's common to call an object an *instance* of a class and to call those objects' methods *instance methods*. Data fields peculiar to each object are often called *instance data* or *object attributes*, and data fields common to all members of that class are *class data*, *class attributes*, or *static data members*.

Also, *base class*, *generic class*, and *superclass* all describe the same notion, whereas *derived class*, *specific class*, and *subclass* describe the other related one.

C++ programmers have *static methods* and *virtual methods*, but Perl only has *class methods* and *object methods*. Actually, Perl only has methods. Whether a method gets used as a class or object method is by usage only. You could accidentally call a class method (one expecting a string argument) on an object (one expecting a reference), or vice versa.

From the C++ perspective, all methods in Perl are virtual. This, by the way, is why they are never checked for function prototypes in the argument list as regular builtin and user–defined functions can be.

Because a class is itself something of an object, Perl's classes can be taken as describing both a "class as meta–object" (also called *object factory*) philosophy and the "class as type definition" (*declaring* behaviour, not *defining* mechanism) idea. C++ supports the latter notion, but not the former.

SEE ALSO

The following manpages will doubtless provide more background for this one: *perlmod*, *perlref*, *perlobj*, *perlbot*, *perltie*, and *overload*.

AUTHOR AND COPYRIGHT

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NAME

perltootc − Tom's OO Tutorial for Class Data in Perl

DESCRIPTION

When designing an object class, you are sometimes faced with the situation of wanting common state shared by all objects of that class. Such *class attributes* act somewhat like global variables for the entire class, but unlike program−wide globals, class attributes have meaning only to the class itself.

Here are a few examples where class attributes might come in handy:

- to keep a count of the objects you've created, or how many are still extant.
- to extract the name or file descriptor for a logfile used by a debugging method.
- to access collective data, like the total amount of cash dispensed by all ATMs in a network in a given day.
- to access the last object created by a class, or the most accessed object, or to retrieve a list of all objects.

Unlike a true global, class attributes should not be accessed directly. Instead, their state should be inspected, and perhaps altered, only through the mediated access of *class methods*. These class attributes accessor methods are similar in spirit and function to accessors used to manipulate the state of instance attributes on an object. They provide a clear firewall between interface and implementation.

You should allow access to class attributes through either the class name or any object of that class. If we assume that `$an_object` is of type Some_Class, and the `&Some_Class::population_count` method accesses class attributes, then these two invocations should both be possible, and almost certainly equivalent.

```
Some_Class->population_count()
$an_object->population_count()
```

The question is, where do you store the state which that method accesses? Unlike more restrictive languages like C++, where these are called static data members, Perl provides no syntactic mechanism to declare class attributes, any more than it provides a syntactic mechanism to declare instance attributes. Perl provides the developer with a broad set of powerful but flexible features that can be uniquely crafted to the particular demands of the situation.

A class in Perl is typically implemented in a module. A module consists of two complementary feature sets: a package for interfacing with the outside world, and a lexical file scope for privacy. Either of these two mechanisms can be used to implement class attributes. That means you get to decide whether to put your class attributes in package variables or to put them in lexical variables.

And those aren't the only decisions to make. If you choose to use package variables, you can make your class attribute accessor methods either ignorant of inheritance or sensitive to it. If you choose lexical variables, you can elect to permit access to them from anywhere in the entire file scope, or you can limit direct data access exclusively to the methods implementing those attributes.

Class Data as Package Variables

Because a class in Perl is really just a package, using package variables to hold class attributes is the most natural choice. This makes it simple for each class to have its own class attributes. Let's say you have a class called Some_Class that needs a couple of different attributes that you'd like to be global to the entire class. The simplest thing to do is to use package variables like `$Some_Class::CData1` and `$Some_Class::CData2` to hold these attributes. But we certainly don't want to encourage outsiders to touch those data directly, so we provide methods to mediate access.

In the accessor methods below, we'll for now just ignore the first argument—that part to the left of the arrow on method invocation, which is either a class name or an object reference.

```
package Some_Class;
sub CData1 {
    shift;  # XXX: ignore calling class/object
    $Some_Class::CData1 = shift if @_;
    return $Some_Class::CData1;
}
sub CData2 {
    shift;  # XXX: ignore calling class/object
    $Some_Class::CData2 = shift if @_;
    return $Some_Class::CData2;
}
```

This technique is highly legible and should be completely straightforward to even the novice Perl programmer. By fully qualifying the package variables, they stand out clearly when reading the code. Unfortunately, if you misspell one of these, you've introduced an error that's hard to catch. It's also somewhat disconcerting to see the class name itself hard-coded in so many places.

Both these problems can be easily fixed. Just add the `use strict` pragma, then pre-declare your package variables. (The `our` operator will be new in 5.6, and will work for package globals just like `my` works for scoped lexicals.)

```
package Some_Class;
use strict;
our($CData1, $CData2);      # our() is new to perl5.6
sub CData1 {
    shift;  # XXX: ignore calling class/object
    $CData1 = shift if @_;
    return $CData1;
}
sub CData2 {
    shift;  # XXX: ignore calling class/object
    $CData2 = shift if @_;
    return $CData2;
}
```

As with any other global variable, some programmers prefer to start their package variables with capital letters. This helps clarity somewhat, but by no longer fully qualifying the package variables, their significance can be lost when reading the code. You can fix this easily enough by choosing better names than were used here.

Putting All Your Eggs in One Basket

Just as the mindless enumeration of accessor methods for instance attributes grows tedious after the first few (see *perltoot*), so too does the repetition begin to grate when listing out accessor methods for class data. Repetition runs counter to the primary virtue of a programmer: Laziness, here manifesting as that innate urge every programmer feels to factor out duplicate code whenever possible.

Here's what to do. First, make just one hash to hold all class attributes.

```
package Some_Class;
use strict;
our %ClassData = (          # our() is new to perl5.6
    CData1 => "",
    CData2 => "",
);
```

Using closures (see *perlref*) and direct access to the package symbol table (see *perlmod*), now clone an accessor method for each key in the %ClassData hash. Each of these methods is used to fetch or store values to the specific, named class attribute.

```
for my $datum (keys %ClassData) {
    no strict "refs"# to register new methods in package
    *$datum = sub {
        shif#;XXX: ignore calling class/object
        $ClassData{$datum} = shift if @_;
        return $ClassData{$datum};
    }
}
```

It's true that you could work out a solution employing an `&AUTOLOAD` method, but this approach is unlikely to prove satisfactory. Your function would have to distinguish between class attributes and object attributes; it could interfere with inheritance; and it would have to careful about DESTROY. Such complexity is uncalled for in most cases, and certainly in this one.

You may wonder why we're rescinding strict refs for the loop. We're manipulating the package's symbol table to introduce new function names using symbolic references (indirect naming), which the strict pragma would otherwise forbid. Normally, symbolic references are a dodgy notion at best. This isn't just because they can be used accidentally when you aren't meaning to. It's also because for most uses to which beginning Perl programmers attempt to put symbolic references, we have much better approaches, like nested hashes or hashes of arrays. But there's nothing wrong with using symbolic references to manipulate something that is meaningful only from the perspective of the package symbol table, like method names or package variables. In other words, when you want to refer to the symbol table, use symbol references.

Clustering all the class attributes in one place has several advantages. They're easy to spot, initialize, and change. The aggregation also makes them convenient to access externally, such as from a debugger or a persistence package. The only possible problem is that we don't automatically know the name of each class's class object, should it have one. This issue is addressed below in *"The Eponymous Meta-Object"*.

Inheritance Concerns

Suppose you have an instance of a derived class, and you access class data using an inherited method call. Should that end up referring to the base class's attributes, or to those in the derived class? How would it work in the earlier examples? The derived class inherits all the base class's methods, including those that access class attributes. But what package are the class attributes stored in?

The answer is that, as written, class attributes are stored in the package into which those methods were compiled. When you invoke the `&CData1` method on the name of the derived class or on one of that class's objects, the version shown above is still run, so you'll access `$Some_Class::CData1`—or in the method cloning version, `$Some_Class::ClassData{CData1}`.

Think of these class methods as executing in the context of their base class, not in that of their derived class. Sometimes this is exactly what you want. If Feline subclasses Carnivore, then the population of Carnivores in the world should go up when a new Feline is born. But what if you wanted to figure out how many Felines you have apart from Carnivores? The current approach doesn't support that.

You'll have to decide on a case-by-case basis whether it makes any sense for class attributes to be package-relative. If you want it to be so, then stop ignoring the first argument to the function. Either it will be a package name if the method was invoked directly on a class name, or else it will be an object reference if the method was invoked on an object reference. In the latter case, the `ref()` function provides the class of that object.

```
package Some_Class;
sub CData1 {
    my $obclass = shift;
    my $class   = ref($obclass) || $obclass;
    my $varname = $class . "::CData1";
    no strict "refs";       # to access package data symbolically
    $$varname = shift if @_;
    return $$varname;
```

```
}
```

And then do likewise for all other class attributes (such as CData2, etc.) that you wish to access as package variables in the invoking package instead of the compiling package as we had previously.

Once again we temporarily disable the strict references ban, because otherwise we couldn't use the fully−qualified symbolic name for the package global. This is perfectly reasonable: since all package variables by definition live in a package, there's nothing wrong with accessing them via that package's symbol table. That's what it's there for (well, somewhat).

What about just using a single hash for everything and then cloning methods? What would that look like? The only difference would be the closure used to produce new method entries for the class's symbol table.

```
no strict "refs";
*$datum = sub {
    my $obclass = shift;
    my $class   = ref($obclass) || $obclass;
    my $varname = $class . "::ClassData";
    $varname->{$datum} = shift if @_;
    return $varname->{$datum};
}
```

The Eponymous Meta−Object

It could be argued that the %ClassData hash in the previous example is neither the most imaginative nor the most intuitive of names. Is there something else that might make more sense, be more useful, or both?

As it happens, yes, there is. For the "class meta−object", we'll use a package variable of the same name as the package itself. Within the scope of a package Some_Class declaration, we'll use the eponymously named hash %Some_Class as that class's meta−object. (Using an eponymously named hash is somewhat reminiscent of classes that name their constructors eponymously in the Python or C++ fashion. That is, class Some_Class would use `&Some_Class::Some_Class` as a constructor, probably even exporting that name as well. The StrNum class in Recipe 13.14 in *The Perl Cookbook* does this, if you're looking for an example.)

This predictable approach has many benefits, including having a well−known identifier to aid in debugging, transparent persistence, or checkpointing. It's also the obvious name for monadic classes and translucent attributes, discussed later.

Here's an example of such a class. Notice how the name of the hash storing the meta−object is the same as the name of the package used to implement the class.

```
package Some_Class;
use strict;

# create class meta-object using that most perfect of names
our %Some_Class = (         # our() is new to perl5.6
    CData1 => "",
    CData2 => "",
);

# this accessor is calling-package-relative
sub CData1 {
    my $obclass = shift;
    my $class   = ref($obclass) || $obclass;
    no strict "refs";       # to access eponymous meta-object
    $class->{CData1} = shift if @_;
    return $class->{CData1};
}

# but this accessor is not
```

```
sub CData2 {
    shift;                  # XXX: ignore calling class/object
    no strict "refs"# to access eponymous meta-object
    __PACKAGE__ -> {CData2} = shift if @_;
    return __PACKAGE__ -> {CData2};
}
```

In the second accessor method, the __PACKAGE__ notation was used for two reasons. First, to avoid hardcoding the literal package name in the code in case we later want to change that name. Second, to clarify to the reader that what matters here is the package currently being compiled into, not the package of the invoking object or class. If the long sequence of non−alphabetic characters bothers you, you can always put the __PACKAGE__ in a variable first.

```
sub CData2 {
    shift;                  # XXX: ignore calling class/object
    no strict "refs";       # to access eponymous meta-object
    my $class = __PACKAGE__;
    $class->{CData2} = shift if @_;
    return $class->{CData2};
}
```

Even though we're using symbolic references for good not evil, some folks tend to become unnerved when they see so many places with strict ref checking disabled. Given a symbolic reference, you can always produce a real reference (the reverse is not true, though). So we'll create a subroutine that does this conversion for us. If invoked as a function of no arguments, it returns a reference to the compiling class's eponymous hash. Invoked as a class method, it returns a reference to the eponymous hash of its caller. And when invoked as an object method, this function returns a reference to the eponymous hash for whatever class the object belongs to.

```
package Some_Class;
use strict;

our %Some_Class = (         # our() is new to perl5.6
    CData1 => "",
    CData2 => "",
);

# tri-natured: function, class method, or object method
sub _classobj {
    my $obclass = shift || __PACKAGE__;
    my $class   = ref($obclass) || $obclass;
    no strict "refs";   # to convert sym ref to real one
    return \%$class;
}

for my $datum (keys %{ _classobj() } ) {
    # turn off strict refs so that we can
    # register a method in the symbol table
    no strict "refs";
    *$datum = sub {
        use strict "refs";
        my $self = shift->_classobj();
        $self->{$datum} = shift if @_;
        return $self->{$datum};
    }
}
```

Indirect References to Class Data

A reasonably common strategy for handling class attributes is to store a reference to each package variable on the object itself. This is a strategy you've probably seen before, such as in *perltoot* and *perlbot*, but there may be variations in the example below that you haven't thought of before.

```
package Some_Class;
our($CData1, $CData2);              # our() is new to perl5.6

sub new {
    my $obclass = shift;
    return bless my $self = {
        ObData1 => "",
        ObData2 => "",
        CData1  => \$CData1,
        CData2  => \$CData2,
    } => (ref $obclass || $obclass);
}

sub ObData1 {
    my $self = shift;
    $self->{ObData1} = shift if @_;
    return $self->{ObData1};
}

sub ObData2 {
    my $self = shift;
    $self->{ObData2} = shift if @_;
    return $self->{ObData2};
}

sub CData1 {
    my $self = shift;
    my $dataref = ref $self
                  ? $self->{CData1}
                  : \$CData1;
    $$dataref = shift if @_;
    return $$dataref;
}

sub CData2 {
    my $self = shift;
    my $dataref = ref $self
                  ? $self->{CData2}
                  : \$CData2;
    $$dataref = shift if @_;
    return $$dataref;
}
```

As written above, a derived class will inherit these methods, which will consequently access package variables in the base class's package. This is not necessarily expected behavior in all circumstances. Here's an example that uses a variable meta-object, taking care to access the proper package's data.

```
    package Some_Class;
    use strict;

    our %Some_Class = (     # our() is new to perl5.6
        CData1 => "",
        CData2 => "",
```

```
);

sub _classobj {
    my $self  = shift;
    my $class = ref($self) || $self;
    no strict "refs";
    # get (hard) ref to eponymous meta-object
    return \%$class;
}

sub new {
    my $obclass  = shift;
    my $classobj = $obclass->_classobj();
    bless my $self = {
        ObData1 => "",
        ObData2 => "",
        CData1  => \$classobj->{CData1},
        CData2  => \$classobj->{CData2},
    } => (ref $obclass || $obclass);
    return $self;
}

sub ObData1 {
    my $self = shift;
    $self->{ObData1} = shift if @_;
    return $self->{ObData1};
}

sub ObData2 {
    my $self = shift;
    $self->{ObData2} = shift if @_;
    return $self->{ObData2};
}

sub CData1 {
    my $self = shift;
    $self = $self->_classobj() unless ref $self;
    my $dataref = $self->{CData1};
    $$dataref = shift if @_;
    return $$dataref;
}

sub CData2 {
    my $self = shift;
    $self = $self->_classobj() unless ref $self;
    my $dataref = $self->{CData2};
    $$dataref = shift if @_;
    return $$dataref;
}
```

Not only are we now strict refs clean, using an eponymous meta−object seems to make the code cleaner. Unlike the previous version, this one does something interesting in the face of inheritance: it accesses the class meta−object in the invoking class instead of the one into which the method was initially compiled.

You can easily access data in the class meta−object, making it easy to dump the complete class state using an external mechanism such as when debugging or implementing a persistent class. This works because the class meta−object is a package variable, has a well−known name, and clusters all its data together. (Transparent persistence is not always feasible, but it's certainly an appealing idea.)

There's still no check that object accessor methods have not been invoked on a class name. If strict ref checking is enabled, you'd blow up. If not, then you get the eponymous meta-object. What you do with—or about—this is up to you. The next two sections demonstrate innovative uses for this powerful feature.

Monadic Classes

Some of the standard modules shipped with Perl provide class interfaces without any attribute methods whatsoever. The most commonly used module not numbered amongst the pragmata, the Exporter module, is a class with neither constructors nor attributes. Its job is simply to provide a standard interface for modules wishing to export part of their namespace into that of their caller. Modules use the Exporter's `&import` method by setting their inheritance list in their package's @ISA array to mention "Exporter". But class Exporter provides no constructor, so you can't have several instances of the class. In fact, you can't have any—it just doesn't make any sense. All you get is its methods. Its interface contains no statefulness, so state data is wholly superfluous.

Another sort of class that pops up from time to time is one that supports a unique instance. Such classes are called *monadic classes*, or less formally, *singletons* or *highlander classes*.

If a class is monadic, where do you store its state, that is, its attributes? How do you make sure that there's never more than one instance? While you could merely use a slew of package variables, it's a lot cleaner to use the eponymously named hash. Here's a complete example of a monadic class:

```
package Cosmos;
%Cosmos = ();

# accessor method for "name" attribute
sub name {
    my $self = shift;
    $self->{name} = shift if @_;
    return $self->{name};
}

# read-only accessor method for "birthday" attribute
sub birthday {
    my $self = shift;
    die "can't reset birthday" if @_;  # XXX: croak() is better
    return $self->{birthday};
}

# accessor method for "stars" attribute
sub stars {
    my $self = shift;
    $self->{stars} = shift if @_;
    return $self->{stars};
}

# oh my - one of our stars just went out!
sub supernova {
    my $self = shift;
    my $count = $self->stars();
    $self->stars($count - 1) if $count > 0;
}

# constructor/initializer method - fix by reboot
sub bigbang {
    my $self = shift;
    %$self = (
        name         => "the world according to tchrist",
        birthday     => time(),
```

```
        stars=> 0,
    );
    return $self;       # yes, it's probably a class.  SURPRISE!
}

# After the class is compiled, but before any use or require
# returns, we start off the universe with a bang.
__PACKAGE__ -> bigbang();
```

Hold on, that doesn't look like anything special. Those attribute accessors look no different than they would if this were a regular class instead of a monadic one. The crux of the matter is there's nothing that says that `$self` must hold a reference to a blessed object. It merely has to be something you can invoke methods on. Here the package name itself, Cosmos, works as an object. Look at the `&supernova` method. Is that a class method or an object method? The answer is that static analysis cannot reveal the answer. Perl doesn't care, and neither should you. In the three attribute methods, `%$self` is really accessing the %Cosmos package variable.

If like Stephen Hawking, you posit the existence of multiple, sequential, and unrelated universes, then you can invoke the `&bigbang` method yourself at any time to start everything all over again. You might think of `&bigbang` as more of an initializer than a constructor, since the function doesn't allocate new memory; it only initializes what's already there. But like any other constructor, it does return a scalar value to use for later method invocations.

Imagine that some day in the future, you decide that one universe just isn't enough. You could write a new class from scratch, but you already have an existing class that does what you want—except that it's monadic, and you want more than just one cosmos.

That's what code reuse via subclassing is all about. Look how short the new code is:

```
package Multiverse;
use Cosmos;
@ISA = qw(Cosmos);

sub new {
    my $protoverse = shift;
    my $class      = ref($protoverse) || $protoverse;
    my $self       = {};
    return bless($self, $class)->bigbang();
}
1;
```

Because we were careful to be good little creators when we designed our Cosmos class, we can now reuse it without touching a single line of code when it comes time to write our Multiverse class. The same code that worked when invoked as a class method continues to work perfectly well when invoked against separate instances of a derived class.

The astonishing thing about the Cosmos class above is that the value returned by the `&bigbang` "constructor" is not a reference to a blessed object at all. It's just the class's own name. A class name is, for virtually all intents and purposes, a perfectly acceptable object. It has state, behavior, and identify, the three crucial components of an object system. It even manifests inheritance, polymorphism, and encapsulation. And what more can you ask of an object?

To understand object orientation in Perl, it's important to recognize the unification of what other programming languages might think of as class methods and object methods into just plain methods. "Class methods" and "object methods" are distinct only in the compartmentalizing mind of the Perl programmer, not in the Perl language itself.

Along those same lines, a constructor is nothing special either, which is one reason why Perl has no pre−ordained name for them. "Constructor" is just an informal term loosely used to describe a method that returns a scalar value that you can make further method calls against. So long as it's either a class name or

an object reference, that's good enough. It doesn't even have to be a reference to a brand new object.

You can have as many—or as few—constructors as you want, and you can name them whatever you care to. Blindly and obediently using `new()` for each and every constructor you ever write is to speak Perl with such a severe C++ accent that you do a disservice to both languages. There's no reason to insist that each class have but one constructor, or that that constructor be named `new()`, or that that constructor be used solely as a class method and not an object method.

The next section shows how useful it can be to further distance ourselves from any formal distinction between class method calls and object method calls, both in constructors and in accessor methods.

Translucent Attributes

A package's eponymous hash can be used for more than just containing per–class, global state data. It can also serve as a sort of template containing default settings for object attributes. These default settings can then be used in constructors for initialization of a particular object. The class's eponymous hash can also be used to implement *translucent attributes*. A translucent attribute is one that has a class–wide default. Each object can set its own value for the attribute, in which case `< $object->attribute()` returns that value. But if no value has been set, then `< $object->attribute()` returns the class–wide default.

We'll apply something of a copy–on–write approach to these translucent attributes. If you're just fetching values from them, you get translucency. But if you store a new value to them, that new value is set on the current object. On the other hand, if you use the class as an object and store the attribute value directly on the class, then the meta–object's value changes, and later fetch operations on objects with uninitialized values for those attributes will retrieve the meta–object's new values. Objects with their own initialized values, however, won't see any change.

Let's look at some concrete examples of using these properties before we show how to implement them. Suppose that a class named Some_Class had a translucent data attribute called "color". First you set the color in the meta–object, then you create three objects using a constructor that happens to be named `&spawn`.

```
use Vermin;
Vermin->color("vermilion");

$ob1 = Vermin->spawn();     # so that's where Jedi come from
$ob2 = Vermin->spawn();
$ob3 = Vermin->spawn();

print $obj3->color();       # prints "vermilion"
```

Each of these objects' colors is now "vermilion", because that's the meta–object's value that attribute, and these objects do not have individual color values set.

Changing the attribute on one object has no effect on other objects previously created.

```
$ob3->color("chartreuse");
print $ob3->color();        # prints "chartreuse"
print $ob1->color();        # prints "vermilion", translucently
```

If you now use `$ob3` to spawn off another object, the new object will take the color its parent held, which now happens to be "chartreuse". That's because the constructor uses the invoking object as its template for initializing attributes. When that invoking object is the class name, the object used as a template is the eponymous meta–object. When the invoking object is a reference to an instantiated object, the `&spawn` constructor uses that existing object as a template.

```
$ob4 = $ob3->spawn();       # $ob3 now template, not %Vermin
print $ob4->color();        # prints "chartreuse"
```

Any actual values set on the template object will be copied to the new object. But attributes undefined in the template object, being translucent, will remain undefined and consequently translucent in the new one as well.

Now let's change the color attribute on the entire class:

```
Vermin->color("azure");
print $ob1->color();        # prints "azure"
print $ob2->color();        # prints "azure"
print $ob3->color();        # prints "chartreuse"
print $ob4->color();        # prints "chartreuse"
```

That color change took effect only in the first pair of objects, which were still translucently accessing the meta-object's values. The second pair had per-object initialized colors, and so didn't change.

One important question remains. Changes to the meta-object are reflected in translucent attributes in the entire class, but what about changes to discrete objects? If you change the color of `$ob3`, does the value of `$ob4` see that change? Or vice-versa. If you change the color of `$ob4`, does then the value of `$ob3` shift?

```
$ob3->color("amethyst");
print $ob3->color();        # prints "amethyst"
print $ob4->color();        # hmm: "chartreuse" or "amethyst"?
```

While one could argue that in certain rare cases it should, let's not do that. Good taste aside, we want the answer to the question posed in the comment above to be "chartreuse", not "amethyst". So we'll treat these attributes similar to the way process attributes like environment variables, user and group IDs, or the current working directory are treated across a `fork()`. You can change only yourself, but you will see those changes reflected in your unspawned children. Changes to one object will propagate neither up to the parent nor down to any existing child objects. Those objects made later, however, will see the changes.

If you have an object with an actual attribute value, and you want to make that object's attribute value translucent again, what do you do? Let's design the class so that when you invoke an accessor method with `undef` as its argument, that attribute returns to translucency.

```
$ob4->color(undef);         # back to "azure"
```

Here's a complete implementation of Vermin as described above.

```
package Vermin;

# here's the class meta-object, eponymously named.
# it holds all class attributes, and also all instance attributes
# so the latter can be used for both initialization
# and translucency.

our %Vermin = (             # our() is new to perl5.6
    PopCount => 0,          # capital for class attributes
    color    => "beige",    # small for instance attributes
);

# constructor method
# invoked as class method or object method
sub spawn {
    my $obclass = shift;
    my $class   = ref($obclass) || $obclass;
    my $self = {};
    bless($self, $class);
    $class->{PopCount}++;
    # init fields from invoking object, or omit if
    # invoking object is the class to provide translucency
    %$self = %$obclass if ref $obclass;
    return $self;
}
```

```
# translucent accessor for "color" attribute
# invoked as class method or object method
sub color {
    my $self  = shift;
    my $class = ref($self) || $self;

    # handle class invocation
    unless (ref $self) {
        $class->{color} = shift if @_;
        return $class->{color}
    }

    # handle object invocation
    $self->{color} = shift if @_;
    if (defined $self->{color}) {  # not exists!
        return $self->{color};
    } else {
        return $class->{color};
    }
}

# accessor for "PopCount" class attribute
# invoked as class method or object method
# but uses object solely to locate meta-object
sub population {
    my $obclass = shift;
    my $class   = ref($obclass) || $obclass;
    return $class->{PopCount};
}

# instance destructor
# invoked only as object method
sub DESTROY {
    my $self  = shift;
    my $class = ref $self;
    $class->{PopCount}--;
}
```

Here are a couple of helper methods that might be convenient. They aren't accessor methods at all. They're used to detect accessibility of data attributes. The `&is_translucent` method determines whether a particular object attribute is coming from the meta–object. The `&has_attribute` method detects whether a class implements a particular property at all. It could also be used to distinguish undefined properties from non–existent ones.

```
# detect whether an object attribute is translucent
# (typically?) invoked only as object method
sub is_translucent {
    my($self, $attr)  = @_;
    return !defined $self->{$attr};
}

# test for presence of attribute in class
# invoked as class method or object method
sub has_attribute {
    my($self, $attr)  = @_;
    my $class = ref $self if $self;
    return exists $class->{$attr};
}
```

If you prefer to install your accessors more generically, you can make use of the upper−case versus lower−case convention to register into the package appropriate methods cloned from generic closures.

```
for my $datum (keys %{ +__PACKAGE__ }) {
    *$datum = ($datum =~ /^[A-Z]/)
        ? sub {  # install class accessor
                 my $obclass = shift;
                 my $class   = ref($obclass) || $obclass;
                 return $class->{$datum};
               }
        : sub { # install translucent accessor
                 my $self  = shift;
                 my $class = ref($self) || $self;
                 unless (ref $self) {
                     $class->{$datum} = shift if @_;
                     return $class->{$datum}
                 }
                 $self->{$datum} = shift if @_;
                 return defined $self->{$datum}
                     ? $self  -> {$datum}
                     : $class -> {$datum}
               }
}
```

Translations of this closure−based approach into C++, Java, and Python have been left as exercises for the reader. Be sure to send us mail as soon as you're done.

Class Data as Lexical Variables

Privacy and Responsibility

Unlike conventions used by some Perl programmers, in the previous examples, we didn't prefix the package variables used for class attributes with an underscore, nor did we do so for the names of the hash keys used for instance attributes. You don't need little markers on data names to suggest nominal privacy on attribute variables or hash keys, because these are **already** notionally private! Outsiders have no business whatsoever playing with anything within a class save through the mediated access of its documented interface; in other words, through method invocations. And not even through just any method, either. Methods that begin with an underscore are traditionally considered off−limits outside the class. If outsiders skip the documented method interface to poke around the internals of your class and end up breaking something, that's not your fault—it's theirs.

Perl believes in individual responsibility rather than mandated control. Perl respects you enough to let you choose your own preferred level of pain, or of pleasure. Perl believes that you are creative, intelligent, and capable of making your own decisions—and fully expects you to take complete responsibility for your own actions. In a perfect world, these admonitions alone would suffice, and everyone would be intelligent, responsible, happy, and creative. And careful. One probably shouldn't forget careful, and that's a good bit harder to expect. Even Einstein would take wrong turns by accident and end up lost in the wrong part of town.

Some folks get the heebie−jeebies when they see package variables hanging out there for anyone to reach over and alter them. Some folks live in constant fear that someone somewhere might do something wicked. The solution to that problem is simply to fire the wicked, of course. But unfortunately, it's not as simple as all that. These cautious types are also afraid that they or others will do something not so much wicked as careless, whether by accident or out of desperation. If we fire everyone who ever gets careless, pretty soon there won't be anybody left to get any work done.

Whether it's needless paranoia or sensible caution, this uneasiness can be a problem for some people. We can take the edge off their discomfort by providing the option of storing class attributes as lexical variables instead of as package variables. The `my()` operator is the source of all privacy in Perl, and it is a powerful

form of privacy indeed.

It is widely perceived, and indeed has often been written, that Perl provides no data hiding, that it affords the class designer no privacy nor isolation, merely a rag–tag assortment of weak and unenforcible social conventions instead. This perception is demonstrably false and easily disproven. In the next section, we show how to implement forms of privacy that are far stronger than those provided in nearly any other object–oriented language.

File–Scoped Lexicals

A lexical variable is visible only through the end of its static scope. That means that the only code able to access that variable is code residing textually below the `my()` operator through the end of its block if it has one, or through the end of the current file if it doesn't.

Starting again with our simplest example given at the start of this document, we replace `our()` variables with `my()` versions.

```
package Some_Class;
my($CData1, $CData2);   # file scope, not in any package
sub CData1 {
    shift;  # XXX: ignore calling class/object
    $CData1 = shift if @_;
    return $CData1;
}
sub CData2 {
    shift;  # XXX: ignore calling class/object
    $CData2 = shift if @_;
    return $CData2;
}
```

So much for that old `$Some_Class::CData1` package variable and its brethren! Those are gone now, replaced with lexicals. No one outside the scope can reach in and alter the class state without resorting to the documented interface. Not even subclasses or superclasses of this one have unmediated access to `$CData1`. They have to invoke the `&CData1` method against Some_Class or an instance thereof, just like anybody else.

To be scrupulously honest, that last statement assumes you haven't packed several classes together into the same file scope, nor strewn your class implementation across several different files. Accessibility of those variables is based uniquely on the static file scope. It has nothing to do with the package. That means that code in a different file but the same package (class) could not access those variables, yet code in the same file but a different package (class) could. There are sound reasons why we usually suggest a one–to–one mapping between files and packages and modules and classes. You don't have to stick to this suggestion if you really know what you're doing, but you're apt to confuse yourself otherwise, especially at first.

If you'd like to aggregate your class attributes into one lexically scoped, composite structure, you're perfectly free to do so.

```
package Some_Class;
my %ClassData = (
    CData1 => "",
    CData2 => "",
);
sub CData1 {
    shift;  # XXX: ignore calling class/object
    $ClassData{CData1} = shift if @_;
    return $ClassData{CData1};
}
sub CData2 {
    shift;  # XXX: ignore calling class/object
```

```
    $ClassData{CData2} = shift if @_;
    return $ClassData{CData2};
}
```

To make this more scalable as other class attributes are added, we can again register closures into the package symbol table to create accessor methods for them.

```
package Some_Class;
my %ClassData = (
    CData1 => "",
    CData2 => "",
);
for my $datum (keys %ClassData) {
    no strict "refs";
    *$datum = sub {
        shift;      # XXX: ignore calling class/object
        $ClassData{$datum} = shift if @_;
        return $ClassData{$datum};
    };
}
```

Requiring even your own class to use accessor methods like anybody else is probably a good thing. But demanding and expecting that everyone else, be they subclass or superclass, friend or foe, will all come to your object through mediation is more than just a good idea. It's absolutely critical to the model. Let there be in your mind no such thing as "public" data, nor even "protected" data, which is a seductive but ultimately destructive notion. Both will come back to bite at you. That's because as soon as you take that first step out of the solid position in which all state is considered completely private, save from the perspective of its own accessor methods, you have violated the envelope. And, having pierced that encapsulating envelope, you shall doubtless someday pay the price when future changes in the implementation break unrelated code. Considering that avoiding this infelicitous outcome was precisely why you consented to suffer the slings and arrows of obsequious abstraction by turning to object orientation in the first place, such breakage seems unfortunate in the extreme.

More Inheritance Concerns

Suppose that Some_Class were used as a base class from which to derive Another_Class. If you invoke a `&CData` method on the derived class or on an object of that class, what do you get? Would the derived class have its own state, or would it piggyback on its base class's versions of the class attributes?

The answer is that under the scheme outlined above, the derived class would **not** have its own state data. As before, whether you consider this a good thing or a bad one depends on the semantics of the classes involved.

The cleanest, sanest, simplest way to address per−class state in a lexical is for the derived class to override its base class's version of the method that accesses the class attributes. Since the actual method called is the one in the object's derived class if this exists, you automatically get per−class state this way. Any urge to provide an unadvertised method to sneak out a reference to the %ClassData hash should be strenuously resisted.

As with any other overridden method, the implementation in the derived class always has the option of invoking its base class's version of the method in addition to its own. Here's an example:

```
package Another_Class;
@ISA = qw(Some_Class);

my %ClassData = (
    CData1 => "",
);

sub CData1 {
```

```
    my($self, $newvalue) = @_;
    if (@_ > 1) {
        # set locally first
        $ClassData{CData1} = $newvalue;

        # then pass the buck up to the first
        # overridden version, if there is one
        if ($self->can("SUPER::CData1")) {
            $self->SUPER::CData1($newvalue);
        }
    }
    return $ClassData{CData1};
}
```

Those dabbling in multiple inheritance might be concerned about there being more than one override.

```
for my $parent (@ISA) {
    my $methname = $parent . "::CData1";
    if ($self->can($methname)) {
        $self->$methname($newvalue);
    }
}
```

Because the `&UNIVERSAL::can` method returns a reference to the function directly, you can use this directly for a significant performance improvement:

```
for my $parent (@ISA) {
    if (my $coderef = $self->can($parent . "::CData1")) {
        $self->$coderef($newvalue);
    }
}
```

Locking the Door and Throwing Away the Key

As currently implemented, any code within the same scope as the file–scoped lexical %ClassData can alter that hash directly. Is that ok? Is it acceptable or even desirable to allow other parts of the implementation of this class to access class attributes directly?

That depends on how careful you want to be. Think back to the Cosmos class. If the `&supernova` method had directly altered `$Cosmos::Stars` or `$Cosmos::Cosmos{stars}`, then we wouldn't have been able to reuse the class when it came to inventing a Multiverse. So letting even the class itself access its own class attributes without the mediating intervention of properly designed accessor methods is probably not a good idea after all.

Restricting access to class attributes from the class itself is usually not enforcible even in strongly object–oriented languages. But in Perl, you can.

Here's one way:

```
package Some_Class;

{  # scope for hiding $CData1
    my $CData1;
    sub CData1 {
        shift;      # XXX: unused
        $CData1 = shift if @_;
        return $CData1;
    }
}

{  # scope for hiding $CData2
```

```
    my $CData2;
    sub CData2 {
        shif#;XXX: unused
        $CData2 = shift if @_;
        return $CData2;
    }
}
```

No one—absolutely no one—is allowed to read or write the class attributes without the mediation of the managing accessor method, since only that method has access to the lexical variable it's managing. This use of mediated access to class attributes is a form of privacy far stronger than most OO languages provide.

The repetition of code used to create per−datum accessor methods chafes at our Laziness, so we'll again use closures to create similar methods.

```
package Some_Class;

{  # scope for ultra-private meta-object for class attributes
    my %ClassData = (
        CData1 => "",
        CData2 => "",
    );

    for my $datum (keys %ClassData ) {
        no strict "refs";
        *$datum = sub {
            use strict "refs";
            my ($self, $newvalue) = @_;
            $ClassData{$datum} = $newvalue if @_ > 1;
            return $ClassData{$datum};
        }
    }

}
```

The closure above can be modified to take inheritance into account using the `&UNIVERSAL::can` method and SUPER as shown previously.

Translucency Revisited

The Vermin class demonstrates translucency using a package variable, eponymously named %Vermin, as its meta−object. If you prefer to use absolutely no package variables beyond those necessary to appease inheritance or possibly the Exporter, this strategy is closed to you. That's too bad, because translucent attributes are an appealing technique, so it would be valuable to devise an implementation using only lexicals.

There's a second reason why you might wish to avoid the eponymous package hash. If you use class names with double−colons in them, you would end up poking around somewhere you might not have meant to poke.

```
package Vermin;
$class = "Vermin";
$class->{PopCount}++;
# accesses $Vermin::Vermin{PopCount}

package Vermin::Noxious;
$class = "Vermin::Noxious";
$class->{PopCount}++;
# accesses $Vermin::Noxious{PopCount}
```

In the first case, because the class name had no double−colons, we got the hash in the current package. But

in the second case, instead of getting some hash in the current package, we got the hash %Noxious in the Vermin package. (The noxious vermin just invaded another package and sprayed their data around it. :–) Perl doesn't support relative packages in its naming conventions, so any double–colons trigger a fully–qualified lookup instead of just looking in the current package.

In practice, it is unlikely that the Vermin class had an existing package variable named %Noxious that you just blew away. If you're still mistrustful, you could always stake out your own territory where you know the rules, such as using Eponymous::Vermin::Noxious or Hieronymus::Vermin::Boschious or Leave_Me_Alone::Vermin::Noxious as class names instead. Sure, it's in theory possible that someone else has a class named Eponymous::Vermin with its own %Noxious hash, but this kind of thing is always true. There's no arbiter of package names. It's always the case that globals like @Cwd::ISA would collide if more than one class uses the same Cwd package.

If this still leaves you with an uncomfortable twinge of paranoia, we have another solution for you. There's nothing that says that you have to have a package variable to hold a class meta–object, either for monadic classes or for translucent attributes. Just code up the methods so that they access a lexical instead.

Here's another implementation of the Vermin class with semantics identical to those given previously, but this time using no package variables.

```
package Vermin;

# Here's the class meta-object, eponymously named.
# It holds all class data, and also all instance data
# so the latter can be used for both initialization
# and translucency.  it's a template.
my %ClassData = (
    PopCount => 0,          # capital for class attributes
    color    => "beige",    # small for instance attributes
);

# constructor method
# invoked as class method or object method
sub spawn {
    my $obclass = shift;
    my $class   = ref($obclass) || $obclass;
    my $self = {};
    bless($self, $class);
    $ClassData{PopCount}++;
    # init fields from invoking object, or omit if
    # invoking object is the class to provide translucency
    %$self = %$obclass if ref $obclass;
    return $self;
}

# translucent accessor for "color" attribute
# invoked as class method or object method
sub color {
    my $self  = shift;

    # handle class invocation
    unless (ref $self) {
        $ClassData{color} = shift if @_;
        return $ClassData{color}
    }

    # handle object invocation
    $self->{color} = shift if @_;
    if (defined $self->{color}) {  # not exists!
```

```
            return $self->{color};
        } else {
            return $ClassData{color};
        }
    }

    # class attribute accessor for "PopCount" attribute
    # invoked as class method or object method
    sub population {
        return $ClassData{PopCount};
    }

    # instance destructor; invoked only as object method
    sub DESTROY {
        $ClassData{PopCount}--;
    }

    # detect whether an object attribute is translucent
    # (typically?) invoked only as object method
    sub is_translucent {
        my($self, $attr)  = @_;
        $self = \%ClassData if !ref $self;
        return !defined $self->{$attr};
    }

    # test for presence of attribute in class
    # invoked as class method or object method
    sub has_attribute {
        my($self, $attr)  = @_;
        return exists $ClassData{$attr};
    }
```

NOTES

Inheritance is a powerful but subtle device, best used only after careful forethought and design. Aggregation instead of inheritance is often a better approach.

We use the hypothetical `our()` syntax for package variables. It works like `use vars`, but looks like `my()`. It should be in this summer's major release (5.6) of perl—we hope.

You can't use file–scoped lexicals in conjunction with the SelfLoader or the AutoLoader, because they alter the lexical scope in which the module's methods wind up getting compiled.

The usual mealy–mouthed package–mungeing doubtless applies to setting up names of object attributes. For example, `< $self-{ObData1} >` should probably be `< $self-{ __PACKAGE__ . "_ObData1" } >`, but that would just confuse the examples.

SEE ALSO

perltoot, *perlobj*, *perlmod*, and *perlbot*.

The Tie::SecureHash module from CPAN is worth checking out.

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are permitted and encouraged to use this code in your own programs for fun or for profit as you see fit. A simple comment in the code giving credit would be courteous but is not required.

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Russ Albery, Jon Orwant, Randy Ray, Larry Rosler, Nat Torkington, and Stephen Warren all contributed suggestions and corrections to this piece. Thanks especially to Damian Conway for his ideas and feedback, and without whose indirect prodding I might never have taken the time to show others how much Perl has to offer in the way of objects once you start thinking outside the tiny little box that today's "popular" object–oriented languages enforce.

HISTORY

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NAME

perltrap – Perl traps for the unwary

DESCRIPTION

The biggest trap of all is forgetting to `use warnings` or use the **–w** switch; see *perllexwarn* and *perlrun*. The second biggest trap is not making your entire program runnable under `use strict`. The third biggest trap is not reading the list of changes in this version of Perl; see *perldelta*.

Awk Traps

Accustomed **awk** users should take special note of the following:

- The English module, loaded via

  ```
  use English;
  ```

  allows you to refer to special variables (like `$/`) with names (like `$RS`), as though they were in **awk**; see *perlvar* for details.

- Semicolons are required after all simple statements in Perl (except at the end of a block). Newline is not a statement delimiter.

- Curly brackets are required on `if`s and `while`s.

- Variables begin with "`$`", "`@`" or "`%`" in Perl.

- Arrays index from 0. Likewise string positions in `substr()` and `index()`.

- You have to decide whether your array has numeric or string indices.

- Hash values do not spring into existence upon mere reference.

- You have to decide whether you want to use string or numeric comparisons.

- Reading an input line does not split it for you. You get to split it to an array yourself. And the `split()` operator has different arguments than **awk**'s.

- The current input line is normally in `$_`, not `$0`. It generally does not have the newline stripped. (`$0` is the name of the program executed.) See *perlvar*.

- `$<`*digit* does not refer to fields—it refers to substrings matched by the last match pattern.

- The `print()` statement does not add field and record separators unless you set `$,` and `$\`. You can set `$OFS` and `$ORS` if you're using the English module.

- You must open your files before you print to them.

- The range operator is "..", not comma. The comma operator works as in C.

- The match operator is "=~", not "~". ("~" is the one's complement operator, as in C.)

- The exponentiation operator is "**", not "^". "^" is the XOR operator, as in C. (You know, one could get the feeling that **awk** is basically incompatible with C.)

- The concatenation operator is ".", not the null string. (Using the null string would render `/pat/ /pat/` unparsable, because the third slash would be interpreted as a division operator—the tokenizer is in fact slightly context sensitive for operators like "/", "?", and "". And in fact, "." itself can be the beginning of a number.)

- The `next`, `exit`, and `continue` keywords work differently.

- The following variables work differently:

  ```
  Awk       Perl
  ARGC      scalar @ARGV (compare with $#ARGV)
  ARGV[0]   $0
  ```

```
FILENAME  $ARGV
FNR$. - something
FS(whatever you like)
NF$#Fld, or some such
NR$.
OFMT%.#g
OFS$,
ORS$\
RLENGTH   length($&)
RS$/
RSTART    length($`)
SUBSEP    $;
```

- You cannot set `$RS` to a pattern, only a string.
- When in doubt, run the **awk** construct through **a2p** and see what it gives you.

C Traps

Cerebral C programmers should take note of the following:

- Curly brackets are required on `if`'s and `while`'s.
- You must use `elsif` rather than `else if`.
- The `break` and `continue` keywords from C become in Perl `last` and `next`, respectively. Unlike in C, these do *not* work within a `do { } while` construct.
- There's no switch statement. (But it's easy to build one on the fly.)
- Variables begin with "`$`", "@" or "%" in Perl.
- Comments begin with "#", not "/*".
- You can't take the address of anything, although a similar operator in Perl is the backslash, which creates a reference.
- `ARGV` must be capitalized. `$ARGV[0]` is C's `argv[1]`, and `argv[0]` ends up in `$0`.
- System calls such as `link()`, `unlink()`, `rename()`, etc. return nonzero for success, not 0. (`system()`, however, returns zero for success.)
- Signal handlers deal with signal names, not numbers. Use `kill -l` to find their names on your system.

Sed Traps

Seasoned **sed** programmers should take note of the following:

- Backreferences in substitutions use "`$`" rather than "\".
- The pattern matching metacharacters "(", ")", and "|" do not have backslashes in front.
- The range operator is `...`, rather than comma.

Shell Traps

Sharp shell programmers should take note of the following:

- The backtick operator does variable interpolation without regard to the presence of single quotes in the command.
- The backtick operator does no translation of the return value, unlike **csh**.
- Shells (especially **csh**) do several levels of substitution on each command line. Perl does substitution in only certain constructs such as double quotes, backticks, angle brackets, and search patterns.

- Shells interpret scripts a little bit at a time. Perl compiles the entire program before executing it (except for `BEGIN` blocks, which execute at compile time).
- The arguments are available via @ARGV, not `$1, $2,` etc.
- The environment is not automatically made available as separate scalar variables.

Perl Traps

Practicing Perl Programmers should take note of the following:

- Remember that many operations behave differently in a list context than they do in a scalar one. See *perldata* for details.
- Avoid barewords if you can, especially all lowercase ones. You can't tell by just looking at it whether a bareword is a function or a string. By using quotes on strings and parentheses on function calls, you won't ever get them confused.
- You cannot discern from mere inspection which builtins are unary operators (like `chop()` and `chdir()`) and which are list operators (like `print()` and `unlink()`). (Unless prototyped, user–defined subroutines can **only** be list operators, never unary ones.) See *perlop* and *perlsub*.
- People have a hard time remembering that some functions default to `$_,` or @ARGV, or whatever, but that others which you might expect to do not.
- The <FH construct is not the name of the filehandle, it is a readline operation on that handle. The data read is assigned to `$_` only if the file read is the sole condition in a while loop:

```
while (<FH>)      { }
while (defined($_ = <FH>)) { }..
<FH>;  # data discarded!
```

- Remember not to use = when you need =~; these two constructs are quite different:

```
$x =  /foo/;
$x =~ /foo/;
```

- The `do {}` construct isn't a real loop that you can use loop control on.
- Use `my()` for local variables whenever you can get away with it (but see *perlform* for where you can't). Using `local()` actually gives a local value to a global variable, which leaves you open to unforeseen side–effects of dynamic scoping.
- If you localize an exported variable in a module, its exported value will not change. The local name becomes an alias to a new value but the external name is still an alias for the original.

Perl4 to Perl5 Traps

Practicing Perl4 Programmers should take note of the following Perl4–to–Perl5 specific traps.

They're crudely ordered according to the following list:

Discontinuance, Deprecation, and BugFix traps

Anything that's been fixed as a perl4 bug, removed as a perl4 feature or deprecated as a perl4 feature with the intent to encourage usage of some other perl5 feature.

Parsing Traps

Traps that appear to stem from the new parser.

Numerical Traps

Traps having to do with numerical or mathematical operators.

General data type traps

Traps involving perl standard data types.

Context Traps – scalar, list contexts

Traps related to context within lists, scalar statements/declarations.

Precedence Traps

Traps related to the precedence of parsing, evaluation, and execution of code.

General Regular Expression Traps using s///, etc.

Traps related to the use of pattern matching.

Subroutine, Signal, Sorting Traps

Traps related to the use of signals and signal handlers, general subroutines, and sorting, along with sorting subroutines.

OS Traps

OS–specific traps.

DBM Traps

Traps specific to the use of `dbmopen()`, and specific dbm implementations.

Unclassified Traps

Everything else.

If you find an example of a conversion trap that is not listed here, please submit it to ***<perlbug@perl.org>*** for inclusion. Also note that at least some of these can be caught with the `use warnings` pragma or the **–w** switch.

Discontinuance, Deprecation, and BugFix traps

Anything that has been discontinued, deprecated, or fixed as a bug from perl4.

• Discontinuance

Symbols starting with "_" are no longer forced into package main, except for `$_` itself (and `@_`, etc.).

```
package test;
$_legacy = 1;

package main;
print "\$_legacy is ",$_legacy,"\n";

# perl4 prints: $_legacy is 1
# perl5 prints: $_legacy is
```

• Deprecation

Double–colon is now a valid package separator in a variable name. Thus these behave differently in perl4 vs. perl5, because the packages don't exist.

```
$a=1;$b=2;$c=3;$var=4;
print "$a::$b::$c ";
print "$var::abc::xyz\n";

# perl4 prints: 1::2::3 4::abc::xyz
# perl5 prints: 3
```

Given that `::` is now the preferred package delimiter, it is debatable whether this should be classed as a bug or not. (The older package delimiter, ' ,is used here)

```
$x = 10 ;
print "x=${'x}\n" ;

# perl4 prints: x=10
# perl5 prints: Can't find string terminator "'" anywhere before EOF
```

You can avoid this problem, and remain compatible with perl4, if you always explicitly include the package name:

```
$x = 10 ;
print "x=${main'x}\n" ;
```

Also see precedence traps, for parsing `$:`.

- BugFix

  The second and third arguments of `splice()` are now evaluated in scalar context (as the Camel says) rather than list context.

```
sub sub1{return(0,2) }          # return a 2-element list
sub sub2{ return(1,2,3)}        # return a 3-element list
@a1 = ("a","b","c","d","e");
@a2 = splice(@a1,&sub1,&sub2);
print join(' ',@a2),"\n";

# perl4 prints: a b
# perl5 prints: c d e
```

- Discontinuance

  You can't do a `goto` into a block that is optimized away. Darn.

```
goto marker1;

for(1){
marker1:
    print "Here I is!\n";
}

# perl4 prints: Here I is!
# perl5 errors: Can't "goto" into the middle of a foreach loop
```

- Discontinuance

  It is no longer syntactically legal to use whitespace as the name of a variable, or as a delimiter for any kind of quote construct. Double darn.

```
$a = ("foo bar");
$b = q baz ;
print "a is $a, b is $b\n";

# perl4 prints: a is foo bar, b is baz
# perl5 errors: Bareword found where operator expected
```

- Discontinuance

  The archaic while/if BLOCK BLOCK syntax is no longer supported.

```
if { 1 } {
    print "True!";
}
else {
    print "False!";
}

# perl4 prints: True!
# perl5 errors: syntax error at test.pl line 1, near "if {"
```

- BugFix

  The `**` operator now binds more tightly than unary minus. It was documented to work this way before, but didn't.

```
print -4**2,"\n";

# perl4 prints: 16
# perl5 prints: -16
```

• Discontinuance

The meaning of `foreach{}` has changed slightly when it is iterating over a list which is not an array. This used to assign the list to a temporary array, but no longer does so (for efficiency). This means that you'll now be iterating over the actual values, not over copies of the values. Modifications to the loop variable can change the original values.

```
@list = ('ab','abc','bcd','def');
foreach $var (grep(/ab/,@list)){
    $var = 1;
}
print (join(':',@list));

# perl4 prints: ab:abc:bcd:def
# perl5 prints: 1:1:bcd:def
```

To retain Perl4 semantics you need to assign your list explicitly to a temporary array and then iterate over that. For example, you might need to change

```
foreach $var (grep(/ab/,@list)){
```

to

```
foreach $var (@tmp = grep(/ab/,@list)){
```

Otherwise changing `$var` will clobber the values of @list. (This most often happens when you use `$_` for the loop variable, and call subroutines in the loop that don't properly localize `$_`.)

• Discontinuance

`split` with no arguments now behaves like `split ' '` (which doesn't return an initial null field if `$_` starts with whitespace), it used to behave like `split /\s+/` (which does).

```
$_ = ' hi mom';
print join(':', split);

# perl4 prints: :hi:mom
# perl5 prints: hi:mom
```

• BugFix

Perl 4 would ignore any text which was attached to an **-e** switch, always taking the code snippet from the following arg. Additionally, it would silently accept an **-e** switch without a following arg. Both of these behaviors have been fixed.

```
perl -e'print "attached to -e"' 'print "separate arg"'

# perl4 prints: separate arg
# perl5 prints: attached to -e

perl -e

# perl4 prints:
# perl5 dies: No code specified for -e.
```

• Discontinuance

In Perl 4 the return value of `push` was undocumented, but it was actually the last value being pushed onto the target list. In Perl 5 the return value of `push` is documented, but has changed, it is the number of elements in the resulting list.

```
@x = ('existing');
```

```
print push(@x, 'first new', 'second new');

# perl4 prints: second new
# perl5 prints: 3
```

- Deprecation

  Some error messages will be different.

- Discontinuance

  In Perl 4, if in list context the delimiters to the first argument of `split()` were `??`, the result would be placed in `@_` as well as being returned. Perl 5 has more respect for your subroutine arguments.

- Discontinuance

  Some bugs may have been inadvertently removed. :–)

Parsing Traps

Perl4–to–Perl5 traps from having to do with parsing.

- Parsing

  Note the space between . and =

```
$string . = "more string";
print $string;

# perl4 prints: more string
# perl5 prints: syntax error at - line 1, near ". ="
```

- Parsing

  Better parsing in perl 5

```
sub foo {}
&foo
print("hello, world\n");

# perl4 prints: hello, world
# perl5 prints: syntax error
```

- Parsing

  "if it looks like a function, it is a function" rule.

```
print
  ($foo == 1) ? "is one\n" : "is zero\n";

  # perl4 prints: is zero
  # perl5 warns: "Useless use of a constant in void context" if using -w
```

- Parsing

  String interpolation of the `$#array` construct differs when braces are to used around the name.

```
@a = (1..3);
print "${#a}";

# perl4 prints: 2
# perl5 fails with syntax error

@ = (1..3);
print "$#{a}";

# perl4 prints: {a}
# perl5 prints: 2
```

Numerical Traps

Perl4–to–Perl5 traps having to do with numerical operators, operands, or output from same.

- Numerical

  Formatted output and significant digits

```
print 7.373504 - 0, "\n";
printf "%20.18f\n", 7.373504 - 0;

# Perl4 prints:
7.375039999999996141
7.37503999999999614

# Perl5 prints:
7.373504
7.37503999999999614
```

- Numerical

  This specific item has been deleted. It demonstrated how the auto–increment operator would not catch when a number went over the signed int limit. Fixed in version 5.003_04. But always be wary when using large integers. If in doubt:

```
use Math::BigInt;
```

- Numerical

  Assignment of return values from numeric equality tests does not work in perl5 when the test evaluates to false (0). Logical tests now return an null, instead of 0

```
$p = ($test == 1);
print $p,"\n";

# perl4 prints: 0
# perl5 prints:
```

  Also see *, etc."* for another example of this new feature...

- Bitwise string ops

  When bitwise operators which can operate upon either numbers or strings (`& | ^ ~`) are given only strings as arguments, perl4 would treat the operands as bitstrings so long as the program contained a call to the `vec()` function. perl5 treats the string operands as bitstrings. (See *Bitwise String Operators* for more details.)

```
$fred = "10";
$barney = "12";
$betty = $fred & $barney;
print "$betty\n";
# Uncomment the next line to change perl4's behavior
# ($dummy) = vec("dummy", 0, 0);

# Perl4 prints:
8

# Perl5 prints:
10

# If vec() is used anywhere in the program, both print:
10
```

General data type traps

Perl4–to–Perl5 traps involving most data–types, and their usage within certain expressions and/or context.

- (Arrays)

  Negative array subscripts now count from the end of the array.

```
@a = (1, 2, 3, 4, 5);
print "The third element of the array is $a[3] also expressed as $a[-2] \n";

# perl4 prints: The third element of the array is 4 also expressed as
# perl5 prints: The third element of the array is 4 also expressed as 4
```

- (Arrays)

  Setting `$#array` lower now discards array elements, and makes them impossible to recover.

```
@a = (a,b,c,d,e);
print "Before: ",join('',@a);
$#a =1;
print ", After: ",join('',@a);
$#a =3;
print ", Recovered: ",join('',@a),"\n";

# perl4 prints: Before: abcde, After: ab, Recovered: abcd
# perl5 prints: Before: abcde, After: ab, Recovered: ab
```

- (Hashes)

  Hashes get defined before use

```
local($s,@a,%h);
die "scalar \$s defined" if defined($s);
die "array \@a defined" if defined(@a);
die "hash \%h defined" if defined(%h);

# perl4 prints:
# perl5 dies: hash %h defined
```

  Perl will now generate a warning when it sees defined(@a) and defined(%h).

- (Globs)

  glob assignment from variable to variable will fail if the assigned variable is localized subsequent to the assignment

```
@a = ("This is Perl 4");
*b = *a;
local(@a);
print @b,"\n";

# perl4 prints: This is Perl 4
# perl5 prints:
```

- (Globs)

  Assigning `undef` to a glob has no effect in Perl 5. In Perl 4 it undefines the associated scalar (but may have other side effects including SEGVs). Perl 5 will also warn if `undef` is assigned to a typeglob. (Note that assigning `undef` to a typeglob is different than calling the `undef` function on a typeglob (`undef *foo`), which has quite a few effects.

```
$foo = "bar";
*foo = undef;
print $foo;
```

```
# perl4 prints:
# perl4 warns: "Use of uninitialized variable" if using -w
# perl5 prints: bar
# perl5 warns: "Undefined value assigned to typeglob" if using -w
```

- (Scalar String)

  Changes in unary negation (of strings) This change effects both the return value and what it does to auto(magic)increment.

```
$x = "aaa";
print ++$x," : ";
print -$x," : ";
print ++$x,"\n";
```

```
# perl4 prints: aab : -0 : 1
# perl5 prints: aab : -aab : aac
```

- (Constants)

  perl 4 lets you modify constants:

```
$foo = "x";
&mod($foo);
for ($x = 0; $x < 3; $x++) {
    &mod("a");
}
sub mod {
    print "before: $_[0]";
    $_[0] = "m";
    print "  after: $_[0]\n";
}
```

```
# perl4:
# before: x  after: m
# before: a  after: m
# before: m  after: m
# before: m  after: m
```

```
# Perl5:
# before: x  after: m
# Modification of a read-only value attempted at foo.pl line 12.
# before: a
```

- (Scalars)

  The behavior is slightly different for:

```
print "$x", defined $x
```

```
# perl 4: 1
# perl 5: <no output, $x is not called into existence>
```

- (Variable Suicide)

  Variable suicide behavior is more consistent under Perl 5. Perl5 exhibits the same behavior for hashes and scalars, that perl4 exhibits for only scalars.

```
$aGlobal{ "aKey" } = "global value";
print "MAIN:", $aGlobal{"aKey"}, "\n";
$GlobalLevel = 0;
&test( *aGlobal );
```

```
sub test {
```

```
    local( *theArgument ) = @_;
    local( %aNewLocal ); # perl 4 != 5.001l,m
    $aNewLocal{"aKey"} = "this should never appear";
    print "SUB: ", $theArgument{"aKey"}, "\n";
    $aNewLocal{"aKey"} = "level $GlobalLevel";   # what should print
    $GlobalLevel++;
    if( $GlobalLevel<4 ) {
        &test( *aNewLocal );
    }
}

# Perl4:
# MAIN:global value
# SUB: global value
# SUB: level 0
# SUB: level 1
# SUB: level 2

# Perl5:
# MAIN:global value
# SUB: global value
# SUB: this should never appear
# SUB: this should never appear
# SUB: this should never appear
```

Context Traps – scalar, list contexts

- (list context)

  The elements of argument lists for formats are now evaluated in list context. This means you can interpolate list values now.

```
@fmt = ("foo","bar","baz");
format STDOUT=
@<<<<< @|||||  @>>>>>
@fmt;
.
write;

# perl4 errors:  Please use commas to separate fields in file
# perl5 prints: foo     bar      baz
```

- (scalar context)

  The `caller()` function now returns a false value in a scalar context if there is no caller. This lets library files determine if they're being required.

```
caller() ? (print "You rang?\n") : (print "Got a 0\n");

# perl4 errors: There is no caller
# perl5 prints: Got a 0
```

- (scalar context)

  The comma operator in a scalar context is now guaranteed to give a scalar context to its arguments.

```
@y= ('a','b','c');
$x = (1, 2, @y);
print "x = $x\n";

# Perl4 prints:  x = c   # Thinks list context interpolates list
# Perl5 prints:  x = 3   # Knows scalar uses length of list
```

- (list, builtin)

  `sprintf()` is prototyped as `($;@)`, so its first argument is given scalar context. Thus, if passed an array, it will probably not do what you want, unlike Perl 4:

```
@z = ('%s%s', 'foo', 'bar');
$x = sprintf(@z);
print $x;

# perl4 prints: foobar
# perl5 prints: 3
```

  `printf()` works the same as it did in Perl 4, though:

```
@z = ('%s%s', 'foo', 'bar');
printf STDOUT (@z);

# perl4 prints: foobar
# perl5 prints: foobar
```

Precedence Traps

Perl4–to–Perl5 traps involving precedence order.

Perl 4 has almost the same precedence rules as Perl 5 for the operators that they both have. Perl 4 however, seems to have had some inconsistencies that made the behavior differ from what was documented.

- Precedence

  LHS vs. RHS of any assignment operator. LHS is evaluated first in perl4, second in perl5; this can affect the relationship between side–effects in sub–expressions.

```
@arr = ( 'left', 'right' );
$a{shift @arr} = shift @arr;
print join( ' ', keys %a );

# perl4 prints: left
# perl5 prints: right
```

- Precedence

  These are now semantic errors because of precedence:

```
@list = (1,2,3,4,5);
%map = ("a",1,"b",2,"c",3,"d",4);
$n = shift @list + 2;   # first item in list plus 2
print "n is $n, ";
$m = keys %map + 2;     # number of items in hash plus 2
print "m is $m\n";

# perl4 prints: n is 3, m is 6
# perl5 errors and fails to compile
```

- Precedence

  The precedence of assignment operators is now the same as the precedence of assignment. Perl 4 mistakenly gave them the precedence of the associated operator. So you now must parenthesize them in expressions like

```
/foo/ ? ($a += 2) : ($a -= 2);
```

  Otherwise

```
/foo/ ? $a += 2 : $a -= 2
```

  would be erroneously parsed as

```
(/foo/ ? $a += 2 : $a) -= 2;
```

On the other hand,

```
$a += /foo/ ? 1 : 2;
```

now works as a C programmer would expect.

- Precedence

```
open FOO || die;
```

is now incorrect. You need parentheses around the filehandle. Otherwise, perl5 leaves the statement as its default precedence:

```
open(FOO || die);
```

```
# perl4 opens or dies
# perl5 opens FOO, dying only if 'FOO' is false, i.e. never
```

- Precedence

perl4 gives the special variable, `$:` precedence, where perl5 treats `$::` as main `package`

```
$a = "x"; print "$::a";
```

```
# perl 4 prints: -:a
# perl 5 prints: x
```

- Precedence

perl4 had buggy precedence for the file test operators vis–a–vis the assignment operators. Thus, although the precedence table for perl4 leads one to believe `-e $foo .= "q"` should parse as `((-e $foo) .= "q")`, it actually parses as `(-e ($foo .= "q"))`. In perl5, the precedence is as documented.

```
-e $foo .= "q"
```

```
# perl4 prints: no output
# perl5 prints: Can't modify -e in concatenation
```

- Precedence

In perl4, `keys()`, `each()` and `values()` were special high–precedence operators that operated on a single hash, but in perl5, they are regular named unary operators. As documented, named unary operators have lower precedence than the arithmetic and concatenation operators `+ - .`, but the perl4 variants of these operators actually bind tighter than `+ - .`. Thus, for:

```
%foo = 1..10;
print keys %foo - 1
```

```
# perl4 prints: 4
# perl5 prints: Type of arg 1 to keys must be hash (not subtraction)
```

The perl4 behavior was probably more useful, if less consistent.

General Regular Expression Traps using s///, etc.

All types of RE traps.

- Regular Expression

`s'$lhs'$rhs'` now does no interpolation on either side. It used to interpolate `$lhs` but not `$rhs`. (And still does not match a literal '`$`' in string)

```
$a=1;$b=2;
$string = '1 2 $a $b';
$string =~ s'$a'$b';
print $string,"\n";
```

```
# perl4 prints: $b 2 $a $b
# perl5 prints: 1 2 $a $b
```

- Regular Expression

  m//g now attaches its state to the searched string rather than the regular expression. (Once the scope of a block is left for the sub, the state of the searched string is lost)

```
$_ = "abababab";
while(m/ab/g){
    &doit("blah");
}
sub doit{local($_) = shift; print "Got $_ "}

# perl4 prints: Got blah Got blah Got blah Got blah
# perl5 prints: infinite loop blah...
```

- Regular Expression

  Currently, if you use the m//o qualifier on a regular expression within an anonymous sub, *all* closures generated from that anonymous sub will use the regular expression as it was compiled when it was used the very first time in any such closure. For instance, if you say

```
sub build_match {
    my($left,$right) = @_;
    return sub { $_[0] =~ /$left stuff $right/o; };
}
$good = build_match('foo','bar');
$bad = build_match('baz','blarch');
print $good->('foo stuff bar') ? "ok\n" : "not ok\n";
print $bad->('baz stuff blarch') ? "ok\n" : "not ok\n";
print $bad->('foo stuff bar') ? "not ok\n" : "ok\n";
```

  For most builds of Perl5, this will print: ok not ok not ok

  build_match() will always return a sub which matches the contents of $left and $right as they were the *first* time that build_match() was called, not as they are in the current call.

- Regular Expression

  If no parentheses are used in a match, Perl4 sets $+ to the whole match, just like $&. Perl5 does not.

```
"abcdef" =~ /b.*e/;
print "\$+ = $+\n";

# perl4 prints: bcde
# perl5 prints:
```

- Regular Expression

  substitution now returns the null string if it fails

```
$string = "test";
$value = ($string =~ s/foo//);
print $value, "\n";

# perl4 prints: 0
# perl5 prints:
```

  Also see *Numerical Traps* for another example of this new feature.

- Regular Expression

  s`lhs`rhs` (using backticks) is now a normal substitution, with no backtick expansion

```
$string = "";
$string =~ s`^`hostname`;
```

```
print $string, "\n";

# perl4 prints: <the local hostname>
# perl5 prints: hostname
```

- Regular Expression

  Stricter parsing of variables used in regular expressions

```
s/^([^$grpc]*$grpc[$opt$plus$rep]?)//o;

# perl4: compiles w/o error
# perl5: with Scalar found where operator expected ..., near "$opt$plus"
```

  an added component of this example, apparently from the same script, is the actual value of the s'd string after the substitution. `[$opt]` is a character class in perl4 and an array subscript in perl5

```
$grpc = 'a';
$opt  = 'r';
$_ = 'bar';
s/^([^$grpc]*$grpc[$opt]?)/foo/;
print ;

# perl4 prints: foo
# perl5 prints: foobar
```

- Regular Expression

  Under perl5, `m?x?` matches only once, like `?x?`. Under perl4, it matched repeatedly, like `/x/` or `m!x!`.

```
$test = "once";
sub match { $test =~ m?once?; }
&match();
if( &match() ) {
    # m?x? matches more then once
    print "perl4\n";
} else {
    # m?x? matches only once
    print "perl5\n";
}

# perl4 prints: perl4
# perl5 prints: perl5
```

Subroutine, Signal, Sorting Traps

The general group of Perl4–to–Perl5 traps having to do with Signals, Sorting, and their related subroutines, as well as general subroutine traps. Includes some OS–Specific traps.

- (Signals)

  Barewords that used to look like strings to Perl will now look like subroutine calls if a subroutine by that name is defined before the compiler sees them.

```
sub SeeYa { warn"Hasta la vista, baby!" }
$SIG{'TERM'} = SeeYa;
print "SIGTERM is now $SIG{'TERM'}\n";

# perl4 prints: SIGTERM is now main'SeeYa
# perl5 prints: SIGTERM is now main::1 (and warns "Hasta la vista, baby!")
```

  Use **–w** to catch this one

- (Sort Subroutine)

  reverse is no longer allowed as the name of a sort subroutine.

```
sub reverse{ print "yup "; $a <=> $b }
print sort reverse (2,1,3);

# perl4 prints: yup yup 123
# perl5 prints: 123
# perl5 warns (if using -w): Ambiguous call resolved as CORE::reverse()
```

- `warn()` won't let you specify a filehandle.

  Although it _always_ printed to STDERR, `warn()` would let you specify a filehandle in perl4. With perl5 it does not.

```
warn STDERR "Foo!";

# perl4 prints: Foo!
# perl5 prints: String found where operator expected
```

OS Traps

- (SysV)

  Under HPUX, and some other SysV OSes, one had to reset any signal handler, within the signal handler function, each time a signal was handled with perl4. With perl5, the reset is now done correctly. Any code relying on the handler _not_ being reset will have to be reworked.

  Since version 5.002, Perl uses `sigaction()` under SysV.

```
sub gotit {
    print "Got @_... ";
}
$SIG{'INT'} = 'gotit';

$| = 1;
$pid = fork;
if ($pid) {
    kill('INT', $pid);
    sleep(1);
    kill('INT', $pid);
} else {
    while (1) {sleep(10);}
}

# perl4 (HPUX) prints: Got INT...
# perl5 (HPUX) prints: Got INT... Got INT...
```

- (SysV)

  Under SysV OSes, `seek()` on a file opened to append `<<` now does the right thing w.r.t. the `fopen()` manpage. e.g., – When a file is opened for append, it is impossible to overwrite information already in the file.

```
open(TEST,">>seek.test");
$start = tell TEST ;
foreach(1 .. 9){
    print TEST "$_ ";
}
$end = tell TEST ;
seek(TEST,$start,0);
print TEST "18 characters here";
```

```
# perl4 (solaris) seek.test has: 18 characters here
# perl5 (solaris) seek.test has: 1 2 3 4 5 6 7 8 9 18 characters here
```

Interpolation Traps

Perl4–to–Perl5 traps having to do with how things get interpolated within certain expressions, statements, contexts, or whatever.

- Interpolation

  @ now always interpolates an array in double–quotish strings.

```
print "To: someone@somewhere.com\n";

# perl4 prints: To:someone@somewhere.com
# perl < 5.6.1, error : In string, @somewhere now must be written as \@somew
# perl >= 5.6.1, warning : Possible unintended interpolation of @somewhere i
```

- Interpolation

  Double–quoted strings may no longer end with an unescaped $ or @.

```
$foo = "foo$";
$bar = "bar@";
print "foo is $foo, bar is $bar\n";

# perl4 prints: foo is foo$, bar is bar@
# perl5 errors: Final $ should be \$ or $name
```

  Note: perl5 DOES NOT error on the terminating @ in `$bar`

- Interpolation

  Perl now sometimes evaluates arbitrary expressions inside braces that occur within double quotes (usually when the opening brace is preceded by $ or @).

```
@www = "buz";
$foo = "foo";
$bar = "bar";
sub foo { return "bar" };
print "|@{w.w.w}|${main'foo}|";

# perl4 prints: |@{w.w.w}|foo|
# perl5 prints: |buz|bar|
```

  Note that you can `use strict;` to ward off such trappiness under perl5.

- Interpolation

  The construct "this is `$$x`" used to interpolate the pid at that point, but now tries to dereference `$x`. `$$` by itself still works fine, however.

```
$s = "a reference";
$x = *s;
print "this is $$x\n";

# perl4 prints: this is XXXx   (XXX is the current pid)
# perl5 prints: this is a reference
```

- Interpolation

  Creation of hashes on the fly with `eval "EXPR"` now requires either both `$`s to be protected in the specification of the hash name, or both curlies to be protected. If both curlies are protected, the result will be compatible with perl4 and perl5. This is a very common practice, and should be changed to use the block form of `eval{}` if possible.

```
$hashname = "foobar";
$key = "baz";
```

```
$value = 1234;
eval "\$$hashname{'$key'} = q|$value|";
(defined($foobar{'baz'})) ?  (print "Yup") : (print "Nope");

# perl4 prints: Yup
# perl5 prints: Nope
```

Changing

```
eval "\$$hashname{'$key'} = q|$value|";
```

to

```
eval "\$\$hashname{'$key'} = q|$value|";
```

causes the following result:

```
# perl4 prints: Nope
# perl5 prints: Yup
```

or, changing to

```
eval "\$$hashname\{'$key'\} = q|$value|";
```

causes the following result:

```
# perl4 prints: Yup
# perl5 prints: Yup
# and is compatible for both versions
```

- Interpolation

  perl4 programs which unconsciously rely on the bugs in earlier perl versions.

```
perl -e '$bar=q/not/; print "This is $foo{$bar} perl5"'

# perl4 prints: This is not perl5
# perl5 prints: This is perl5
```

- Interpolation

  You also have to be careful about array references.

```
print "$foo{"

perl 4 prints: {
perl 5 prints: syntax error
```

- Interpolation

  Similarly, watch out for:

```
$foo = "baz";
print "\$$foo{bar}\n";

# perl4 prints: $baz{bar}
# perl5 prints: $
```

  Perl 5 is looking for `$foo{bar}` which doesn't exist, but perl 4 is happy just to expand `$foo` to "baz" by itself. Watch out for this especially in `eval`'s.

- Interpolation

  `qq()` string passed to `eval`

```
eval qq(
    foreach \$y (keys %\$x\) {
        \$count++;
    }
```

```
);

# perl4 runs this ok
# perl5 prints: Can't find string terminator ")"
```

DBM Traps

General DBM traps.

- DBM Existing dbm databases created under perl4 (or any other dbm/ndbm tool) may cause the same script, run under perl5, to fail. The build of perl5 must have been linked with the same dbm/ndbm as the default for `dbmopen()` to function properly without `tie`'ing to an extension dbm implementation.

```
dbmopen (%dbm, "file", undef);
print "ok\n";

# perl4 prints: ok
# perl5 prints: ok (IFF linked with -ldbm or -lndbm)
```

- DBM Existing dbm databases created under perl4 (or any other dbm/ndbm tool) may cause the same script, run under perl5, to fail. The error generated when exceeding the limit on the key/value size will cause perl5 to exit immediately.

```
dbmopen(DB, "testdb",0600) || die "couldn't open db! $!";
$DB{'trap'} = "x" x 1024;  # value too large for most dbm/ndbm
print "YUP\n";

# perl4 prints:
dbm store returned -1, errno 28, key "trap" at - line 3.
YUP

# perl5 prints:
dbm store returned -1, errno 28, key "trap" at - line 3.
```

Unclassified Traps

Everything else.

- `require`/`do` trap using returned value

  If the file doit.pl has:

```
sub foo {
    $rc = do "./do.pl";
    return 8;
}
print &foo, "\n";
```

  And the do.pl file has the following single line:

```
return 3;
```

  Running doit.pl gives the following:

```
# perl 4 prints: 3 (aborts the subroutine early)
# perl 5 prints: 8
```

  Same behavior if you replace `do` with `require`.

- `split` on empty string with LIMIT specified

```
$string = '';
@list = split(/foo/, $string, 2)
```

  Perl4 returns a one element list containing the empty string but Perl5 returns an empty list.

As always, if any of these are ever officially declared as bugs, they'll be fixed and removed.

NAME

perlunicode – Unicode support in Perl

DESCRIPTION

Important Caveat

WARNING: The implementation of Unicode support in Perl is incomplete.

The following areas need further work.

Input and Output Disciplines

There is currently no easy way to mark data read from a file or other external source as being utf8. This will be one of the major areas of focus in the near future.

Regular Expressions

The existing regular expression compiler does not produce polymorphic opcodes. This means that the determination on whether to match Unicode characters is made when the pattern is compiled, based on whether the pattern contains Unicode characters, and not when the matching happens at run time. This needs to be changed to adaptively match Unicode if the string to be matched is Unicode.

`use utf8` still needed to enable a few features

The `utf8` pragma implements the tables used for Unicode support. These tables are automatically loaded on demand, so the `utf8` pragma need not normally be used.

However, as a compatibility measure, this pragma must be explicitly used to enable recognition of UTF–8 encoded literals and identifiers in the source text.

Byte and Character semantics

Beginning with version 5.6, Perl uses logically wide characters to represent strings internally. This internal representation of strings uses the UTF–8 encoding.

In future, Perl–level operations can be expected to work with characters rather than bytes, in general.

However, as strictly an interim compatibility measure, Perl v5.6 aims to provide a safe migration path from byte semantics to character semantics for programs. For operations where Perl can unambiguously decide that the input data is characters, Perl now switches to character semantics. For operations where this determination cannot be made without additional information from the user, Perl decides in favor of compatibility, and chooses to use byte semantics.

This behavior preserves compatibility with earlier versions of Perl, which allowed byte semantics in Perl operations, but only as long as none of the program's inputs are marked as being as source of Unicode character data. Such data may come from filehandles, from calls to external programs, from information provided by the system (such as %ENV), or from literals and constants in the source text.

If the `-C` command line switch is used, (or the `${^WIDE_SYSTEM_CALLS}` global flag is set to `1`), all system calls will use the corresponding wide character APIs. This is currently only implemented on Windows.

Regardless of the above, the `bytes` pragma can always be used to force byte semantics in a particular lexical scope. See *bytes*.

The `utf8` pragma is primarily a compatibility device that enables recognition of UTF–8 in literals encountered by the parser. It may also be used for enabling some of the more experimental Unicode support features. Note that this pragma is only required until a future version of Perl in which character semantics will become the default. This pragma may then become a no–op. See *utf8*.

Unless mentioned otherwise, Perl operators will use character semantics when they are dealing with Unicode data, and byte semantics otherwise. Thus, character semantics for these operations apply transparently; if the input data came from a Unicode source (for example, by adding a character encoding discipline to the filehandle whence it came, or a literal UTF–8 string constant in the program), character semantics apply;

otherwise, byte semantics are in effect. To force byte semantics on Unicode data, the `bytes` pragma should be used.

Under character semantics, many operations that formerly operated on bytes change to operating on characters. For ASCII data this makes no difference, because UTF−8 stores ASCII in single bytes, but for any character greater than `chr(127)`, the character may be stored in a sequence of two or more bytes, all of which have the high bit set. But by and large, the user need not worry about this, because Perl hides it from the user. A character in Perl is logically just a number ranging from 0 to 2**32 or so. Larger characters encode to longer sequences of bytes internally, but again, this is just an internal detail which is hidden at the Perl level.

Effects of character semantics

Character semantics have the following effects:

- Strings and patterns may contain characters that have an ordinal value larger than 255.

  Presuming you use a Unicode editor to edit your program, such characters will typically occur directly within the literal strings as UTF−8 characters, but you can also specify a particular character with an extension of the `\x` notation. UTF−8 characters are specified by putting the hexadecimal code within curlies after the `\x`. For instance, a Unicode smiley face is `\x{263A}`.

- Identifiers within the Perl script may contain Unicode alphanumeric characters, including ideographs. (You are currently on your own when it comes to using the canonical forms of characters—Perl doesn't (yet) attempt to canonicalize variable names for you.)

- Regular expressions match characters instead of bytes. For instance, "." matches a character instead of a byte. (However, the `\C` pattern is provided to force a match a single byte ("`char`" in C, hence `\C`).)

- Character classes in regular expressions match characters instead of bytes, and match against the character properties specified in the Unicode properties database. So `\w` can be used to match an ideograph, for instance.

- Named Unicode properties and block ranges make be used as character classes via the new `\p{}` (matches property) and `\P{}` (doesn't match property) constructs. For instance, `\p{Lu}` matches any character with the Unicode uppercase property, while `\p{M}` matches any mark character. Single letter properties may omit the brackets, so that can be written `\pM` also. Many predefined character classes are available, such as `\p{IsMirrored}` and `\p{InTibetan}`.

- The special pattern `\X` match matches any extended Unicode sequence (a "combining character sequence" in Standardese), where the first character is a base character and subsequent characters are mark characters that apply to the base character. It is equivalent to `(?:\PM\pM*)`.

- The `tr///` operator translates characters instead of bytes. Note that the `tr///CU` functionality has been removed, as the interface was a mistake. For similar functionality see pack('U0', ...) and pack('C0', ...).

- Case translation operators use the Unicode case translation tables when provided character input. Note that `uc()` translates to uppercase, while `ucfirst` translates to titlecase (for languages that make the distinction). Naturally the corresponding backslash sequences have the same semantics.

- Most operators that deal with positions or lengths in the string will automatically switch to using character positions, including `chop()`, `substr()`, `pos()`, `index()`, `rindex()`, `sprintf()`, `write()`, and `length()`. Operators that specifically don't switch include `vec()`, `pack()`, and `unpack()`. Operators that really don't care include `chomp()`, as well as any other operator that treats a string as a bucket of bits, such as `sort()`, and the operators dealing with filenames.

- The `pack()/unpack()` letters "`c`" and "`C`" do *not* change, since they're often used for byte−oriented formats. (Again, think "`char`" in the C language.) However, there is a new "`U`" specifier that will convert between UTF−8 characters and integers. (It works outside of the utf8 pragma too.)

- The `chr()` and `ord()` functions work on characters. This is like `pack("U")` and `unpack("U")`, not like `pack("C")` and `unpack("C")`. In fact, the latter are how you now emulate byte-oriented `chr()` and `ord()` under utf8.
- The bit string operators `& | ^ ~` can operate on character data. However, for backward compatibility reasons (bit string operations when the characters all are less than 256 in ordinal value) one cannot mix `~` (the bit complement) and characters both less than 256 and equal or greater than 256. Most importantly, the DeMorgan's laws (`~($x|$y) eq ~$x&~$y`, `~($x&$y) eq ~$x|~$y`) won't hold. Another way to look at this is that the complement cannot return **both** the 8-bit (byte) wide bit complement, and the full character wide bit complement.
- And finally, `scalar reverse()` reverses by character rather than by byte.

Character encodings for input and output

[XXX: This feature is not yet implemented.]

CAVEATS

As of yet, there is no method for automatically coercing input and output to some encoding other than UTF-8. This is planned in the near future, however.

Whether an arbitrary piece of data will be treated as "characters" or "bytes" by internal operations cannot be divined at the current time.

Use of locales with utf8 may lead to odd results. Currently there is some attempt to apply 8-bit locale info to characters in the range 0..255, but this is demonstrably incorrect for locales that use characters above that range (when mapped into Unicode). It will also tend to run slower. Avoidance of locales is strongly encouraged.

SEE ALSO

bytes, *utf8*, *${^WIDE_SYSTEM_CALLS} in perlvar*

NAME

perlutil – utilities packaged with the Perl distribution

DESCRIPTION

Along with the Perl interpreter itself, the Perl distribution installs a range of utilities on your system. There are also several utilities which are used by the Perl distribution itself as part of the install process. This document exists to list all of these utilities, explain what they are for and provide pointers to each module's documentation, if appropriate.

DOCUMENTATION

perldoc|*perldoc*

The main interface to Perl's documentation is `perldoc`, although if you're reading this, it's more than likely that you've already found it. ***perldoc*** will extract and format the documentation from any file in the current directory, any Perl module installed on the system, or any of the standard documentation pages, such as this one. Use `perldoc <name>` to get information on any of the utilities described in this document.

pod2man|*pod2man* and *pod2text*|*pod2text*

If it's run from a terminal, ***perldoc*** will usually call ***pod2man*** to translate POD (Plain Old Documentation – see *perlpod* for an explanation) into a man page, and then run ***man*** to display it; if ***man*** isn't available, ***pod2text*** will be used instead and the output piped through your favourite pager.

pod2html|*pod2html* and *pod2latex*|*pod2latex*

As well as these two, there are two other converters: ***pod2html*** will produce HTML pages from POD, and ***pod2latex***, which produces LaTeX files.

pod2usage|*pod2usage*

If you just want to know how to use the utilities described here, ***pod2usage*** will just extract the "USAGE" section; some of the utilities will automatically call ***pod2usage*** on themselves when you call them with `-help`.

podselect|*podselect*

pod2usage is a special case of ***podselect***, a utility to extract named sections from documents written in POD. For instance, while utilities have "USAGE" sections, Perl modules usually have "SYNOPSIS" sections: `podselect -s "SYNOPSIS" ...` will extract this section for a given file.

podchecker|*podchecker*

If you're writing your own documentation in POD, the ***podchecker*** utility will look for errors in your markup.

splain|*splain*

splain is an interface to *perldiag* – paste in your error message to it, and it'll explain it for you.

roffitall|*roffitall*

The `roffitall` utility is not installed on your system but lives in the ***pod/*** directory of your Perl source kit; it converts all the documentation from the distribution to ****roff*** format, and produces a typeset PostScript or text file of the whole lot.

CONVERTORS

To help you convert legacy programs to Perl, we've included three conversion filters:

a2p|*a2p*

a2p converts ***awk*** scripts to Perl programs; for example, `a2p -F:` on the simple ***awk*** script `{print $2}` will produce a Perl program based around this code:

```
while (<>) {
    ($Fld1,$Fld2) = split(/[:\n]/, $_, 9999);
```

```
        print $Fld2;
    }
```

s2p|s2p

Similarly, ***s2p*** converts ***sed*** scripts to Perl programs. ***s2p*** run on `s/foo/bar` will produce a Perl program based around this:

```
while (<>) {
    chop;
    s/foo/bar/g;
    print if $printit;
}
```

find2perl|find2perl

Finally, ***find2perl*** translates `find` commands to Perl equivalents which use the *File::Find|File::Find* module. As an example, `find2perl . -user root -perm 4000 -print` produces the following callback subroutine for `File::Find`:

```
sub wanted {
    my ($dev,$ino,$mode,$nlink,$uid,$gid);
    (($dev,$ino,$mode,$nlink,$uid,$gid) = lstat($_)) &&
    $uid == $uid{'root'}) &&
    (($mode & 0777) == 04000);
    print("$name\n");
}
```

As well as these filters for converting other languages, the *pl2pm|pl2pm* utility will help you convert old−style Perl 4 libraries to new−style Perl5 modules.

Development

There are a set of utilities which help you in developing Perl programs, and in particular, extending Perl with C.

perlbug|perlbug

perlbug is the recommended way to report bugs in the perl interpreter itself or any of the standard library modules back to the developers; please read through the documentation for ***perlbug*** thoroughly before using it to submit a bug report.

h2ph|h2ph

Back before Perl had the XS system for connecting with C libraries, programmers used to get library constants by reading through the C header files. You may still see `require 'syscall.ph'` or similar around − the ***.ph*** file should be created by running ***h2ph*** on the corresponding ***.h*** file. See the ***h2ph*** documentation for more on how to convert a whole bunch of header files at ones.

c2ph|c2ph and *pstruct|pstruct*

c2ph and ***pstruct***, which are actually the same program but behave differently depending on how they are called, provide another way of getting at C with Perl − they'll convert C structures and union declarations to Perl code. This is deprecated in favour of ***h2xs*** these days.

h2xs|h2xs

h2xs converts C header files into XS modules, and will try and write as much glue between C libraries and Perl modules as it can. It's also very useful for creating skeletons of pure Perl modules.

dprofpp|dprofpp

Perl comes with a profiler, the ***Devel::Dprof*** module. The ***dprofpp*** utility analyzes the output of this profiler and tells you which subroutines are taking up the most run time. See *Devel::Dprof* for more information.

perlcc|perlcc

perlcc is the interface to the experimental Perl compiler suite.

SEE ALSO

perldoc|perldoc, *pod2man|pod2man*, *perlpod*, *pod2html|pod2html*, *pod2usage|pod2usage*, *podselect|podselect*, *podchecker|podchecker*, *splain|splain*, *perldiag*, *roffitall|roffitall*, *a2p|a2p*, *s2p|s2p*, *find2perl|find2perl*, *File::Find|File::Find*, *pl2pm|pl2pm*, *perlbug|perlbug*, *h2ph|h2ph*, *c2ph|c2ph*, *h2xs|h2xs*, *dprofpp|dprofpp*, *Devel::Dprof*, *perlcc|perlcc*

NAME

perlvar – Perl predefined variables

DESCRIPTION

Predefined Names

The following names have special meaning to Perl. Most punctuation names have reasonable mnemonics, or analogs in the shells. Nevertheless, if you wish to use long variable names, you need only say

```
use English;
```

at the top of your program. This will alias all the short names to the long names in the current package. Some even have medium names, generally borrowed from **awk**.

If you don't mind the performance hit, variables that depend on the currently selected filehandle may instead be set by calling an appropriate object method on the IO::Handle object. (Summary lines below for this contain the word HANDLE.) First you must say

```
use IO::Handle;
```

after which you may use either

```
method HANDLE EXPR
```

or more safely,

```
HANDLE->method(EXPR)
```

Each method returns the old value of the IO::Handle attribute. The methods each take an optional EXPR, which if supplied specifies the new value for the IO::Handle attribute in question. If not supplied, most methods do nothing to the current value—except for `autoflush()`, which will assume a 1 for you, just to be different. Because loading in the IO::Handle class is an expensive operation, you should learn how to use the regular built–in variables.

A few of these variables are considered "read–only". This means that if you try to assign to this variable, either directly or indirectly through a reference, you'll raise a run–time exception.

The following list is ordered by scalar variables first, then the arrays, then the hashes.

`$ARG`

`$_` The default input and pattern–searching space. The following pairs are equivalent:

```
while (<>) {...}    # equivalent only in while!
while (defined($_ = <>)) {...}

/^Subject:/
$_ =~ /^Subject:/

tr/a-z/A-Z/
$_ =~ tr/a-z/A-Z/

chomp
chomp($_)
```

Here are the places where Perl will assume `$_` even if you don't use it:

- Various unary functions, including functions like `ord()` and `int()`, as well as the all file tests (`-f`, `-d`) except for `-t`, which defaults to STDIN.
- Various list functions like `print()` and `unlink()`.
- The pattern matching operations `m//`, `s///`, and `tr///` when used without an `=~` operator.

- The default iterator variable in a `foreach` loop if no other variable is supplied.
- The implicit iterator variable in the `grep()` and `map()` functions.
- The default place to put an input record when a `< <FH` operation's result is tested by itself as the sole criterion of a `while` test. Outside a `while` test, this will not happen.

(Mnemonic: underline is understood in certain operations.)

`$<`*digits*

Contains the subpattern from the corresponding set of capturing parentheses from the last pattern match, not counting patterns matched in nested blocks that have been exited already. (Mnemonic: like \digits.) These variables are all read–only and dynamically scoped to the current BLOCK.

`$MATCH`
`$&` The string matched by the last successful pattern match (not counting any matches hidden within a BLOCK or `eval()` enclosed by the current BLOCK). (Mnemonic: like `&` in some editors.) This variable is read–only and dynamically scoped to the current BLOCK.

The use of this variable anywhere in a program imposes a considerable performance penalty on all regular expression matches. See *BUGS*.

`$PREMATCH`
`$`` The string preceding whatever was matched by the last successful pattern match (not counting any matches hidden within a BLOCK or eval enclosed by the current BLOCK). (Mnemonic: `` ` `` often precedes a quoted string.) This variable is read–only.

The use of this variable anywhere in a program imposes a considerable performance penalty on all regular expression matches. See *BUGS*.

`$POSTMATCH`
`$'` The string following whatever was matched by the last successful pattern match (not counting any matches hidden within a BLOCK or `eval()` enclosed by the current BLOCK). (Mnemonic: `'` often follows a quoted string.) Example:

```
$_ = 'abcdefghi';
/def/;
print "$`:$&:$'\n";          # prints abc:def:ghi
```

This variable is read–only and dynamically scoped to the current BLOCK.

The use of this variable anywhere in a program imposes a considerable performance penalty on all regular expression matches. See *BUGS*.

`$LAST_PAREN_MATCH`
`$+` The last bracket matched by the last search pattern. This is useful if you don't know which one of a set of alternative patterns matched. For example:

```
/Version: (.*)|Revision: (.*)/ && ($rev = $+);
```

(Mnemonic: be positive and forward looking.) This variable is read–only and dynamically scoped to the current BLOCK.

`@LAST_MATCH_END`
`@+` This array holds the offsets of the ends of the last successful submatches in the currently active dynamic scope. `$+[0]` is the offset into the string of the end of the entire match. This is the same value as what the `pos` function returns when called on the variable that was matched against. The *n*th element of this array holds the offset of the *n*th submatch, so `$+[1]` is the offset past where `$1` ends, `$+[2]` the offset past where `$2` ends, and so on. You can use `$#+` to determine how many subgroups were in the last successful match. See the examples given for the `@-` variable.

$MULTILINE_MATCHING

$*

Set to 1 to do multi−line matching within a string, 0 to tell Perl that it can assume that strings contain a single line, for the purpose of optimizing pattern matches. Pattern matches on strings containing multiple newlines can produce confusing results when `$*` is 0. Default is 0. (Mnemonic: * matches multiple things.) This variable influences the interpretation of only ^ and `$.`. A literal newline can be searched for even when `$* == 0`.

Use of `$*` is deprecated in modern Perl, supplanted by the `/s` and `/m` modifiers on pattern matching.

input_line_number HANDLE EXPR

$INPUT_LINE_NUMBER

$NR

$.

The current input record number for the last file handle from which you just `read()` (or called a `seek` or `tell` on). The value may be different from the actual physical line number in the file, depending on what notion of "line" is in effect—see `$/` on how to change that. An explicit close on a filehandle resets the line number. Because `< <` never does an explicit close, line numbers increase across ARGV files (but see examples in *eof*). Consider this variable read−only: setting it does not reposition the seek pointer; you'll have to do that on your own. Localizing `$.` has the effect of also localizing Perl's notion of "the last read filehandle". (Mnemonic: many programs use "." to mean the current line number.)

input_record_separator HANDLE EXPR

$INPUT_RECORD_SEPARATOR

$RS

$/

The input record separator, newline by default. This influences Perl's idea of what a "line" is. Works like **awk**'s RS variable, including treating empty lines as a terminator if set to the null string. (An empty line cannot contain any spaces or tabs.) You may set it to a multi−character string to match a multi−character terminator, or to `undef` to read through the end of file. Setting it to `"\n\n"` means something slightly different than setting to `""`, if the file contains consecutive empty lines. Setting to `""` will treat two or more consecutive empty lines as a single empty line. Setting to `"\n\n"` will blindly assume that the next input character belongs to the next paragraph, even if it's a newline. (Mnemonic: / delimits line boundaries when quoting poetry.)

```
undef $/;           # enable "slurp" mode
$_ = <FH>;          # whole file now here
s/\n[ \t]+/ /g;
```

Remember: the value of `$/` is a string, not a regex. **awk** has to be better for something. :−)

Setting `$/` to a reference to an integer, scalar containing an integer, or scalar that's convertible to an integer will attempt to read records instead of lines, with the maximum record size being the referenced integer. So this:

```
$/ = \32768; # or \"32768", or \$var_containing_32768
open(FILE, $myfile);
$_ = <FILE>;
```

will read a record of no more than 32768 bytes from FILE. If you're not reading from a record−oriented file (or your OS doesn't have record−oriented files), then you'll likely get a full chunk of data with every read. If a record is larger than the record size you've set, you'll get the record back in pieces.

On VMS, record reads are done with the equivalent of `sysread`, so it's best not to mix record and non−record reads on the same file. (This is unlikely to be a problem, because any file you'd want to read in record mode is probably unusable in line mode.) Non−VMS systems do normal I/O, so it's safe to mix record and non−record reads of a file.

See also *Newlines in perlport*. Also see `$.`.

autoflush HANDLE EXPR

`$OUTPUT_AUTOFLUSH`

`$|` If set to nonzero, forces a flush right away and after every write or print on the currently selected output channel. Default is 0 (regardless of whether the channel is really buffered by the system or not; `$|` tells you only whether you've asked Perl explicitly to flush after each write). STDOUT will typically be line buffered if output is to the terminal and block buffered otherwise. Setting this variable is useful primarily when you are outputting to a pipe or socket, such as when you are running a Perl program under **rsh** and want to see the output as it's happening. This has no effect on input buffering. See *getc* for that. (Mnemonic: when you want your pipes to be piping hot.)

output_field_separator HANDLE EXPR

`$OUTPUT_FIELD_SEPARATOR`

`$OFS`

`$,` The output field separator for the print operator. Ordinarily the print operator simply prints out its arguments without further adornment. To get behavior more like **awk**, set this variable as you would set **awk**'s OFS variable to specify what is printed between fields. (Mnemonic: what is printed when there is a "," in your print statement.)

output_record_separator HANDLE EXPR

`$OUTPUT_RECORD_SEPARATOR`

`$ORS`

`$\` The output record separator for the print operator. Ordinarily the print operator simply prints out its arguments as is, with no trailing newline or other end-of-record string added. To get behavior more like **awk**, set this variable as you would set **awk**'s ORS variable to specify what is printed at the end of the print. (Mnemonic: you set `$\` instead of adding "\n" at the end of the print. Also, it's just like `$/`, but it's what you get "back" from Perl.)

`$LIST_SEPARATOR`

`$"` This is like `$,` except that it applies to array and slice values interpolated into a double-quoted string (or similar interpreted string). Default is a space. (Mnemonic: obvious, I think.)

`$SUBSCRIPT_SEPARATOR`

`$SUBSEP`

`$;` The subscript separator for multidimensional array emulation. If you refer to a hash element as

```
$foo{$a,$b,$c}
```

it really means

```
$foo{join($;, $a, $b, $c)}
```

But don't put

```
@foo{$a,$b,$c}       # a slice--note the @
```

which means

```
($foo{$a},$foo{$b},$foo{$c})
```

Default is "\034", the same as SUBSEP in **awk**. If your keys contain binary data there might not be any safe value for `$;`. (Mnemonic: comma (the syntactic subscript separator) is a semi-semicolon. Yeah, I know, it's pretty lame, but `$,` is already taken for something more important.)

Consider using "real" multidimensional arrays as described in *perllol*.

`$OFMT`

$# The output format for printed numbers. This variable is a half–hearted attempt to emulate **awk**'s OFMT variable. There are times, however, when **awk** and Perl have differing notions of what counts as numeric. The initial value is "%.*n*g", where *n* is the value of the macro DBL_DIG from your system's ***float.h***. This is different from **awk**'s default OFMT setting of "%.6g", so you need to set `$#` explicitly to get **awk**'s value. (Mnemonic: # is the number sign.)

Use of `$#` is deprecated.

format_page_number HANDLE EXPR

`$FORMAT_PAGE_NUMBER`

`$%` The current page number of the currently selected output channel. Used with formats. (Mnemonic: % is page number in **nroff**.)

format_lines_per_page HANDLE EXPR

`$FORMAT_LINES_PER_PAGE`

`$=` The current page length (printable lines) of the currently selected output channel. Default is 60. Used with formats. (Mnemonic: = has horizontal lines.)

format_lines_left HANDLE EXPR

`$FORMAT_LINES_LEFT`

`$-` The number of lines left on the page of the currently selected output channel. Used with formats. (Mnemonic: lines_on_page – lines_printed.)

@LAST_MATCH_START

@– `$-[0]` is the offset of the start of the last successful match. `$-[`*n*`]` is the offset of the start of the substring matched by *n*–th subpattern, or undef if the subpattern did not match.

Thus after a match against `$_`, `$&` coincides with `substr $_, $-[0], $+[0] - $-[0]`. Similarly, `$`*n* coincides with `substr $_, $-[`*n*`], $+[`*n*`] - $-[`*n*`]` if `$-[`*n*`]` is defined, and `$+` coincides with `substr $_, $-[$#-], $+[$#-]`. One can use `$#-` to find the last matched subgroup in the last successful match. Contrast with `$#+`, the number of subgroups in the regular expression. Compare with `@+`.

This array holds the offsets of the beginnings of the last successful submatches in the currently active dynamic scope. `$-[0]` is the offset into the string of the beginning of the entire match. The *n*th element of this array holds the offset of the *n*th submatch, so `$+[1]` is the offset where `$1` begins, `$+[2]` the offset where `$2` begins, and so on. You can use `$#-` to determine how many subgroups were in the last successful match. Compare with the `@+` variable.

After a match against some variable `$var`:

`$`` is the same as `substr($var, 0, $-[0])`
`$&` is the same as `substr($var, $-[0], $+[0] - $-[0])`
`$'` is the same as `substr($var, $+[0])`
`$1` is the same as `substr($var, $-[1], $+[1] - $-[1])`
`$2` is the same as `substr($var, $-[2], $+[2] - $-[2])`
`$3` is the same as `substr $var, $-[3], $+[3] - $-[3])`

format_name HANDLE EXPR

`$FORMAT_NAME`

`$~` The name of the current report format for the currently selected output channel. Default is the name of the filehandle. (Mnemonic: brother to `$^`.)

format_top_name HANDLE EXPR

`$FORMAT_TOP_NAME`

`$^` The name of the current top–of–page format for the currently selected output channel. Default is the name of the filehandle with _TOP appended. (Mnemonic: points to top of page.)

format_line_break_characters HANDLE EXPR

$FORMAT_LINE_BREAK_CHARACTERS

$: The current set of characters after which a string may be broken to fill continuation fields (starting with ^) in a format. Default is " \n-", to break on whitespace or hyphens. (Mnemonic: a "colon" in poetry is a part of a line.)

format_formfeed HANDLE EXPR

$FORMAT_FORMFEED

$^L What formats output as a form feed. Default is \f.

$ACCUMULATOR

$^A The current value of the `write()` accumulator for `format()` lines. A format contains `formline()` calls that put their result into `$^A`. After calling its format, `write()` prints out the contents of `$^A` and empties. So you never really see the contents of `$^A` unless you call `formline()` yourself and then look at it. See *perlform* and *`formline()`*.

$CHILD_ERROR

$? The status returned by the last pipe close, backtick (`` ` ` ``) command, successful call to `wait()` or `waitpid()`, or from the `system()` operator. This is just the 16-bit status word returned by the `wait()` system call (or else is made up to look like it). Thus, the exit value of the subprocess is really (`<< $? 8`), and `$? & 127` gives which signal, if any, the process died from, and `$? & 128` reports whether there was a core dump. (Mnemonic: similar to **sh** and **ksh**.)

Additionally, if the `h_errno` variable is supported in C, its value is returned via `$?` if any `gethost*()` function fails.

If you have installed a signal handler for `SIGCHLD`, the value of `$?` will usually be wrong outside that handler.

Inside an `END` subroutine `$?` contains the value that is going to be given to `exit()`. You can modify `$?` in an `END` subroutine to change the exit status of your program. For example:

```
END {
    $? = 1 if $? == 255;  # die would make it 255
}
```

Under VMS, the pragma `use vmsish 'status'` makes `$?` reflect the actual VMS exit status, instead of the default emulation of POSIX status.

Also see *Error Indicators*.

$OS_ERROR

$ERRNO

$! If used numerically, yields the current value of the C `errno` variable, with all the usual caveats. (This means that you shouldn't depend on the value of `$!` to be anything in particular unless you've gotten a specific error return indicating a system error.) If used an a string, yields the corresponding system error string. You can assign a number to `$!` to set *errno* if, for instance, you want `"$!"` to return the string for error *n*, or you want to set the exit value for the `die()` operator. (Mnemonic: What just went bang?)

Also see *Error Indicators*.

$EXTENDED_OS_ERROR

$^E Error information specific to the current operating system. At the moment, this differs from `$!` under only VMS, OS/2, and Win32 (and for MacPerl). On all other platforms, `$^E` is always just the same as `$!`.

Under VMS, `$^E` provides the VMS status value from the last system error. This is more specific information about the last system error than that provided by `$!`. This is particularly important when `$!` is set to **EVMSERR**.

Under OS/2, $^E is set to the error code of the last call to OS/2 API either via CRT, or directly from perl.

Under Win32, $^E always returns the last error information reported by the Win32 call GetLastError() which describes the last error from within the Win32 API. Most Win32-specific code will report errors via $^E. ANSI C and Unix-like calls set errno and so most portable Perl code will report errors via $!.

Caveats mentioned in the description of $! generally apply to $^E, also. (Mnemonic: Extra error explanation.)

Also see *Error Indicators*.

$EVAL_ERROR
$@ The Perl syntax error message from the last eval() operator. If null, the last eval() parsed and executed correctly (although the operations you invoked may have failed in the normal fashion). (Mnemonic: Where was the syntax error "at"?)

Warning messages are not collected in this variable. You can, however, set up a routine to process warnings by setting $SIG{__WARN__} as described below.

Also see *Error Indicators*.

$PROCESS_ID
$PID
$$ The process number of the Perl running this script. You should consider this variable read-only, although it will be altered across fork() calls. (Mnemonic: same as shells.)

$REAL_USER_ID
$UID
$< The real uid of this process. (Mnemonic: it's the uid you came *from*, if you're running setuid.) You can change both the real uid and the effective uid at the same time by using POSIX::setuid().

$EFFECTIVE_USER_ID
$EUID
$ The effective uid of this process. Example:

```
$< = $>;            # set real to effective uid
($<,$>) = ($>,$<);  # swap real and effective uid
```

You can change both the effective uid and the real uid at the same time by using POSIX::setuid().

(Mnemonic: it's the uid you went *to*, if you're running setuid.) < $< and < $ can be swapped only on machines supporting setreuid().

$REAL_GROUP_ID
$GID
$(The real gid of this process. If you are on a machine that supports membership in multiple groups simultaneously, gives a space separated list of groups you are in. The first number is the one returned by getgid(), and the subsequent ones by getgroups(), one of which may be the same as the first number.

However, a value assigned to $(must be a single number used to set the real gid. So the value given by $(should *not* be assigned back to $(without being forced numeric, such as by adding zero.

You can change both the real gid and the effective gid at the same time by using POSIX::setgid().

(Mnemonic: parentheses are used to *group* things. The real gid is the group you *left*, if you're

running setgid.)

$EFFECTIVE_GROUP_ID
$EGID
$)
: The effective gid of this process. If you are on a machine that supports membership in multiple groups simultaneously, gives a space separated list of groups you are in. The first number is the one returned by `getegid()`, and the subsequent ones by `getgroups()`, one of which may be the same as the first number.

  Similarly, a value assigned to `$)` must also be a space−separated list of numbers. The first number sets the effective gid, and the rest (if any) are passed to `setgroups()`. To get the effect of an empty list for `setgroups()`, just repeat the new effective gid; that is, to force an effective gid of 5 and an effectively empty `setgroups()` list, say `$) = "5 5"`.

  You can change both the effective gid and the real gid at the same time by using `POSIX::setgid()` (use only a single numeric argument).

  (Mnemonic: parentheses are used to *group* things. The effective gid is the group that's *right* for you, if you're running setgid.)

  `< $<` , `< $` , `$(` and `$)` can be set only on machines that support the corresponding *set[re][ug]id()* routine. `$(` and `$)` can be swapped only on machines supporting `setregid()`.

$PROGRAM_NAME
$0
: Contains the name of the program being executed. On some operating systems assigning to `$0` modifies the argument area that the **ps** program sees. This is more useful as a way of indicating the current program state than it is for hiding the program you're running. (Mnemonic: same as **sh** and **ksh**.)

  Note for BSD users: setting `$0` does not completely remove "perl" from the ps(1) output. For example, setting `$0` to `"foobar"` will result in `"perl: foobar (perl)"`. This is an operating system feature.

$[
: The index of the first element in an array, and of the first character in a substring. Default is 0, but you could theoretically set it to 1 to make Perl behave more like **awk** (or Fortran) when subscripting and when evaluating the `index()` and `substr()` functions. (Mnemonic: [begins subscripts.)

  As of release 5 of Perl, assignment to `$[` is treated as a compiler directive, and cannot influence the behavior of any other file. Its use is highly discouraged.

$]
: The version + patchlevel / 1000 of the Perl interpreter. This variable can be used to determine whether the Perl interpreter executing a script is in the right range of versions. (Mnemonic: Is this version of perl in the right bracket?) Example:

```
warn "No checksumming!\n" if $] < 3.019;
```

  See also the documentation of `use VERSION` and `require VERSION` for a convenient way to fail if the running Perl interpreter is too old.

  The use of this variable is deprecated. The floating point representation can sometimes lead to inaccurate numeric comparisons. See `$^V` for a more modern representation of the Perl version that allows accurate string comparisons.

$COMPILING
$^C
: The current value of the flag associated with the **−c** switch. Mainly of use with **−MO=...** to allow code to alter its behavior when being compiled, such as for example to AUTOLOAD at compile time rather than normal, deferred loading. See *perlcc*. Setting `$^C = 1` is similar to calling `B::minus_c`.

$DEBUGGING

$^D The current value of the debugging flags. (Mnemonic: value of **–D** switch.)

$SYSTEM_FD_MAX

$^F The maximum system file descriptor, ordinarily 2. System file descriptors are passed to exec()ed processes, while higher file descriptors are not. Also, during an open(), system file descriptors are preserved even if the open() fails. (Ordinary file descriptors are closed before the open() is attempted.) The close–on–exec status of a file descriptor will be decided according to the value of $^F when the corresponding file, pipe, or socket was opened, not the time of the exec().

$^H WARNING: This variable is strictly for internal use only. Its availability, behavior, and contents are subject to change without notice.

This variable contains compile–time hints for the Perl interpreter. At the end of compilation of a BLOCK the value of this variable is restored to the value when the interpreter started to compile the BLOCK.

When perl begins to parse any block construct that provides a lexical scope (e.g., eval body, required file, subroutine body, loop body, or conditional block), the existing value of $^H is saved, but its value is left unchanged. When the compilation of the block is completed, it regains the saved value. Between the points where its value is saved and restored, code that executes within BEGIN blocks is free to change the value of $^H.

This behavior provides the semantic of lexical scoping, and is used in, for instance, the use strict pragma.

The contents should be an integer; different bits of it are used for different pragmatic flags. Here's an example:

```
sub add_100 { $^H |= 0x100 }

sub foo {
    BEGIN { add_100() }
    bar->baz($boon);
}
```

Consider what happens during execution of the BEGIN block. At this point the BEGIN block has already been compiled, but the body of foo() is still being compiled. The new value of $^H will therefore be visible only while the body of foo() is being compiled.

Substitution of the above BEGIN block with:

```
BEGIN { require strict; strict->import('vars') }
```

demonstrates how use strict 'vars' is implemented. Here's a conditional version of the same lexical pragma:

```
BEGIN { require strict; strict->import('vars') if $condition }
```

%^H WARNING: This variable is strictly for internal use only. Its availability, behavior, and contents are subject to change without notice.

The %^H hash provides the same scoping semantic as $^H. This makes it useful for implementation of lexically scoped pragmas.

$INPLACE_EDIT

$^I The current value of the inplace–edit extension. Use undef to disable inplace editing. (Mnemonic: value of **–i** switch.)

$^M By default, running out of memory is an untrappable, fatal error. However, if suitably built, Perl can use the contents of $^M as an emergency memory pool after die()ing. Suppose that your Perl were compiled with –DPERL_EMERGENCY_SBRK and used Perl's malloc. Then

```
$^M = 'a' x (1 << 16);
```

would allocate a 64K buffer for use in an emergency. See the ***INSTALL*** file in the Perl distribution for information on how to enable this option. To discourage casual use of this advanced feature, there is no *English\English* long name for this variable.

$OSNAME
$^O The name of the operating system under which this copy of Perl was built, as determined during the configuration process. The value is identical to $Config{'osname'}. See also *Config* and the **–V** command–line switch documented in *perlrun*.

$PERLDB
$^P The internal variable for debugging support. The meanings of the various bits are subject to change, but currently indicate:

0x01 Debug subroutine enter/exit.

0x02 Line–by–line debugging.

0x04 Switch off optimizations.

0x08 Preserve more data for future interactive inspections.

0x10 Keep info about source lines on which a subroutine is defined.

0x20 Start with single–step on.

0x40 Use subroutine address instead of name when reporting.

0x80 Report goto &subroutine as well.

0x100 Provide informative "file" names for evals based on the place they were compiled.

0x200 Provide informative names to anonymous subroutines based on the place they were compiled.

Some bits may be relevant at compile–time only, some at run–time only. This is a new mechanism and the details may change.

$LAST_REGEXP_CODE_RESULT
$^R The result of evaluation of the last successful (?{ code }) regular expression assertion (see *perlre*). May be written to.

$EXCEPTIONS_BEING_CAUGHT
$^S Current state of the interpreter. Undefined if parsing of the current module/eval is not finished (may happen in $SIG{__DIE__} and $SIG{__WARN__} handlers). True if inside an eval(), otherwise false.

$BASETIME
$^T The time at which the program began running, in seconds since the epoch (beginning of 1970). The values returned by the **–M**, **–A**, and **–C** filetests are based on this value.

$PERL_VERSION
$^V The revision, version, and subversion of the Perl interpreter, represented as a string composed of characters with those ordinals. Thus in Perl v5.6.0 it equals chr(5) . chr(6) . chr(0) and will return true for $^V eq v5.6.0. Note that the characters in this string value can potentially be in Unicode range.

This can be used to determine whether the Perl interpreter executing a script is in the right range of versions. (Mnemonic: use ^V for Version Control.) Example:

```
warn "No "our" declarations!\n" if $^V and $^V lt v5.6.0;
```

See the documentation of `use VERSION` and `require VERSION` for a convenient way to fail if the running Perl interpreter is too old.

See also `$]` for an older representation of the Perl version.

`$WARNING`
`$^W` The current value of the warning switch, initially true if **-w** was used, false otherwise, but directly modifiable. (Mnemonic: related to the **-w** switch.) See also *warnings*.

`${^WARNING_BITS}`

The current set of warning checks enabled by the `use warnings` pragma. See the documentation of `warnings` for more details.

`${^WIDE_SYSTEM_CALLS}`

Global flag that enables system calls made by Perl to use wide character APIs native to the system, if available. This is currently only implemented on the Windows platform.

This can also be enabled from the command line using the `-C` switch.

The initial value is typically for compatibility with Perl versions earlier than 5.6, but may be automatically set to `1` by Perl if the system provides a user-settable default (e.g., `$ENV{LC_CTYPE}`).

The `bytes` pragma always overrides the effect of this flag in the current lexical scope. See *bytes*.

`$EXECUTABLE_NAME`
`$^X` The name that the Perl binary itself was executed as, from C's `argv[0]`. This may not be a full pathname, nor even necessarily in your path.

`$ARGV` contains the name of the current file when reading from <.

@ARGV The array @ARGV contains the command-line arguments intended for the script. `$#ARGV` is generally the number of arguments minus one, because `$ARGV[0]` is the first argument, *not* the program's command name itself. See `$0` for the command name.

@INC The array @INC contains the list of places that the `do EXPR`, `require`, or `use` constructs look for their library files. It initially consists of the arguments to any **-I** command-line switches, followed by the default Perl library, probably ***/usr/local/lib/perl***, followed by ".", to represent the current directory. If you need to modify this at runtime, you should use the `use lib` pragma to get the machine-dependent library properly loaded also:

```
use lib '/mypath/libdir/';
use SomeMod;
```

@_ Within a subroutine the array @_ contains the parameters passed to that subroutine. See *perlsub*.

%INC The hash %INC contains entries for each filename included via the `do`, `require`, or `use` operators. The key is the filename you specified (with module names converted to pathnames), and the value is the location of the file found. The `require` operator uses this hash to determine whether a particular file has already been included.

%ENV
`$ENV{expr}`

The hash %ENV contains your current environment. Setting a value in `ENV` changes the environment for any child processes you subsequently `fork()` off.

%SIG
$SIG{expr}

The hash %SIG contains signal handlers for signals. For example:

```
sub handler {       # 1st argument is signal name
    my($sig) = @_;
    print "Caught a SIG$sig--shutting down\n";
    close(LOG);
    exit(0);
}

$SIG{'INT'}  = \&handler;
$SIG{'QUIT'} = \&handler;
...
$SIG{'INT'}  = 'DEFAULT';   # restore default action
$SIG{'QUIT'} = 'IGNORE';    # ignore SIGQUIT
```

Using a value of `'IGNORE'` usually has the effect of ignoring the signal, except for the `CHLD` signal. See *perlipc* for more about this special case.

Here are some other examples:

```
$SIG{"PIPE"} = "Plumber";   # assumes main::Plumber (not recommended)
$SIG{"PIPE"} = \&Plumber;   # just fine; assume current Plumber
$SIG{"PIPE"} = *Plumber;    # somewhat esoteric
$SIG{"PIPE"} = Plumber();   # oops, what did Plumber() return??
```

Be sure not to use a bareword as the name of a signal handler, lest you inadvertently call it.

If your system has the `sigaction()` function then signal handlers are installed using it. This means you get reliable signal handling. If your system has the SA_RESTART flag it is used when signals handlers are installed. This means that system calls for which restarting is supported continue rather than returning when a signal arrives. If you want your system calls to be interrupted by signal delivery then do something like this:

```
use POSIX ':signal_h';

my $alarm = 0;
sigaction SIGALRM, new POSIX::SigAction sub { $alarm = 1 }
    or die "Error setting SIGALRM handler: $!\n";
```

See *POSIX*.

Certain internal hooks can be also set using the %SIG hash. The routine indicated by `$SIG{__WARN__}` is called when a warning message is about to be printed. The warning message is passed as the first argument. The presence of a __WARN__ hook causes the ordinary printing of warnings to STDERR to be suppressed. You can use this to save warnings in a variable, or turn warnings into fatal errors, like this:

```
local $SIG{__WARN__} = sub { die $_[0] };
eval $proggie;
```

The routine indicated by `$SIG{__DIE__}` is called when a fatal exception is about to be thrown. The error message is passed as the first argument. When a __DIE__ hook routine returns, the exception processing continues as it would have in the absence of the hook, unless the hook routine itself exits via a `goto`, a loop exit, or a `die()`. The `__DIE__` handler is explicitly disabled during the call, so that you can die from a `__DIE__` handler. Similarly for `__WARN__`.

Due to an implementation glitch, the `$SIG{__DIE__}` hook is called even inside an `eval()`. Do not use this to rewrite a pending exception in `$@`, or as a bizarre substitute for overriding

CORE::GLOBAL::die(). This strange action at a distance may be fixed in a future release so that $SIG{__DIE__} is only called if your program is about to exit, as was the original intent. Any other use is deprecated.

__DIE__/__WARN__ handlers are very special in one respect: they may be called to report (probable) errors found by the parser. In such a case the parser may be in inconsistent state, so any attempt to evaluate Perl code from such a handler will probably result in a segfault. This means that warnings or errors that result from parsing Perl should be used with extreme caution, like this:

```
require Carp if defined $^S;
Carp::confess("Something wrong") if defined &Carp::confess;
die "Something wrong, but could not load Carp to give backtrace...
     To see backtrace try starting Perl with -MCarp switch";
```

Here the first line will load Carp *unless* it is the parser who called the handler. The second line will print backtrace and die if Carp was available. The third line will be executed only if Carp was not available.

See *die*, *warn*, *eval*, and *warnings* for additional information.

Error Indicators

The variables $@, $!, $^E, and $? contain information about different types of error conditions that may appear during execution of a Perl program. The variables are shown ordered by the "distance" between the subsystem which reported the error and the Perl process. They correspond to errors detected by the Perl interpreter, C library, operating system, or an external program, respectively.

To illustrate the differences between these variables, consider the following Perl expression, which uses a single-quoted string:

```
eval q{
    open PIPE, "/cdrom/install |";
    @res = <PIPE>;
    close PIPE or die "bad pipe: $?, $!";
};
```

After execution of this statement all 4 variables may have been set.

$@ is set if the string to be eval-ed did not compile (this may happen if open or close were imported with bad prototypes), or if Perl code executed during evaluation die()d. In these cases the value of $@ is the compile error, or the argument to die (which will interpolate $! and $?!). (See also *Fatal*, though.)

When the eval() expression above is executed, open(), < <PIPE, and close are translated to calls in the C run-time library and thence to the operating system kernel. $! is set to the C library's errno if one of these calls fails.

Under a few operating systems, $^E may contain a more verbose error indicator, such as in this case, "CDROM tray not closed." Systems that do not support extended error messages leave $^E the same as $!.

Finally, $? may be set to non-0 value if the external program ***/cdrom/install*** fails. The upper eight bits reflect specific error conditions encountered by the program (the program's exit() value). The lower eight bits reflect mode of failure, like signal death and core dump information See wait(2) for details. In contrast to $! and $^E, which are set only if error condition is detected, the variable $? is set on each wait or pipe close, overwriting the old value. This is more like $@, which on every eval() is always set on failure and cleared on success.

For more details, see the individual descriptions at $@, $!, $^E, and $?.

Technical Note on the Syntax of Variable Names

Variable names in Perl can have several formats. Usually, they must begin with a letter or underscore, in which case they can be arbitrarily long (up to an internal limit of 251 characters) and may contain letters, digits, underscores, or the special sequence `::` or `'`. In this case, the part before the last `::` or `'` is taken to be a *package qualifier*; see *perlmod*.

Perl variable names may also be a sequence of digits or a single punctuation or control character. These names are all reserved for special uses by Perl; for example, the all–digits names are used to hold data captured by backreferences after a regular expression match. Perl has a special syntax for the single–control–character names: It understands `^X` (caret `X`) to mean the control–`X` character. For example, the notation `$^W` (dollar–sign caret `W`) is the scalar variable whose name is the single character control–`W`. This is better than typing a literal control–`W` into your program.

Finally, new in Perl 5.6, Perl variable names may be alphanumeric strings that begin with control characters (or better yet, a caret). These variables must be written in the form `${^Foo}`; the braces are not optional. `${^Foo}` denotes the scalar variable whose name is a control–`F` followed by two `o`'s. These variables are reserved for future special uses by Perl, except for the ones that begin with `^_` (control–underscore or caret–underscore). No control–character name that begins with `^_` will acquire a special meaning in any future version of Perl; such names may therefore be used safely in programs. `$^_` itself, however, *is* reserved.

Perl identifiers that begin with digits, control characters, or punctuation characters are exempt from the effects of the `package` declaration and are always forced to be in package `main`. A few other names are also exempt:

```
ENV             STDIN
INC             STDOUT
ARGV            STDERR
ARGVOUT
SIG
```

In particular, the new special `${^_XYZ}` variables are always taken to be in package `main`, regardless of any `package` declarations presently in scope.

BUGS

Due to an unfortunate accident of Perl's implementation, `use English` imposes a considerable performance penalty on all regular expression matches in a program, regardless of whether they occur in the scope of `use English`. For that reason, saying `use English` in libraries is strongly discouraged. See the Devel::SawAmpersand module documentation from CPAN (http://www.perl.com/CPAN/modules/by–module/Devel/) for more information.

Having to even think about the `$^S` variable in your exception handlers is simply wrong. `$SIG{__DIE__}` as currently implemented invites grievous and difficult to track down errors. Avoid it and use an `END{}` or CORE::GLOBAL::die override instead.

NAME

perlxs − XS language reference manual

DESCRIPTION

Introduction

XS is an interface description file format used to create an extension interface between Perl and C code (or a C library) which one wishes to use with Perl. The XS interface is combined with the library to create a new library which can then be either dynamically loaded or statically linked into perl. The XS interface description is written in the XS language and is the core component of the Perl extension interface.

An **XSUB** forms the basic unit of the XS interface. After compilation by the **xsubpp** compiler, each XSUB amounts to a C function definition which will provide the glue between Perl calling conventions and C calling conventions.

The glue code pulls the arguments from the Perl stack, converts these Perl values to the formats expected by a C function, call this C function, transfers the return values of the C function back to Perl. Return values here may be a conventional C return value or any C function arguments that may serve as output parameters. These return values may be passed back to Perl either by putting them on the Perl stack, or by modifying the arguments supplied from the Perl side.

The above is a somewhat simplified view of what really happens. Since Perl allows more flexible calling conventions than C, XSUBs may do much more in practice, such as checking input parameters for validity, throwing exceptions (or returning undef/empty list) if the return value from the C function indicates failure, calling different C functions based on numbers and types of the arguments, providing an object−oriented interface, etc.

Of course, one could write such glue code directly in C. However, this would be a tedious task, especially if one needs to write glue for multiple C functions, and/or one is not familiar enough with the Perl stack discipline and other such arcana. XS comes to the rescue here: instead of writing this glue C code in long−hand, one can write a more concise short−hand *description* of what should be done by the glue, and let the XS compiler **xsubpp** handle the rest.

The XS language allows one to describe the mapping between how the C routine is used, and how the corresponding Perl routine is used. It also allows creation of Perl routines which are directly translated to C code and which are not related to a pre−existing C function. In cases when the C interface coincides with the Perl interface, the XSUB declaration is almost identical to a declaration of a C function (in K&R style). In such circumstances, there is another tool called `h2xs` that is able to translate an entire C header file into a corresponding XS file that will provide glue to the functions/macros described in the header file.

The XS compiler is called **xsubpp**. This compiler creates the constructs necessary to let an XSUB manipulate Perl values, and creates the glue necessary to let Perl call the XSUB. The compiler uses **typemaps** to determine how to map C function parameters and output values to Perl values and back. The default typemap (which comes with Perl) handles many common C types. A supplementary typemap may also be needed to handle any special structures and types for the library being linked.

A file in XS format starts with a C language section which goes until the first `MODULE =` directive. Other XS directives and XSUB definitions may follow this line. The "language" used in this part of the file is usually referred to as the XS language.

See *perlxstut* for a tutorial on the whole extension creation process.

Note: For some extensions, Dave Beazley's SWIG system may provide a significantly more convenient mechanism for creating the extension glue code. See http://www.swig.org/ for more information.

On The Road

Many of the examples which follow will concentrate on creating an interface between Perl and the ONC+ RPC bind library functions. The `rpcb_gettime()` function is used to demonstrate many features of the XS language. This function has two parameters; the first is an input parameter and the second is an output

parameter. The function also returns a status value.

```
bool_t rpcb_gettime(const char *host, time_t *timep);
```

From C this function will be called with the following statements.

```
#include <rpc/rpc.h>
bool_t status;
time_t timep;
status = rpcb_gettime( "localhost", &timep );
```

If an XSUB is created to offer a direct translation between this function and Perl, then this XSUB will be used from Perl with the following code. The `$status` and `$timep` variables will contain the output of the function.

```
use RPC;
$status = rpcb_gettime( "localhost", $timep );
```

The following XS file shows an XS subroutine, or XSUB, which demonstrates one possible interface to the `rpcb_gettime()` function. This XSUB represents a direct translation between C and Perl and so preserves the interface even from Perl. This XSUB will be invoked from Perl with the usage shown above. Note that the first three #include statements, for `EXTERN.h`, `perl.h`, and `XSUB.h`, will always be present at the beginning of an XS file. This approach and others will be expanded later in this document.

```
#include "EXTERN.h"
#include "perl.h"
#include "XSUB.h"
#include <rpc/rpc.h>

MODULE = RPC  PACKAGE = RPC

bool_t
rpcb_gettime(host,timep)
     char *host
     time_t &timep
   OUTPUT:
     timep
```

Any extension to Perl, including those containing XSUBs, should have a Perl module to serve as the bootstrap which pulls the extension into Perl. This module will export the extension's functions and variables to the Perl program and will cause the extension's XSUBs to be linked into Perl. The following module will be used for most of the examples in this document and should be used from Perl with the `use` command as shown earlier. Perl modules are explained in more detail later in this document.

```
package RPC;

require Exporter;
require DynaLoader;
@ISA = qw(Exporter DynaLoader);
@EXPORT = qw( rpcb_gettime );

bootstrap RPC;
1;
```

Throughout this document a variety of interfaces to the `rpcb_gettime()` XSUB will be explored. The XSUBs will take their parameters in different orders or will take different numbers of parameters. In each case the XSUB is an abstraction between Perl and the real C `rpcb_gettime()` function, and the XSUB must always ensure that the real `rpcb_gettime()` function is called with the correct parameters. This abstraction will allow the programmer to create a more Perl–like interface to the C function.

The Anatomy of an XSUB

The simplest XSUBs consist of 3 parts: a description of the return value, the name of the XSUB routine and the names of its arguments, and a description of types or formats of the arguments.

The following XSUB allows a Perl program to access a C library function called `sin()`. The XSUB will imitate the C function which takes a single argument and returns a single value.

```
double
sin(x)
  double x
```

Optionally, one can merge the description of types and the list of argument names, rewriting this as

```
double
sin(double x)
```

This makes this XSUB look similar to an ANSI C declaration. An optional semicolon is allowed after the argument list, as in

```
double
sin(double x);
```

Parameters with C pointer types can have different semantic: C functions with similar declarations

```
bool string_looks_as_a_number(char *s);
bool make_char_uppercase(char *c);
```

are used in absolutely incompatible manner. Parameters to these functions could be described **xsubpp** like this:

```
char *  s
char    &c
```

Both these XS declarations correspond to the `char*` C type, but they have different semantics, see *"The & Unary Operator"*.

It is convenient to think that the indirection operator `*` should be considered as a part of the type and the address operator `&` should be considered part of the variable. See *"The Typemap"* for more info about handling qualifiers and unary operators in C types.

The function name and the return type must be placed on separate lines and should be flush left–adjusted.

```
INCORRECT                       CORRECT

double sin(x)                   double
  double x                      sin(x)
                                  double x
```

The rest of the function description may be indented or left–adjusted. The following example shows a function with its body left–adjusted. Most examples in this document will indent the body for better readability.

```
CORRECT

double
sin(x)
double x
```

More complicated XSUBs may contain many other sections. Each section of an XSUB starts with the corresponding keyword, such as INIT: or CLEANUP:. However, the first two lines of an XSUB always contain the same data: descriptions of the return type and the names of the function and its parameters. Whatever immediately follows these is considered to be an INPUT: section unless explicitly marked with another keyword. (See *The INPUT: Keyword*.)

An XSUB section continues until another section−start keyword is found.

The Argument Stack

The Perl argument stack is used to store the values which are sent as parameters to the XSUB and to store the XSUB's return value(s). In reality all Perl functions (including non−XSUB ones) keep their values on this stack all the same time, each limited to its own range of positions on the stack. In this document the first position on that stack which belongs to the active function will be referred to as position 0 for that function.

XSUBs refer to their stack arguments with the macro **ST(x)**, where *x* refers to a position in this XSUB's part of the stack. Position 0 for that function would be known to the XSUB as ST(0). The XSUB's incoming parameters and outgoing return values always begin at ST(0). For many simple cases the **xsubpp** compiler will generate the code necessary to handle the argument stack by embedding code fragments found in the typemaps. In more complex cases the programmer must supply the code.

The RETVAL Variable

The RETVAL variable is a special C variable that is declared automatically for you. The C type of RETVAL matches the return type of the C library function. The **xsubpp** compiler will declare this variable in each XSUB with non−`void` return type. By default the generated C function will use RETVAL to hold the return value of the C library function being called. In simple cases the value of RETVAL will be placed in ST(0) of the argument stack where it can be received by Perl as the return value of the XSUB.

If the XSUB has a return type of `void` then the compiler will not declare a RETVAL variable for that function. When using a PPCODE: section no manipulation of the RETVAL variable is required, the section may use direct stack manipulation to place output values on the stack.

If PPCODE: directive is not used, `void` return value should be used only for subroutines which do not return a value, *even if* CODE: directive is used which sets ST(0) explicitly.

Older versions of this document recommended to use `void` return value in such cases. It was discovered that this could lead to segfaults in cases when XSUB was *truly* `void`. This practice is now deprecated, and may be not supported at some future version. Use the return value `SV *` in such cases. (Currently `xsubpp` contains some heuristic code which tries to disambiguate between "truly−void" and "old−practice−declared−as−void" functions. Hence your code is at mercy of this heuristics unless you use `SV *` as return value.)

The MODULE Keyword

The MODULE keyword is used to start the XS code and to specify the package of the functions which are being defined. All text preceding the first MODULE keyword is considered C code and is passed through to the output untouched. Every XS module will have a bootstrap function which is used to hook the XSUBs into Perl. The package name of this bootstrap function will match the value of the last MODULE statement in the XS source files. The value of MODULE should always remain constant within the same XS file, though this is not required.

The following example will start the XS code and will place all functions in a package named RPC.

```
MODULE = RPC
```

The PACKAGE Keyword

When functions within an XS source file must be separated into packages the PACKAGE keyword should be used. This keyword is used with the MODULE keyword and must follow immediately after it when used.

```
MODULE = RPC  PACKAGE = RPC

[ XS code in package RPC ]

MODULE = RPC  PACKAGE = RPCB

[ XS code in package RPCB ]

MODULE = RPC  PACKAGE = RPC
```

```
[ XS code in package RPC ]
```

Although this keyword is optional and in some cases provides redundant information it should always be used. This keyword will ensure that the XSUBs appear in the desired package.

The PREFIX Keyword

The PREFIX keyword designates prefixes which should be removed from the Perl function names. If the C function is `rpcb_gettime()` and the PREFIX value is `rpcb_` then Perl will see this function as `gettime()`.

This keyword should follow the PACKAGE keyword when used. If PACKAGE is not used then PREFIX should follow the MODULE keyword.

```
MODULE = RPC  PREFIX = rpc_

MODULE = RPC  PACKAGE = RPCB  PREFIX = rpcb_
```

The OUTPUT: Keyword

The OUTPUT: keyword indicates that certain function parameters should be updated (new values made visible to Perl) when the XSUB terminates or that certain values should be returned to the calling Perl function. For simple functions which have no CODE: or PPCODE: section, such as the `sin()` function above, the RETVAL variable is automatically designated as an output value. For more complex functions the **xsubpp** compiler will need help to determine which variables are output variables.

This keyword will normally be used to complement the CODE: keyword. The RETVAL variable is not recognized as an output variable when the CODE: keyword is present. The OUTPUT: keyword is used in this situation to tell the compiler that RETVAL really is an output variable.

The OUTPUT: keyword can also be used to indicate that function parameters are output variables. This may be necessary when a parameter has been modified within the function and the programmer would like the update to be seen by Perl.

```
bool_t
rpcb_gettime(host,timep)
     char *host
     time_t &timep
   OUTPUT:
     timep
```

The OUTPUT: keyword will also allow an output parameter to be mapped to a matching piece of code rather than to a typemap.

```
bool_t
rpcb_gettime(host,timep)
     char *host
     time_t &timep
   OUTPUT:
     timep sv_setnv(ST(1), (double)timep);
```

xsubpp emits an automatic `SvSETMAGIC()` for all parameters in the OUTPUT section of the XSUB, except RETVAL. This is the usually desired behavior, as it takes care of properly invoking 'set' magic on output parameters (needed for hash or array element parameters that must be created if they didn't exist). If for some reason, this behavior is not desired, the OUTPUT section may contain a `SETMAGIC: DISABLE` line to disable it for the remainder of the parameters in the OUTPUT section. Likewise, `SETMAGIC: ENABLE` can be used to reenable it for the remainder of the OUTPUT section. See *perlguts* for more details about 'set' magic.

The NO_OUTPUT Keyword

The NO_OUTPUT can be placed as the first token of the XSUB. This keyword indicates that while the C subroutine we provide an interface to has a non-`void` return type, the return value of this C subroutine

should not be returned from the generated Perl subroutine.

With this keyword present *The RETVAL Variable* is created, and in the generated call to the subroutine this variable is assigned to, but the value of this variable is not going to be used in the auto−generated code.

This keyword makes sense only if `RETVAL` is going to be accessed by the user−supplied code. It is especially useful to make a function interface more Perl−like, especially when the C return value is just an error condition indicator. For example,

```
NO_OUTPUT int
delete_file(char *name)
  POST_CALL:
    if (RETVAL != 0)
        croak("Error %d while deleting file '%s'", RETVAL, name);
```

Here the generated XS function returns nothing on success, and will `die()` with a meaningful error message on error.

The CODE: Keyword

This keyword is used in more complicated XSUBs which require special handling for the C function. The RETVAL variable is still declared, but it will not be returned unless it is specified in the OUTPUT: section.

The following XSUB is for a C function which requires special handling of its parameters. The Perl usage is given first.

```
$status = rpcb_gettime( "localhost", $timep );
```

The XSUB follows.

```
bool_t
rpcb_gettime(host,timep)
      char *host
      time_t timep
   CODE:
          RETVAL = rpcb_gettime( host, &timep );
   OUTPUT:
      timep
      RETVAL
```

The INIT: Keyword

The INIT: keyword allows initialization to be inserted into the XSUB before the compiler generates the call to the C function. Unlike the CODE: keyword above, this keyword does not affect the way the compiler handles RETVAL.

```
bool_t
rpcb_gettime(host,timep)
      char *host
      time_t &timep
   INIT:
      printf("# Host is %s\n", host );
   OUTPUT:
      timep
```

Another use for the INIT: section is to check for preconditions before making a call to the C function:

```
long long
lldiv(a,b)
    long long a
    long long b
  INIT:
    if (a == 0 && b == 0)
```

```
        XSRETURN_UNDEF;
    if (b == 0)
        croak("lldiv: cannot divide by 0");
```

The NO_INIT Keyword

The NO_INIT keyword is used to indicate that a function parameter is being used only as an output value. The **xsubpp** compiler will normally generate code to read the values of all function parameters from the argument stack and assign them to C variables upon entry to the function. NO_INIT will tell the compiler that some parameters will be used for output rather than for input and that they will be handled before the function terminates.

The following example shows a variation of the `rpcb_gettime()` function. This function uses the timep variable only as an output variable and does not care about its initial contents.

```
bool_t
rpcb_gettime(host,timep)
     char *host
     time_t &timep = NO_INIT
   OUTPUT:
     timep
```

Initializing Function Parameters

C function parameters are normally initialized with their values from the argument stack (which in turn contains the parameters that were passed to the XSUB from Perl). The typemaps contain the code segments which are used to translate the Perl values to the C parameters. The programmer, however, is allowed to override the typemaps and supply alternate (or additional) initialization code. Initialization code starts with the first `=`, `;` or `+` on a line in the INPUT: section. The only exception happens if this `;` terminates the line, then this `;` is quietly ignored.

The following code demonstrates how to supply initialization code for function parameters. The initialization code is eval'd within double quotes by the compiler before it is added to the output so anything which should be interpreted literally [mainly `$`, `@`, or `\\`] must be protected with backslashes. The variables `$var`, `$arg`, and `$type` can be used as in typemaps.

```
bool_t
rpcb_gettime(host,timep)
     char *host = (char *)SvPV($arg,PL_na);
     time_t &timep = 0;
   OUTPUT:
     timep
```

This should not be used to supply default values for parameters. One would normally use this when a function parameter must be processed by another library function before it can be used. Default parameters are covered in the next section.

If the initialization begins with `=`, then it is output in the declaration for the input variable, replacing the initialization supplied by the typemap. If the initialization begins with `;` or `+`, then it is performed after all of the input variables have been declared. In the `;` case the initialization normally supplied by the typemap is not performed. For the `+` case, the declaration for the variable will include the initialization from the typemap. A global variable, `%v`, is available for the truly rare case where information from one initialization is needed in another initialization.

Here's a truly obscure example:

```
bool_t
rpcb_gettime(host,timep)
     time_t &timep ; /* \$v{timep}=@{[$v{timep}=$arg]} */
     char *host + SvOK($v{timep}) ? SvPV($arg,PL_na) : NULL;
   OUTPUT:
```

```
        timep
```

The construct `\$v{timep}=@{[$v{timep}=$arg]}` used in the above example has a two-fold purpose: first, when this line is processed by **xsubpp**, the Perl snippet `$v{timep}=$arg` is evaluated. Second, the text of the evaluated snippet is output into the generated C file (inside a C comment)! During the processing of `char *host` line, `$arg` will evaluate to `ST(0)`, and `$v{timep}` will evaluate to `ST(1)`.

Default Parameter Values

Default values for XSUB arguments can be specified by placing an assignment statement in the parameter list. The default value may be a number, a string or the special string `NO_INIT`. Defaults should always be used on the right-most parameters only.

To allow the XSUB for `rpcb_gettime()` to have a default host value the parameters to the XSUB could be rearranged. The XSUB will then call the real `rpcb_gettime()` function with the parameters in the correct order. This XSUB can be called from Perl with either of the following statements:

```
$status = rpcb_gettime( $timep, $host );

$status = rpcb_gettime( $timep );
```

The XSUB will look like the code which follows. A CODE: block is used to call the real `rpcb_gettime()` function with the parameters in the correct order for that function.

```
bool_t
rpcb_gettime(timep,host="localhost")
     char *host
     time_t timep = NO_INIT
   CODE:
          RETVAL = rpcb_gettime( host, &timep );
   OUTPUT:
     timep
     RETVAL
```

The PREINIT: Keyword

The PREINIT: keyword allows extra variables to be declared immediately before or after the declarations of the parameters from the INPUT: section are emitted.

If a variable is declared inside a CODE: section it will follow any typemap code that is emitted for the input parameters. This may result in the declaration ending up after C code, which is C syntax error. Similar errors may happen with an explicit `;`-type or `+`-type initialization of parameters is used (see *"Initializing Function Parameters"*). Declaring these variables in an INIT: section will not help.

In such cases, to force an additional variable to be declared together with declarations of other variables, place the declaration into a PREINIT: section. The PREINIT: keyword may be used one or more times within an XSUB.

The following examples are equivalent, but if the code is using complex typemaps then the first example is safer.

```
bool_t
rpcb_gettime(timep)
     time_t timep = NO_INIT
   PREINIT:
     char *host = "localhost";
   CODE:
     RETVAL = rpcb_gettime( host, &timep );
   OUTPUT:
     timep
     RETVAL
```

For this particular case an INIT: keyword would generate the same C code as the PREINIT: keyword. Another correct, but error−prone example:

```
bool_t
rpcb_gettime(timep)
     time_t timep = NO_INIT
   CODE:
     char *host = "localhost";
     RETVAL = rpcb_gettime( host, &timep );
   OUTPUT:
     timep
     RETVAL
```

Another way to declare `host` is to use a C block in the CODE: section:

```
bool_t
rpcb_gettime(timep)
     time_t timep = NO_INIT
   CODE:
     {
       char *host = "localhost";
       RETVAL = rpcb_gettime( host, &timep );
     }
   OUTPUT:
     timep
     RETVAL
```

The ability to put additional declarations before the typemap entries are processed is very handy in the cases when typemap conversions manipulate some global state:

```
MyObject
mutate(o)
    PREINIT:
        MyState st = global_state;
    INPUT:
        MyObject o;
    CLEANUP:
        reset_to(global_state, st);
```

Here we suppose that conversion to `MyObject` in the INPUT: section and from MyObject when processing RETVAL will modify a global variable `global_state`. After these conversions are performed, we restore the old value of `global_state` (to avoid memory leaks, for example).

There is another way to trade clarity for compactness: INPUT sections allow declaration of C variables which do not appear in the parameter list of a subroutine. Thus the above code for `mutate()` can be rewritten as

```
MyObject
mutate(o)
      MyState st = global_state;
      MyObject o;
    CLEANUP:
      reset_to(global_state, st);
```

and the code for `rpcb_gettime()` can be rewritten as

```
bool_t
rpcb_gettime(timep)
     time_t timep = NO_INIT
```

```
      char *host = "localhost";
    C_ARGS:
      host, &timep
    OUTPUT:
      timep
      RETVAL
```

The SCOPE: Keyword

The SCOPE: keyword allows scoping to be enabled for a particular XSUB. If enabled, the XSUB will invoke ENTER and LEAVE automatically.

To support potentially complex type mappings, if a typemap entry used by an XSUB contains a comment like `/*scope*/` then scoping will be automatically enabled for that XSUB.

To enable scoping:

```
SCOPE: ENABLE
```

To disable scoping:

```
SCOPE: DISABLE
```

The INPUT: Keyword

The XSUB's parameters are usually evaluated immediately after entering the XSUB. The INPUT: keyword can be used to force those parameters to be evaluated a little later. The INPUT: keyword can be used multiple times within an XSUB and can be used to list one or more input variables. This keyword is used with the PREINIT: keyword.

The following example shows how the input parameter `timep` can be evaluated late, after a PREINIT.

```
bool_t
rpcb_gettime(host,timep)
      char *host
    PREINIT:
      time_t tt;
    INPUT:
      time_t timep
    CODE:
           RETVAL = rpcb_gettime( host, &tt );
           timep = tt;
    OUTPUT:
      timep
      RETVAL
```

The next example shows each input parameter evaluated late.

```
bool_t
rpcb_gettime(host,timep)
    PREINIT:
      time_t tt;
    INPUT:
      char *host
    PREINIT:
      char *h;
    INPUT:
      time_t timep
    CODE:
           h = host;
           RETVAL = rpcb_gettime( h, &tt );
           timep = tt;
```

```
    OUTPUT:
      timep
      RETVAL
```

Since INPUT sections allow declaration of C variables which do not appear in the parameter list of a subroutine, this may be shortened to:

```
bool_t
rpcb_gettime(host,timep)
      time_t tt;
      char *host;
      char *h = host;
      time_t timep;
    CODE:
      RETVAL = rpcb_gettime( h, &tt );
      timep = tt;
    OUTPUT:
      timep
      RETVAL
```

(We used our knowledge that input conversion for `char *` is a "simple" one, thus `host` is initialized on the declaration line, and our assignment `h = host` is not performed too early. Otherwise one would need to have the assignment `h = host` in a CODE: or INIT: section.)

The IN/OUTLIST/IN_OUTLIST Keywords

In the list of parameters for an XSUB, one can precede parameter names by the `IN`/`OUTLIST`/`IN_OUTLIST` keywords. `IN` keyword is a default, the other two keywords indicate how the Perl interface should differ from the C interface.

Parameters preceded by `OUTLIST`/`IN_OUTLIST` keywords are considered to be used by the C subroutine *via pointers*. `OUTLIST` keyword indicates that the C subroutine does not inspect the memory pointed by this parameter, but will write through this pointer to provide additional return values. Such parameters do not appear in the usage signature of the generated Perl function.

Parameters preceded by `IN_OUTLIST` *do* appear as parameters to the Perl function. These parameters are converted to the corresponding C type, then pointers to these data are given as arguments to the C function. It is expected that the C function will write through these pointers

The return list of the generated Perl function consists of the C return value from the function (unless the XSUB is of `void` return type or `The NO_INIT Keyword` was used) followed by all the `OUTLIST` and `IN_OUTLIST` parameters (in the order of appearence). Say, an XSUB

```
void
day_month(OUTLIST day, IN unix_time, OUTLIST month)
  int day
  int unix_time
  int month
```

should be used from Perl as

```
my ($day, $month) = day_month(time);
```

The C signature of the corresponding function should be

```
void day_month(int *day, int unix_time, int *month);
```

The `in`/`OUTLIST`/`IN_OUTLIST` keywords can be mixed with ANSI–style declarations, as in

```
void
day_month(OUTLIST int day, int unix_time, OUTLIST int month)
```

(here the optional IN keyword is omitted).

The IN_OUTLIST parameters are somewhat similar to parameters introduced with *The & Unary Operator* and put into the OUTPUT: section (see *The OUTPUT: Keyword*). Say, the same C function can be interfaced with as

```
void
day_month(day, unix_time, month)
    int &day = NO_INIT
    int  unix_time
    int &month = NO_INIT
  OUTPUT:
    day
    month
```

However, the generated Perl function is called in very C–ish style:

```
my ($day, $month);
day_month($day, time, $month);
```

Variable–length Parameter Lists

XSUBs can have variable–length parameter lists by specifying an ellipsis (...) in the parameter list. This use of the ellipsis is similar to that found in ANSI C. The programmer is able to determine the number of arguments passed to the XSUB by examining the items variable which the **xsubpp** compiler supplies for all XSUBs. By using this mechanism one can create an XSUB which accepts a list of parameters of unknown length.

The *host* parameter for the rpcb_gettime() XSUB can be optional so the ellipsis can be used to indicate that the XSUB will take a variable number of parameters. Perl should be able to call this XSUB with either of the following statements.

```
$status = rpcb_gettime( $timep, $host );

$status = rpcb_gettime( $timep );
```

The XS code, with ellipsis, follows.

```
bool_t
rpcb_gettime(timep, ...)
     time_t timep = NO_INIT
   PREINIT:
     char *host = "localhost";
     STRLEN n_a;
   CODE:
     if( items > 1 )
          host = (char *)SvPV(ST(1), n_a);
     RETVAL = rpcb_gettime( host, &timep );
   OUTPUT:
     timep
     RETVAL
```

The C_ARGS: Keyword

The C_ARGS: keyword allows creating of XSUBS which have different calling sequence from Perl than from C, without a need to write CODE: or PPCODE: section. The contents of the C_ARGS: paragraph is put as the argument to the called C function without any change.

For example, suppose that a C function is declared as

```
symbolic nth_derivative(int n, symbolic function, int flags);
```

and that the default flags are kept in a global C variable default_flags. Suppose that you want to create

an interface which is called as

```
$second_deriv = $function->nth_derivative(2);
```

To do this, declare the XSUB as

```
symbolic
nth_derivative(function, n)
    symbolic        function
    int             n
  C_ARGS:
    n, function, default_flags
```

The PPCODE: Keyword

The PPCODE: keyword is an alternate form of the CODE: keyword and is used to tell the **xsubpp** compiler that the programmer is supplying the code to control the argument stack for the XSUBs return values. Occasionally one will want an XSUB to return a list of values rather than a single value. In these cases one must use PPCODE: and then explicitly push the list of values on the stack. The PPCODE: and CODE: keywords should not be used together within the same XSUB.

The actual difference between PPCODE: and CODE: sections is in the initialization of `SP` macro (which stands for the *current* Perl stack pointer), and in the handling of data on the stack when returning from an XSUB. In CODE: sections SP preserves the value which was on entry to the XSUB: SP is on the function pointer (which follows the last parameter). In PPCODE: sections SP is moved backward to the beginning of the parameter list, which allows `PUSH*()` macros to place output values in the place Perl expects them to be when the XSUB returns back to Perl.

The generated trailer for a CODE: section ensures that the number of return values Perl will see is either 0 or 1 (depending on the `void`ness of the return value of the C function, and heuristics mentioned in *"The RETVAL Variable"*). The trailer generated for a PPCODE: section is based on the number of return values and on the number of times `SP` was updated by `[X]PUSH*()` macros.

Note that macros `ST(i)`, `XST_m*()` and `XSRETURN*()` work equally well in CODE: sections and PPCODE: sections.

The following XSUB will call the C `rpcb_gettime()` function and will return its two output values, timep and status, to Perl as a single list.

```
void
rpcb_gettime(host)
      char *host
   PREINIT:
     time_t  timep;
     bool_t  status;
   PPCODE:
     status = rpcb_gettime( host, &timep );
     EXTEND(SP, 2);
     PUSHs(sv_2mortal(newSViv(status)));
     PUSHs(sv_2mortal(newSViv(timep)));
```

Notice that the programmer must supply the C code necessary to have the real `rpcb_gettime()` function called and to have the return values properly placed on the argument stack.

The `void` return type for this function tells the **xsubpp** compiler that the RETVAL variable is not needed or used and that it should not be created. In most scenarios the void return type should be used with the PPCODE: directive.

The `EXTEND()` macro is used to make room on the argument stack for 2 return values. The PPCODE: directive causes the **xsubpp** compiler to create a stack pointer available as `SP`, and it is this pointer which is being used in the `EXTEND()` macro. The values are then pushed onto the stack with the `PUSHs()` macro.

Now the `rpcb_gettime()` function can be used from Perl with the following statement.

```
($status, $timep) = rpcb_gettime("localhost");
```

When handling output parameters with a PPCODE section, be sure to handle 'set' magic properly. See *perlguts* for details about 'set' magic.

Returning Undef And Empty Lists

Occasionally the programmer will want to return simply `undef` or an empty list if a function fails rather than a separate status value. The `rpcb_gettime()` function offers just this situation. If the function succeeds we would like to have it return the time and if it fails we would like to have undef returned. In the following Perl code the value of `$timep` will either be undef or it will be a valid time.

```
$timep = rpcb_gettime( "localhost" );
```

The following XSUB uses the `SV *` return type as a mnemonic only, and uses a CODE: block to indicate to the compiler that the programmer has supplied all the necessary code. The `sv_newmortal()` call will initialize the return value to undef, making that the default return value.

```
SV *
rpcb_gettime(host)
     char *  host
   PREINIT:
     time_t  timep;
     bool_t x;
   CODE:
     ST(0) = sv_newmortal();
     if( rpcb_gettime( host, &timep ) )
          sv_setnv( ST(0), (double)timep);
```

The next example demonstrates how one would place an explicit undef in the return value, should the need arise.

```
SV *
rpcb_gettime(host)
     char *  host
   PREINIT:
     time_t  timep;
     bool_t x;
   CODE:
     ST(0) = sv_newmortal();
     if( rpcb_gettime( host, &timep ) ){
          sv_setnv( ST(0), (double)timep);
     }
     else{
          ST(0) = &PL_sv_undef;
     }
```

To return an empty list one must use a PPCODE: block and then not push return values on the stack.

```
void
rpcb_gettime(host)
     char *host
   PREINIT:
     time_t  timep;
   PPCODE:
     if( rpcb_gettime( host, &timep ) )
          PUSHs(sv_2mortal(newSViv(timep)));
     else{
```

```
        /* Nothing pushed on stack, so an empty
         * list is implicitly returned. */
    }
```

Some people may be inclined to include an explicit `return` in the above XSUB, rather than letting control fall through to the end. In those situations `XSRETURN_EMPTY` should be used, instead. This will ensure that the XSUB stack is properly adjusted. Consult *API LISTING in perlguts* for other `XSRETURN` macros.

Since `XSRETURN_*` macros can be used with CODE blocks as well, one can rewrite this example as:

```
int
rpcb_gettime(host)
      char *host
   PREINIT:
     time_t  timep;
   CODE:
     RETVAL = rpcb_gettime( host, &timep );
     if (RETVAL == 0)
           XSRETURN_UNDEF;
   OUTPUT:
     RETVAL
```

In fact, one can put this check into a POST_CALL: section as well. Together with PREINIT: simplifications, this leads to:

```
int
rpcb_gettime(host)
      char *host
      time_t  timep;
   POST_CALL:
     if (RETVAL == 0)
           XSRETURN_UNDEF;
```

The REQUIRE: Keyword

The REQUIRE: keyword is used to indicate the minimum version of the **xsubpp** compiler needed to compile the XS module. An XS module which contains the following statement will compile with only **xsubpp** version 1.922 or greater:

```
REQUIRE: 1.922
```

The CLEANUP: Keyword

This keyword can be used when an XSUB requires special cleanup procedures before it terminates. When the CLEANUP: keyword is used it must follow any CODE:, PPCODE:, or OUTPUT: blocks which are present in the XSUB. The code specified for the cleanup block will be added as the last statements in the XSUB.

The POST_CALL: Keyword

This keyword can be used when an XSUB requires special procedures executed after the C subroutine call is performed. When the POST_CALL: keyword is used it must precede OUTPUT: and CLEANUP: blocks which are present in the XSUB.

The POST_CALL: block does not make a lot of sense when the C subroutine call is supplied by user by providing either CODE: or PPCODE: section.

The BOOT: Keyword

The BOOT: keyword is used to add code to the extension's bootstrap function. The bootstrap function is generated by the **xsubpp** compiler and normally holds the statements necessary to register any XSUBs with Perl. With the BOOT: keyword the programmer can tell the compiler to add extra statements to the bootstrap function.

This keyword may be used any time after the first MODULE keyword and should appear on a line by itself. The first blank line after the keyword will terminate the code block.

```
BOOT:
# The following message will be printed when the
# bootstrap function executes.
printf("Hello from the bootstrap!\n");
```

The VERSIONCHECK: Keyword

The VERSIONCHECK: keyword corresponds to **xsubpp**'s `-versioncheck` and `-noversioncheck` options. This keyword overrides the command line options. Version checking is enabled by default. When version checking is enabled the XS module will attempt to verify that its version matches the version of the PM module.

To enable version checking:

```
VERSIONCHECK: ENABLE
```

To disable version checking:

```
VERSIONCHECK: DISABLE
```

The PROTOTYPES: Keyword

The PROTOTYPES: keyword corresponds to **xsubpp**'s `-prototypes` and `-noprototypes` options. This keyword overrides the command line options. Prototypes are enabled by default. When prototypes are enabled XSUBs will be given Perl prototypes. This keyword may be used multiple times in an XS module to enable and disable prototypes for different parts of the module.

To enable prototypes:

```
PROTOTYPES: ENABLE
```

To disable prototypes:

```
PROTOTYPES: DISABLE
```

The PROTOTYPE: Keyword

This keyword is similar to the PROTOTYPES: keyword above but can be used to force **xsubpp** to use a specific prototype for the XSUB. This keyword overrides all other prototype options and keywords but affects only the current XSUB. Consult *Prototypes* for information about Perl prototypes.

```
bool_t
rpcb_gettime(timep, ...)
      time_t timep = NO_INIT
    PROTOTYPE: $;$
    PREINIT:
      char *host = "localhost";
      STRLEN n_a;
    CODE:
              if( items > 1 )
                   host = (char *)SvPV(ST(1), n_a);
              RETVAL = rpcb_gettime( host, &timep );
    OUTPUT:
      timep
      RETVAL
```

The ALIAS: Keyword

The ALIAS: keyword allows an XSUB to have two or more unique Perl names and to know which of those names was used when it was invoked. The Perl names may be fully–qualified with package names. Each alias is given an index. The compiler will setup a variable called `ix` which contain the index of the alias which was used. When the XSUB is called with its declared name `ix` will be 0.

The following example will create aliases FOO::gettime() and BAR::getit() for this function.

```
bool_t
rpcb_gettime(host,timep)
      char *host
      time_t &timep
    ALIAS:
        FOO::gettime = 1
        BAR::getit = 2
    INIT:
      printf("# ix = %d\n", ix );
    OUTPUT:
      timep
```

The INTERFACE: Keyword

This keyword declares the current XSUB as a keeper of the given calling signature. If some text follows this keyword, it is considered as a list of functions which have this signature, and should be attached to the current XSUB.

For example, if you have 4 C functions multiply(), divide(), add(), subtract() all having the signature:

```
symbolic f(symbolic, symbolic);
```

you can make them all to use the same XSUB using this:

```
symbolic
interface_s_ss(arg1, arg2)
    symbolic        arg1
    symbolic        arg2
INTERFACE:
    multiply divide
    add subtract
```

(This is the complete XSUB code for 4 Perl functions!) Four generated Perl function share names with corresponding C functions.

The advantage of this approach comparing to ALIAS: keyword is that there is no need to code a switch statement, each Perl function (which shares the same XSUB) knows which C function it should call. Additionally, one can attach an extra function remainder() at runtime by using

```
CV *mycv = newXSproto("Symbolic::remainder",
                      XS_Symbolic_interface_s_ss, __FILE__, "$$");
XSINTERFACE_FUNC_SET(mycv, remainder);
```

say, from another XSUB. (This example supposes that there was no INTERFACE_MACRO: section, otherwise one needs to use something else instead of XSINTERFACE_FUNC_SET, see the next section.)

The INTERFACE_MACRO: Keyword

This keyword allows one to define an INTERFACE using a different way to extract a function pointer from an XSUB. The text which follows this keyword should give the name of macros which would extract/set a function pointer. The extractor macro is given return type, CV*, and XSANY.any_dptr for this CV*. The setter macro is given cv, and the function pointer.

The default value is XSINTERFACE_FUNC and XSINTERFACE_FUNC_SET. An INTERFACE keyword with an empty list of functions can be omitted if INTERFACE_MACRO keyword is used.

Suppose that in the previous example functions pointers for multiply(), divide(), add(), subtract() are kept in a global C array fp[] with offsets being multiply_off, divide_off, add_off, subtract_off. Then one can use

```
#define XSINTERFACE_FUNC_BYOFFSET(ret,cv,f) \
    ((XSINTERFACE_CVT(ret,))fp[CvXSUBANY(cv).any_i32])
#define XSINTERFACE_FUNC_BYOFFSET_set(cv,f) \
    CvXSUBANY(cv).any_i32 = CAT2( f, _off )
```

in C section,

```
symbolic
interface_s_ss(arg1, arg2)
    symbolic        arg1
    symbolic        arg2
  INTERFACE_MACRO:
    XSINTERFACE_FUNC_BYOFFSET
    XSINTERFACE_FUNC_BYOFFSET_set
  INTERFACE:
    multiply divide
    add subtract
```

in XSUB section.

The INCLUDE: Keyword

This keyword can be used to pull other files into the XS module. The other files may have XS code. INCLUDE: can also be used to run a command to generate the XS code to be pulled into the module.

The file ***Rpcb1.xsh*** contains our `rpcb_gettime()` function:

```
bool_t
rpcb_gettime(host,timep)
      char *host
      time_t &timep
    OUTPUT:
      timep
```

The XS module can use INCLUDE: to pull that file into it.

```
INCLUDE: Rpcb1.xsh
```

If the parameters to the INCLUDE: keyword are followed by a pipe (`|`) then the compiler will interpret the parameters as a command.

```
INCLUDE: cat Rpcb1.xsh |
```

The CASE: Keyword

The CASE: keyword allows an XSUB to have multiple distinct parts with each part acting as a virtual XSUB. CASE: is greedy and if it is used then all other XS keywords must be contained within a CASE:. This means nothing may precede the first CASE: in the XSUB and anything following the last CASE: is included in that case.

A CASE: might switch via a parameter of the XSUB, via the `ix` ALIAS: variable (see *"The ALIAS: Keyword"*), or maybe via the `items` variable (see *"Variable-length Parameter Lists"*). The last CASE: becomes the **default** case if it is not associated with a conditional. The following example shows CASE switched via `ix` with a function `rpcb_gettime()` having an alias `x_gettime()`. When the function is called as `rpcb_gettime()` its parameters are the usual `(char *host, time_t *timep)`, but when the function is called as `x_gettime()` its parameters are reversed, `(time_t *timep, char *host)`.

```
long
rpcb_gettime(a,b)
  CASE: ix == 1
    ALIAS:
      x_gettime = 1
```

```
    INPUT:
      # 'a' is timep, 'b' is host
      char *b
      time_t a = NO_INIT
    CODE:
           RETVAL = rpcb_gettime( b, &a );
    OUTPUT:
      a
      RETVAL
  CASE:
      # 'a' is host, 'b' is timep
      char *a
      time_t &b = NO_INIT
    OUTPUT:
      b
      RETVAL
```

That function can be called with either of the following statements. Note the different argument lists.

```
$status = rpcb_gettime( $host, $timep );

$status = x_gettime( $timep, $host );
```

The & Unary Operator

The & unary operator in the INPUT: section is used to tell **xsubpp** that it should convert a Perl value to/from C using the C type to the left of &, but provide a pointer to this value when the C function is called.

This is useful to avoid a CODE: block for a C function which takes a parameter by reference. Typically, the parameter should be not a pointer type (an `int` or `long` but not a `int*` or `long*`).

The following XSUB will generate incorrect C code. The **xsubpp** compiler will turn this into code which calls `rpcb_gettime()` with parameters `(char *host, time_t timep)`, but the real `rpcb_gettime()` wants the `timep` parameter to be of type `time_t*` rather than `time_t`.

```
bool_t
rpcb_gettime(host,timep)
      char *host
      time_t timep
    OUTPUT:
      timep
```

That problem is corrected by using the & operator. The **xsubpp** compiler will now turn this into code which calls `rpcb_gettime()` correctly with parameters `(char *host, time_t *timep)`. It does this by carrying the & through, so the function call looks like `rpcb_gettime(host, &timep)`.

```
bool_t
rpcb_gettime(host,timep)
      char *host
      time_t &timep
    OUTPUT:
      timep
```

Inserting Comments and C Preprocessor Directives

C preprocessor directives are allowed within BOOT:, PREINIT: INIT:, CODE:, PPCODE:, POST_CALL:, and CLEANUP: blocks, as well as outside the functions. Comments are allowed anywhere after the MODULE keyword. The compiler will pass the preprocessor directives through untouched and will remove the commented lines.

Comments can be added to XSUBs by placing a # as the first non−whitespace of a line. Care should be taken to avoid making the comment look like a C preprocessor directive, lest it be interpreted as such. The

simplest way to prevent this is to put whitespace in front of the #.

If you use preprocessor directives to choose one of two versions of a function, use

```
#if ... version1
#else /* ... version2  */
#endif
```

and not

```
#if ... version1
#endif
#if ... version2
#endif
```

because otherwise **xsubpp** will believe that you made a duplicate definition of the function. Also, put a blank line before the #else/#endif so it will not be seen as part of the function body.

Using XS With C++

If an XSUB name contains `::`, it is considered to be a C++ method. The generated Perl function will assume that its first argument is an object pointer. The object pointer will be stored in a variable called THIS. The object should have been created by C++ with the `new()` function and should be blessed by Perl with the `sv_setref_pv()` macro. The blessing of the object by Perl can be handled by a typemap. An example typemap is shown at the end of this section.

If the return type of the XSUB includes `static`, the method is considered to be a static method. It will call the C++ function using the `class::method()` syntax. If the method is not static the function will be called using the `THIS->method()` syntax.

The next examples will use the following C++ class.

```
class color {
     public:
     color();
     ~color();
     int blue();
     void set_blue( int );

     private:
     int c_blue;
};
```

The XSUBs for the `blue()` and `set_blue()` methods are defined with the class name but the parameter for the object (THIS, or "self") is implicit and is not listed.

```
int
color::blue()

void
color::set_blue( val )
     int val
```

Both Perl functions will expect an object as the first parameter. In the generated C++ code the object is called `THIS`, and the method call will be performed on this object. So in the C++ code the `blue()` and `set_blue()` methods will be called as this:

```
RETVAL = THIS->blue();

THIS->set_blue( val );
```

You could also write a single get/set method using an optional argument:

```
int
```

```
color::blue( val = NO_INIT )
    int val
    PROTOTYPE $;$
    CODE:
        if (items > 1)
            THIS->set_blue( val );
        RETVAL = THIS->blue();
    OUTPUT:
        RETVAL
```

If the function's name is **DESTROY** then the C++ `delete` function will be called and `THIS` will be given as its parameter. The generated C++ code for

```
void
color::DESTROY()
```

will look like this:

```
color *THIS = ...; // Initialized as in typemap

delete THIS;
```

If the function's name is **new** then the C++ `new` function will be called to create a dynamic C++ object. The XSUB will expect the class name, which will be kept in a variable called `CLASS`, to be given as the first argument.

```
color *
color::new()
```

The generated C++ code will call `new`.

```
RETVAL = new color();
```

The following is an example of a typemap that could be used for this C++ example.

```
TYPEMAP
color *             O_OBJECT

OUTPUT
# The Perl object is blessed into 'CLASS', which should be a
# char* having the name of the package for the blessing.
O_OBJECT
    sv_setref_pv( $arg, CLASS, (void*)$var );

INPUT
O_OBJECT
    if( sv_isobject($arg) && (SvTYPE(SvRV($arg)) == SVt_PVMG) )
            $var = ($type)SvIV((SV*)SvRV( $arg ));
    else{
            warn( \"${Package}::$func_name() -- $var is not a blessed SV referenc
            XSRETURN_UNDEF;
    }
```

Interface Strategy

When designing an interface between Perl and a C library a straight translation from C to XS (such as created by `h2xs -x`) is often sufficient. However, sometimes the interface will look very C–like and occasionally nonintuitive, especially when the C function modifies one of its parameters, or returns failure inband (as in "negative return values mean failure"). In cases where the programmer wishes to create a more Perl–like interface the following strategy may help to identify the more critical parts of the interface.

Identify the C functions with input/output or output parameters. The XSUBs for these functions may be able to return lists to Perl.

Identify the C functions which use some inband info as an indication of failure. They may be candidates to return undef or an empty list in case of failure. If the failure may be detected without a call to the C function, you may want to use an INIT: section to report the failure. For failures detectable after the C function returns one may want to use a POST_CALL: section to process the failure. In more complicated cases use CODE: or PPCODE: sections.

If many functions use the same failure indication based on the return value, you may want to create a special typedef to handle this situation. Put

```
typedef int negative_is_failure;
```

near the beginning of XS file, and create an OUTPUT typemap entry for `negative_is_failure` which converts negative values to `undef`, or maybe `croak()`s. After this the return value of type `negative_is_failure` will create more Perl-like interface.

Identify which values are used by only the C and XSUB functions themselves, say, when a parameter to a function should be a contents of a global variable. If Perl does not need to access the contents of the value then it may not be necessary to provide a translation for that value from C to Perl.

Identify the pointers in the C function parameter lists and return values. Some pointers may be used to implement input/output or output parameters, they can be handled in XS with the `&` unary operator, and, possibly, using the NO_INIT keyword. Some others will require handling of types like `int *`, and one needs to decide what a useful Perl translation will do in such a case. When the semantic is clear, it is advisable to put the translation into a typemap file.

Identify the structures used by the C functions. In many cases it may be helpful to use the T_PTROBJ typemap for these structures so they can be manipulated by Perl as blessed objects. (This is handled automatically by `h2xs -x`.)

If the same C type is used in several different contexts which require different translations, `typedef` several new types mapped to this C type, and create separate ***typemap*** entries for these new types. Use these types in declarations of return type and parameters to XSUBs.

Perl Objects And C Structures

When dealing with C structures one should select either **T_PTROBJ** or **T_PTRREF** for the XS type. Both types are designed to handle pointers to complex objects. The T_PTRREF type will allow the Perl object to be unblessed while the T_PTROBJ type requires that the object be blessed. By using T_PTROBJ one can achieve a form of type-checking because the XSUB will attempt to verify that the Perl object is of the expected type.

The following XS code shows the `getnetconfigent()` function which is used with ONC+ TIRPC. The `getnetconfigent()` function will return a pointer to a C structure and has the C prototype shown below. The example will demonstrate how the C pointer will become a Perl reference. Perl will consider this reference to be a pointer to a blessed object and will attempt to call a destructor for the object. A destructor will be provided in the XS source to free the memory used by `getnetconfigent()`. Destructors in XS can be created by specifying an XSUB function whose name ends with the word **DESTROY**. XS destructors can be used to free memory which may have been malloc'd by another XSUB.

```
struct netconfig *getnetconfigent(const char *netid);
```

A `typedef` will be created for `struct netconfig`. The Perl object will be blessed in a class matching the name of the C type, with the tag `Ptr` appended, and the name should not have embedded spaces if it will be a Perl package name. The destructor will be placed in a class corresponding to the class of the object and the PREFIX keyword will be used to trim the name to the word DESTROY as Perl will expect.

```
typedef struct netconfig Netconfig;

MODULE = RPC  PACKAGE = RPC

Netconfig *
getnetconfigent(netid)
```

```
     char *netid

MODULE = RPC  PACKAGE = NetconfigPtr  PREFIX = rpcb_

void
rpcb_DESTROY(netconf)
     Netconfig *netconf
   CODE:
     printf("Now in NetconfigPtr::DESTROY\n");
     free( netconf );
```

This example requires the following typemap entry. Consult the typemap section for more information about adding new typemaps for an extension.

```
TYPEMAP
Netconfig *  T_PTROBJ
```

This example will be used with the following Perl statements.

```
use RPC;
$netconf = getnetconfigent("udp");
```

When Perl destroys the object referenced by `$netconf` it will send the object to the supplied XSUB DESTROY function. Perl cannot determine, and does not care, that this object is a C struct and not a Perl object. In this sense, there is no difference between the object created by the `getnetconfigent()` XSUB and an object created by a normal Perl subroutine.

The Typemap

The typemap is a collection of code fragments which are used by the **xsubpp** compiler to map C function parameters and values to Perl values. The typemap file may consist of three sections labeled `TYPEMAP`, `INPUT`, and `OUTPUT`. An unlabelled initial section is assumed to be a `TYPEMAP` section. The INPUT section tells the compiler how to translate Perl values into variables of certain C types. The OUTPUT section tells the compiler how to translate the values from certain C types into values Perl can understand. The TYPEMAP section tells the compiler which of the INPUT and OUTPUT code fragments should be used to map a given C type to a Perl value. The section labels `TYPEMAP`, `INPUT`, or `OUTPUT` must begin in the first column on a line by themselves, and must be in uppercase.

The default typemap in the `lib/ExtUtils` directory of the Perl source contains many useful types which can be used by Perl extensions. Some extensions define additional typemaps which they keep in their own directory. These additional typemaps may reference INPUT and OUTPUT maps in the main typemap. The **xsubpp** compiler will allow the extension's own typemap to override any mappings which are in the default typemap.

Most extensions which require a custom typemap will need only the TYPEMAP section of the typemap file. The custom typemap used in the `getnetconfigent()` example shown earlier demonstrates what may be the typical use of extension typemaps. That typemap is used to equate a C structure with the T_PTROBJ typemap. The typemap used by `getnetconfigent()` is shown here. Note that the C type is separated from the XS type with a tab and that the C unary operator `*` is considered to be a part of the C type name.

```
TYPEMAP
Netconfig *<tab>T_PTROBJ
```

Here's a more complicated example: suppose that you wanted `struct netconfig` to be blessed into the class `Net::Config`. One way to do this is to use underscores (_) to separate package names, as follows:

```
typedef struct netconfig * Net_Config;
```

And then provide a typemap entry `T_PTROBJ_SPECIAL` that maps underscores to double–colons (::), and declare `Net_Config` to be of that type:

```
TYPEMAP
Net_Config      T_PTROBJ_SPECIAL
```

```
INPUT
T_PTROBJ_SPECIAL
        if (sv_derived_from($arg, \"${(my $ntt=$ntype)=~s/_/::/g;\$ntt}\")) {
                IV tmp = SvIV((SV*)SvRV($arg));
        $var = ($type) tmp;
        }
        else
                croak(\"$var is not of type ${(my $ntt=$ntype)=~s/_/::/g;\$nt

OUTPUT
T_PTROBJ_SPECIAL
        sv_setref_pv($arg, \"${(my $ntt=$ntype)=~s/_/::/g;\$ntt}\",
        (void*)$var);
```

The INPUT and OUTPUT sections substitute underscores for double−colons on the fly, giving the desired effect. This example demonstrates some of the power and versatility of the typemap facility.

EXAMPLES

File `RPC.xs`: Interface to some ONC+ RPC bind library functions.

```
#include "EXTERN.h"
#include "perl.h"
#include "XSUB.h"

#include <rpc/rpc.h>

typedef struct netconfig Netconfig;

MODULE = RPC  PACKAGE = RPC

SV *
rpcb_gettime(host="localhost")
     char *host
   PREINIT:
     time_t  timep;
   CODE:
     ST(0) = sv_newmortal();
     if( rpcb_gettime( host, &timep ) )
          sv_setnv( ST(0), (double)timep );

Netconfig *
getnetconfigent(netid="udp")
     char *netid

MODULE = RPC  PACKAGE = NetconfigPtr  PREFIX = rpcb_

void
rpcb_DESTROY(netconf)
     Netconfig *netconf
   CODE:
     printf("NetconfigPtr::DESTROY\n");
     free( netconf );
```

File `typemap`: Custom typemap for RPC.xs.

```
TYPEMAP
Netconfig *  T_PTROBJ
```

File `RPC.pm`: Perl module for the RPC extension.

```
package RPC;
```

```
require Exporter;
require DynaLoader;
@ISA = qw(Exporter DynaLoader);
@EXPORT = qw(rpcb_gettime getnetconfigent);

bootstrap RPC;
1;
```

File `rpctest.pl`: Perl test program for the RPC extension.

```
use RPC;

$netconf = getnetconfigent();
$a = rpcb_gettime();
print "time = $a\n";
print "netconf = $netconf\n";

$netconf = getnetconfigent("tcp");
$a = rpcb_gettime("poplar");
print "time = $a\n";
print "netconf = $netconf\n";
```

XS VERSION

This document covers features supported by `xsubpp` 1.935.

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NAME

perlXStut – Tutorial for writing XSUBs

DESCRIPTION

This tutorial will educate the reader on the steps involved in creating a Perl extension. The reader is assumed to have access to *perlguts*, *perlapi* and *perlxs*.

This tutorial starts with very simple examples and becomes more complex, with each new example adding new features. Certain concepts may not be completely explained until later in the tutorial in order to slowly ease the reader into building extensions.

This tutorial was written from a Unix point of view. Where I know them to be otherwise different for other platforms (e.g. Win32), I will list them. If you find something that was missed, please let me know.

SPECIAL NOTES

make

This tutorial assumes that the make program that Perl is configured to use is called `make`. Instead of running "make" in the examples that follow, you may have to substitute whatever make program Perl has been configured to use. Running **perl –V:make** should tell you what it is.

Version caveat

When writing a Perl extension for general consumption, one should expect that the extension will be used with versions of Perl different from the version available on your machine. Since you are reading this document, the version of Perl on your machine is probably 5.005 or later, but the users of your extension may have more ancient versions.

To understand what kinds of incompatibilities one may expect, and in the rare case that the version of Perl on your machine is older than this document, see the section on "Troubleshooting these Examples" for more information.

If your extension uses some features of Perl which are not available on older releases of Perl, your users would appreciate an early meaningful warning. You would probably put this information into the ***README*** file, but nowadays installation of extensions may be performed automatically, guided by ***CPAN.pm*** module or other tools.

In MakeMaker–based installations, ***Makefile.PL*** provides the earliest opportunity to perform version checks. One can put something like this in ***Makefile.PL*** for this purpose:

```
eval { require 5.007 }
    or die <<EOD;
############
### This module uses frobnication framework which is not available before
### version 5.007 of Perl.  Upgrade your Perl before installing Kara::Mba.
############
EOD
```

Dynamic Loading versus Static Loading

It is commonly thought that if a system does not have the capability to dynamically load a library, you cannot build XSUBs. This is incorrect. You *can* build them, but you must link the XSUBs subroutines with the rest of Perl, creating a new executable. This situation is similar to Perl 4.

This tutorial can still be used on such a system. The XSUB build mechanism will check the system and build a dynamically–loadable library if possible, or else a static library and then, optionally, a new statically–linked executable with that static library linked in.

Should you wish to build a statically–linked executable on a system which can dynamically load libraries, you may, in all the following examples, where the command "`make`" with no arguments is executed, run the command "`make perl`" instead.

If you have generated such a statically−linked executable by choice, then instead of saying "`make test`", you should say "`make test_static`". On systems that cannot build dynamically−loadable libraries at all, simply saying "`make test`" is sufficient.

TUTORIAL

Now let's go on with the show!

EXAMPLE 1

Our first extension will be very simple. When we call the routine in the extension, it will print out a well−known message and return.

Run "`h2xs -A -n Mytest`". This creates a directory named Mytest, possibly under ext/ if that directory exists in the current working directory. Several files will be created in the Mytest dir, including MANIFEST, Makefile.PL, Mytest.pm, Mytest.xs, test.pl, and Changes.

The MANIFEST file contains the names of all the files just created in the Mytest directory.

The file Makefile.PL should look something like this:

```
use ExtUtils::MakeMaker;
# See lib/ExtUtils/MakeMaker.pm for details of how to influence
# the contents of the Makefile that is written.
WriteMakefile(
    NAME         => 'Mytest',
    VERSION_FROM => 'Mytest.pm', # finds $VERSION
    LIBS         => [''],   # e.g., '-lm'
    DEFINE       => '',     # e.g., '-DHAVE_SOMETHING'
    INC          => '',     # e.g., '-I/usr/include/other'
);
```

The file Mytest.pm should start with something like this:

```
package Mytest;

use strict;
use warnings;

require Exporter;
require DynaLoader;

our @ISA = qw(Exporter DynaLoader);
# Items to export into callers namespace by default. Note: do not export
# names by default without a very good reason. Use EXPORT_OK instead.
# Do not simply export all your public functions/methods/constants.
our @EXPORT = qw(

);
our $VERSION = '0.01';

bootstrap Mytest $VERSION;

# Preloaded methods go here.

# Autoload methods go after __END__, and are processed by the autosplit progr

1;
__END__
# Below is the stub of documentation for your module. You better edit it!
```

The rest of the .pm file contains sample code for providing documentation for the extension.

Finally, the Mytest.xs file should look something like this:

```
#include "EXTERN.h"
#include "perl.h"
#include "XSUB.h"

MODULE = Mytest          PACKAGE = Mytest
```

Let's edit the .xs file by adding this to the end of the file:

```
void
hello()
    CODE:
        printf("Hello, world!\n");
```

It is okay for the lines starting at the "CODE:" line to not be indented. However, for readability purposes, it is suggested that you indent CODE: one level and the lines following one more level.

Now we'll run "`perl Makefile.PL`". This will create a real Makefile, which make needs. Its output looks something like:

```
% perl Makefile.PL
Checking if your kit is complete...
Looks good
Writing Makefile for Mytest
%
```

Now, running make will produce output that looks something like this (some long lines have been shortened for clarity and some extraneous lines have been deleted):

```
% make
umask 0 && cp Mytest.pm ./blib/Mytest.pm
perl xsubpp -typemap typemap Mytest.xs >Mytest.tc && mv Mytest.tc Mytest.c
Please specify prototyping behavior for Mytest.xs (see perlxs manual)
cc -c Mytest.c
Running Mkbootstrap for Mytest ()
chmod 644 Mytest.bs
LD_RUN_PATH="" ld -o ./blib/PA-RISC1.1/auto/Mytest/Mytest.sl -b Mytest.o
chmod 755 ./blib/PA-RISC1.1/auto/Mytest/Mytest.sl
cp Mytest.bs ./blib/PA-RISC1.1/auto/Mytest/Mytest.bs
chmod 644 ./blib/PA-RISC1.1/auto/Mytest/Mytest.bs
Manifying ./blib/man3/Mytest.3
%
```

You can safely ignore the line about "prototyping behavior" – it is explained in the section "The PROTOTYPES: Keyword" in *perlxs*.

If you are on a Win32 system, and the build process fails with linker errors for functions in the C library, check if your Perl is configured to use PerlCRT (running **perl –V:libc** should show you if this is the case). If Perl is configured to use PerlCRT, you have to make sure PerlCRT.lib is copied to the same location that msvcrt.lib lives in, so that the compiler can find it on its own. msvcrt.lib is usually found in the Visual C compiler's lib directory (e.g. C:/DevStudio/VC/lib).

Perl has its own special way of easily writing test scripts, but for this example only, we'll create our own test script. Create a file called hello that looks like this:

```
#! /opt/perl5/bin/perl

use ExtUtils::testlib;

use Mytest;

Mytest::hello();
```

Now we make the script executable (`chmod -x hello`), run the script and we should see the following output:

```
% ./hello
Hello, world!
%
```

EXAMPLE 2

Now let's add to our extension a subroutine that will take a single numeric argument as input and return 0 if the number is even or 1 if the number is odd.

Add the following to the end of Mytest.xs:

```
int
is_even(input)
        int     input
    CODE:
        RETVAL = (input % 2 == 0);
    OUTPUT:
        RETVAL
```

There does not need to be white space at the start of the "`int input`" line, but it is useful for improving readability. Placing a semi–colon at the end of that line is also optional. Any amount and kind of white space may be placed between the "`int`" and "`input`".

Now re–run make to rebuild our new shared library.

Now perform the same steps as before, generating a Makefile from the Makefile.PL file, and running make.

In order to test that our extension works, we now need to look at the file test.pl. This file is set up to imitate the same kind of testing structure that Perl itself has. Within the test script, you perform a number of tests to confirm the behavior of the extension, printing "ok" when the test is correct, "not ok" when it is not. Change the print statement in the BEGIN block to print "1..4", and add the following code to the end of the file:

```
print &Mytest::is_even(0) == 1 ? "ok 2" : "not ok 2", "\n";
print &Mytest::is_even(1) == 0 ? "ok 3" : "not ok 3", "\n";
print &Mytest::is_even(2) == 1 ? "ok 4" : "not ok 4", "\n";
```

We will be calling the test script through the command "`make test`". You should see output that looks something like this:

```
% make test
PERL_DL_NONLAZY=1 /opt/perl5.004/bin/perl (lots of -I arguments) test.pl
1..4
ok 1
ok 2
ok 3
ok 4
%
```

What has gone on?

The program h2xs is the starting point for creating extensions. In later examples we'll see how we can use h2xs to read header files and generate templates to connect to C routines.

h2xs creates a number of files in the extension directory. The file Makefile.PL is a perl script which will generate a true Makefile to build the extension. We'll take a closer look at it later.

The .pm and .xs files contain the meat of the extension. The .xs file holds the C routines that make up the extension. The .pm file contains routines that tell Perl how to load your extension.

Generating the Makefile and running `make` created a directory called blib (which stands for "build library") in the current working directory. This directory will contain the shared library that we will build. Once we

have tested it, we can install it into its final location.

Invoking the test script via "`make test`" did something very important. It invoked perl with all those `-I` arguments so that it could find the various files that are part of the extension. It is *very* important that while you are still testing extensions that you use "`make test`". If you try to run the test script all by itself, you will get a fatal error. Another reason it is important to use "`make test`" to run your test script is that if you are testing an upgrade to an already-existing version, using "`make test`" insures that you will test your new extension, not the already-existing version.

When Perl sees a `use extension;`, it searches for a file with the same name as the `use`'d extension that has a .pm suffix. If that file cannot be found, Perl dies with a fatal error. The default search path is contained in the `@INC` array.

In our case, Mytest.pm tells perl that it will need the Exporter and Dynamic Loader extensions. It then sets the `@ISA` and `@EXPORT` arrays and the `$VERSION` scalar; finally it tells perl to bootstrap the module. Perl will call its dynamic loader routine (if there is one) and load the shared library.

The two arrays `@ISA` and `@EXPORT` are very important. The `@ISA` array contains a list of other packages in which to search for methods (or subroutines) that do not exist in the current package. This is usually only important for object-oriented extensions (which we will talk about much later), and so usually doesn't need to be modified.

The `@EXPORT` array tells Perl which of the extension's variables and subroutines should be placed into the calling package's namespace. Because you don't know if the user has already used your variable and subroutine names, it's vitally important to carefully select what to export. Do *not* export method or variable names *by default* without a good reason.

As a general rule, if the module is trying to be object-oriented then don't export anything. If it's just a collection of functions and variables, then you can export them via another array, called `@EXPORT_OK`. This array does not automatically place its subroutine and variable names into the namespace unless the user specifically requests that this be done.

See *perlmod* for more information.

The `$VERSION` variable is used to ensure that the .pm file and the shared library are "in sync" with each other. Any time you make changes to the .pm or .xs files, you should increment the value of this variable.

Writing good test scripts

The importance of writing good test scripts cannot be overemphasized. You should closely follow the "ok/not ok" style that Perl itself uses, so that it is very easy and unambiguous to determine the outcome of each test case. When you find and fix a bug, make sure you add a test case for it.

By running "`make test`", you ensure that your test.pl script runs and uses the correct version of your extension. If you have many test cases, you might want to copy Perl's test style. Create a directory named "t" in the extension's directory and append the suffix ".t" to the names of your test files. When you run "`make test`", all of these test files will be executed.

EXAMPLE 3

Our third extension will take one argument as its input, round off that value, and set the *argument* to the rounded value.

Add the following to the end of Mytest.xs:

```
void
round(arg)
        double  arg
    CODE:
        if (arg > 0.0) {
                arg = floor(arg + 0.5);
        } else if (arg < 0.0) {
                arg = ceil(arg - 0.5);
```

```
        } else {
                arg = 0.0;
        }
OUTPUT:
        arg
```

Edit the Makefile.PL file so that the corresponding line looks like this:

```
'LIBS'      => ['-lm'],   # e.g., '-lm'
```

Generate the Makefile and run make. Change the BEGIN block to print "1..9" and add the following to test.pl:

```
$i = -1.5; &Mytest::round($i); print $i == -2.0 ? "ok 5" : "not ok 5", "\n";
$i = -1.1; &Mytest::round($i); print $i == -1.0 ? "ok 6" : "not ok 6", "\n";
$i = 0.0; &Mytest::round($i); print $i == 0.0 ? "ok 7" : "not ok 7", "\n";
$i = 0.5; &Mytest::round($i); print $i == 1.0 ? "ok 8" : "not ok 8", "\n";
$i = 1.2; &Mytest::round($i); print $i == 1.0 ? "ok 9" : "not ok 9", "\n";
```

Running "`make test`" should now print out that all nine tests are okay.

Notice that in these new test cases, the argument passed to round was a scalar variable. You might be wondering if you can round a constant or literal. To see what happens, temporarily add the following line to test.pl:

```
&Mytest::round(3);
```

Run "`make test`" and notice that Perl dies with a fatal error. Perl won't let you change the value of constants!

What's new here?

- We've made some changes to Makefile.PL. In this case, we've specified an extra library to be linked into the extension's shared library, the math library libm in this case. We'll talk later about how to write XSUBs that can call every routine in a library.
- The value of the function is not being passed back as the function's return value, but by changing the value of the variable that was passed into the function. You might have guessed that when you saw that the return value of round is of type "void".

Input and Output Parameters

You specify the parameters that will be passed into the XSUB on the line(s) after you declare the function's return value and name. Each input parameter line starts with optional white space, and may have an optional terminating semicolon.

The list of output parameters occurs at the very end of the function, just before after the OUTPUT: directive. The use of RETVAL tells Perl that you wish to send this value back as the return value of the XSUB function. In Example 3, we wanted the "return value" placed in the original variable which we passed in, so we listed it (and not RETVAL) in the OUTPUT: section.

The XSUBPP Program

The **xsubpp** program takes the XS code in the .xs file and translates it into C code, placing it in a file whose suffix is .c. The C code created makes heavy use of the C functions within Perl.

The TYPEMAP file

The **xsubpp** program uses rules to convert from Perl's data types (scalar, array, etc.) to C's data types (int, char, etc.). These rules are stored in the typemap file (`$PERLLIB/ExtUtils/typemap`). This file is split into three parts.

The first section maps various C data types to a name, which corresponds somewhat with the various Perl types. The second section contains C code which **xsubpp** uses to handle input parameters. The third section contains C code which **xsubpp** uses to handle output parameters.

Let's take a look at a portion of the .c file created for our extension. The file name is Mytest.c:

```
XS(XS_Mytest_round)
{
    dXSARGS;
    if (items != 1)
        croak("Usage: Mytest::round(arg)");
    {
        double  arg = (double)SvNV(ST(0));      /* XXXXX */
        if (arg > 0.0) {
                arg = floor(arg + 0.5);
        } else if (arg < 0.0) {
                arg = ceil(arg - 0.5);
        } else {
                arg = 0.0;
        }
        sv_setnv(ST(0), (double)arg);   /* XXXXX */
    }
    XSRETURN(1);
}
```

Notice the two lines commented with "XXXXX". If you check the first section of the typemap file, you'll see that doubles are of type T_DOUBLE. In the INPUT section, an argument that is T_DOUBLE is assigned to the variable arg by calling the routine SvNV on something, then casting it to double, then assigned to the variable arg. Similarly, in the OUTPUT section, once arg has its final value, it is passed to the sv_setnv function to be passed back to the calling subroutine. These two functions are explained in *perlguts*; we'll talk more later about what that "ST(0)" means in the section on the argument stack.

Warning about Output Arguments

In general, it's not a good idea to write extensions that modify their input parameters, as in Example 3. Instead, you should probably return multiple values in an array and let the caller handle them (we'll do this in a later example). However, in order to better accommodate calling pre−existing C routines, which often do modify their input parameters, this behavior is tolerated.

EXAMPLE 4

In this example, we'll now begin to write XSUBs that will interact with pre−defined C libraries. To begin with, we will build a small library of our own, then let h2xs write our .pm and .xs files for us.

Create a new directory called Mytest2 at the same level as the directory Mytest. In the Mytest2 directory, create another directory called mylib, and cd into that directory.

Here we'll create some files that will generate a test library. These will include a C source file and a header file. We'll also create a Makefile.PL in this directory. Then we'll make sure that running make at the Mytest2 level will automatically run this Makefile.PL file and the resulting Makefile.

In the mylib directory, create a file mylib.h that looks like this:

```
#define TESTVAL 4

extern double   foo(int, long, const char*);
```

Also create a file mylib.c that looks like this:

```
#include <stdlib.h>
#include "./mylib.h"

double
foo(int a, long b, const char *c)
{
        return (a + b + atof(c) + TESTVAL);
```

```
}
```

And finally create a file Makefile.PL that looks like this:

```
use ExtUtils::MakeMaker;
$Verbose = 1;
WriteMakefile(
    NAME   => 'Mytest2::mylib',
    SKIP   => [qw(all static static_lib dynamic dynamic_lib)],
    clean  => {'FILES' => 'libmylib$(LIBEEXT)'},
);

sub MY::top_targets {
        '
all :: static

pure_all :: static

static ::       libmylib$(LIB_EXT)

libmylib$(LIB_EXT): $(O_FILES)
        $(AR) cr libmylib$(LIB_EXT) $(O_FILES)
        $(RANLIB) libmylib$(LIB_EXT)

';
}
```

Make sure you use a tab and not spaces on the lines beginning with "`$(AR)`" and "`$(RANLIB)`". Make will not function properly if you use spaces. It has also been reported that the "cr" argument to `$(AR)` is unnecessary on Win32 systems.

We will now create the main top-level Mytest2 files. Change to the directory above Mytest2 and run the following command:

```
% h2xs -O -n Mytest2 ./Mytest2/mylib/mylib.h
```

This will print out a warning about overwriting Mytest2, but that's okay. Our files are stored in Mytest2/mylib, and will be untouched.

The normal Makefile.PL that h2xs generates doesn't know about the mylib directory. We need to tell it that there is a subdirectory and that we will be generating a library in it. Let's add the argument MYEXTLIB to the WriteMakefile call so that it looks like this:

```
WriteMakefile(
    'NAME'      => 'Mytest2',
    'VERSION_FROM' => 'Mytest2.pm', # finds $VERSION
    'LIBS'      => [''],   # e.g., '-lm'
    'DEFINE'    => '',     # e.g., '-DHAVE_SOMETHING'
    'INC'       => '',     # e.g., '-I/usr/include/other'
    'MYEXTLIB' => 'mylib/libmylib$(LIB_EXT)',
);
```

and then at the end add a subroutine (which will override the pre-existing subroutine). Remember to use a tab character to indent the line beginning with "cd"!

```
sub MY::postamble {
'
$(MYEXTLIB): mylib/Makefile
        cd mylib && $(MAKE) $(PASSTHRU)
';
}
```

Let's also fix the MANIFEST file so that it accurately reflects the contents of our extension. The single line that says "mylib" should be replaced by the following three lines:

```
mylib/Makefile.PL
mylib/mylib.c
mylib/mylib.h
```

To keep our namespace nice and unpolluted, edit the .pm file and change the variable `@EXPORT` to `@EXPORT_OK`. Finally, in the .xs file, edit the #include line to read:

```
#include "mylib/mylib.h"
```

And also add the following function definition to the end of the .xs file:

```
double
foo(a,b,c)
        int             a
        long            b
        const char *    c
    OUTPUT:
        RETVAL
```

Now we also need to create a typemap file because the default Perl doesn't currently support the const char * type. Create a file called typemap in the Mytest2 directory and place the following in it:

```
const char *    T_PV
```

Now run perl on the top–level Makefile.PL. Notice that it also created a Makefile in the mylib directory. Run make and watch that it does cd into the mylib directory and run make in there as well.

Now edit the test.pl script and change the BEGIN block to print "1..4", and add the following lines to the end of the script:

```
print &Mytest2::foo(1, 2, "Hello, world!") == 7 ? "ok 2\n" : "not ok 2\n";
print &Mytest2::foo(1, 2, "0.0") == 7 ? "ok 3\n" : "not ok 3\n";
print abs(&Mytest2::foo(0, 0, "-3.4") - 0.6) <= 0.01 ? "ok 4\n" : "not ok 4\n
```

(When dealing with floating–point comparisons, it is best to not check for equality, but rather that the difference between the expected and actual result is below a certain amount (called epsilon) which is 0.01 in this case)

Run "`make test`" and all should be well.

What has happened here?

Unlike previous examples, we've now run h2xs on a real include file. This has caused some extra goodies to appear in both the .pm and .xs files.

- In the .xs file, there's now a #include directive with the absolute path to the mylib.h header file. We changed this to a relative path so that we could move the extension directory if we wanted to.
- There's now some new C code that's been added to the .xs file. The purpose of the `constant` routine is to make the values that are #define'd in the header file accessible by the Perl script (by calling either `TESTVAL` or `&Mytest2::TESTVAL`). There's also some XS code to allow calls to the `constant` routine.
- The .pm file originally exported the name `TESTVAL` in the `@EXPORT` array. This could lead to name clashes. A good rule of thumb is that if the #define is only going to be used by the C routines themselves, and not by the user, they should be removed from the `@EXPORT` array. Alternately, if you don't mind using the "fully qualified name" of a variable, you could move most or all of the items from the `@EXPORT` array into the `@EXPORT_OK` array.

- If our include file had contained #include directives, these would not have been processed by h2xs. There is no good solution to this right now.
- We've also told Perl about the library that we built in the mylib subdirectory. That required only the addition of the `MYEXTLIB` variable to the WriteMakefile call and the replacement of the postamble subroutine to cd into the subdirectory and run make. The Makefile.PL for the library is a bit more complicated, but not excessively so. Again we replaced the postamble subroutine to insert our own code. This code simply specified that the library to be created here was a static archive library (as opposed to a dynamically loadable library) and provided the commands to build it.

Anatomy of .xs file

The .xs file of *"EXAMPLE 4"* contained some new elements. To understand the meaning of these elements, pay attention to the line which reads

```
MODULE = Mytest2                PACKAGE = Mytest2
```

Anything before this line is plain C code which describes which headers to include, and defines some convenience functions. No translations are performed on this part, it goes into the generated output C file as is.

Anything after this line is the description of XSUB functions. These descriptions are translated by **xsubpp** into C code which implements these functions using Perl calling conventions, and which makes these functions visible from Perl interpreter.

Pay a special attention to the function `constant`. This name appears twice in the generated .xs file: once in the first part, as a static C function, the another time in the second part, when an XSUB interface to this static C function is defined.

This is quite typical for .xs files: usually the .xs file provides an interface to an existing C function. Then this C function is defined somewhere (either in an external library, or in the first part of .xs file), and a Perl interface to this function (i.e. "Perl glue") is described in the second part of .xs file. The situation in *"EXAMPLE 1"*, *"EXAMPLE 2"*, and *"EXAMPLE 3"*, when all the work is done inside the "Perl glue", is somewhat of an exception rather than the rule.

Getting the fat out of XSUBs

In *"EXAMPLE 4"* the second part of .xs file contained the following description of an XSUB:

```
double
foo(a,b,c)
        int             a
        long            b
        const char *    c
    OUTPUT:
        RETVAL
```

Note that in contrast with *"EXAMPLE 1"*, *"EXAMPLE 2"* and *"EXAMPLE 3"*, this description does not contain the actual *code* for what is done is done during a call to Perl function `foo()`. To understand what is going on here, one can add a CODE section to this XSUB:

```
double
foo(a,b,c)
        int             a
        long            b
        const char *    c
    CODE:
        RETVAL = foo(a,b,c);
    OUTPUT:
        RETVAL
```

However, these two XSUBs provide almost identical generated C code: **xsubpp** compiler is smart enough to figure out the `CODE:` section from the first two lines of the description of XSUB. What about `OUTPUT:` section? In fact, that is absolutely the same! The `OUTPUT:` section can be removed as well, *as far as `CODE:` section or `PPCODE:` section* is not specified: **xsubpp** can see that it needs to generate a function call section, and will autogenerate the OUTPUT section too. Thus one can shortcut the XSUB to become:

```
double
foo(a,b,c)
        int             a
        long            b
        const char *    c
```

Can we do the same with an XSUB

```
int
is_even(input)
        int     input
    CODE:
        RETVAL = (input % 2 == 0);
    OUTPUT:
        RETVAL
```

of *"EXAMPLE 2"*? To do this, one needs to define a C function `int is_even(int input)`. As we saw in *Anatomy of .xs file*, a proper place for this definition is in the first part of .xs file. In fact a C function

```
int
is_even(int arg)
{
        return (arg % 2 == 0);
}
```

is probably overkill for this. Something as simple as a `#define` will do too:

```
#define is_even(arg)    ((arg) % 2 == 0)
```

After having this in the first part of .xs file, the "Perl glue" part becomes as simple as

```
int
is_even(input)
        int     input
```

This technique of separation of the glue part from the workhorse part has obvious tradeoffs: if you want to change a Perl interface, you need to change two places in your code. However, it removes a lot of clutter, and makes the workhorse part independent from idiosyncrasies of Perl calling convention. (In fact, there is nothing Perl–specific in the above description, a different version of **xsubpp** might have translated this to TCL glue or Python glue as well.)

More about XSUB arguments

With the completion of Example 4, we now have an easy way to simulate some real–life libraries whose interfaces may not be the cleanest in the world. We shall now continue with a discussion of the arguments passed to the **xsubpp** compiler.

When you specify arguments to routines in the .xs file, you are really passing three pieces of information for each argument listed. The first piece is the order of that argument relative to the others (first, second, etc). The second is the type of argument, and consists of the type declaration of the argument (e.g., int, char*, etc). The third piece is the calling convention for the argument in the call to the library function.

While Perl passes arguments to functions by reference, C passes arguments by value; to implement a C function which modifies data of one of the "arguments", the actual argument of this C function would be a pointer to the data. Thus two C functions with declarations

```
int string_length(char *s);
int upper_case_char(char *cp);
```

may have completely different semantics: the first one may inspect an array of chars pointed by s, and the second one may immediately dereference `cp` and manipulate `*cp` only (using the return value as, say, a success indicator). From Perl one would use these functions in a completely different manner.

One conveys this info to **xsubpp** by replacing `*` before the argument by `&`. `&` means that the argument should be passed to a library function by its address. The above two function may be XSUB−ified as

```
int
string_length(s)
        char *  s

int
upper_case_char(cp)
        char    &cp
```

For example, consider:

```
int
foo(a,b)
        char    &a
        char *  b
```

The first Perl argument to this function would be treated as a char and assigned to the variable a, and its address would be passed into the function foo. The second Perl argument would be treated as a string pointer and assigned to the variable b. The *value* of b would be passed into the function foo. The actual call to the function foo that **xsubpp** generates would look like this:

```
foo(&a, b);
```

xsubpp will parse the following function argument lists identically:

```
char    &a
char&a
char    & a
```

However, to help ease understanding, it is suggested that you place a "`&`" next to the variable name and away from the variable type), and place a "*" near the variable type, but away from the variable name (as in the call to foo above). By doing so, it is easy to understand exactly what will be passed to the C function — it will be whatever is in the "last column".

You should take great pains to try to pass the function the type of variable it wants, when possible. It will save you a lot of trouble in the long run.

The Argument Stack

If we look at any of the C code generated by any of the examples except example 1, you will notice a number of references to ST(n), where n is usually 0. "ST" is actually a macro that points to the n'th argument on the argument stack. ST(0) is thus the first argument on the stack and therefore the first argument passed to the XSUB, ST(1) is the second argument, and so on.

When you list the arguments to the XSUB in the .xs file, that tells **xsubpp** which argument corresponds to which of the argument stack (i.e., the first one listed is the first argument, and so on). You invite disaster if you do not list them in the same order as the function expects them.

The actual values on the argument stack are pointers to the values passed in. When an argument is listed as being an OUTPUT value, its corresponding value on the stack (i.e., ST(0) if it was the first argument) is changed. You can verify this by looking at the C code generated for Example 3. The code for the `round()` XSUB routine contains lines that look like this:

```
double  arg = (double)SvNV(ST(0));
```

```
/* Round the contents of the variable arg */
sv_setnv(ST(0), (double)arg);
```

The arg variable is initially set by taking the value from ST(0), then is stored back into ST(0) at the end of the routine.

XSUBs are also allowed to return lists, not just scalars. This must be done by manipulating stack values ST(0), ST(1), etc, in a subtly different way. See *perlxs* for details.

XSUBs are also allowed to avoid automatic conversion of Perl function arguments to C function arguments. See *perlxs* for details. Some people prefer manual conversion by inspecting `ST(i)` even in the cases when automatic conversion will do, arguing that this makes the logic of an XSUB call clearer. Compare with *"Getting the fat out of XSUBs"* for a similar tradeoff of a complete separation of "Perl glue" and "workhorse" parts of an XSUB.

While experts may argue about these idioms, a novice to Perl guts may prefer a way which is as little Perl−guts−specific as possible, meaning automatic conversion and automatic call generation, as in *"Getting the fat out of XSUBs"*. This approach has the additional benefit of protecting the XSUB writer from future changes to the Perl API.

Extending your Extension

Sometimes you might want to provide some extra methods or subroutines to assist in making the interface between Perl and your extension simpler or easier to understand. These routines should live in the .pm file. Whether they are automatically loaded when the extension itself is loaded or only loaded when called depends on where in the .pm file the subroutine definition is placed. You can also consult *AutoLoader* for an alternate way to store and load your extra subroutines.

Documenting your Extension

There is absolutely no excuse for not documenting your extension. Documentation belongs in the .pm file. This file will be fed to pod2man, and the embedded documentation will be converted to the man page format, then placed in the blib directory. It will be copied to Perl‘s man page directory when the extension is installed.

You may intersperse documentation and Perl code within the .pm file. In fact, if you want to use method autoloading, you must do this, as the comment inside the .pm file explains.

See *perlpod* for more information about the pod format.

Installing your Extension

Once your extension is complete and passes all its tests, installing it is quite simple: you simply run "make install". You will either need to have write permission into the directories where Perl is installed, or ask your system administrator to run the make for you.

Alternately, you can specify the exact directory to place the extension‘s files by placing a "PREFIX=/destination/directory" after the make install. (or in between the make and install if you have a brain−dead version of make). This can be very useful if you are building an extension that will eventually be distributed to multiple systems. You can then just archive the files in the destination directory and distribute them to your destination systems.

EXAMPLE 5

In this example, we‘ll do some more work with the argument stack. The previous examples have all returned only a single value. We‘ll now create an extension that returns an array.

This extension is very Unix−oriented (struct statfs and the statfs system call). If you are not running on a Unix system, you can substitute for statfs any other function that returns multiple values, you can hard−code values to be returned to the caller (although this will be a bit harder to test the error case), or you can simply not do this example. If you change the XSUB, be sure to fix the test cases to match the changes.

Return to the Mytest directory and add the following code to the end of Mytest.xs:

```
void
statfs(path)
        char *  path
    INIT:
        int i;
        struct statfs buf;

    PPCODE:
        i = statfs(path, &buf);
        if (i == 0) {
                XPUSHs(sv_2mortal(newSVnv(buf.f_bavail)));
                XPUSHs(sv_2mortal(newSVnv(buf.f_bfree)));
                XPUSHs(sv_2mortal(newSVnv(buf.f_blocks)));
                XPUSHs(sv_2mortal(newSVnv(buf.f_bsize)));
                XPUSHs(sv_2mortal(newSVnv(buf.f_ffree)));
                XPUSHs(sv_2mortal(newSVnv(buf.f_files)));
                XPUSHs(sv_2mortal(newSVnv(buf.f_type)));
                XPUSHs(sv_2mortal(newSVnv(buf.f_fsid[0])));
                XPUSHs(sv_2mortal(newSVnv(buf.f_fsid[1])));
        } else {
                XPUSHs(sv_2mortal(newSVnv(errno)));
        }
```

You'll also need to add the following code to the top of the .xs file, just after the include of "XSUB.h":

```
#include <sys/vfs.h>
```

Also add the following code segment to test.pl while incrementing the "1..9" string in the BEGIN block to "1..11":

```
@a = &Mytest::statfs("/blech");
print ((scalar(@a) == 1 && $a[0] == 2) ? "ok 10\n" : "not ok 10\n");
@a = &Mytest::statfs("/");
print scalar(@a) == 9 ? "ok 11\n" : "not ok 11\n";
```

New Things in this Example

This example added quite a few new concepts. We'll take them one at a time.

- The INIT: directive contains code that will be placed immediately after the argument stack is decoded. C does not allow variable declarations at arbitrary locations inside a function, so this is usually the best way to declare local variables needed by the XSUB. (Alternatively, one could put the whole `PPCODE:` section into braces, and put these declarations on top.)

- This routine also returns a different number of arguments depending on the success or failure of the call to statfs. If there is an error, the error number is returned as a single–element array. If the call is successful, then a 9–element array is returned. Since only one argument is passed into this function, we need room on the stack to hold the 9 values which may be returned.

  We do this by using the PPCODE: directive, rather than the CODE: directive. This tells **xsubpp** that we will be managing the return values that will be put on the argument stack by ourselves.

- When we want to place values to be returned to the caller onto the stack, we use the series of macros that begin with "XPUSH". There are five different versions, for placing integers, unsigned integers, doubles, strings, and Perl scalars on the stack. In our example, we placed a Perl scalar onto the stack. (In fact this is the only macro which can be used to return multiple values.)

  The XPUSH* macros will automatically extend the return stack to prevent it from being overrun. You push values onto the stack in the order you want them seen by the calling program.

- The values pushed onto the return stack of the XSUB are actually mortal SV's. They are made mortal so that once the values are copied by the calling program, the SV's that held the returned values can be deallocated. If they were not mortal, then they would continue to exist after the XSUB routine returned, but would not be accessible. This is a memory leak.
- If we were interested in performance, not in code compactness, in the success branch we would not use `XPUSHs` macros, but `PUSHs` macros, and would pre−extend the stack before pushing the return values:

  ```
  EXTEND(SP, 9);
  ```

  The tradeoff is that one needs to calculate the number of return values in advance (though overextending the stack will not typically hurt anything but memory consumption).

  Similarly, in the failure branch we could use `PUSHs` *without* extending the stack: the Perl function reference comes to an XSUB on the stack, thus the stack is *always* large enough to take one return value.

EXAMPLE 6

In this example, we will accept a reference to an array as an input parameter, and return a reference to an array of hashes. This will demonstrate manipulation of complex Perl data types from an XSUB.

This extension is somewhat contrived. It is based on the code in the previous example. It calls the statfs function multiple times, accepting a reference to an array of filenames as input, and returning a reference to an array of hashes containing the data for each of the filesystems.

Return to the Mytest directory and add the following code to the end of Mytest.xs:

```
SV *
multi_statfs(paths)
        SV * paths
    INIT:
        AV * results;
        I32 numpaths = 0;
        int i, n;
        struct statfs buf;

        if ((!SvROK(paths))
            || (SvTYPE(SvRV(paths)) != SVt_PVAV)
            || ((numpaths = av_len((AV *)SvRV(paths))) < 0))
        {
            XSRETURN_UNDEF;
        }
        results = (AV *)sv_2mortal((SV *)newAV());
    CODE:
        for (n = 0; n <= numpaths; n++) {
            HV * rh;
            STRLEN l;
            char * fn = SvPV(*av_fetch((AV *)SvRV(paths), n, 0), l);

            i = statfs(fn, &buf);
            if (i != 0) {
                av_push(results, newSVnv(errno));
                continue;
            }

            rh = (HV *)sv_2mortal((SV *)newHV());

            hv_store(rh, "f_bavail", 8, newSVnv(buf.f_bavail), 0);
            hv_store(rh, "f_bfree",  7, newSVnv(buf.f_bfree),  0);
```

```
    hv_store(rh, "f_blocks", 8, newSVnv(buf.f_blocks), 0);
    hv_store(rh, "f_bsize",  7, newSVnv(buf.f_bsize),  0);
    hv_store(rh, "f_ffree",  7, newSVnv(buf.f_ffree),  0);
    hv_store(rh, "f_files",  7, newSVnv(buf.f_files),  0);
    hv_store(rh, "f_type",   6, newSVnv(buf.f_type),   0);

        av_push(results, newRV((SV *)rh));
    }
    RETVAL = newRV((SV *)results);
OUTPUT:
    RETVAL
```

And add the following code to test.pl, while incrementing the "1..11" string in the BEGIN block to "1..13":

```
$results = Mytest::multi_statfs([ '/', '/blech' ]);
print ((ref $results->[0]) ? "ok 12\n" : "not ok 12\n");
print ((! ref $results->[1]) ? "ok 13\n" : "not ok 13\n");
```

New Things in this Example

There are a number of new concepts introduced here, described below:

- This function does not use a typemap. Instead, we declare it as accepting one SV* (scalar) parameter, and returning an SV* value, and we take care of populating these scalars within the code. Because we are only returning one value, we don't need a `PPCODE:` directive – instead, we use `CODE:` and `OUTPUT:` directives.

- When dealing with references, it is important to handle them with caution. The `INIT:` block first checks that `SvROK` returns true, which indicates that paths is a valid reference. It then verifies that the object referenced by paths is an array, using `SvRV` to dereference paths, and `SvTYPE` to discover its type. As an added test, it checks that the array referenced by paths is non–empty, using the `av_len` function (which returns –1 if the array is empty). The XSRETURN_UNDEF macro is used to abort the XSUB and return the undefined value whenever all three of these conditions are not met.

- We manipulate several arrays in this XSUB. Note that an array is represented internally by an AV* pointer. The functions and macros for manipulating arrays are similar to the functions in Perl: `av_len` returns the highest index in an AV*, much like `$#array; av_fetch` fetches a single scalar value from an array, given its index; `av_push` pushes a scalar value onto the end of the array, automatically extending the array as necessary.

  Specifically, we read pathnames one at a time from the input array, and store the results in an output array (results) in the same order. If statfs fails, the element pushed onto the return array is the value of errno after the failure. If statfs succeeds, though, the value pushed onto the return array is a reference to a hash containing some of the information in the statfs structure.

  As with the return stack, it would be possible (and a small performance win) to pre–extend the return array before pushing data into it, since we know how many elements we will return:

  ```
  av_extend(results, numpaths);
  ```

- We are performing only one hash operation in this function, which is storing a new scalar under a key using `hv_store`. A hash is represented by an HV* pointer. Like arrays, the functions for manipulating hashes from an XSUB mirror the functionality available from Perl. See *perlguts* and *perlapi* for details.

- To create a reference, we use the `newRV` function. Note that you can cast an AV* or an HV* to type SV* in this case (and many others). This allows you to take references to arrays, hashes and scalars with the same function. Conversely, the `SvRV` function always returns an SV*, which may need to be be cast to the appropriate type if it is something other than a scalar (check with `SvTYPE`).

- At this point, xsubpp is doing very little work – the differences between Mytest.xs and Mytest.c are minimal.

EXAMPLE 7 (Coming Soon)

XPUSH args AND set RETVAL AND assign return value to array

EXAMPLE 8 (Coming Soon)

Setting `$!`

EXAMPLE 9 (Coming Soon)

Getting fd's from filehandles

Troubleshooting these Examples

As mentioned at the top of this document, if you are having problems with these example extensions, you might see if any of these help you.

- In versions of 5.002 prior to the gamma version, the test script in Example 1 will not function properly. You need to change the "use lib" line to read:

```
use lib './blib';
```

- In versions of 5.002 prior to version 5.002b1h, the test.pl file was not automatically created by h2xs. This means that you cannot say "make test" to run the test script. You will need to add the following line before the "use extension" statement:

```
use lib './blib';
```

- In versions 5.000 and 5.001, instead of using the above line, you will need to use the following line:

```
BEGIN { unshift(@INC, "./blib") }
```

- This document assumes that the executable named "perl" is Perl version 5. Some systems may have installed Perl version 5 as "perl5".

See also

For more information, consult *perlguts*, *perlapi*, *perlxs*, *perlmod*, and *perlpod*.

Author

Jeff Okamoto ***<okamoto@corp.hp.com>***

Reviewed and assisted by Dean Roehrich, Ilya Zakharevich, Andreas Koenig, and Tim Bunce.

Last Changed

1999/11/30

NAME

attrs – set/get attributes of a subroutine (deprecated)

SYNOPSIS

```
sub foo {
    use attrs qw(locked method);
    ...
}

@a = attrs::get(\&foo);
```

DESCRIPTION

NOTE: Use of this pragma is deprecated. Use the syntax

```
sub foo : locked method { }
```

to declare attributes instead. See also *attributes*.

This pragma lets you set and get attributes for subroutines. Setting attributes takes place at compile time; trying to set invalid attribute names causes a compile–time error. Calling `attrs::get` on a subroutine reference or name returns its list of attribute names. Notice that `attrs::get` is not exported. Valid attributes are as follows.

method

Indicates that the invoking subroutine is a method.

locked

Setting this attribute is only meaningful when the subroutine or method is to be called by multiple threads. When set on a method subroutine (i.e. one marked with the **method** attribute above), perl ensures that any invocation of it implicitly locks its first argument before execution. When set on a non–method subroutine, perl ensures that a lock is taken on the subroutine itself before execution. The semantics of the lock are exactly those of one explicitly taken with the `lock` operator immediately after the subroutine is entered.

NAME

B::Asmdata – Autogenerated data about Perl ops, used to generate bytecode

SYNOPSIS

```
use Asmdata;
```

DESCRIPTION

See ***ext/B/B/Asmdata.pm***.

AUTHOR

Malcolm Beattie, mbeattie@sable.ox.ac.uk

NAME

B::Assembler – Assemble Perl bytecode

SYNOPSIS

```
use B::Assembler qw(newasm endasm assemble);
newasm(\&printsub);     # sets up for assembly
assemble($buf);         # assembles one line
endasm();               # closes down

use B::Assembler qw(assemble_fh);
assemble_fh($fh, \&printsub);   # assemble everything in $fh
```

DESCRIPTION

See ***ext/B/B/Assembler.pm***.

AUTHORS

Malcolm Beattie, mbeattie@sable.ox.ac.uk Per–statement interface by Benjamin Stuhl, sho_pi@hotmail.com

NAME

B::Bblock – Walk basic blocks

SYNOPSIS

```
perl -MO=Bblock[,OPTIONS] foo.pl
```

DESCRIPTION

This module is used by the B::CC back end. It walks "basic blocks". A basic block is a series of operations which is known to execute from start to finish, with no possiblity of branching or halting.

AUTHOR

Malcolm Beattie, mbeattie@sable.ox.ac.uk

NAME

B::Bytecode – Perl compiler's bytecode backend

SYNOPSIS

```
perl -MO=Bytecode[,OPTIONS] foo.pl
```

DESCRIPTION

This compiler backend takes Perl source and generates a platform–independent bytecode encapsulating code to load the internal structures perl uses to run your program. When the generated bytecode is loaded in, your program is ready to run, reducing the time which perl would have taken to load and parse your program into its internal semi–compiled form. That means that compiling with this backend will not help improve the runtime execution speed of your program but may improve the start–up time. Depending on the environment in which your program runs this may or may not be a help.

The resulting bytecode can be run with a special byteperl executable or (for non–main programs) be loaded via the `byteload_fh` function in the ***B*** module.

OPTIONS

If there are any non–option arguments, they are taken to be names of objects to be saved (probably doesn't work properly yet). Without extra arguments, it saves the main program.

–ofilename

Output to filename instead of STDOUT.

–afilename

Append output to filename.

— Force end of options.

–f Force optimisations on or off one at a time. Each can be preceded by **no–** to turn the option off (e.g. **–fno–compress–nullops**).

–fcompress–nullops

Only fills in the necessary fields of ops which have been optimised away by perl's internal compiler.

–fomit–sequence–numbers

Leaves out code to fill in the op_seq field of all ops which is only used by perl's internal compiler.

–fbypass–nullops

If op–op_next ever points to a NULLOP, replaces the op_next field with the first non–NULLOP in the path of execution.

–On

Optimisation level (n = 0, 1, 2, ...). **–O** means **–O1**. **–O1** sets **–fcompress–nullops –fomit–sequence numbers**. **–O2** adds **–fbypass–nullops**.

–D Debug options (concatenated or separate flags like `perl -D`).

–Do Prints each OP as it's processed.

–Db Print debugging information about bytecompiler progress.

–Da Tells the (bytecode) assembler to include source assembler lines in its output as bytecode comments.

–DC

Prints each CV taken from the final symbol tree walk.

–S Output (bytecode) assembler source rather than piping it through the assembler and outputting bytecode.

–upackage

Stores package in the output.

EXAMPLES

```
perl -MO=Bytecode,-O6,-ofoo.plc,-umain foo.pl
```

```
perl -MO=Bytecode,-S,-umain foo.pl > foo.S
assemble foo.S > foo.plc
```

Note that `assemble` lives in the `B` subdirectory of your perl library directory. The utility called perlcc may also be used to help make use of this compiler.

```
perl -MO=Bytecode,-uFoo,-oFoo.pmc Foo.pm
```

BUGS

Output is still huge and there are still occasional crashes during either compilation or ByteLoading. Current status: experimental.

AUTHORS

Malcolm Beattie, `mbeattie@sable.ox.ac.uk` Benjamin Stuhl, `sho_pi@hotmail.com`

NAME

B::C – Perl compiler's C backend

SYNOPSIS

```
perl -MO=C[,OPTIONS] foo.pl
```

DESCRIPTION

This compiler backend takes Perl source and generates C source code corresponding to the internal structures that perl uses to run your program. When the generated C source is compiled and run, it cuts out the time which perl would have taken to load and parse your program into its internal semi–compiled form. That means that compiling with this backend will not help improve the runtime execution speed of your program but may improve the start–up time. Depending on the environment in which your program runs this may be either a help or a hindrance.

OPTIONS

If there are any non–option arguments, they are taken to be names of objects to be saved (probably doesn't work properly yet). Without extra arguments, it saves the main program.

–ofilename

Output to filename instead of STDOUT

–v Verbose compilation (currently gives a few compilation statistics).

— Force end of options

–uPackname

Force apparently unused subs from package Packname to be compiled. This allows programs to use eval `"foo()"` even when sub foo is never seen to be used at compile time. The down side is that any subs which really are never used also have code generated. This option is necessary, for example, if you have a signal handler foo which you initialise with `$SIG{BAR} = "foo"`. A better fix, though, is just to change it to `$SIG{BAR} = \&foo`. You can have multiple **–u** options. The compiler tries to figure out which packages may possibly have subs in which need compiling but the current version doesn't do it very well. In particular, it is confused by nested packages (i.e. of the form `A::B`) where package `A` does not contain any subs.

–D Debug options (concatenated or separate flags like `perl -D`).

–Do OPs, prints each OP as it's processed

–Dc COPs, prints COPs as processed (incl. file & line num)

–DA

prints AV information on saving

–DC

prints CV information on saving

–DM

prints MAGIC information on saving

–f Force optimisations on or off one at a time.

–fcog

Copy–on–grow: PVs declared and initialised statically.

–fno–cog

No copy–on–grow.

–On

Optimisation level (n = 0, 1, 2, ...). **–O** means **–O1**. Currently, **–O1** and higher set **–fcog**.

–llimit

Some C compilers impose an arbitrary limit on the length of string constants (e.g. 2048 characters for Microsoft Visual C++). The **–llimit** options tells the C backend not to generate string literals exceeding that limit.

EXAMPLES

```
perl -MO=C,-ofoo.c foo.pl
perl cc_harness -o foo foo.c
```

Note that `cc_harness` lives in the `B` subdirectory of your perl library directory. The utility called `perlcc` may also be used to help make use of this compiler.

```
perl -MO=C,-v,-DcA,-l2048 bar.pl > /dev/null
```

BUGS

Plenty. Current status: experimental.

AUTHOR

Malcolm Beattie, `mbeattie@sable.ox.ac.uk`

NAME

B::CC – Perl compiler's optimized C translation backend

SYNOPSIS

```
perl -MO=CC[,OPTIONS] foo.pl
```

DESCRIPTION

This compiler backend takes Perl source and generates C source code corresponding to the flow of your program. In other words, this backend is somewhat a "real" compiler in the sense that many people think about compilers. Note however that, currently, it is a very poor compiler in that although it generates (mostly, or at least sometimes) correct code, it performs relatively few optimisations. This will change as the compiler develops. The result is that running an executable compiled with this backend may start up more quickly than running the original Perl program (a feature shared by the **C** compiler backend—see ***B::C***) and may also execute slightly faster. This is by no means a good optimising compiler—yet.

OPTIONS

If there are any non–option arguments, they are taken to be names of objects to be saved (probably doesn't work properly yet). Without extra arguments, it saves the main program.

–ofilename

Output to filename instead of STDOUT

–v Verbose compilation (currently gives a few compilation statistics).

— Force end of options

–uPackname

Force apparently unused subs from package Packname to be compiled. This allows programs to use eval `"foo()"` even when sub foo is never seen to be used at compile time. The down side is that any subs which really are never used also have code generated. This option is necessary, for example, if you have a signal handler foo which you initialise with `$SIG{BAR} = "foo"`. A better fix, though, is just to change it to `$SIG{BAR} = \&foo`. You can have multiple **–u** options. The compiler tries to figure out which packages may possibly have subs in which need compiling but the current version doesn't do it very well. In particular, it is confused by nested packages (i.e. of the form `A::B`) where package `A` does not contain any subs.

–mModulename

Instead of generating source for a runnable executable, generate source for an XSUB module. The boot_Modulename function (which DynaLoader can look for) does the appropriate initialisation and runs the main part of the Perl source that is being compiled.

–D Debug options (concatenated or separate flags like `perl -D`).

–Dr Writes debugging output to STDERR just as it's about to write to the program's runtime (otherwise writes debugging info as comments in its C output).

–DO

Outputs each OP as it's compiled

–Ds Outputs the contents of the shadow stack at each OP

–Dp Outputs the contents of the shadow pad of lexicals as it's loaded for each sub or the main program.

–Dq Outputs the name of each fake PP function in the queue as it's about to process it.

–Dl Output the filename and line number of each original line of Perl code as it's processed (`pp_nextstate`).

–Dt Outputs timing information of compilation stages.

–f Force optimisations on or off one at a time.

–ffreetmps–each–bblock

Delays FREETMPS from the end of each statement to the end of the each basic block.

–ffreetmps–each–loop

Delays FREETMPS from the end of each statement to the end of the group of basic blocks forming a loop. At most one of the freetmps–each–* options can be used.

–fomit–taint

Omits generating code for handling perl's tainting mechanism.

–On

Optimisation level (n = 0, 1, 2, ...). **–O** means **–O1**. Currently, **–O1** sets **–ffreetmps–each–bblock** and **–O2** sets **–ffreetmps–each–loop**.

EXAMPLES

```
perl -MO=CC,-O2,-ofoo.c foo.pl
perl cc_harness -o foo foo.c
```

Note that `cc_harness` lives in the `B` subdirectory of your perl library directory. The utility called `perlcc` may also be used to help make use of this compiler.

```
perl -MO=CC,-mFoo,-oFoo.c Foo.pm
perl cc_harness -shared -c -o Foo.so Foo.c
```

BUGS

Plenty. Current status: experimental.

DIFFERENCES

These aren't really bugs but they are constructs which are heavily tied to perl's compile–and–go implementation and with which this compiler backend cannot cope.

Loops

Standard perl calculates the target of "next", "last", and "redo" at run–time. The compiler calculates the targets at compile–time. For example, the program

```
sub skip_on_odd { next NUMBER if $_[0] % 2 }
NUMBER: for ($i = 0; $i < 5; $i++) {
    skip_on_odd($i);
    print $i;
}
```

produces the output

```
024
```

with standard perl but gives a compile–time error with the compiler.

Context of ".."

The context (scalar or array) of the ".." operator determines whether it behaves as a range or a flip/flop. Standard perl delays until runtime the decision of which context it is in but the compiler needs to know the context at compile–time. For example,

```
@a = (4,6,1,0,0,1);
sub range { (shift @a)..(shift @a) }
print range();
while (@a) { print scalar(range()) }
```

generates the output

```
456123E0
```

with standard Perl but gives a compile−time error with compiled Perl.

Arithmetic

Compiled Perl programs use native C arithemtic much more frequently than standard perl. Operations on large numbers or on boundary cases may produce different behaviour.

Deprecated features

Features of standard perl such as `$[` which have been deprecated in standard perl since Perl5 was released have not been implemented in the compiler.

AUTHOR

Malcolm Beattie, `mbeattie@sable.ox.ac.uk`

NAME

B::Debug – Walk Perl syntax tree, printing debug info about ops

SYNOPSIS

```
perl -MO=Debug[,OPTIONS] foo.pl
```

DESCRIPTION

See ***ext/B/README***.

AUTHOR

Malcolm Beattie, mbeattie@sable.ox.ac.uk

NAME

B::Deparse – Perl compiler backend to produce perl code

SYNOPSIS

perl –MO=Deparse[**,–u***PACKAGE*][**,–p**][**,–q**][**,–l**][**,–s***LETTERS*]
prog.pl

DESCRIPTION

B::Deparse is a backend module for the Perl compiler that generates perl source code, based on the internal compiled structure that perl itself creates after parsing a program. The output of B::Deparse won't be exactly the same as the original source, since perl doesn't keep track of comments or whitespace, and there isn't a one–to–one correspondence between perl's syntactical constructions and their compiled form, but it will often be close. When you use the **–p** option, the output also includes parentheses even when they are not required by precedence, which can make it easy to see if perl is parsing your expressions the way you intended.

Please note that this module is mainly new and untested code and is still under development, so it may change in the future.

OPTIONS

As with all compiler backend options, these must follow directly after the '–MO=Deparse', separated by a comma but not any white space.

–l Add '#line' declarations to the output based on the line and file locations of the original code.

–p Print extra parentheses. Without this option, B::Deparse includes parentheses in its output only when they are needed, based on the structure of your program. With **–p**, it uses parentheses (almost) whenever they would be legal. This can be useful if you are used to LISP, or if you want to see how perl parses your input. If you say

```
if ($var & 0x7f == 65) {print "Gimme an A!"}
print ($which ? $a : $b), "\n";
$name = $ENV{USER} or "Bob";
```

`B::Deparse,-p` will print

```
if (($var & 0)) {
    print('Gimme an A!')
};
(print(($which ? $a : $b)), '???');
(($name = $ENV{'USER'}) or '???')
```

which probably isn't what you intended (the `'???'` is a sign that perl optimized away a constant value).

–q Expand double–quoted strings into the corresponding combinations of concatenation, uc, ucfirst, lc, lcfirst, quotemeta, and join. For instance, print

```
print "Hello, $world, @ladies, \u$gentlemen\E, \u\L$me!";
```

as

```
print 'Hello, ' . $world . ', ' . join($", @ladies) . ', '
      . ucfirst($gentlemen) . ', ' . ucfirst(lc $me . '!');
```

Note that the expanded form represents the way perl handles such constructions internally — this option actually turns off the reverse translation that B::Deparse usually does. On the other hand, note that `$x = "$y"` is not the same as `$x = $y`: the former makes the value of `$y` into a string before doing the assignment.

–u*PACKAGE*

Normally, B::Deparse deparses the main code of a program, all the subs called by the main program (and all the subs called by them, recursively), and any other subs in the main:: package. To include subs in other packages that aren't called directly, such as AUTOLOAD, DESTROY, other subs called automatically by perl, and methods (which aren't resolved to subs until runtime), use the **–u** option. The argument to **–u** is the name of a package, and should follow directly after the 'u'. Multiple **–u** options may be given, separated by commas. Note that unlike some other backends, B::Deparse doesn't (yet) try to guess automatically when **–u** is needed — you must invoke it yourself.

–s*LETTERS*

Tweak the style of B::Deparse's output. The letters should follow directly after the 's', with no space or punctuation. The following options are available:

C Cuddle `elsif`, `else`, and `continue` blocks. For example, print

```
if (...) {
     ...
} else {
     ...
}
```

instead of

```
if (...) {
     ...
}
else {
     ...
}
```

The default is not to cuddle.

i*NUMBER*

Indent lines by multiples of *NUMBER* columns. The default is 4 columns.

T Use tabs for each 8 columns of indent. The default is to use only spaces. For instance, if the style options are **–si4T**, a line that's indented 3 times will be preceded by one tab and four spaces; if the options were **–si8T**, the same line would be preceded by three tabs.

v*STRING***.**

Print *STRING* for the value of a constant that can't be determined because it was optimized away (mnemonic: this happens when a constant is used in **v**oid context). The end of the string is marked by a period. The string should be a valid perl expression, generally a constant. Note that unless it's a number, it probably needs to be quoted, and on a command line quotes need to be protected from the shell. Some conventional values include 0, 1, 42, '', 'foo', and 'Useless use of constant omitted' (which may need to be **–sv"'Useless use of constant omitted'."** or something similar depending on your shell). The default is '???'. If you're using B::Deparse on a module or other file that's require'd, you shouldn't use a value that evaluates to false, since the customary true constant at the end of a module will be in void context when the file is compiled as a main program.

USING B::Deparse AS A MODULE

Synopsis

```
use B::Deparse;
$deparse = B::Deparse->new("-p", "-sC");
$body = $deparse->coderef2text(\&func);
eval "sub func $body"; # the inverse operation
```

Description

B::Deparse can also be used on a sub–by–sub basis from other perl programs.

new

```
$deparse = B::Deparse->new(OPTIONS)
```

Create an object to store the state of a deparsing operation and any options. The options are the same as those that can be given on the command line (see */OPTIONS*); options that are separated by commas after **–MO=Deparse** should be given as separate strings. Some options, like **–u**, don't make sense for a single subroutine, so don't pass them.

coderef2text

```
$body = $deparse->coderef2text(\&func)
$body = $deparse->coderef2text(sub ($$) { ... })
```

Return source code for the body of a subroutine (a block, optionally preceded by a prototype in parens), given a reference to the sub. Because a subroutine can have no names, or more than one name, this method doesn't return a complete subroutine definition — if you want to eval the result, you should prepend "sub subname ", or "sub " for an anonymous function constructor. Unless the sub was defined in the main:: package, the code will include a package declaration.

BUGS

See the 'to do' list at the beginning of the module file.

AUTHOR

Stephen McCamant <smccam@uclink4.berkeley.edu, based on an earlier version by Malcolm Beattie <mbeattie@sable.ox.ac.uk, with contributions from Gisle Aas, James Duncan, Albert Dvornik, Hugo van der Sanden, Gurusamy Sarathy, and Nick Ing–Simmons.

NAME

B::Disassembler – Disassemble Perl bytecode

SYNOPSIS

```
use Disassembler;
```

DESCRIPTION

See ***ext/B/B/Disassembler.pm***.

AUTHOR

Malcolm Beattie, mbeattie@sable.ox.ac.uk

NAME

B::Lint – Perl lint

SYNOPSIS

perl –MO=Lint[,OPTIONS] foo.pl

DESCRIPTION

The B::Lint module is equivalent to an extended version of the **–w** option of **perl**. It is named after the program **lint** which carries out a similar process for C programs.

OPTIONS AND LINT CHECKS

Option words are separated by commas (not whitespace) and follow the usual conventions of compiler backend options. Following any options (indicated by a leading **–**) come lint check arguments. Each such argument (apart from the special **all** and **none** options) is a word representing one possible lint check (turning on that check) or is **no–foo** (turning off that check). Before processing the check arguments, a standard list of checks is turned on. Later options override earlier ones. Available options are:

context Produces a warning whenever an array is used in an implicit scalar context. For example, both of the lines

```
$foo = length(@bar);
$foo = @bar;
```

will elicit a warning. Using an explicit **`scalar()`** silences the warning. For example,

```
$foo = scalar(@bar);
```

implicit–read and **implicit–write**

These options produce a warning whenever an operation implicitly reads or (respectively) writes to one of Perl's special variables. For example, **implicit–read** will warn about these:

```
/foo/;
```

and **implicit–write** will warn about these:

```
s/foo/bar/;
```

Both **implicit–read** and **implicit–write** warn about this:

```
for (@a) { ... }
```

dollar–underscore

This option warns whenever `$_` is used either explicitly anywhere or as the implicit argument of a **print** statement.

private–names

This option warns on each use of any variable, subroutine or method name that lives in a non–current package but begins with an underscore ("_"). Warnings aren't issued for the special case of the single character name "_" by itself (e.g. `$_` and `@_`).

undefined–subs

This option warns whenever an undefined subroutine is invoked. This option will only catch explicitly invoked subroutines such as `foo()` and not indirect invocations such as `&$subref()` or `$obj->meth()`. Note that some programs or modules delay definition of subs until runtime by means of the AUTOLOAD mechanism.

regexp–variables

This option warns whenever one of the regexp variables `$``, `$&` or `$'` is used. Any occurrence of any of these variables in your program can slow your whole program down. See *perlre* for details.

all Turn all warnings on.

none Turn all warnings off.

NON LINT–CHECK OPTIONS

–u Package

Normally, Lint only checks the main code of the program together with all subs defined in package main. The **–u** option lets you include other package names whose subs are then checked by Lint.

BUGS

This is only a very preliminary version.

AUTHOR

Malcolm Beattie, mbeattie@sable.ox.ac.uk.

NAME

B::Showlex – Show lexical variables used in functions or files

SYNOPSIS

```
perl -MO=Showlex[,SUBROUTINE] foo.pl
```

DESCRIPTION

When a subroutine name is provided in OPTIONS, prints the lexical variables used in that subroutine. Otherwise, prints the file–scope lexicals in the file.

AUTHOR

Malcolm Beattie, mbeattie@sable.ox.ac.uk

NAME

B::Stackobj – Helper module for CC backend

SYNOPSIS

```
use B::Stackobj;
```

DESCRIPTION

See ***ext/B/README***.

AUTHOR

Malcolm Beattie, mbeattie@sable.ox.ac.uk

NAME

B::Stash – show what stashes are loaded

NAME

B::Terse – Walk Perl syntax tree, printing terse info about ops

SYNOPSIS

```
perl -MO=Terse[,OPTIONS] foo.pl
```

DESCRIPTION

See ***ext/B/README***.

AUTHOR

Malcolm Beattie, mbeattie@sable.ox.ac.uk

NAME

B::Xref – Generates cross reference reports for Perl programs

SYNOPSIS

perl –MO=Xref[,OPTIONS] foo.pl

DESCRIPTION

The B::Xref module is used to generate a cross reference listing of all definitions and uses of variables, subroutines and formats in a Perl program. It is implemented as a backend for the Perl compiler.

The report generated is in the following format:

```
File filename1
  Subroutine subname1
    Package package1
      object1        C<line numbers>
      object2        C<line numbers>
      ...
    Package package2
    ...
```

Each **File** section reports on a single file. Each **Subroutine** section reports on a single subroutine apart from the special cases "(definitions)" and "(main)". These report, respectively, on subroutine definitions found by the initial symbol table walk and on the main part of the program or module external to all subroutines.

The report is then grouped by the **Package** of each variable, subroutine or format with the special case "(lexicals)" meaning lexical variables. Each **object** name (implicitly qualified by its containing **Package**) includes its type character(s) at the beginning where possible. Lexical variables are easier to track and even included dereferencing information where possible.

The `line numbers` are a comma separated list of line numbers (some preceded by code letters) where that object is used in some way. Simple uses aren't preceded by a code letter. Introductions (such as where a lexical is first defined with `my`) are indicated with the letter "i". Subroutine and method calls are indicated by the character "`&`". Subroutine definitions are indicated by "s" and format definitions by "f".

OPTIONS

Option words are separated by commas (not whitespace) and follow the usual conventions of compiler backend options.

`-oFILENAME`

Directs output to `FILENAME` instead of standard output.

`-r` Raw output. Instead of producing a human–readable report, outputs a line in machine–readable form for each definition/use of a variable/sub/format.

`-D[tO]` (Internal) debug options, probably only useful if `-r` included. The `t` option prints the object on the top of the stack as it's being tracked. The `O` option prints each operator as it's being processed in the execution order of the program.

BUGS

Non–lexical variables are quite difficult to track through a program. Sometimes the type of a non–lexical variable's use is impossible to determine. Introductions of non–lexical non–scalars don't seem to be reported properly.

AUTHOR

Malcolm Beattie, mbeattie@sable.ox.ac.uk.

NAME

B – The Perl Compiler

SYNOPSIS

```
use B;
```

DESCRIPTION

The B module supplies classes which allow a Perl program to delve into its own innards. It is the module used to implement the "backends" of the Perl compiler. Usage of the compiler does not require knowledge of this module: see the ***O*** module for the user–visible part. The B module is of use to those who want to write new compiler backends. This documentation assumes that the reader knows a fair amount about perl's internals including such things as SVs, OPs and the internal symbol table and syntax tree of a program.

OVERVIEW OF CLASSES

The C structures used by Perl's internals to hold SV and OP information (PVIV, AV, HV, ..., OP, SVOP, UNOP, ...) are modelled on a class hierarchy and the B module gives access to them via a true object hierarchy. Structure fields which point to other objects (whether types of SV or types of OP) are represented by the B module as Perl objects of the appropriate class. The bulk of the B module is the methods for accessing fields of these structures. Note that all access is read–only: you cannot modify the internals by using this module.

SV–RELATED CLASSES

B::IV, B::NV, B::RV, B::PV, B::PVIV, B::PVNV, B::PVMG, B::BM, B::PVLV, B::AV, B::HV, B::CV, B::GV, B::FM, B::IO. These classes correspond in the obvious way to the underlying C structures of similar names. The inheritance hierarchy mimics the underlying C "inheritance". Access methods correspond to the underlying C macros for field access, usually with the leading "class indication" prefix removed (Sv, Av, Hv, ...). The leading prefix is only left in cases where its removal would cause a clash in method name. For example, GvREFCNT stays as–is since its abbreviation would clash with the "superclass" method REFCNT (corresponding to the C function SvREFCNT).

B::SV METHODS

REFCNT
FLAGS

B::IV METHODS

IV
IVX
needs64bits
packiv

B::NV METHODS

NV
NVX

B::RV METHODS

RV

B::PV METHODS

PV

B::PVMG METHODS

MAGIC
SvSTASH

B::MAGIC METHODS

MOREMAGIC
PRIVATE
TYPE
FLAGS
OBJ
PTR

B::PVLV METHODS

TARGOFF
TARGLEN
TYPE
TARG

B::BM METHODS

USEFUL
PREVIOUS
RARE
TABLE

B::GV METHODS

is_empty

This method returns TRUE if the GP field of the GV is NULL.

NAME
STASH
SV
IO
FORM
AV
HV
EGV
CV
CVGEN
LINE
FILE
FILEGV
GvREFCNT
FLAGS

B::IO METHODS

LINES
PAGE
PAGE_LEN
LINES_LEFT
TOP_NAME
TOP_GV
FMT_NAME
FMT_GV
BOTTOM_NAME
BOTTOM_GV
SUBPROCESS

IoTYPE
IoFLAGS

B::AV METHODS

FILL
MAX
OFF
ARRAY
AvFLAGS

B::CV METHODS

STASH
START
ROOT
GV
FILE
DEPTH
PADLIST
OUTSIDE
XSUB
XSUBANY
CvFLAGS
const_sv

B::HV METHODS

FILL
MAX
KEYS
RITER
NAME
PMROOT
ARRAY

OP-RELATED CLASSES

B::OP, B::UNOP, B::BINOP, B::LOGOP, B::LISTOP, B::PMOP, B::SVOP, B::PADOP, B::PVOP, B::CVOP, B::LOOP, B::COP. These classes correspond in the obvious way to the underlying C structures of similar names. The inheritance hierarchy mimics the underlying C "inheritance". Access methods correspond to the underlying C structre field names, with the leading "class indication" prefix removed (op_).

B::OP METHODS

next
sibling
name

This returns the op name as a string (e.g. "add", "rv2av").

ppaddr

This returns the function name as a string (e.g. "PL_ppaddr[OP_ADD]", "PL_ppaddr[OP_RV2AV]").

desc

This returns the op description from the global C PL_op_desc array (e.g. "addition" "array deref").

targ
type
seq

flags
private

B::UNOP METHOD

first

B::BINOP METHOD

last

B::LOGOP METHOD

other

B::LISTOP METHOD

children

B::PMOP METHODS

pmreplroot
pmreplstart
pmnext
pmregexp
pmflags
pmpermflags
precomp

B::SVOP METHOD

sv
gv

B::PADOP METHOD

padix

B::PVOP METHOD

pv

B::LOOP METHODS

redoop
nextop
lastop

B::COP METHODS

label
stash
file
cop_seq
arybase
line

FUNCTIONS EXPORTED BY B

The B module exports a variety of functions: some are simple utility functions, others provide a Perl program with a way to get an initial "handle" on an internal object.

main_cv

Return the (faked) CV corresponding to the main part of the Perl program.

init_av

Returns the AV object (i.e. in class B::AV) representing INIT blocks.

main_root

Returns the root op (i.e. an object in the appropriate B::OP−derived class) of the main part of the Perl program.

main_start

Returns the starting op of the main part of the Perl program.

comppadlist

Returns the AV object (i.e. in class B::AV) of the global comppadlist.

sv_undef

Returns the SV object corresponding to the C variable `sv_undef`.

sv_yes

Returns the SV object corresponding to the C variable `sv_yes`.

sv_no

Returns the SV object corresponding to the C variable `sv_no`.

amagic_generation

Returns the SV object corresponding to the C variable `amagic_generation`.

walkoptree(OP, METHOD)

Does a tree−walk of the syntax tree based at OP and calls METHOD on each op it visits. Each node is visited before its children. If `walkoptree_debug` (q.v.) has been called to turn debugging on then the method `walkoptree_debug` is called on each op before METHOD is called.

walkoptree_debug(DEBUG)

Returns the current debugging flag for `walkoptree`. If the optional DEBUG argument is non−zero, it sets the debugging flag to that. See the description of `walkoptree` above for what the debugging flag does.

walksymtable(SYMREF, METHOD, RECURSE)

Walk the symbol table starting at SYMREF and call METHOD on each symbol visited. When the walk reached package symbols "Foo::" it invokes RECURSE and only recurses into the package if that sub returns true.

svref_2object(SV)

Takes any Perl variable and turns it into an object in the appropriate B::OP−derived or B::SV−derived class. Apart from functions such as `main_root`, this is the primary way to get an initial "handle" on a internal perl data structure which can then be followed with the other access methods.

ppname(OPNUM)

Return the PP function name (e.g. "pp_add") of op number OPNUM.

hash(STR)

Returns a string in the form "0x..." representing the value of the internal hash function used by perl on string STR.

cast_I32(I)

Casts I to the internal I32 type used by that perl.

minus_c

Does the equivalent of the `-c` command−line option. Obviously, this is only useful in a BEGIN block or else the flag is set too late.

cstring(STR)

Returns a double−quote−surrounded escaped version of STR which can be used as a string in C source code.

class(OBJ)

Returns the class of an object without the part of the classname preceding the first "::". This is used to turn "B::UNOP" into "UNOP" for example.

threadsv_names

In a perl compiled for threads, this returns a list of the special per−thread threadsv variables.

AUTHOR

Malcolm Beattie, mbeattie@sable.ox.ac.uk

NAME

O – Generic interface to Perl Compiler backends

SYNOPSIS

```
perl -MO=Backend[,OPTIONS] foo.pl
```

DESCRIPTION

This is the module that is used as a frontend to the Perl Compiler.

CONVENTIONS

Most compiler backends use the following conventions: OPTIONS consists of a comma–separated list of words (no white–space). The `-v` option usually puts the backend into verbose mode. The `-ofile` option generates output to **file** instead of stdout. The `-D` option followed by various letters turns on various internal debugging flags. See the documentation for the desired backend (named `B::Backend` for the example above) to find out about that backend.

IMPLEMENTATION

This section is only necessary for those who want to write a compiler backend module that can be used via this module.

The command–line mentioned in the SYNOPSIS section corresponds to the Perl code

```
use O ("Backend", OPTIONS);
```

The `import` function which that calls loads in the appropriate `B::Backend` module and calls the `compile` function in that package, passing it OPTIONS. That function is expected to return a sub reference which we'll call CALLBACK. Next, the "compile–only" flag is switched on (equivalent to the command–line option `-c`) and a CHECK block is registered which calls CALLBACK. Thus the main Perl program mentioned on the command–line is read in, parsed and compiled into internal syntax tree form. Since the `-c` flag is set, the program does not start running (excepting BEGIN blocks of course) but the CALLBACK function registered by the compiler backend is called.

In summary, a compiler backend module should be called "B::Foo" for some foo and live in the appropriate directory for that name. It should define a function called `compile`. When the user types

```
perl -MO=Foo,OPTIONS foo.pl
```

that function is called and is passed those OPTIONS (split on commas). It should return a sub ref to the main compilation function. After the user's program is loaded and parsed, that returned sub ref is invoked which can then go ahead and do the compilation, usually by making use of the `B` module's functionality.

AUTHOR

Malcolm Beattie, `mbeattie@sable.ox.ac.uk`

NAME

ByteLoader – load byte compiled perl code

SYNOPSIS

```
use ByteLoader 0.04;
<byte code>
```

```
use ByteLoader 0.04;
<byte code>
```

DESCRIPTION

This module is used to load byte compiled perl code. It uses the source filter mechanism to read the byte code and insert it into the compiled code at the appropriate point.

AUTHOR

Tom Hughes <tom@compton.nu based on the ideas of Tim Bunce and others.

SEE ALSO

perl(1).

NAME

Data::Dumper – stringified perl data structures, suitable for both printing and `eval`

SYNOPSIS

```
use Data::Dumper;

# simple procedural interface
print Dumper($foo, $bar);

# extended usage with names
print Data::Dumper->Dump([$foo, $bar], [qw(foo *ary)]);

# configuration variables
{
  local $Data::Dump::Purity = 1;
  eval Data::Dumper->Dump([$foo, $bar], [qw(foo *ary)]);
}

# OO usage
$d = Data::Dumper->new([$foo, $bar], [qw(foo *ary)]);
   ...
print $d->Dump;
   ...
$d->Purity(1)->Terse(1)->Deepcopy(1);
eval $d->Dump;
```

DESCRIPTION

Given a list of scalars or reference variables, writes out their contents in perl syntax. The references can also be objects. The contents of each variable is output in a single Perl statement. Handles self–referential structures correctly.

The return value can be `eval`ed to get back an identical copy of the original reference structure.

Any references that are the same as one of those passed in will be named `$VAR`*n* (where *n* is a numeric suffix), and other duplicate references to substructures within `$VAR`*n* will be appropriately labeled using arrow notation. You can specify names for individual values to be dumped if you use the `Dump()` method, or you can change the default `$VAR` prefix to something else. See `$Data::Dumper::Varname` and `$Data::Dumper::Terse` below.

The default output of self–referential structures can be `eval`ed, but the nested references to `$VAR`*n* will be undefined, since a recursive structure cannot be constructed using one Perl statement. You should set the `Purity` flag to 1 to get additional statements that will correctly fill in these references.

In the extended usage form, the references to be dumped can be given user–specified names. If a name begins with a `*`, the output will describe the dereferenced type of the supplied reference for hashes and arrays, and coderefs. Output of names will be avoided where possible if the `Terse` flag is set.

In many cases, methods that are used to set the internal state of the object will return the object itself, so method calls can be conveniently chained together.

Several styles of output are possible, all controlled by setting the `Indent` flag. See *Configuration Variables or Methods* below for details.

Methods

PACKAGE–new(*ARRAYREF [, ARRAYREF]*)

Returns a newly created `Data::Dumper` object. The first argument is an anonymous array of values to be dumped. The optional second argument is an anonymous array of names for the values. The names need not have a leading `$` sign, and must be comprised of alphanumeric characters. You can begin a name with a `*` to specify that the dereferenced type must be dumped instead of the reference

itself, for ARRAY and HASH references.

The prefix specified by `$Data::Dumper::Varname` will be used with a numeric suffix if the name for a value is undefined.

Data::Dumper will catalog all references encountered while dumping the values. Cross–references (in the form of names of substructures in perl syntax) will be inserted at all possible points, preserving any structural interdependencies in the original set of values. Structure traversal is depth–first, and proceeds in order from the first supplied value to the last.

$OBJ–Dump *or PACKAGE*–Dump(*ARRAYREF [, ARRAYREF]*)

Returns the stringified form of the values stored in the object (preserving the order in which they were supplied to `new`), subject to the configuration options below. In a list context, it returns a list of strings corresponding to the supplied values.

The second form, for convenience, simply calls the `new` method on its arguments before dumping the object immediately.

$OBJ–Seen(*[HASHREF]*)

Queries or adds to the internal table of already encountered references. You must use `Reset` to explicitly clear the table if needed. Such references are not dumped; instead, their names are inserted wherever they are encountered subsequently. This is useful especially for properly dumping subroutine references.

Expects a anonymous hash of name = value pairs. Same rules apply for names as in `new`. If no argument is supplied, will return the "seen" list of name = value pairs, in a list context. Otherwise, returns the object itself.

$OBJ–Values(*[ARRAYREF]*)

Queries or replaces the internal array of values that will be dumped. When called without arguments, returns the values. Otherwise, returns the object itself.

$OBJ–Names(*[ARRAYREF]*)

Queries or replaces the internal array of user supplied names for the values that will be dumped. When called without arguments, returns the names. Otherwise, returns the object itself.

$OBJ–Reset

Clears the internal table of "seen" references and returns the object itself.

Functions

Dumper(*LIST*)

Returns the stringified form of the values in the list, subject to the configuration options below. The values will be named `$VAR`*n* in the output, where *n* is a numeric suffix. Will return a list of strings in a list context.

Configuration Variables or Methods

Several configuration variables can be used to control the kind of output generated when using the procedural interface. These variables are usually `localized` in a block so that other parts of the code are not affected by the change.

These variables determine the default state of the object created by calling the `new` method, but cannot be used to alter the state of the object thereafter. The equivalent method names should be used instead to query or set the internal state of the object.

The method forms return the object itself when called with arguments, so that they can be chained together nicely.

$Data::Dumper::Indent *or* *$OBJ*–**Indent(***[NEWVAL]***)**

Controls the style of indentation. It can be set to 0, 1, 2 or 3. Style 0 spews output without any newlines, indentation, or spaces between list items. It is the most compact format possible that can still be called valid perl. Style 1 outputs a readable form with newlines but no fancy indentation (each level in the structure is simply indented by a fixed amount of whitespace). Style 2 (the default) outputs a very readable form which takes into account the length of hash keys (so the hash value lines up). Style 3 is like style 2, but also annotates the elements of arrays with their index (but the comment is on its own line, so array output consumes twice the number of lines). Style 2 is the default.

$Data::Dumper::Purity *or* *$OBJ*–Purity(*[NEWVAL]*)

Controls the degree to which the output can be `eval`ed to recreate the supplied reference structures. Setting it to 1 will output additional perl statements that will correctly recreate nested references. The default is 0.

$Data::Dumper::Pad *or* *$OBJ*–Pad(*[NEWVAL]*)

Specifies the string that will be prefixed to every line of the output. Empty string by default.

$Data::Dumper::Varname *or* *$OBJ*–Varname(*[NEWVAL]*)

Contains the prefix to use for tagging variable names in the output. The default is "VAR".

$Data::Dumper::Useqq *or* *$OBJ*–Useqq(*[NEWVAL]*)

When set, enables the use of double quotes for representing string values. Whitespace other than space will be represented as `[\n\t\r]`, "unsafe" characters will be backslashed, and unprintable characters will be output as quoted octal integers. Since setting this variable imposes a performance penalty, the default is 0. `Dump()` will run slower if this flag is set, since the fast XSUB implementation doesn't support it yet.

$Data::Dumper::Terse *or* *$OBJ*–Terse(*[NEWVAL]*)

When set, Data::Dumper will emit single, non–self–referential values as atoms/terms rather than statements. This means that the `$VAR`*n* names will be avoided where possible, but be advised that such output may not always be parseable by `eval`.

$Data::Dumper::Freezer *or* *$OBJ*–Freezer(*[NEWVAL]*)

Can be set to a method name, or to an empty string to disable the feature. Data::Dumper will invoke that method via the object before attempting to stringify it. This method can alter the contents of the object (if, for instance, it contains data allocated from C), and even rebless it in a different package. The client is responsible for making sure the specified method can be called via the object, and that the object ends up containing only perl data types after the method has been called. Defaults to an empty string.

$Data::Dumper::Toaster *or* *$OBJ*–Toaster(*[NEWVAL]*)

Can be set to a method name, or to an empty string to disable the feature. Data::Dumper will emit a method call for any objects that are to be dumped using the syntax `bless(DATA, CLASS)->METHOD()`. Note that this means that the method specified will have to perform any modifications required on the object (like creating new state within it, and/or reblessing it in a different package) and then return it. The client is responsible for making sure the method can be called via the object, and that it returns a valid object. Defaults to an empty string.

$Data::Dumper::Deepcopy *or* *$OBJ*–Deepcopy(*[NEWVAL]*)

Can be set to a boolean value to enable deep copies of structures. Cross–referencing will then only be done when absolutely essential (i.e., to break reference cycles). Default is 0.

$Data::Dumper::Quotekeys *or* *$OBJ*–Quotekeys(*[NEWVAL]*)

Can be set to a boolean value to control whether hash keys are quoted. A false value will avoid quoting hash keys when it looks like a simple string. Default is 1, which will always enclose hash keys in quotes.

$Data::Dumper::Bless *or* **$*OBJ*->Bless(*[NEWVAL]*)**

Can be set to a string that specifies an alternative to the `bless` builtin operator used to create objects. A function with the specified name should exist, and should accept the same arguments as the builtin. Default is `bless`.

`$Data::Dumper::Maxdepth` *or* `$OBJ->`Maxdepth(*[NEWVAL]*)

Can be set to a positive integer that specifies the depth beyond which which we don't venture into a structure. Has no effect when `Data::Dumper::Purity` is set. (Useful in debugger when we often don't want to see more than enough). Default is 0, which means there is no maximum depth.

Exports

Dumper

EXAMPLES

Run these code snippets to get a quick feel for the behavior of this module. When you are through with these examples, you may want to add or change the various configuration variables described above, to see their behavior. (See the testsuite in the Data::Dumper distribution for more examples.)

```
use Data::Dumper;

package Foo;
sub new {bless {'a' => 1, 'b' => sub { return "foo" }}, $_[0]};

package Fuz;                       # a weird REF-REF-SCALAR object
sub new {bless \($_ = \ 'fu\'z'), $_[0]};

package main;
$foo = Foo->new;
$fuz = Fuz->new;
$boo = [ 1, [], "abcd", \*foo,
         {1 => 'a', 023 => 'b', 0x45 => 'c'},
         \\"p\q\'r", $foo, $fuz];

########
# simple usage
########

$bar = eval(Dumper($boo));
print($@) if $@;
print Dumper($boo), Dumper($bar);  # pretty print (no array indices)

$Data::Dumper::Terse = 1;          # don't output names where feasible
$Data::Dumper::Indent = 0;         # turn off all pretty print
print Dumper($boo), "\n";

$Data::Dumper::Indent = 1;         # mild pretty print
print Dumper($boo);

$Data::Dumper::Indent = 3;         # pretty print with array indices
print Dumper($boo);

$Data::Dumper::Useqq = 1;          # print strings in double quotes
print Dumper($boo);

########
# recursive structures
########

@c = ('c');
$c = \@c;
```

```
$b = {};
$a = [1, $b, $c];
$b->{a} = $a;
$b->{b} = $a->[1];
$b->{c} = $a->[2];
print Data::Dumper->Dump([$a,$b,$c], [qw(a b c)]);

$Data::Dumper::Purity = 1;         # fill in the holes for eval
print Data::Dumper->Dump([$a, $b], [qw(*a b)]); # print as @a
print Data::Dumper->Dump([$b, $a], [qw(*b a)]); # print as %b

$Data::Dumper::Deepcopy = 1;       # avoid cross-refs
print Data::Dumper->Dump([$b, $a], [qw(*b a)]);

$Data::Dumper::Purity = 0;         # avoid cross-refs
print Data::Dumper->Dump([$b, $a], [qw(*b a)]);

########
# deep structures
########

$a = "pearl";
$b = [ $a ];
$c = { 'b' => $b };
$d = [ $c ];
$e = { 'd' => $d };
$f = { 'e' => $e };
print Data::Dumper->Dump([$f], [qw(f)]);

$Data::Dumper::Maxdepth = 3;       # no deeper than 3 refs down
print Data::Dumper->Dump([$f], [qw(f)]);

########
# object-oriented usage
########

$d = Data::Dumper->new([$a,$b], [qw(a b)]);
$d->Seen({'*c' => $c});            # stash a ref without printing it
$d->Indent(3);
print $d->Dump;
$d->Reset->Purity(0);              # empty the seen cache
print join "----\n", $d->Dump;

########
# persistence
########

package Foo;
sub new { bless { state => 'awake' }, shift }
sub Freeze {
    my $s = shift;
    print STDERR "preparing to sleep\n";
    $s->{state} = 'asleep';
    return bless $s, 'Foo::ZZZ';
}

package Foo::ZZZ;
sub Thaw {
    my $s = shift;
    print STDERR "waking up\n";
```

```
    $s->{state} = 'awake';
    return bless $s, 'Foo';
}

package Foo;
use Data::Dumper;
$a = Foo->new;
$b = Data::Dumper->new([$a], ['c']);
$b->Freezer('Freeze');
$b->Toaster('Thaw');
$c = $b->Dump;
print $c;
$d = eval $c;
print Data::Dumper->Dump([$d], ['d']);

########
# symbol substitution (useful for recreating CODE refs)
########

sub foo { print "foo speaking\n" }
*other = \&foo;
$bar = [ \&other ];
$d = Data::Dumper->new([\&other,$bar],['*other','bar']);
$d->Seen({ '*foo' => \&foo });
print $d->Dump;
```

BUGS

Due to limitations of Perl subroutine call semantics, you cannot pass an array or hash. Prepend it with a \ to pass its reference instead. This will be remedied in time, with the arrival of prototypes in later versions of Perl. For now, you need to use the extended usage form, and prepend the name with a `*` to output it as a hash or array.

`Data::Dumper` cheats with CODE references. If a code reference is encountered in the structure being processed, an anonymous subroutine that contains the string '"DUMMY"' will be inserted in its place, and a warning will be printed if `Purity` is set. You can `eval` the result, but bear in mind that the anonymous sub that gets created is just a placeholder. Someday, perl will have a switch to cache-on-demand the string representation of a compiled piece of code, I hope. If you have prior knowledge of all the code refs that your data structures are likely to have, you can use the `Seen` method to pre-seed the internal reference table and make the dumped output point to them, instead. See *EXAMPLES* above.

The `Useqq` flag makes `Dump()` run slower, since the XSUB implementation does not support it.

SCALAR objects have the weirdest looking `bless` workaround.

AUTHOR

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VERSION

Version 2.11 (unreleased)

SEE ALSO

perl(1)

NAME

DB_File – Perl5 access to Berkeley DB version 1.x

SYNOPSIS

```
use DB_File ;

[$X =] tie %hash,  'DB_File', [$filename, $flags, $mode, $DB_HASH] ;
[$X =] tie %hash,  'DB_File', $filename, $flags, $mode, $DB_BTREE ;
[$X =] tie @array, 'DB_File', $filename, $flags, $mode, $DB_RECNO ;

$status = $X->del($key [, $flags]) ;
$status = $X->put($key, $value [, $flags]) ;
$status = $X->get($key, $value [, $flags]) ;
$status = $X->seq($key, $value, $flags) ;
$status = $X->sync([$flags]) ;
$status = $X->fd ;

# BTREE only
$count = $X->get_dup($key) ;
@list  = $X->get_dup($key) ;
%list  = $X->get_dup($key, 1) ;
$status = $X->find_dup($key, $value) ;
$status = $X->del_dup($key, $value) ;

# RECNO only
$a = $X->length;
$a = $X->pop ;
$X->push(list);
$a = $X->shift;
$X->unshift(list);

# DBM Filters
$old_filter = $db->filter_store_key  ( sub { ... } ) ;
$old_filter = $db->filter_store_value( sub { ... } ) ;
$old_filter = $db->filter_fetch_key  ( sub { ... } ) ;
$old_filter = $db->filter_fetch_value( sub { ... } ) ;

untie %hash ;
untie @array ;
```

DESCRIPTION

DB_File is a module which allows Perl programs to make use of the facilities provided by Berkeley DB version 1.x (if you have a newer version of DB, see *Using DB_File with Berkeley DB version 2 or 3*). It is assumed that you have a copy of the Berkeley DB manual pages at hand when reading this documentation. The interface defined here mirrors the Berkeley DB interface closely.

Berkeley DB is a C library which provides a consistent interface to a number of database formats. **DB_File** provides an interface to all three of the database types currently supported by Berkeley DB.

The file types are:

DB_HASH

This database type allows arbitrary key/value pairs to be stored in data files. This is equivalent to the functionality provided by other hashing packages like DBM, NDBM, ODBM, GDBM, and SDBM. Remember though, the files created using DB_HASH are not compatible with any of the other packages mentioned.

A default hashing algorithm, which will be adequate for most applications, is built into Berkeley DB. If you do need to use your own hashing algorithm it is possible to write your own in Perl and have

DB_File use it instead.

DB_BTREE

The btree format allows arbitrary key/value pairs to be stored in a sorted, balanced binary tree.

As with the DB_HASH format, it is possible to provide a user defined Perl routine to perform the comparison of keys. By default, though, the keys are stored in lexical order.

DB_RECNO

DB_RECNO allows both fixed−length and variable−length flat text files to be manipulated using the same key/value pair interface as in DB_HASH and DB_BTREE. In this case the key will consist of a record (line) number.

Using DB_File with Berkeley DB version 2 or 3

Although **DB_File** is intended to be used with Berkeley DB version 1, it can also be used with version 2.or 3 In this case the interface is limited to the functionality provided by Berkeley DB 1.x. Anywhere the version 2 or 3 interface differs, **DB_File** arranges for it to work like version 1. This feature allows **DB_File** scripts that were built with version 1 to be migrated to version 2 or 3 without any changes.

If you want to make use of the new features available in Berkeley DB 2.x or greater, use the Perl module **BerkeleyDB** instead.

Note: The database file format has changed in both Berkeley DB version 2 and 3. If you cannot recreate your databases, you must dump any existing databases with the `db_dump185` utility that comes with Berkeley DB. Once you have rebuilt DB_File to use Berkeley DB version 2 or 3, your databases can be recreated using `db_load`. Refer to the Berkeley DB documentation for further details.

Please read *"COPYRIGHT"* before using version 2.x or 3.x of Berkeley DB with DB_File.

Interface to Berkeley DB

DB_File allows access to Berkeley DB files using the `tie()` mechanism in Perl 5 (for full details, see *`tie()`*). This facility allows **DB_File** to access Berkeley DB files using either an associative array (for DB_HASH & DB_BTREE file types) or an ordinary array (for the DB_RECNO file type).

In addition to the `tie()` interface, it is also possible to access most of the functions provided in the Berkeley DB API directly. See *THE API INTERFACE*.

Opening a Berkeley DB Database File

Berkeley DB uses the function `dbopen()` to open or create a database. Here is the C prototype for `dbopen()`:

```
DB*
dbopen (const char * file, int flags, int mode,
        DBTYPE type, const void * openinfo)
```

The parameter `type` is an enumeration which specifies which of the 3 interface methods (DB_HASH, DB_BTREE or DB_RECNO) is to be used. Depending on which of these is actually chosen, the final parameter, *openinfo* points to a data structure which allows tailoring of the specific interface method.

This interface is handled slightly differently in **DB_File**. Here is an equivalent call using **DB_File**:

```
tie %array, 'DB_File', $filename, $flags, $mode, $DB_HASH ;
```

The `filename`, `flags` and `mode` parameters are the direct equivalent of their `dbopen()` counterparts. The final parameter `$DB_HASH` performs the function of both the `type` and `openinfo` parameters in `dbopen()`.

In the example above `$DB_HASH` is actually a pre−defined reference to a hash object. **DB_File** has three of these pre−defined references. Apart from `$DB_HASH`, there is also `$DB_BTREE` and `$DB_RECNO`.

The keys allowed in each of these pre−defined references is limited to the names used in the equivalent C structure. So, for example, the `$DB_HASH` reference will only allow keys called `bsize`, `cachesize`,

ffactor, hash, lorder and nelem.

To change one of these elements, just assign to it like this:

```
$DB_HASH->{'cachesize'} = 10000 ;
```

The three predefined variables $DB_HASH, $DB_BTREE and $DB_RECNO are usually adequate for most applications. If you do need to create extra instances of these objects, constructors are available for each file type.

Here are examples of the constructors and the valid options available for DB_HASH, DB_BTREE and DB_RECNO respectively.

```
$a = new DB_File::HASHINFO ;
$a->{'bsize'} ;
$a->{'cachesize'} ;
$a->{'ffactor'};
$a->{'hash'} ;
$a->{'lorder'} ;
$a->{'nelem'} ;

$b = new DB_File::BTREEINFO ;
$b->{'flags'} ;
$b->{'cachesize'} ;
$b->{'maxkeypage'} ;
$b->{'minkeypage'} ;
$b->{'psize'} ;
$b->{'compare'} ;
$b->{'prefix'} ;
$b->{'lorder'} ;

$c = new DB_File::RECNOINFO ;
$c->{'bval'} ;
$c->{'cachesize'} ;
$c->{'psize'} ;
$c->{'flags'} ;
$c->{'lorder'} ;
$c->{'reclen'} ;
$c->{'bfname'} ;
```

The values stored in the hashes above are mostly the direct equivalent of their C counterpart. Like their C counterparts, all are set to a default values – that means you don't have to set *all* of the values when you only want to change one. Here is an example:

```
$a = new DB_File::HASHINFO ;
$a->{'cachesize'} =  12345 ;
tie %y, 'DB_File', "filename", $flags, 0777, $a ;
```

A few of the options need extra discussion here. When used, the C equivalent of the keys hash, compare and prefix store pointers to C functions. In **DB_File** these keys are used to store references to Perl subs. Below are templates for each of the subs:

```
sub hash
{
    my ($data) = @_ ;
    ...
    # return the hash value for $data
    return $hash ;
}
```

```
sub compare
{
    my ($key, $key2) = @_ ;
    ...
    # return  0 if $key1 eq $key2
    #        -1 if $key1 lt $key2
    #         1 if $key1 gt $key2
    return (-1 , 0 or 1) ;
}

sub prefix
{
    my ($key, $key2) = @_ ;
    ...
    # return number of bytes of $key2 which are
    # necessary to determine that it is greater than $key1
    return $bytes ;
}
```

See *Changing the BTREE sort order* for an example of using the `compare` template.

If you are using the DB_RECNO interface and you intend making use of `bval`, you should check out *The 'bval' Option*.

Default Parameters

It is possible to omit some or all of the final 4 parameters in the call to `tie` and let them take default values. As DB_HASH is the most common file format used, the call:

```
tie %A, "DB_File", "filename" ;
```

is equivalent to:

```
tie %A, "DB_File", "filename", O_CREAT|O_RDWR, 0666, $DB_HASH ;
```

It is also possible to omit the filename parameter as well, so the call:

```
tie %A, "DB_File" ;
```

is equivalent to:

```
tie %A, "DB_File", undef, O_CREAT|O_RDWR, 0666, $DB_HASH ;
```

See *In Memory Databases* for a discussion on the use of `undef` in place of a filename.

In Memory Databases

Berkeley DB allows the creation of in–memory databases by using NULL (that is, a `(char *)0` in C) in place of the filename. **DB_File** uses `undef` instead of NULL to provide this functionality.

DB_HASH

The DB_HASH file format is probably the most commonly used of the three file formats that **DB_File** supports. It is also very straightforward to use.

A Simple Example

This example shows how to create a database, add key/value pairs to the database, delete keys/value pairs and finally how to enumerate the contents of the database.

```
use strict ;
use DB_File ;
use vars qw( %h $k $v ) ;

unlink "fruit" ;
tie %h, "DB_File", "fruit", O_RDWR|O_CREAT, 0640, $DB_HASH
```

```
    or die "Cannot open file 'fruit': $!\n";

# Add a few key/value pairs to the file
$h{"apple"} = "red" ;
$h{"orange"} = "orange" ;
$h{"banana"} = "yellow" ;
$h{"tomato"} = "red" ;

# Check for existence of a key
print "Banana Exists\n\n" if $h{"banana"} ;

# Delete a key/value pair.
delete $h{"apple"} ;

# print the contents of the file
while (($k, $v) = each %h)
  { print "$k -> $v\n" }

untie %h ;
```

here is the output:

```
Banana Exists

orange -> orange
tomato -> red
banana -> yellow
```

Note that the like ordinary associative arrays, the order of the keys retrieved is in an apparently random order.

DB_BTREE

The DB_BTREE format is useful when you want to store data in a given order. By default the keys will be stored in lexical order, but as you will see from the example shown in the next section, it is very easy to define your own sorting function.

Changing the BTREE sort order

This script shows how to override the default sorting algorithm that BTREE uses. Instead of using the normal lexical ordering, a case insensitive compare function will be used.

```
use strict ;
use DB_File ;

my %h ;

sub Compare
{
    my ($key1, $key2) = @_ ;
    "\L$key1" cmp "\L$key2" ;
}

# specify the Perl sub that will do the comparison
$DB_BTREE->{'compare'} = \&Compare ;

unlink "tree" ;
tie %h, "DB_File", "tree", O_RDWR|O_CREAT, 0640, $DB_BTREE
    or die "Cannot open file 'tree': $!\n" ;

# Add a key/value pair to the file
$h{'Wall'} = 'Larry' ;
$h{'Smith'} = 'John' ;
$h{'mouse'} = 'mickey' ;
$h{'duck'}  = 'donald' ;
```

```
# Delete
delete $h{"duck"} ;

# Cycle through the keys printing them in order.
# Note it is not necessary to sort the keys as
# the btree will have kept them in order automatically.
foreach (keys %h)
  { print "$_\n" }

untie %h ;
```

Here is the output from the code above.

```
mouse
Smith
Wall
```

There are a few point to bear in mind if you want to change the ordering in a BTREE database:

1. The new compare function must be specified when you create the database.
2. You cannot change the ordering once the database has been created. Thus you must use the same compare function every time you access the database.

Handling Duplicate Keys

The BTREE file type optionally allows a single key to be associated with an arbitrary number of values. This option is enabled by setting the flags element of `$DB_BTREE` to R_DUP when creating the database.

There are some difficulties in using the tied hash interface if you want to manipulate a BTREE database with duplicate keys. Consider this code:

```
use strict ;
use DB_File ;

use vars qw($filename %h ) ;

$filename = "tree" ;
unlink $filename ;

# Enable duplicate records
$DB_BTREE->{'flags'} = R_DUP ;

tie %h, "DB_File", $filename, O_RDWR|O_CREAT, 0640, $DB_BTREE
    or die "Cannot open $filename: $!\n";

# Add some key/value pairs to the file
$h{'Wall'} = 'Larry' ;
$h{'Wall'} = 'Brick' ; # Note the duplicate key
$h{'Wall'} = 'Brick' ; # Note the duplicate key and value
$h{'Smith'} = 'John' ;
$h{'mouse'} = 'mickey' ;

# iterate through the associative array
# and print each key/value pair.
foreach (sort keys %h)
  { print "$_  -> $h{$_}\n" }

untie %h ;
```

Here is the output:

```
Smith   -> John
Wall    -> Larry
Wall    -> Larry
```

```
Wall    -> Larry
mouse   -> mickey
```

As you can see 3 records have been successfully created with key `Wall` – the only thing is, when they are retrieved from the database they *seem* to have the same value, namely `Larry`. The problem is caused by the way that the associative array interface works. Basically, when the associative array interface is used to fetch the value associated with a given key, it will only ever retrieve the first value.

Although it may not be immediately obvious from the code above, the associative array interface can be used to write values with duplicate keys, but it cannot be used to read them back from the database.

The way to get around this problem is to use the Berkeley DB API method called `seq`. This method allows sequential access to key/value pairs. See *THE API INTERFACE* for details of both the `seq` method and the API in general.

Here is the script above rewritten using the `seq` API method.

```
use strict ;
use DB_File ;

use vars qw($filename $x %h $status $key $value) ;

$filename = "tree" ;
unlink $filename ;

# Enable duplicate records
$DB_BTREE->{'flags'} = R_DUP ;

$x = tie %h, "DB_File", $filename, O_RDWR|O_CREAT, 0640, $DB_BTREE
    or die "Cannot open $filename: $!\n";

# Add some key/value pairs to the file
$h{'Wall'} = 'Larry' ;
$h{'Wall'} = 'Brick' ; # Note the duplicate key
$h{'Wall'} = 'Brick' ; # Note the duplicate key and value
$h{'Smith'} = 'John' ;
$h{'mouse'} = 'mickey' ;

# iterate through the btree using seq
# and print each key/value pair.
$key = $value = 0 ;
for ($status = $x->seq($key, $value, R_FIRST) ;
     $status == 0 ;
     $status = $x->seq($key, $value, R_NEXT) )
  {  print "$key -> $value\n" }

undef $x ;
untie %h ;
```

that prints:

```
Smith   -> John
Wall    -> Brick
Wall    -> Brick
Wall    -> Larry
mouse   -> mickey
```

This time we have got all the key/value pairs, including the multiple values associated with the key `Wall`.

To make life easier when dealing with duplicate keys, **DB_File** comes with a few utility methods.

The `get_dup()` Method

The `get_dup` method assists in reading duplicate values from BTREE databases. The method can take the following forms:

```
$count = $x->get_dup($key) ;
@list  = $x->get_dup($key) ;
%list  = $x->get_dup($key, 1) ;
```

In a scalar context the method returns the number of values associated with the key, `$key`.

In list context, it returns all the values which match `$key`. Note that the values will be returned in an apparently random order.

In list context, if the second parameter is present and evaluates TRUE, the method returns an associative array. The keys of the associative array correspond to the values that matched in the BTREE and the values of the array are a count of the number of times that particular value occurred in the BTREE.

So assuming the database created above, we can use `get_dup` like this:

```
use strict ;
use DB_File ;

use vars qw($filename $x %h ) ;

$filename = "tree" ;

# Enable duplicate records
$DB_BTREE->{'flags'} = R_DUP ;

$x = tie %h, "DB_File", $filename, O_RDWR|O_CREAT, 0640, $DB_BTREE
    or die "Cannot open $filename: $!\n";

my $cnt  = $x->get_dup("Wall") ;
print "Wall occurred $cnt times\n" ;

my %hash = $x->get_dup("Wall", 1) ;
print "Larry is there\n" if $hash{'Larry'} ;
print "There are $hash{'Brick'} Brick Walls\n" ;

my @list = sort $x->get_dup("Wall") ;
print "Wall =>      [@list]\n" ;

@list = $x->get_dup("Smith") ;
print "Smith =>     [@list]\n" ;

@list = $x->get_dup("Dog") ;
print "Dog =>       [@list]\n" ;
```

and it will print:

```
Wall occurred 3 times
Larry is there
There are 2 Brick Walls
Wall =>     [Brick Brick Larry]
Smith =>    [John]
Dog =>      []
```

The `find_dup()` Method

```
$status = $X->find_dup($key, $value) ;
```

This method checks for the existence of a specific key/value pair. If the pair exists, the cursor is left pointing to the pair and the method returns 0. Otherwise the method returns a non–zero value.

Assuming the database from the previous example:

```
use strict ;
use DB_File ;

use vars qw($filename $x %h $found) ;

my $filename = "tree" ;

# Enable duplicate records
$DB_BTREE->{'flags'} = R_DUP ;

$x = tie %h, "DB_File", $filename, O_RDWR|O_CREAT, 0640, $DB_BTREE
    or die "Cannot open $filename: $!\n";

$found = ( $x->find_dup("Wall", "Larry") == 0 ? "" : "not") ;
print "Larry Wall is $found there\n" ;

$found = ( $x->find_dup("Wall", "Harry") == 0 ? "" : "not") ;
print "Harry Wall is $found there\n" ;

undef $x ;
untie %h ;
```

prints this

```
Larry Wall is  there
Harry Wall is not there
```

The `del_dup()` Method

```
$status = $X->del_dup($key, $value) ;
```

This method deletes a specific key/value pair. It returns 0 if they exist and have been deleted successfully. Otherwise the method returns a non−zero value.

Again assuming the existence of the `tree` database

```
use strict ;
use DB_File ;

use vars qw($filename $x %h $found) ;

my $filename = "tree" ;

# Enable duplicate records
$DB_BTREE->{'flags'} = R_DUP ;

$x = tie %h, "DB_File", $filename, O_RDWR|O_CREAT, 0640, $DB_BTREE
    or die "Cannot open $filename: $!\n";

$x->del_dup("Wall", "Larry") ;

$found = ( $x->find_dup("Wall", "Larry") == 0 ? "" : "not") ;
print "Larry Wall is $found there\n" ;

undef $x ;
untie %h ;
```

prints this

```
Larry Wall is not there
```

Matching Partial Keys

The BTREE interface has a feature which allows partial keys to be matched. This functionality is *only* available when the `seq` method is used along with the R_CURSOR flag.

```
$x->seq($key, $value, R_CURSOR) ;
```

Here is the relevant quote from the dbopen man page where it defines the use of the R_CURSOR flag with seq:

```
Note, for the DB_BTREE access method, the returned key is not
necessarily an exact match for the specified key. The returned key
is the smallest key greater than or equal to the specified key,
permitting partial key matches and range searches.
```

In the example script below, the `match` sub uses this feature to find and print the first matching key/value pair given a partial key.

```
use strict ;
use DB_File ;
use Fcntl ;

use vars qw($filename $x %h $st $key $value) ;

sub match
{
    my $key = shift ;
    my $value = 0;
    my $orig_key = $key ;
    $x->seq($key, $value, R_CURSOR) ;
    print "$orig_key\t-> $key\t-> $value\n" ;
}

$filename = "tree" ;
unlink $filename ;

$x = tie %h, "DB_File", $filename, O_RDWR|O_CREAT, 0640, $DB_BTREE
    or die "Cannot open $filename: $!\n";

# Add some key/value pairs to the file
$h{'mouse'} = 'mickey' ;
$h{'Wall'} = 'Larry' ;
$h{'Walls'} = 'Brick' ;
$h{'Smith'} = 'John' ;

$key = $value = 0 ;
print "IN ORDER\n" ;
for ($st = $x->seq($key, $value, R_FIRST) ;
     $st == 0 ;
     $st = $x->seq($key, $value, R_NEXT) )

  {  print "$key    -> $value\n" }

print "\nPARTIAL MATCH\n" ;

match "Wa" ;
match "A" ;
match "a" ;

undef $x ;
untie %h ;
```

Here is the output:

```
IN ORDER
Smith -> John
Wall  -> Larry
```

```
Walls -> Brick
mouse -> mickey

PARTIAL MATCH
Wa -> Wall  -> Larry
A  -> Smith -> John
a  -> mouse -> mickey
```

DB_RECNO

DB_RECNO provides an interface to flat text files. Both variable and fixed length records are supported.

In order to make RECNO more compatible with Perl, the array offset for all RECNO arrays begins at 0 rather than 1 as in Berkeley DB.

As with normal Perl arrays, a RECNO array can be accessed using negative indexes. The index −1 refers to the last element of the array, −2 the second last, and so on. Attempting to access an element before the start of the array will raise a fatal run−time error.

The 'bval' Option

The operation of the bval option warrants some discussion. Here is the definition of bval from the Berkeley DB 1.85 recno manual page:

```
The delimiting byte to be used to mark  the  end  of  a
record for variable-length records, and the pad charac-
ter for fixed-length records.  If no  value  is  speci-
fied,  newlines  (''\n'')  are  used to mark the end of
variable-length records and  fixed-length  records  are
padded with spaces.
```

The second sentence is wrong. In actual fact bval will only default to `"\n"` when the openinfo parameter in dbopen is NULL. If a non−NULL openinfo parameter is used at all, the value that happens to be in bval will be used. That means you always have to specify bval when making use of any of the options in the openinfo parameter. This documentation error will be fixed in the next release of Berkeley DB.

That clarifies the situation with regards Berkeley DB itself. What about **DB_File**? Well, the behavior defined in the quote above is quite useful, so **DB_File** conforms to it.

That means that you can specify other options (e.g. cachesize) and still have bval default to `"\n"` for variable length records, and space for fixed length records.

A Simple Example

Here is a simple example that uses RECNO (if you are using a version of Perl earlier than 5.004_57 this example won't work — see *Extra RECNO Methods* for a workaround).

```
use strict ;
use DB_File ;

my $filename = "text" ;
unlink $filename ;

my @h ;
tie @h, "DB_File", $filename, O_RDWR|O_CREAT, 0640, $DB_RECNO
    or die "Cannot open file 'text': $!\n" ;

# Add a few key/value pairs to the file
$h[0] = "orange" ;
$h[1] = "blue" ;
$h[2] = "yellow" ;

push @h, "green", "black" ;
```

```
my $elements = scalar @h ;
print "The array contains $elements entries\n" ;

my $last = pop @h ;
print "popped $last\n" ;

unshift @h, "white" ;
my $first = shift @h ;
print "shifted $first\n" ;

# Check for existence of a key
print "Element 1 Exists with value $h[1]\n" if $h[1] ;

# use a negative index
print "The last element is $h[-1]\n" ;
print "The 2nd last element is $h[-2]\n" ;

untie @h ;
```

Here is the output from the script:

```
The array contains 5 entries
popped black
shifted white
Element 1 Exists with value blue
The last element is green
The 2nd last element is yellow
```

Extra RECNO Methods

If you are using a version of Perl earlier than 5.004_57, the tied array interface is quite limited. In the example script above `push`, `pop`, `shift`, `unshift` or determining the array length will not work with a tied array.

To make the interface more useful for older versions of Perl, a number of methods are supplied with **DB_File** to simulate the missing array operations. All these methods are accessed via the object returned from the tie call.

Here are the methods:

`$X->push(list) ;`

Pushes the elements of `list` to the end of the array.

`$value = $X->pop ;`

Removes and returns the last element of the array.

`$X->shift`

Removes and returns the first element of the array.

`$X->unshift(list) ;`

Pushes the elements of `list` to the start of the array.

`$X->length`

Returns the number of elements in the array.

Another Example

Here is a more complete example that makes use of some of the methods described above. It also makes use of the API interface directly (see *THE API INTERFACE*).

```
use strict ;
use vars qw(@h $H $file $i) ;
use DB_File ;
use Fcntl ;
```

```
$file = "text" ;

unlink $file ;

$H = tie @h, "DB_File", $file, O_RDWR|O_CREAT, 0640, $DB_RECNO
    or die "Cannot open file $file: $!\n" ;

# first create a text file to play with
$h[0] = "zero" ;
$h[1] = "one" ;
$h[2] = "two" ;
$h[3] = "three" ;
$h[4] = "four" ;

# Print the records in order.
#
# The length method is needed here because evaluating a tied
# array in a scalar context does not return the number of
# elements in the array.

print "\nORIGINAL\n" ;
foreach $i (0 .. $H->length - 1) {
    print "$i: $h[$i]\n" ;
}

# use the push & pop methods
$a = $H->pop ;
$H->push("last") ;
print "\nThe last record was [$a]\n" ;

# and the shift & unshift methods
$a = $H->shift ;
$H->unshift("first") ;
print "The first record was [$a]\n" ;

# Use the API to add a new record after record 2.
$i = 2 ;
$H->put($i, "Newbie", R_IAFTER) ;

# and a new record before record 1.
$i = 1 ;
$H->put($i, "New One", R_IBEFORE) ;

# delete record 3
$H->del(3) ;

# now print the records in reverse order
print "\nREVERSE\n" ;
for ($i = $H->length - 1 ; $i >= 0 ; -- $i)
  { print "$i: $h[$i]\n" }

# same again, but use the API functions instead
print "\nREVERSE again\n" ;
my ($s, $k, $v)  = (0, 0, 0) ;
for ($s = $H->seq($k, $v, R_LAST) ;
         $s == 0 ;
         $s = $H->seq($k, $v, R_PREV))
  { print "$k: $v\n" }

undef $H ;
untie @h ;
```

and this is what it outputs:

```
ORIGINAL
0: zero
1: one
2: two
3: three
4: four

The last record was [four]
The first record was [zero]

REVERSE
5: last
4: three
3: Newbie
2: one
1: New One
0: first

REVERSE again
5: last
4: three
3: Newbie
2: one
1: New One
0: first
```

Notes:

1. Rather than iterating through the array, `@h` like this:

   ```
   foreach $i (@h)
   ```

   it is necessary to use either this:

   ```
   foreach $i (0 .. $H->length - 1)
   ```

   or this:

   ```
   for ($a = $H->get($k, $v, R_FIRST) ;
        $a == 0 ;
        $a = $H->get($k, $v, R_NEXT) )
   ```

2. Notice that both times the `put` method was used the record index was specified using a variable, `$i`, rather than the literal value itself. This is because `put` will return the record number of the inserted line via that parameter.

THE API INTERFACE

As well as accessing Berkeley DB using a tied hash or array, it is also possible to make direct use of most of the API functions defined in the Berkeley DB documentation.

To do this you need to store a copy of the object returned from the tie.

```
$db = tie %hash, "DB_File", "filename" ;
```

Once you have done that, you can access the Berkeley DB API functions as **DB_File** methods directly like this:

```
$db->put($key, $value, R_NOOVERWRITE) ;
```

Important: If you have saved a copy of the object returned from `tie`, the underlying database file will *not* be closed until both the tied variable is untied and all copies of the saved object are destroyed.

```
use DB_File ;
$db = tie %hash, "DB_File", "filename"
    or die "Cannot tie filename: $!" ;
...
undef $db ;
untie %hash ;
```

See *The `untie()` Gotcha* for more details.

All the functions defined in *dbopen* are available except for `close()` and `dbopen()` itself. The **DB_File** method interface to the supported functions have been implemented to mirror the way Berkeley DB works whenever possible. In particular note that:

- The methods return a status value. All return 0 on success. All return −1 to signify an error and set `$!` to the exact error code. The return code 1 generally (but not always) means that the key specified did not exist in the database.

  Other return codes are defined. See below and in the Berkeley DB documentation for details. The Berkeley DB documentation should be used as the definitive source.

- Whenever a Berkeley DB function returns data via one of its parameters, the equivalent **DB_File** method does exactly the same.

- If you are careful, it is possible to mix API calls with the tied hash/array interface in the same piece of code. Although only a few of the methods used to implement the tied interface currently make use of the cursor, you should always assume that the cursor has been changed any time the tied hash/array interface is used. As an example, this code will probably not do what you expect:

  ```
  $X = tie %x, 'DB_File', $filename, O_RDWR|O_CREAT, 0777, $DB_BTREE
      or die "Cannot tie $filename: $!" ;

  # Get the first key/value pair and set  the cursor
  $X->seq($key, $value, R_FIRST) ;

  # this line will modify the cursor
  $count = scalar keys %x ;

  # Get the second key/value pair.
  # oops, it didn't, it got the last key/value pair!
  $X->seq($key, $value, R_NEXT) ;
  ```

  The code above can be rearranged to get around the problem, like this:

  ```
  $X = tie %x, 'DB_File', $filename, O_RDWR|O_CREAT, 0777, $DB_BTREE
      or die "Cannot tie $filename: $!" ;

  # this line will modify the cursor
  $count = scalar keys %x ;

  # Get the first key/value pair and set  the cursor
  $X->seq($key, $value, R_FIRST) ;

  # Get the second key/value pair.
  # worked this time.
  $X->seq($key, $value, R_NEXT) ;
  ```

All the constants defined in *dbopen* for use in the flags parameters in the methods defined below are also available. Refer to the Berkeley DB documentation for the precise meaning of the flags values.

Below is a list of the methods available.

$status = $X->get($key, $value [, $flags]) ;

Given a key (`$key`) this method reads the value associated with it from the database. The value read from the database is returned in the `$value` parameter.

If the key does not exist the method returns 1.

No flags are currently defined for this method.

$status = $X->put($key, $value [, $flags]) ;

Stores the key/value pair in the database.

If you use either the R_IAFTER or R_IBEFORE flags, the `$key` parameter will have the record number of the inserted key/value pair set.

Valid flags are R_CURSOR, R_IAFTER, R_IBEFORE, R_NOOVERWRITE and R_SETCURSOR.

$status = $X->del($key [, $flags]) ;

Removes all key/value pairs with key `$key` from the database.

A return code of 1 means that the requested key was not in the database.

R_CURSOR is the only valid flag at present.

$status = $X->fd ;

Returns the file descriptor for the underlying database.

See *Locking: The Trouble with fd* for an explanation for why you should not use `fd` to lock your database.

$status = $X->seq($key, $value, $flags) ;

This interface allows sequential retrieval from the database. See *dbopen* for full details.

Both the `$key` and `$value` parameters will be set to the key/value pair read from the database.

The flags parameter is mandatory. The valid flag values are R_CURSOR, R_FIRST, R_LAST, R_NEXT and R_PREV.

$status = $X->sync([$flags]) ;

Flushes any cached buffers to disk.

R_RECNOSYNC is the only valid flag at present.

DBM FILTERS

A DBM Filter is a piece of code that is be used when you *always* want to make the same transformation to all keys and/or values in a DBM database.

There are four methods associated with DBM Filters. All work identically, and each is used to install (or uninstall) a single DBM Filter. Each expects a single parameter, namely a reference to a sub. The only difference between them is the place that the filter is installed.

To summarise:

filter_store_key

If a filter has been installed with this method, it will be invoked every time you write a key to a DBM database.

filter_store_value

If a filter has been installed with this method, it will be invoked every time you write a value to a DBM database.

filter_fetch_key

If a filter has been installed with this method, it will be invoked every time you read a key from a DBM database.

filter_fetch_value

If a filter has been installed with this method, it will be invoked every time you read a value from a DBM database.

You can use any combination of the methods, from none, to all four.

All filter methods return the existing filter, if present, or `undef` in not.

To delete a filter pass `undef` to it.

The Filter

When each filter is called by Perl, a local copy of `$_` will contain the key or value to be filtered. Filtering is achieved by modifying the contents of `$_`. The return code from the filter is ignored.

An Example — the NULL termination problem.

Consider the following scenario. You have a DBM database that you need to share with a third–party C application. The C application assumes that *all* keys and values are NULL terminated. Unfortunately when Perl writes to DBM databases it doesn't use NULL termination, so your Perl application will have to manage NULL termination itself. When you write to the database you will have to use something like this:

```
$hash{"$key\0"} = "$value\0" ;
```

Similarly the NULL needs to be taken into account when you are considering the length of existing keys/values.

It would be much better if you could ignore the NULL terminations issue in the main application code and have a mechanism that automatically added the terminating NULL to all keys and values whenever you write to the database and have them removed when you read from the database. As I'm sure you have already guessed, this is a problem that DBM Filters can fix very easily.

```
use strict ;
use DB_File ;

my %hash ;
my $filename = "/tmp/filt" ;
unlink $filename ;

my $db = tie %hash, 'DB_File', $filename, O_CREAT|O_RDWR, 0666, $DB_HASH
  or die "Cannot open $filename: $!\n" ;

# Install DBM Filters
$db->filter_fetch_key  ( sub { s/\0$//    } ) ;
$db->filter_store_key  ( sub { $_ .= "\0" } ) ;
$db->filter_fetch_value( sub { s/\0$//    } ) ;
$db->filter_store_value( sub { $_ .= "\0" } ) ;

$hash{"abc"} = "def" ;
my $a = $hash{"ABC"} ;
# ...
undef $db ;
untie %hash ;
```

Hopefully the contents of each of the filters should be self–explanatory. Both "fetch" filters remove the terminating NULL, and both "store" filters add a terminating NULL.

Another Example — Key is a C int.

Here is another real–life example. By default, whenever Perl writes to a DBM database it always writes the key and value as strings. So when you use this:

```
$hash{12345} = "soemthing" ;
```

the key 12345 will get stored in the DBM database as the 5 byte string "12345". If you actually want the key to be stored in the DBM database as a C int, you will have to use `pack` when writing, and `unpack` when reading.

Here is a DBM Filter that does it:

```
use strict ;
use DB_File ;
my %hash ;
my $filename = "/tmp/filt" ;
unlink $filename ;

my $db = tie %hash, 'DB_File', $filename, O_CREAT|O_RDWR, 0666, $DB_HASH
  or die "Cannot open $filename: $!\n" ;

$db->filter_fetch_key  ( sub { $_ = unpack("i", $_) } ) ;
$db->filter_store_key  ( sub { $_ = pack ("i", $_) } ) ;
$hash{123} = "def" ;
# ...
undef $db ;
untie %hash ;
```

This time only two filters have been used — we only need to manipulate the contents of the key, so it wasn't necessary to install any value filters.

HINTS AND TIPS

Locking: The Trouble with fd

Until version 1.72 of this module, the recommended technique for locking **DB_File** databases was to flock the filehandle returned from the "fd" function. Unfortunately this technique has been shown to be fundamentally flawed (Kudos to David Harris for tracking this down). Use it at your own peril!

The locking technique went like this.

```
$db = tie(%db, 'DB_File', '/tmp/foo.db', O_CREAT|O_RDWR, 0644)
    || die "dbcreat /tmp/foo.db $!";
$fd = $db->fd;
open(DB_FH, "+<&=$fd") || die "dup $!";
flock (DB_FH, LOCK_EX) || die "flock: $!";
...
$db{"Tom"} = "Jerry" ;
...
flock(DB_FH, LOCK_UN);
undef $db;
untie %db;
close(DB_FH);
```

In simple terms, this is what happens:

1. Use "tie" to open the database.
2. Lock the database with fd & flock.
3. Read & Write to the database.
4. Unlock and close the database.

Here is the crux of the problem. A side–effect of opening the **DB_File** database in step 2 is that an initial block from the database will get read from disk and cached in memory.

To see why this is a problem, consider what can happen when two processes, say "A" and "B", both want to update the same **DB_File** database using the locking steps outlined above. Assume process "A" has already

opened the database and has a write lock, but it hasn't actually updated the database yet (it has finished step 2, but not started step 3 yet). Now process "B" tries to open the same database – step 1 will succeed, but it will block on step 2 until process "A" releases the lock. The important thing to notice here is that at this point in time both processes will have cached identical initial blocks from the database.

Now process "A" updates the database and happens to change some of the data held in the initial buffer. Process "A" terminates, flushing all cached data to disk and releasing the database lock. At this point the database on disk will correctly reflect the changes made by process "A".

With the lock released, process "B" can now continue. It also updates the database and unfortunately it too modifies the data that was in its initial buffer. Once that data gets flushed to disk it will overwrite some/all of the changes process "A" made to the database.

The result of this scenario is at best a database that doesn't contain what you expect. At worst the database will corrupt.

The above won't happen every time competing process update the same **DB_File** database, but it does illustrate why the technique should not be used.

Safe ways to lock a database

Starting with version 2.x, Berkeley DB has internal support for locking. The companion module to this one, **BerkeleyDB**, provides an interface to this locking functionality. If you are serious about locking Berkeley DB databases, I strongly recommend using **BerkeleyDB**.

If using **BerkeleyDB** isn't an option, there are a number of modules available on CPAN that can be used to implement locking. Each one implements locking differently and has different goals in mind. It is therefore worth knowing the difference, so that you can pick the right one for your application. Here are the three locking wrappers:

Tie::DB_Lock

A **DB_File** wrapper which creates copies of the database file for read access, so that you have a kind of a multiversioning concurrent read system. However, updates are still serial. Use for databases where reads may be lengthy and consistency problems may occur.

Tie::DB_LockFile

A **DB_File** wrapper that has the ability to lock and unlock the database while it is being used. Avoids the tie–before–flock problem by simply re–tie–ing the database when you get or drop a lock. Because of the flexibility in dropping and re–acquiring the lock in the middle of a session, this can be massaged into a system that will work with long updates and/or reads if the application follows the hints in the POD documentation.

DB_File::Lock

An extremely lightweight **DB_File** wrapper that simply flocks a lockfile before tie–ing the database and drops the lock after the untie. Allows one to use the same lockfile for multiple databases to avoid deadlock problems, if desired. Use for databases where updates are reads are quick and simple flock locking semantics are enough.

Sharing Databases With C Applications

There is no technical reason why a Berkeley DB database cannot be shared by both a Perl and a C application.

The vast majority of problems that are reported in this area boil down to the fact that C strings are NULL terminated, whilst Perl strings are not. See *DBM FILTERS* for a generic way to work around this problem.

Here is a real example. Netscape 2.0 keeps a record of the locations you visit along with the time you last visited them in a DB_HASH database. This is usually stored in the file ***~/.netscape/history.db***. The key field in the database is the location string and the value field is the time the location was last visited stored as a 4 byte binary value.

If you haven't already guessed, the location string is stored with a terminating NULL. This means you need

to be careful when accessing the database.

Here is a snippet of code that is loosely based on Tom Christiansen's *ggh* script (available from your nearest CPAN archive in ***authors/id/TOMC/scripts/nshist.gz***).

```
use strict ;
use DB_File ;
use Fcntl ;

use vars qw( $dotdir $HISTORY %hist_db $href $binary_time $date ) ;
$dotdir = $ENV{HOME} || $ENV{LOGNAME};

$HISTORY = "$dotdir/.netscape/history.db";

tie %hist_db, 'DB_File', $HISTORY
    or die "Cannot open $HISTORY: $!\n" ;;

# Dump the complete database
while ( ($href, $binary_time) = each %hist_db ) {

    # remove the terminating NULL
    $href =~ s/\x00$// ;

    # convert the binary time into a user friendly string
    $date = localtime unpack("V", $binary_time);
    print "$date $href\n" ;
}

# check for the existence of a specific key
# remember to add the NULL
if ( $binary_time = $hist_db{"http://mox.perl.com/\x00"} ) {
    $date = localtime unpack("V", $binary_time) ;
    print "Last visited mox.perl.com on $date\n" ;
}
else {
    print "Never visited mox.perl.com\n"
}

untie %hist_db ;
```

The `untie()` Gotcha

If you make use of the Berkeley DB API, it is *very* strongly recommended that you read *The untie Gotcha*.

Even if you don't currently make use of the API interface, it is still worth reading it.

Here is an example which illustrates the problem from a **DB_File** perspective:

```
use DB_File ;
use Fcntl ;

my %x ;
my $X ;

$X = tie %x, 'DB_File', 'tst.fil' , O_RDWR|O_TRUNC
    or die "Cannot tie first time: $!" ;

$x{123} = 456 ;

untie %x ;

tie %x, 'DB_File', 'tst.fil' , O_RDWR|O_CREAT
    or die "Cannot tie second time: $!" ;

untie %x ;
```

When run, the script will produce this error message:

```
Cannot tie second time: Invalid argument at bad.file line 14.
```

Although the error message above refers to the second `tie()` statement in the script, the source of the problem is really with the `untie()` statement that precedes it.

Having read *perltie* you will probably have already guessed that the error is caused by the extra copy of the tied object stored in `$X`. If you haven't, then the problem boils down to the fact that the **DB_File** destructor, DESTROY, will not be called until *all* references to the tied object are destroyed. Both the tied variable, `%x`, and `$X` above hold a reference to the object. The call to `untie()` will destroy the first, but `$X` still holds a valid reference, so the destructor will not get called and the database file ***tst.fil*** will remain open. The fact that Berkeley DB then reports the attempt to open a database that is already open via the catch−all "Invalid argument" doesn't help.

If you run the script with the `−w` flag the error message becomes:

```
untie attempted while 1 inner references still exist at bad.file line 12.
Cannot tie second time: Invalid argument at bad.file line 14.
```

which pinpoints the real problem. Finally the script can now be modified to fix the original problem by destroying the API object before the untie:

```
...
$x{123} = 456 ;

undef $X ;
untie %x ;

$X = tie %x, 'DB_File', 'tst.fil' , O_RDWR|O_CREAT
...
```

COMMON QUESTIONS

Why is there Perl source in my database?

If you look at the contents of a database file created by DB_File, there can sometimes be part of a Perl script included in it.

This happens because Berkeley DB uses dynamic memory to allocate buffers which will subsequently be written to the database file. Being dynamic, the memory could have been used for anything before DB malloced it. As Berkeley DB doesn't clear the memory once it has been allocated, the unused portions will contain random junk. In the case where a Perl script gets written to the database, the random junk will correspond to an area of dynamic memory that happened to be used during the compilation of the script.

Unless you don't like the possibility of there being part of your Perl scripts embedded in a database file, this is nothing to worry about.

How do I store complex data structures with DB_File?

Although **DB_File** cannot do this directly, there is a module which can layer transparently over **DB_File** to accomplish this feat.

Check out the MLDBM module, available on CPAN in the directory ***modules/by−module/MLDBM***.

What does "Invalid Argument" mean?

You will get this error message when one of the parameters in the `tie` call is wrong. Unfortunately there are quite a few parameters to get wrong, so it can be difficult to figure out which one it is.

Here are a couple of possibilities:

1. Attempting to reopen a database without closing it.

2. Using the O_WRONLY flag.

What does "Bareword 'DB_File' not allowed" mean?

You will encounter this particular error message when you have the `strict 'subs'` pragma (or the full strict pragma) in your script. Consider this script:

```
use strict ;
use DB_File ;
use vars qw(%x) ;
tie %x, DB_File, "filename" ;
```

Running it produces the error in question:

```
Bareword "DB_File" not allowed while "strict subs" in use
```

To get around the error, place the word `DB_File` in either single or double quotes, like this:

```
tie %x, "DB_File", "filename" ;
```

Although it might seem like a real pain, it is really worth the effort of having a `use strict` in all your scripts.

REFERENCES

Articles that are either about **DB_File** or make use of it.

1. *Full−Text Searching in Perl*, Tim Kientzle (tkientzle@ddj.com), Dr. Dobb's Journal, Issue 295, January 1999, pp 34−41

HISTORY

Moved to the Changes file.

BUGS

Some older versions of Berkeley DB had problems with fixed length records using the RECNO file format. This problem has been fixed since version 1.85 of Berkeley DB.

I am sure there are bugs in the code. If you do find any, or can suggest any enhancements, I would welcome your comments.

AVAILABILITY

DB_File comes with the standard Perl source distribution. Look in the directory ***ext/DB_File***. Given the amount of time between releases of Perl the version that ships with Perl is quite likely to be out of date, so the most recent version can always be found on CPAN (see *CPAN* for details), in the directory ***modules/by−module/DB_File***.

This version of **DB_File** will work with either version 1.x, 2.x or 3.x of Berkeley DB, but is limited to the functionality provided by version 1.

The official web site for Berkeley DB is ***http://www.sleepycat.com***. All versions of Berkeley DB are available there.

Alternatively, Berkeley DB version 1 is available at your nearest CPAN archive in ***src/misc/db.1.85.tar.gz***.

If you are running IRIX, then get Berkeley DB version 1 from ***http://reality.sgi.com/ariel***. It has the patches necessary to compile properly on IRIX 5.3.

COPYRIGHT

Here are are few words taken from the Berkeley DB FAQ (at ***http://www.sleepycat.com***) regarding the license:

```
Do I have to license DB to use it in Perl scripts?

No. The Berkeley DB license requires that software that uses
Berkeley DB be freely redistributable. In the case of Perl, that
software is Perl, and not your scripts. Any Perl scripts that you
write are your property, including scripts that make use of
Berkeley DB. Neither the Perl license nor the Berkeley DB license
place any restriction on what you may do with them.
```

If you are in any doubt about the license situation, contact either the Berkeley DB authors or the author of DB_File. See *"AUTHOR"* for details.

SEE ALSO

perl(1), *dbopen(3)*, *hash(3)*, *recno(3)*, *btree(3)*, *dbmfilter*

AUTHOR

The DB_File interface was written by Paul Marquess <Paul.Marquess@btinternet.com>. Questions about the DB system itself may be addressed to <db@sleepycat.com<gt.

NAME

Devel::DProf – a Perl code profiler

SYNOPSIS

```
perl5 -d:DProf test.pl
```

DESCRIPTION

The Devel::DProf package is a Perl code profiler. This will collect information on the execution time of a Perl script and of the subs in that script. This information can be used to determine which subroutines are using the most time and which subroutines are being called most often. This information can also be used to create an execution graph of the script, showing subroutine relationships.

To profile a Perl script run the perl interpreter with the **-d** debugging switch. The profiler uses the debugging hooks. So to profile script ***test.pl*** the following command should be used:

```
perl5 -d:DProf test.pl
```

When the script terminates (or when the output buffer is filled) the profiler will dump the profile information to a file called ***tmon.out***. A tool like *dprofpp* can be used to interpret the information which is in that profile. The following command will print the top 15 subroutines which used the most time:

```
dprofpp
```

To print an execution graph of the subroutines in the script use the following command:

```
dprofpp -T
```

Consult *dprofpp* for other options.

PROFILE FORMAT

The old profile is a text file which looks like this:

```
#fOrTyTwO
$hz=100;
$XS_VERSION='DProf 19970606';
# All values are given in HZ
$rrun_utime=2; $rrun_stime=0; $rrun_rtime=7
PART2
+ 26 28 566822884 DynaLoader::import
- 26 28 566822884 DynaLoader::import
+ 27 28 566822885 main::bar
- 27 28 566822886 main::bar
+ 27 28 566822886 main::baz
+ 27 28 566822887 main::bar
- 27 28 566822888 main::bar
[....]
```

The first line is the magic number. The second line is the hertz value, or clock ticks, of the machine where the profile was collected. The third line is the name and version identifier of the tool which created the profile. The fourth line is a comment. The fifth line contains three variables holding the user time, system time, and realtime of the process while it was being profiled. The sixth line indicates the beginning of the sub entry/exit profile section.

The columns in **PART2** are:

```
sub entry(+)/exit(-) mark
app's user time at sub entry/exit mark, in ticks
app's system time at sub entry/exit mark, in ticks
app's realtime at sub entry/exit mark, in ticks
fully-qualified sub name, when possible
```

With newer perls another format is used, which may look like this:

```
#fOrTyTwO
$hz=10000;
$XS_VERSION='DProf 19971213';
# All values are given in HZ
$over_utime=5917; $over_stime=0; $over_rtime=5917;
$over_tests=10000;
$rrun_utime=1284; $rrun_stime=0; $rrun_rtime=1284;
$total_marks=6;

PART2
@ 406 0 406
& 2 main bar
+ 2
@ 456 0 456
- 2
@ 1 0 1
& 3 main baz
+ 3
@ 141 0 141
+ 2
@ 141 0 141
- 2
@ 1 0 1
& 4 main foo
+ 4
@ 142 0 142
+ & Devel::DProf::write
@ 5 0 5
- & Devel::DProf::write
```

(with high value of `$ENV{PERL_DPROF_TICKS}`).

New `$over_*` values show the measured overhead of making `$over_tests` calls to the profiler These values are used by the profiler to subtract the overhead from the runtimes.

The lines starting with `@` mark time passed from the previous `@` line. The lines starting with `&` introduce new subroutine *id* and show the package and the subroutine name of this id. Lines starting with `+`, `-` and `*` mark entering and exit of subroutines by *id*s, and `goto &subr`.

The *old-style* `+-` and `--`lines are used to mark the overhead related to writing to profiler-output file.

AUTOLOAD

When Devel::DProf finds a call to an `&AUTOLOAD` subroutine it looks at the `$AUTOLOAD` variable to find the real name of the sub being called. See *Autoloading in perlsub*.

ENVIRONMENT

`PERL_DPROF_BUFFER` sets size of output buffer in words. Defaults to 2**14.

`PERL_DPROF_TICKS` sets number of ticks per second on some systems where a replacement for `times()` is used. Defaults to the value of `HZ` macro.

`PERL_DPROF_OUT_FILE_NAME` sets the name of the output file. If not set, defaults to tmon.out.

BUGS

Builtin functions cannot be measured by Devel::DProf.

With a newer Perl DProf relies on the fact that the numeric slot of `$DB::sub` contains an address of a subroutine. Excessive manipulation of this variable may overwrite this slot, as in

```
$DB::sub = 'current_sub';
...
$addr = $DB::sub + 0;
```

will set this numeric slot to numeric value of the string `current_sub`, i.e., to . This will cause a segfault on the exit from this subroutine. Note that the first assignment above does not change the numeric slot (it will *mark* it as invalid, but will not write over it).

Mail bug reports and feature requests to the perl5−porters mailing list at ***<perl5−porters@perl.org>***.

SEE ALSO

perl, *dprofpp*, times(2)

NAME

Devel::Peek – A data debugging tool for the XS programmer

SYNOPSIS

```
use Devel::Peek;
Dump( $a );
Dump( $a, 5 );
DumpArray( 5, $a, $b, ... );
mstat "Point 5";
```

DESCRIPTION

Devel::Peek contains functions which allows raw Perl datatypes to be manipulated from a Perl script. This is used by those who do XS programming to check that the data they are sending from C to Perl looks as they think it should look. The trick, then, is to know what the raw datatype is supposed to look like when it gets to Perl. This document offers some tips and hints to describe good and bad raw data.

It is very possible that this document will fall far short of being useful to the casual reader. The reader is expected to understand the material in the first few sections of *perlguts*.

Devel::Peek supplies a `Dump()` function which can dump a raw Perl datatype, and `mstat("marker")` function to report on memory usage (if perl is compiled with corresponding option). The function `DeadCode()` provides statistics on the data "frozen" into inactive `CV`. Devel::Peek also supplies `SvREFCNT()`, `SvREFCNT_inc()`, and `SvREFCNT_dec()` which can query, increment, and decrement reference counts on SVs. This document will take a passive, and safe, approach to data debugging and for that it will describe only the `Dump()` function.

Function `DumpArray()` allows dumping of multiple values (useful when you need to analyze returns of functions).

The global variable `$Devel::Peek::pv_limit` can be set to limit the number of character printed in various string values. Setting it to 0 means no limit.

Memory footprint debugging

When perl is compiled with support for memory footprint debugging (default with Perl's `malloc()`), Devel::Peek provides an access to this API.

Use `mstat()` function to emit a memory state statistic to the terminal. For more information on the format of output of `mstat()` see *Using $ENV{PERL_DEBUG_MSTATS}*.

Three additional functions allow access to this statistic from Perl. First, use `mstats_fillhash(%hash)` to get the information contained in the output of `mstat()` into %hash. The field of this hash are

```
minbucket nbuckets sbrk_good sbrk_slack sbrked_remains sbrks start_slack
topbucket topbucket_ev topbucket_odd total total_chain total_sbrk totfree
```

Two additional fields `free`, `used` contain array references which provide per–bucket count of free and used chunks. Two other fields `mem_size`, `available_size` contain array references which provide the information about the allocated size and usable size of chunks in each bucket. Again, see *Using $ENV{PERL_DEBUG_MSTATS}* for details.

Keep in mind that only the first several "odd–numbered" buckets are used, so the information on size of the "odd–numbered" buckets which are not used is probably meaningless.

The information in

```
mem_size available_size minbucket nbuckets
```

is the property of a particular build of perl, and does not depend on the current process. If you do not provide the optional argument to the functions `mstats_fillhash()`, `fill_mstats()`, `mstats2hash()`, then the information in fields `mem_size`, `available_size` is not updated.

`fill_mstats($buf)` is a much cheaper call (both speedwise and memory–wise) which collects the statistic into `$buf` in machine–readable form. At a later moment you may need to call `mstats2hash($buf, %hash)` to use this information to fill %hash.

All three APIs `fill_mstats($buf)`, `mstats_fillhash(%hash)`, and `mstats2hash($buf, %hash)` are designed to allocate no memory if used *the second time* on the same `$buf` and/or %hash.

So, if you want to collect memory info in a cycle, you may call

```
$#buf = 999;
fill_mstats($_) for @buf;
mstats_fillhash(%report, 1);          # Static info too

foreach (@buf) {
  # Do something...
  fill_mstats $_;                     # Collect statistic
}
foreach (@buf) {
  mstats2hash($_, %report);           # Preserve static info
  # Do something with %report
}
```

EXAMPLES

The following examples don't attempt to show everything as that would be a monumental task, and, frankly, we don't want this manpage to be an internals document for Perl. The examples do demonstrate some basics of the raw Perl datatypes, and should suffice to get most determined people on their way. There are no guidewires or safety nets, nor blazed trails, so be prepared to travel alone from this point and on and, if at all possible, don't fall into the quicksand (it's bad for business).

Oh, one final bit of advice: take *perlguts* with you. When you return we expect to see it well–thumbed.

A simple scalar string

Let's begin by looking a simple scalar which is holding a string.

```
use Devel::Peek;
$a = "hello";
Dump $a;
```

The output:

```
SV = PVIV(0xbc288)
  REFCNT = 1
  FLAGS = (POK,pPOK)
  IV = 0
  PV = 0xb2048 "hello"\0
  CUR = 5
  LEN = 6
```

This says `$a` is an SV, a scalar. The scalar is a PVIV, a string. Its reference count is 1. It has the `POK` flag set, meaning its current PV field is valid. Because POK is set we look at the PV item to see what is in the scalar. The \0 at the end indicate that this PV is properly NUL–terminated. If the FLAGS had been IOK we would look at the IV item. CUR indicates the number of characters in the PV. LEN indicates the number of bytes requested for the PV (one more than CUR, in this case, because LEN includes an extra byte for the end–of–string marker).

A simple scalar number

If the scalar contains a number the raw SV will be leaner.

```
use Devel::Peek;
$a = 42;
```

```
Dump $a;
```

The output:

```
SV = IV(0xbc818)
  REFCNT = 1
  FLAGS = (IOK,pIOK)
  IV = 42
```

This says `$a` is an SV, a scalar. The scalar is an IV, a number. Its reference count is 1. It has the `IOK` flag set, meaning it is currently being evaluated as a number. Because IOK is set we look at the IV item to see what is in the scalar.

A simple scalar with an extra reference

If the scalar from the previous example had an extra reference:

```
use Devel::Peek;
$a = 42;
$b = \$a;
Dump $a;
```

The output:

```
SV = IV(0xbe860)
  REFCNT = 2
  FLAGS = (IOK,pIOK)
  IV = 42
```

Notice that this example differs from the previous example only in its reference count. Compare this to the next example, where we dump `$b` instead of `$a`.

A reference to a simple scalar

This shows what a reference looks like when it references a simple scalar.

```
use Devel::Peek;
$a = 42;
$b = \$a;
Dump $b;
```

The output:

```
SV = RV(0xf041c)
  REFCNT = 1
  FLAGS = (ROK)
  RV = 0xbab08
SV = IV(0xbe860)
  REFCNT = 2
  FLAGS = (IOK,pIOK)
  IV = 42
```

Starting from the top, this says `$b` is an SV. The scalar is an RV, a reference. It has the `ROK` flag set, meaning it is a reference. Because ROK is set we have an RV item rather than an IV or PV. Notice that Dump follows the reference and shows us what `$b` was referencing. We see the same `$a` that we found in the previous example.

Note that the value of `RV` coincides with the numbers we see when we stringify `$b`. The addresses inside `RV()` and `IV()` are addresses of `X***` structure which holds the current state of an `SV`. This address may change during lifetime of an SV.

A reference to an array

This shows what a reference to an array looks like.

```
use Devel::Peek;
$a = [42];
Dump $a;
```

The output:

```
SV = RV(0xf041c)
  REFCNT = 1
  FLAGS = (ROK)
  RV = 0xb2850
SV = PVAV(0xbd448)
  REFCNT = 1
  FLAGS = ()
  IV = 0
  NV = 0
  ARRAY = 0xb2048
  ALLOC = 0xb2048
  FILL = 0
  MAX = 0
  ARYLEN = 0x0
  FLAGS = (REAL)
Elt No. 0 0xb5658
SV = IV(0xbe860)
  REFCNT = 1
  FLAGS = (IOK,pIOK)
  IV = 42
```

This says `$a` is an SV and that it is an RV. That RV points to another SV which is a PVAV, an array. The array has one element, element zero, which is another SV. The field `FILL` above indicates the last element in the array, similar to `$#$a`.

If `$a` pointed to an array of two elements then we would see the following.

```
use Devel::Peek 'Dump';
$a = [42,24];
Dump $a;
```

The output:

```
SV = RV(0xf041c)
  REFCNT = 1
  FLAGS = (ROK)
  RV = 0xb2850
SV = PVAV(0xbd448)
  REFCNT = 1
  FLAGS = ()
  IV = 0
  NV = 0
  ARRAY = 0xb2048
  ALLOC = 0xb2048
  FILL = 0
  MAX = 0
  ARYLEN = 0x0
  FLAGS = (REAL)
Elt No. 0  0xb5658
```

```
SV = IV(0xbe860)
  REFCNT = 1
  FLAGS = (IOK,pIOK)
  IV = 42
Elt No. 1  0xb5680
SV = IV(0xbe818)
  REFCNT = 1
  FLAGS = (IOK,pIOK)
  IV = 24
```

Note that `Dump` will not report *all* the elements in the array, only several first (depending on how deep it already went into the report tree).

A reference to a hash

The following shows the raw form of a reference to a hash.

```
use Devel::Peek;
$a = {hello=>42};
Dump $a;
```

The output:

```
SV = RV(0xf041c)
  REFCNT = 1
  FLAGS = (ROK)
  RV = 0xb2850
SV = PVHV(0xbd448)
  REFCNT = 1
  FLAGS = ()
  NV = 0
  ARRAY = 0xbd748
  KEYS = 1
  FILL = 1
  MAX = 7
  RITER = -1
  EITER = 0x0
Elt "hello" => 0xbaaf0
SV = IV(0xbe860)
  REFCNT = 1
  FLAGS = (IOK,pIOK)
  IV = 42
```

This shows `$a` is a reference pointing to an SV. That SV is a PVHV, a hash. Fields RITER and EITER are used by *each*.

Dumping a large array or hash

The `Dump()` function, by default, dumps up to 4 elements from a toplevel array or hash. This number can be increased by supplying a second argument to the function.

```
use Devel::Peek;
$a = [10,11,12,13,14];
Dump $a;
```

Notice that `Dump()` prints only elements 10 through 13 in the above code. The following code will print all of the elements.

```
use Devel::Peek 'Dump';
$a = [10,11,12,13,14];
Dump $a, 5;
```

A reference to an SV which holds a C pointer

This is what you really need to know as an XS programmer, of course. When an XSUB returns a pointer to a C structure that pointer is stored in an SV and a reference to that SV is placed on the XSUB stack. So the output from an XSUB which uses something like the T_PTROBJ map might look something like this:

```
SV = RV(0xf381c)
  REFCNT = 1
  FLAGS = (ROK)
  RV = 0xb8ad8
SV = PVMG(0xbb3c8)
  REFCNT = 1
  FLAGS = (OBJECT,IOK,pIOK)
  IV = 729160
  NV = 0
  PV = 0
  STASH = 0xc1d10       "CookBookB::Opaque"
```

This shows that we have an SV which is an RV. That RV points at another SV. In this case that second SV is a PVMG, a blessed scalar. Because it is blessed it has the `OBJECT` flag set. Note that an SV which holds a C pointer also has the `IOK` flag set. The `STASH` is set to the package name which this SV was blessed into.

The output from an XSUB which uses something like the T_PTRREF map, which doesn't bless the object, might look something like this:

```
SV = RV(0xf381c)
  REFCNT = 1
  FLAGS = (ROK)
  RV = 0xb8ad8
SV = PVMG(0xbb3c8)
  REFCNT = 1
  FLAGS = (IOK,pIOK)
  IV = 729160
  NV = 0
  PV = 0
```

A reference to a subroutine

Looks like this:

```
SV = RV(0x798ec)
  REFCNT = 1
  FLAGS = (TEMP,ROK)
  RV = 0x1d453c
SV = PVCV(0x1c768c)
  REFCNT = 2
  FLAGS = ()
  IV = 0
  NV = 0
  COMP_STASH = 0x31068  "main"
  START = 0xb20e0
  ROOT = 0xbece0
  XSUB = 0x0
  XSUBANY = 0
  GVGV::GV = 0x1d44e8   "MY" :: "top_targets"
  FILE = "(eval 5)"
  DEPTH = 0
  PADLIST = 0x1c9338
```

This shows that

- the subroutine is not an XSUB (since `START` and `ROOT` are non–zero, and `XSUB` is zero);
- that it was compiled in the package `main`;
- under the name `MY::top_targets`;
- inside a 5th eval in the program;
- it is not currently executed (see `DEPTH`);
- it has no prototype (`PROTOTYPE` field is missing).

EXPORTS

`Dump`, `mstat`, `DeadCode`, `DumpArray`, `DumpWithOP` and `DumpProg`, `fill_mstats`, `mstats_fillhash`, `mstats2hash` by default. Additionally available `SvREFCNT`, `SvREFCNT_inc` and `SvREFCNT_dec`.

BUGS

Readers have been known to skip important parts of *perlguts*, causing much frustration for all.

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SEE ALSO

perlguts, and *perlguts*, again.

NAME

Encode – character encodings

TERMINOLOGY

- *char*: a character in the range 0..maxint (at least 2**32−1)
- *byte*: a character in the range 0..255

The marker [INTERNAL] marks Internal Implementation Details, in general meant only for those who think they know what they are doing, and such details may change in future releases.

bytes

- ```
  bytes_to_utf8(STRING [, FROM])
  ```

  The bytes in STRING are recoded in−place into UTF−8. If no FROM is specified the bytes are expected to be encoded in US−ASCII or ISO 8859−1 (Latin 1). Returns the new size of STRING, or `undef` if there's a failure.

  [INTERNAL] Also the UTF−8 flag of STRING is turned on.

- ```
  utf8_to_bytes(STRING [, TO [, CHECK]])
  ```

  The UTF−8 in STRING is decoded in−place into bytes. If no TO encoding is specified the bytes are expected to be encoded in US−ASCII or ISO 8859−1 (Latin 1). Returns the new size of STRING, or `undef` if there's a failure.

  What if there are characters 255? What if the UTF−8 in STRING is malformed? See .

  [INTERNAL] The UTF−8 flag of STRING is not checked.

chars

- ```
  chars_to_utf8(STRING)
  ```

  The chars in STRING are encoded in−place into UTF−8. Returns the new size of STRING, or `undef` if there's a failure.

  No assumptions are made on the encoding of the chars. If you want to assume that the chars are Unicode and to trap illegal Unicode characters, you must use `from_to('Unicode', ...)`.

  [INTERNAL] Also the UTF−8 flag of STRING is turned on.

  - ```
    utf8_to_chars(STRING)
    ```

    The UTF−8 in STRING is decoded in−place into chars. Returns the new size of STRING, or `undef` if there's a failure.

    If the UTF−8 in STRING is malformed `undef` is returned, and also an optional lexical warning (category utf8) is given.

    [INTERNAL] The UTF−8 flag of STRING is not checked.

  - ```
    utf8_to_chars_check(STRING [, CHECK])
    ```

    (Note that special naming of this interface since a two−argument `utf8_to_chars()` has different semantics.)
    ```

The UTF−8 in STRING is decoded in−place into chars. Returns the new size of STRING, or `undef` if there is a failure.

If the UTF−8 in STRING is malformed? See .

[INTERNAL] The UTF−8 flag of STRING is not checked.

chars With Encoding

- ```
  chars_to_utf8(STRING, FROM [, CHECK])
  ```

  The chars in STRING encoded in FROM are recoded in−place into UTF−8. Returns the new size of STRING, or `undef` if there's a failure.

  No assumptions are made on the encoding of the chars. If you want to assume that the chars are Unicode and to trap illegal Unicode characters, you must use `from_to('Unicode', ...)`.

  [INTERNAL] Also the UTF−8 flag of STRING is turned on.

- ```
  utf8_to_chars(STRING, TO [, CHECK])
  ```

  The UTF−8 in STRING is decoded in−place into chars encoded in TO. Returns the new size of STRING, or `undef` if there's a failure.

  If the UTF−8 in STRING is malformed? See .

  [INTERNAL] The UTF−8 flag of STRING is not checked.

- ```
  bytes_to_chars(STRING, FROM [, CHECK])
  ```

  The bytes in STRING encoded in FROM are recoded in−place into chars. Returns the new size of STRING in bytes, or `undef` if there's a failure.

  If the mapping is impossible? See .

- ```
  chars_to_bytes(STRING, TO [, CHECK])
  ```

  The chars in STRING are recoded in−place to bytes encoded in TO. Returns the new size of STRING in bytes, or `undef` if there's a failure.

  If the mapping is impossible? See .

- ```
  from_to(STRING, FROM, TO [, CHECK])
  ```

  The chars in STRING encoded in FROM are recoded in−place into TO. Returns the new size of STRING, or `undef` if there's a failure.

  If mapping between the encodings is impossible? See .

  [INTERNAL] If TO is UTF−8, also the UTF−8 flag of STRING is turned on.

Testing For UTF−8

- ```
  is_utf8(STRING [, CHECK])
  ```

  [INTERNAL] Test whether the UTF−8 flag is turned on in the STRING. If CHECK is true, also checks the data in STRING for being well−formed UTF−8. Returns true if successful, false otherwise.

Toggling UTF−8−ness

- ```
  on_utf8(STRING)
  ```

  [INTERNAL] Turn on the UTF−8 flag in STRING. The data in STRING is **not** checked for being well−formed UTF−8. Do not use unless you **know** that the STRING is well−formed UTF−8. Returns the previous state of the UTF−8 flag (so please don't test the return value as *not* success or failure), or `undef` if STRING is not a string.

- ```
  off_utf8(STRING)
  ```

  [INTERNAL] Turn off the UTF−8 flag in STRING. Do not use frivolously. Returns the previous state of the UTF−8 flag (so please don't test the return value as *not* success or failure), or `undef` if STRING is not a string.

UTF−16 and UTF−32 Encodings

- ```
  utf_to_utf(STRING, FROM, TO [, CHECK])
  ```

  The data in STRING is converted from Unicode Transfer Encoding FROM to Unicode Transfer Encoding TO. Both FROM and TO may be any of the following tags (case−insensitive, with or without 'utf' or 'utf−' prefix):

  ```
  tag             meaning

  '7'             UTF-7
  '8'             UTF-8
  '16be'          UTF-16 big-endian
  '16le'          UTF-16 little-endian
  '16'            UTF-16 native-endian
  '32be'          UTF-32 big-endian
  '32le'          UTF-32 little-endian
  '32'            UTF-32 native-endian
  ```

  UTF−16 is also known as UCS−2, 16 bit or 2−byte chunks, and UTF−32 as UCS−4, 32−bit or 4−byte chunks. Returns the new size of STRING, or `undef` is there's a failure.

  If FROM is UTF−8 and the UTF−8 in STRING is malformed? See .

  [INTERNAL] Even if CHECK is true and FROM is UTF−8, the UTF−8 flag of STRING is not checked. If TO is UTF−8, also the UTF−8 flag of STRING is turned on. Identical FROM and TO are fine.

Handling Malformed Data

If CHECK is not set, `undef` is returned. If the data is supposed to be UTF−8, an optional lexical warning (category utf8) is given. If CHECK is true but not a code reference, dies. If CHECK is a code reference, it is called with the arguments

```
(MALFORMED_STRING, STRING_FROM_SO_FAR, STRING_TO_SO_FAR)
```

Two return values are expected from the call: the string to be used in the result string in place of the malformed section, and the length of the malformed section in bytes.
```

NAME

Fcntl – load the C Fcntl.h defines

SYNOPSIS

```
use Fcntl;
use Fcntl qw(:DEFAULT :flock);
```

DESCRIPTION

This module is just a translation of the C ***fnctl.h*** file. Unlike the old mechanism of requiring a translated ***fnctl.ph*** file, this uses the **h2xs** program (see the Perl source distribution) and your native C compiler. This means that it has a far more likely chance of getting the numbers right.

NOTE

Only `#define` symbols get translated; you must still correctly pack up your own arguments to pass as args for locking functions, etc.

EXPORTED SYMBOLS

By default your system's F_* and O_* constants (eg, F_DUPFD and O_CREAT) and the FD_CLOEXEC constant are exported into your namespace.

You can request that the `flock()` constants (LOCK_SH, LOCK_EX, LOCK_NB and LOCK_UN) be provided by using the tag `:flock`. See *Exporter*.

You can request that the old constants (FAPPEND, FASYNC, FCREAT, FDEFER, FEXCL, FNDELAY, FNONBLOCK, FSYNC, FTRUNC) be provided for compatibility reasons by using the tag `:Fcompat`. For new applications the newer versions of these constants are suggested (O_APPEND, O_ASYNC, O_CREAT, O_DEFER, O_EXCL, O_NDELAY, O_NONBLOCK, O_SYNC, O_TRUNC).

For ease of use also the SEEK_* constants (for `seek()` and `sysseek()`, e.g. SEEK_END) and the S_I* constants (for `chmod()` and `stat()`) are available for import. They can be imported either separately or using the tags `:seek` and `:mode`.

Please refer to your native fcntl(2), open(2), fseek(3), lseek(2) (equal to Perl's `seek()` and `sysseek()`, respectively), and chmod(2) documentation to see what constants are implemented in your system.

See *perlopentut* to learn about the uses of the O_* constants with `sysopen()`.

See *seek* and *sysseek* about the SEEK_* constants.

See *stat* about the S_I* constants.

NAME

File::Glob – Perl extension for BSD glob routine

SYNOPSIS

```
use File::Glob ':glob';
@list = bsd_glob('*.[ch]');
$homedir = bsd_glob('~gnat', GLOB_TILDE | GLOB_ERR);
if (GLOB_ERROR) {
  # an error occurred reading $homedir
}

## override the core glob (CORE::glob() does this automatically
## by default anyway, since v5.6.0)
use File::Glob ':globally';
my @sources = <*.{c,h,y}>

## override the core glob, forcing case sensitivity
use File::Glob qw(:globally :case);
my @sources = <*.{c,h,y}>

## override the core glob forcing case insensitivity
use File::Glob qw(:globally :nocase);
my @sources = <*.{c,h,y}>
```

DESCRIPTION

`File::Glob::bsd_glob()` implements the FreeBSD glob(3) routine, which is a superset of the POSIX `glob()` (described in IEEE Std 1003.2 "POSIX.2"). `bsd_glob()` takes a mandatory `pattern` argument, and an optional `flags` argument, and returns a list of filenames matching the pattern, with interpretation of the pattern modified by the `flags` variable.

Since v5.6.0, Perl's `CORE::glob()` is implemented in terms of `bsd_glob()`. Note that they don't share the same prototype—`CORE::glob()` only accepts a single argument. Due to historical reasons, `CORE::glob()` will also split its argument on whitespace, treating it as multiple patterns, whereas `bsd_glob()` considers them as one pattern.

The POSIX defined flags for `bsd_glob()` are:

`GLOB_ERR`

Force `bsd_glob()` to return an error when it encounters a directory it cannot open or read. Ordinarily `bsd_glob()` continues to find matches.

`GLOB_MARK`

Each pathname that is a directory that matches the pattern has a slash appended.

`GLOB_NOCASE`

By default, file names are assumed to be case sensitive; this flag makes `bsd_glob()` treat case differences as not significant.

`GLOB_NOCHECK`

If the pattern does not match any pathname, then `bsd_glob()` returns a list consisting of only the pattern. If `GLOB_QUOTE` is set, its effect is present in the pattern returned.

`GLOB_NOSORT`

By default, the pathnames are sorted in ascending ASCII order; this flag prevents that sorting (speeding up `bsd_glob()`).

The FreeBSD extensions to the POSIX standard are the following flags:

GLOB_BRACE

Pre–process the string to expand {pat,pat,...} strings like csh(1). The pattern '{}' is left unexpanded for historical reasons (and csh(1) does the same thing to ease typing of find(1) patterns).

GLOB_NOMAGIC

Same as GLOB_NOCHECK but it only returns the pattern if it does not contain any of the special characters "*", "?" or "[". NOMAGIC is provided to simplify implementing the historic csh(1) globbing behaviour and should probably not be used anywhere else.

GLOB_QUOTE

Use the backslash ('\') character for quoting: every occurrence of a backslash followed by a character in the pattern is replaced by that character, avoiding any special interpretation of the character. (But see below for exceptions on DOSISH systems).

GLOB_TILDE

Expand patterns that start with '~' to user name home directories.

GLOB_CSH

For convenience, GLOB_CSH is a synonym for GLOB_BRACE | GLOB_NOMAGIC | GLOB_QUOTE | GLOB_TILDE.

The POSIX provided GLOB_APPEND, GLOB_DOOFFS, and the FreeBSD extensions GLOB_ALTDIRFUNC, and GLOB_MAGCHAR flags have not been implemented in the Perl version because they involve more complex interaction with the underlying C structures.

DIAGNOSTICS

bsd_glob() returns a list of matching paths, possibly zero length. If an error occurred, &File::Glob::GLOB_ERROR will be non–zero and $! will be set. &File::Glob::GLOB_ERROR is guaranteed to be zero if no error occurred, or one of the following values otherwise:

GLOB_NOSPACE

An attempt to allocate memory failed.

GLOB_ABEND

The glob was stopped because an error was encountered.

In the case where bsd_glob() has found some matching paths, but is interrupted by an error, it will return a list of filenames **and** set &File::Glob::ERROR.

Note that bsd_glob() deviates from POSIX and FreeBSD glob(3) behaviour by not considering ENOENT and ENOTDIR as errors – bsd_glob() will continue processing despite those errors, unless the GLOB_ERR flag is set.

Be aware that all filenames returned from File::Glob are tainted.

NOTES

- If you want to use multiple patterns, e.g. bsd_glob "a* b*", you should probably throw them in a set as in bsd_glob "{a*,b*}". This is because the argument to bsd_glob() isn't subjected to parsing by the C shell. Remember that you can use a backslash to escape things.
- On DOSISH systems, backslash is a valid directory separator character. In this case, use of backslash as a quoting character (via GLOB_QUOTE) interferes with the use of backslash as a directory separator. The best (simplest, most portable) solution is to use forward slashes for directory separators, and backslashes for quoting. However, this does not match "normal practice" on these systems. As a concession to user expectation, therefore, backslashes (under GLOB_QUOTE) only quote the glob metacharacters '[', ']', '{', '}', '–', '~', and backslash itself. All other backslashes are passed through unchanged.

- Win32 users should use the real slash. If you really want to use backslashes, consider using Sarathy's File::DosGlob, which comes with the standard Perl distribution.

AUTHOR

The Perl interface was written by Nathan Torkington <gnat@frii.com>, and is released under the artistic license. Further modifications were made by Greg Bacon <gbacon@cs.uah.edu> and Gurusamy Sarathy <gsar@activestate.com>. The C glob code has the following copyright:

NAME

GDBM_File – Perl5 access to the gdbm library.

SYNOPSIS

```
use GDBM_File ;
tie %hash, 'GDBM_File', $filename, &GDBM_WRCREAT, 0640;
# Use the %hash array.
untie %hash ;
```

DESCRIPTION

GDBM_File is a module which allows Perl programs to make use of the facilities provided by the GNU gdbm library. If you intend to use this module you should really have a copy of the gdbm manualpage at hand.

Most of the libgdbm.a functions are available through the GDBM_File interface.

AVAILABILITY

Gdbm is available from any GNU archive. The master site is `prep.ai.mit.edu`, but your are strongly urged to use one of the many mirrors. You can obtain a list of mirror sites by issuing the command

```
finger fsf@prep.ai.mit.edu.
```

BUGS

The available functions and the gdbm/perl interface need to be documented.

SEE ALSO

perl(1), *DB_File(3)*, *perldbmfilter*.

NAME

IO – load various IO modules

SYNOPSIS

```
use IO;
```

DESCRIPTION

`IO` provides a simple mechanism to load some of the IO modules at one go. Currently this includes:

```
IO::Handle
IO::Seekable
IO::File
IO::Pipe
IO::Socket
IO::Dir
```

For more information on any of these modules, please see its respective documentation.

NAME

IO::Dir – supply object methods for directory handles

SYNOPSIS

```
use IO::Dir;
$d = new IO::Dir ".";
if (defined $d) {
    while (defined($_ = $d->read)) { something($_); }
    $d->rewind;
    while (defined($_ = $d->read)) { something_else($_); }
    undef $d;
}

tie %dir, IO::Dir, ".";
foreach (keys %dir) {
    print $_, " " , $dir{$_}->size,"\n";
}
```

DESCRIPTION

The `IO::Dir` package provides two interfaces to perl's directory reading routines.

The first interface is an object approach. `IO::Dir` provides an object constructor and methods, which are just wrappers around perl's built in directory reading routines.

new ([DIRNAME])

`new` is the constuctor for `IO::Dir` objects. It accepts one optional argument which, if given, `new` will pass to `open`

The following methods are wrappers for the directory related functions built into perl (the trailing 'dir' has been removed from the names). See *perlfunc* for details of these functions.

open (DIRNAME)
read `()`
seek (POS)
tell `()`
rewind `()`
close `()`

`IO::Dir` also provides a interface to reading directories via a tied HASH. The tied HASH extends the interface beyond just the directory reading routines by the use of `lstat`, from the `File::stat` package, `unlink`, `rmdir` and `utime`.

tie %hash, IO::Dir, DIRNAME [, OPTIONS]

The keys of the HASH will be the names of the entries in the directory. Reading a value from the hash will be the result of calling `File::stat::lstat`. Deleting an element from the hash will call `unlink` providing that `DIR_UNLINK` is passed in the `OPTIONS`.

Assigning to an entry in the HASH will cause the time stamps of the file to be modified. If the file does not exist then it will be created. Assigning a single integer to a HASH element will cause both the access and modification times to be changed to that value. Alternatively a reference to an array of two values can be passed. The first array element will be used to set the access time and the second element will be used to set the modification time.

SEE ALSO

File::stat

AUTHOR

Graham Barr. Currently maintained by the Perl Porters. Please report all bugs to <perl5−porters@perl.org.

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NAME

IO::File – supply object methods for filehandles

SYNOPSIS

```
use IO::File;

$fh = new IO::File;
if ($fh->open("< file")) {
    print <$fh>;
    $fh->close;
}

$fh = new IO::File "> file";
if (defined $fh) {
    print $fh "bar\n";
    $fh->close;
}

$fh = new IO::File "file", "r";
if (defined $fh) {
    print <$fh>;
    undef $fh;       # automatically closes the file
}

$fh = new IO::File "file", O_WRONLY|O_APPEND;
if (defined $fh) {
    print $fh "corge\n";

    $pos = $fh->getpos;
    $fh->setpos($pos);

    undef $fh;       # automatically closes the file
}

autoflush STDOUT 1;
```

DESCRIPTION

`IO::File` inherits from `IO::Handle` and `IO::Seekable`. It extends these classes with methods that are specific to file handles.

CONSTRUCTOR

new (FILENAME [,MODE [,PERMS]])

Creates a `IO::File`. If it receives any parameters, they are passed to the method `open`; if the open fails, the object is destroyed. Otherwise, it is returned to the caller.

new_tmpfile

Creates an `IO::File` opened for read/write on a newly created temporary file. On systems where this is possible, the temporary file is anonymous (i.e. it is unlinked after creation, but held open). If the temporary file cannot be created or opened, the `IO::File` object is destroyed. Otherwise, it is returned to the caller.

METHODS

open(FILENAME [,MODE [,PERMS]])

`open` accepts one, two or three parameters. With one parameter, it is just a front end for the built–in `open` function. With two or three parameters, the first parameter is a filename that may include whitespace or other special characters, and the second parameter is the open mode, optionally followed by a file permission value.

If `IO::File::open` receives a Perl mode string (">", "+<", etc.) or a ANSI C `fopen()` mode string ("w", "r+", etc.), it uses the basic Perl `open` operator (but protects any special characters).

If `IO::File::open` is given a numeric mode, it passes that mode and the optional permissions value to the Perl `sysopen` operator. The permissions default to 0666.

For convenience, `IO::File` exports the O_XXX constants from the Fcntl module, if this module is available.

SEE ALSO

perlfunc, *I/O Operators in perlop*, *IO::Handle IO::Seekable*

HISTORY

Derived from FileHandle.pm by Graham Barr <***gbarr@pobox.com***>.

NAME

IO::Handle – supply object methods for I/O handles

SYNOPSIS

```
use IO::Handle;

$io = new IO::Handle;
if ($io->fdopen(fileno(STDIN),"r")) {
    print $io->getline;
    $io->close;
}

$io = new IO::Handle;
if ($io->fdopen(fileno(STDOUT),"w")) {
    $io->print("Some text\n");
}

use IO::Handle '_IOLBF';
$io->setvbuf($buffer_var, _IOLBF, 1024);

undef $io;       # automatically closes the file if it's open

autoflush STDOUT 1;
```

DESCRIPTION

`IO::Handle` is the base class for all other IO handle classes. It is not intended that objects of `IO::Handle` would be created directly, but instead `IO::Handle` is inherited from by several other classes in the IO hierarchy.

If you are reading this documentation, looking for a replacement for the `FileHandle` package, then I suggest you read the documentation for `IO::File` too.

CONSTRUCTOR

new ()

Creates a new `IO::Handle` object.

new_from_fd (FD, MODE)

Creates a `IO::Handle` like `new` does. It requires two parameters, which are passed to the method `fdopen`; if the fdopen fails, the object is destroyed. Otherwise, it is returned to the caller.

METHODS

See *perlfunc* for complete descriptions of each of the following supported `IO::Handle` methods, which are just front ends for the corresponding built–in functions:

```
$io->close
$io->eof
$io->fileno
$io->format_write( [FORMAT_NAME] )
$io->getc
$io->read ( BUF, LEN, [OFFSET] )
$io->print ( ARGS )
$io->printf ( FMT, [ARGS] )
$io->stat
$io->sysread ( BUF, LEN, [OFFSET] )
$io->syswrite ( BUF, [LEN, [OFFSET]] )
$io->truncate ( LEN )
```

See *perlvar* for complete descriptions of each of the following supported `IO::Handle` methods. All of them return the previous value of the attribute and takes an optional single argument that when given will set

the value. If no argument is given the previous value is unchanged (except for $io–autoflush will actually turn ON autoflush by default).

```
$io->autoflush ( [BOOL] )                          $|
$io->format_page_number( [NUM] )                   $%
$io->format_lines_per_page( [NUM] )                $=
$io->format_lines_left( [NUM] )                    $-
$io->format_name( [STR] )                          $~
$io->format_top_name( [STR] )                      $^
$io->input_line_number( [NUM])                     $.
```

The following methods are not supported on a per–filehandle basis.

```
IO::Handle->format_line_break_characters( [STR] ) $:
IO::Handle->format_formfeed( [STR])               $^L
IO::Handle->output_field_separator( [STR] )       $,
IO::Handle->output_record_separator( [STR] )      $\

IO::Handle->input_record_separator( [STR] )       $/
```

Furthermore, for doing normal I/O you might need these:

$io–fdopen (FD, MODE)

fdopen is like an ordinary open except that its first parameter is not a filename but rather a file handle name, a IO::Handle object, or a file descriptor number.

$io–opened

Returns true if the object is currently a valid file descriptor, false otherwise.

$io–getline

This works like <$io described in *I/O Operators in perlop* except that it's more readable and can be safely called in a list context but still returns just one line.

$io–getlines

This works like <$io when called in a list context to read all the remaining lines in a file, except that it's more readable. It will also croak() if accidentally called in a scalar context.

$io–ungetc (ORD)

Pushes a character with the given ordinal value back onto the given handle's input stream. Only one character of pushback per handle is guaranteed.

$io–write (BUF, LEN [, OFFSET])

This write is like write found in C, that is it is the opposite of read. The wrapper for the perl write function is called format_write.

$io–error

Returns a true value if the given handle has experienced any errors since it was opened or since the last call to clearerr, or if the handle is invalid. It only returns false for a valid handle with no outstanding errors.

$io–clearerr

Clear the given handle's error indicator. Returns –1 if the handle is invalid, 0 otherwise.

$io–sync

sync synchronizes a file's in–memory state with that on the physical medium. sync does not operate at the perlio api level, but operates on the file descriptor (similar to sysread, sysseek and systell). This means that any data held at the perlio api level will not be synchronized. To synchronize data that is buffered at the perlio api level you must use the flush method. sync is not implemented on all platforms. Returns 0 on success, –1 on error, –1 for an invalid handle. See *fsync(3c)*.

$io–flush

`flush` causes perl to flush any buffered data at the perlio api level. Any unread data in the buffer will be discarded, and any unwritten data will be written to the underlying file descriptor. Returns 0 on success, or a negative value on error.

$io–printflush (ARGS)

Turns on autoflush, print ARGS and then restores the autoflush status of the `IO::Handle` object. Returns the return value from print.

$io–blocking ([BOOL])

If called with an argument `blocking` will turn on non–blocking IO if `BOOL` is false, and turn it off if `BOOL` is true.

`blocking` will return the value of the previous setting, or the current setting if `BOOL` is not given.

If an error occurs `blocking` will return undef and `$!` will be set.

If the C functions `setbuf()` and/or `setvbuf()` are available, then `IO::Handle::setbuf` and `IO::Handle::setvbuf` set the buffering policy for an IO::Handle. The calling sequences for the Perl functions are the same as their C counterparts—including the constants `_IOFBF`, `_IOLBF`, and `_IONBF` for `setvbuf()`—except that the buffer parameter specifies a scalar variable to use as a buffer. You should only change the buffer before any I/O, or immediately after calling flush.

WARNING: A variable used as a buffer by `setbuf` or `setvbuf` **must not be modified** in any way until the IO::Handle is closed or `setbuf` or `setvbuf` is called again, or memory corruption may result! Remember that the order of global destruction is undefined, so even if your buffer variable remains in scope until program termination, it may be undefined before the file IO::Handle is closed. Note that you need to import the constants `_IOFBF`, `_IOLBF`, and `_IONBF` explicitly. Like C, setbuf returns nothing, setvbuf returns 0 on success, –1 on failure.

Lastly, there is a special method for working under **–T** and setuid/gid scripts:

$io–untaint

Marks the object as taint–clean, and as such data read from it will also be considered taint–clean. Note that this is a very trusting action to take, and appropriate consideration for the data source and potential vulnerability should be kept in mind. Returns 0 on success, –1 if setting the taint–clean flag failed. (eg invalid handle)

NOTE

A `IO::Handle` object is a reference to a symbol/GLOB reference (see the `Symbol` package). Some modules that inherit from `IO::Handle` may want to keep object related variables in the hash table part of the GLOB. In an attempt to prevent modules trampling on each other I propose the that any such module should prefix its variables with its own name separated by _'s. For example the IO::Socket module keeps a `timeout` variable in 'io_socket_timeout'.

SEE ALSO

perlfunc, *I/O Operators in perlop*, *IO::File*

BUGS

Due to backwards compatibility, all filehandles resemble objects of class `IO::Handle`, or actually classes derived from that class. They actually aren't. Which means you can't derive your own class from `IO::Handle` and inherit those methods.

HISTORY

Derived from FileHandle.pm by Graham Barr <***gbarr@pobox.com***>

NAME

IO::Pipe – supply object methods for pipes

SYNOPSIS

```
use IO::Pipe;

$pipe = new IO::Pipe;

if($pid = fork()) { # Parent
    $pipe->reader();

    while(<$pipe> {
        ....
    }

}
elsif(defined $pid) { # Child
    $pipe->writer();

    print $pipe ....
}

or

$pipe = new IO::Pipe;

$pipe->reader(qw(ls -l));

while(<$pipe>) {
    ....
}
```

DESCRIPTION

`IO::Pipe` provides an interface to creating pipes between processes.

CONSTRUCTOR

new ([READER, WRITER])

Creates a `IO::Pipe`, which is a reference to a newly created symbol (see the `Symbol` package). `IO::Pipe::new` optionally takes two arguments, which should be objects blessed into `IO::Handle`, or a subclass thereof. These two objects will be used for the system call to `pipe`. If no arguments are given then method `handles` is called on the new `IO::Pipe` object.

These two handles are held in the array part of the GLOB until either `reader` or `writer` is called.

METHODS

reader ([ARGS])

The object is re–blessed into a sub–class of `IO::Handle`, and becomes a handle at the reading end of the pipe. If `ARGS` are given then `fork` is called and `ARGS` are passed to exec.

writer ([ARGS])

The object is re–blessed into a sub–class of `IO::Handle`, and becomes a handle at the writing end of the pipe. If `ARGS` are given then `fork` is called and `ARGS` are passed to exec.

handles ()

This method is called during construction by `IO::Pipe::new` on the newly created `IO::Pipe` object. It returns an array of two objects blessed into `IO::Pipe::End`, or a subclass thereof.

SEE ALSO

IO::Handle

AUTHOR

Graham Barr. Currently maintained by the Perl Porters. Please report all bugs to <perl5−porters@perl.org.

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NAME

IO::Poll – Object interface to system poll call

SYNOPSIS

```
use IO::Poll qw(POLLRDNORM POLLWRNORM POLLIN POLLHUP);

$poll = new IO::Poll;

$poll->mask($input_handle => POLLIN);
$poll->mask($output_handle => POLLOUT);

$poll->poll($timeout);

$ev = $poll->events($input);
```

DESCRIPTION

`IO::Poll` is a simple interface to the system level poll routine.

METHODS

mask (IO [, EVENT_MASK])

If EVENT_MASK is given, then, if EVENT_MASK is non–zero, IO is added to the list of file descriptors and the next call to poll will check for any event specified in EVENT_MASK. If EVENT_MASK is zero then IO will be removed from the list of file descriptors.

If EVENT_MASK is not given then the return value will be the current event mask value for IO.

poll ([TIMEOUT])

Call the system level poll routine. If TIMEOUT is not specified then the call will block. Returns the number of handles which had events happen, or –1 on error.

events (IO)

Returns the event mask which represents the events that happend on IO during the last call to `poll`.

remove (IO)

Remove IO from the list of file descriptors for the next poll.

handles([EVENT_MASK])

Returns a list of handles. If EVENT_MASK is not given then a list of all handles known will be returned. If EVENT_MASK is given then a list of handles will be returned which had one of the events specified by EVENT_MASK happen during the last call ti `poll`

SEE ALSO

poll(2), *IO::Handle*, *IO::Select*

AUTHOR

Graham Barr. Currently maintained by the Perl Porters. Please report all bugs to <perl5–porters@perl.org.

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NAME

IO::Seekable – supply seek based methods for I/O objects

SYNOPSIS

```
use IO::Seekable;
package IO::Something;
@ISA = qw(IO::Seekable);
```

DESCRIPTION

`IO::Seekable` does not have a constructor of its own as it is intended to be inherited by other `IO::Handle` based objects. It provides methods which allow seeking of the file descriptors.

`$io->`getpos

Returns an opaque value that represents the current position of the IO::File, or `undef` if this is not possible (eg an unseekable stream such as a terminal, pipe or socket). If the `fgetpos()` function is available in your C library it is used to implements getpos, else perl emulates getpos using C's `ftell()` function.

`$io->`setpos

Uses the value of a previous getpos call to return to a previously visited position. Returns 0 on success, −1 on failure.

See *perlfunc* for complete descriptions of each of the following supported `IO::Seekable` methods, which are just front ends for the corresponding built−in functions:

`$io->`setpos (POS, WHENCE)

Seek the IO::File to position POS, relative to WHENCE:

WHENCE=0 (SEEK_SET)

POS is absolute position. (Seek relative to the start of the file)

WHENCE=1 (SEEK_CUR)

POS is an offset from the current position. (Seek relative to current)

WHENCE=1 (SEEK_END)

POS is an offset from the end of the file. (Seek relative to end)

The SEEK_* constants can be imported from the `Fcntl` module if you don't wish to use the numbers `1` or `2` in your code.

Returns `1` upon success, otherwise.

`$io->`sysseek(POS, WHENCE)

Similar to `$io->`seek, but sets the IO::File's position using the system call lseek(2) directly, so will confuse most perl IO operators except sysread and syswrite (see *perlfunc* for full details)

Returns the new position, or `undef` on failure. A position of zero is returned as the string `"0 but true"`

`$io->`tell

Returns the IO::File's current position, or −1 on error.

SEE ALSO

perlfunc, *I/O Operators in perlop*, *IO::Handle IO::File*

HISTORY

Derived from FileHandle.pm by Graham Barr <gbarr@pobox.com>

NAME

IO::Select – OO interface to the select system call

SYNOPSIS

```
use IO::Select;

$s = IO::Select->new();

$s->add(\*STDIN);
$s->add($some_handle);

@ready = $s->can_read($timeout);

@ready = IO::Select->new(@handles)->read(0);
```

DESCRIPTION

The `IO::Select` package implements an object approach to the system `select` function call. It allows the user to see what IO handles, see *IO::Handle*, are ready for reading, writing or have an error condition pending.

CONSTRUCTOR

new ([HANDLES])

The constructor creates a new object and optionally initialises it with a set of handles.

METHODS

add (HANDLES)

Add the list of handles to the `IO::Select` object. It is these values that will be returned when an event occurs. `IO::Select` keeps these values in a cache which is indexed by the `fileno` of the handle, so if more than one handle with the same `fileno` is specified then only the last one is cached.

Each handle can be an `IO::Handle` object, an integer or an array reference where the first element is a `IO::Handle` or an integer.

remove (HANDLES)

Remove all the given handles from the object. This method also works by the `fileno` of the handles. So the exact handles that were added need not be passed, just handles that have an equivalent `fileno`

exists (HANDLE)

Returns a true value (actually the handle itself) if it is present. Returns undef otherwise.

handles

Return an array of all registered handles.

can_read ([TIMEOUT])

Return an array of handles that are ready for reading. `TIMEOUT` is the maximum amount of time to wait before returning an empty list, in seconds, possibly fractional. If `TIMEOUT` is not given and any handles are registered then the call will block.

can_write ([TIMEOUT])

Same as `can_read` except check for handles that can be written to.

has_exception ([TIMEOUT])

Same as `can_read` except check for handles that have an exception condition, for example pending out–of–band data.

count ()

Returns the number of handles that the object will check for when one of the `can_` methods is called or the object is passed to the `select` static method.

bits()

Return the bit string suitable as argument to the core `select()` call.

select (READ, WRITE, ERROR [, TIMEOUT])

`select` is a static method, that is you call it with the package name like `new`. `READ`, `WRITE` and `ERROR` are either `undef` or `IO::Select` objects. `TIMEOUT` is optional and has the same effect as for the core select call.

The result will be an array of 3 elements, each a reference to an array which will hold the handles that are ready for reading, writing and have error conditions respectively. Upon error an empty array is returned.

EXAMPLE

Here is a short example which shows how `IO::Select` could be used to write a server which communicates with several sockets while also listening for more connections on a listen socket

```
use IO::Select;
use IO::Socket;

$lsn = new IO::Socket::INET(Listen => 1, LocalPort => 8080);
$sel = new IO::Select( $lsn );

while(@ready = $sel->can_read) {
    foreach $fh (@ready) {
        if($fh == $lsn) {
            # Create a new socket
            $new = $lsn->accept;
            $sel->add($new);
        }
        else {
            # Process socket

            # Maybe we have finished with the socket
            $sel->remove($fh);
            $fh->close;
        }
    }
}
```

AUTHOR

Graham Barr. Currently maintained by the Perl Porters. Please report all bugs to <perl5−porters@perl.org.

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NAME

IO::Socket::INET – Object interface for AF_INET domain sockets

SYNOPSIS

```
use IO::Socket::INET;
```

DESCRIPTION

`IO::Socket::INET` provides an object interface to creating and using sockets in the AF_INET domain. It is built upon the *IO::Socket* interface and inherits all the methods defined by *IO::Socket*.

CONSTRUCTOR

new ([ARGS])

Creates an `IO::Socket::INET` object, which is a reference to a newly created symbol (see the `Symbol` package). `new` optionally takes arguments, these arguments are in key–value pairs.

In addition to the key–value pairs accepted by *IO::Socket*, `IO::Socket::INET` provides.

```
PeerAddr    Remote host address          <hostname>[:<port>]
PeerHost    Synonym for PeerAddr
PeerPort    Remote port or service       <service>[(<no>)] | <no>
LocalAddr   Local host bind address      hostname[:port]
LocalHost   Synonym for LocalAddr
LocalPort   Local host bind port         <service>[(<no>)] | <no>
Proto       Protocol name (or number)    "tcp" | "udp" | ...
Type        Socket type                  SOCK_STREAM | SOCK_DGRAM | ...
Listen      Queue size for listen
Reuse       Set SO_REUSEADDR before binding
Timeout     Timeout value for various operations
MultiHomed  Try all adresses for multi-homed hosts
```

If `Listen` is defined then a listen socket is created, else if the socket type, which is derived from the protocol, is SOCK_STREAM then `connect()` is called.

Although it is not illegal, the use of `MultiHomed` on a socket which is in non–blocking mode is of little use. This is because the first connect will never fail with a timeout as the connaect call will not block.

The `PeerAddr` can be a hostname or the IP–address on the "xx.xx.xx.xx" form. The `PeerPort` can be a number or a symbolic service name. The service name might be followed by a number in parenthesis which is used if the service is not known by the system. The `PeerPort` specification can also be embedded in the `PeerAddr` by preceding it with a ":".

If `Proto` is not given and you specify a symbolic `PeerPort` port, then the constructor will try to derive `Proto` from the service name. As a last resort `Proto` "tcp" is assumed. The `Type` parameter will be deduced from `Proto` if not specified.

If the constructor is only passed a single argument, it is assumed to be a `PeerAddr` specification.

Examples:

```
$sock = IO::Socket::INET->new(PeerAddr => 'www.perl.org',
                              PeerPort => 'http(80)',
                              Proto    => 'tcp');

$sock = IO::Socket::INET->new(PeerAddr => 'localhost:smtp(25)');

$sock = IO::Socket::INET->new(Listen    => 5,
                              LocalAddr => 'localhost',
                              LocalPort => 9000,
                              Proto     => 'tcp');
```

```
    $sock = IO::Socket::INET->new('127.0.0.1:25');
```

NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE

As of VERSION 1.18 all IO::Socket objects have autoflush turned on by default. This was not the case with earlier releases.

NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE

METHODS

sockaddr ()

Return the address part of the sockaddr structure for the socket

sockport ()

Return the port number that the socket is using on the local host

sockhost ()

Return the address part of the sockaddr structure for the socket in a text form xx.xx.xx.xx

peeraddr ()

Return the address part of the sockaddr structure for the socket on the peer host

peerport ()

Return the port number for the socket on the peer host.

peerhost ()

Return the address part of the sockaddr structure for the socket on the peer host in a text form xx.xx.xx.xx

SEE ALSO

Socket, *IO::Socket*

AUTHOR

Graham Barr. Currently maintained by the Perl Porters. Please report all bugs to <perl5−porters@perl.org.

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NAME

IO::Socket::UNIX – Object interface for AF_UNIX domain sockets

SYNOPSIS

```
use IO::Socket::UNIX;
```

DESCRIPTION

`IO::Socket::UNIX` provides an object interface to creating and using sockets in the AF_UNIX domain. It is built upon the *IO::Socket* interface and inherits all the methods defined by *IO::Socket*.

CONSTRUCTOR

new ([ARGS])

Creates an `IO::Socket::UNIX` object, which is a reference to a newly created symbol (see the `Symbol` package). `new` optionally takes arguments, these arguments are in key–value pairs.

In addition to the key–value pairs accepted by *IO::Socket*, `IO::Socket::UNIX` provides.

```
Type        Type of socket (eg SOCK_STREAM or SOCK_DGRAM)
Local       Path to local fifo
Peer        Path to peer fifo
Listen      Create a listen socket
```

If the constructor is only passed a single argument, it is assumed to be a `Peer` specification.

```
NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE
```

As of VERSION 1.18 all IO::Socket objects have autoflush turned on by default. This was not the case with earlier releases.

```
NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE
```

METHODS

`hostpath()`

Returns the pathname to the fifo at the local end

`peerpath()`

Returns the pathanme to the fifo at the peer end

SEE ALSO

Socket, *IO::Socket*

AUTHOR

Graham Barr. Currently maintained by the Perl Porters. Please report all bugs to <perl5–porters@perl.org.

COPYRIGHT

NAME

IO::Socket – Object interface to socket communications

SYNOPSIS

```
use IO::Socket;
```

DESCRIPTION

`IO::Socket` provides an object interface to creating and using sockets. It is built upon the *IO::Handle* interface and inherits all the methods defined by *IO::Handle*.

`IO::Socket` only defines methods for those operations which are common to all types of socket. Operations which are specified to a socket in a particular domain have methods defined in sub classes of `IO::Socket`

`IO::Socket` will export all functions (and constants) defined by *Socket*.

CONSTRUCTOR

new ([ARGS])

Creates an `IO::Socket`, which is a reference to a newly created symbol (see the `Symbol` package). `new` optionally takes arguments, these arguments are in key–value pairs. `new` only looks for one key `Domain` which tells new which domain the socket will be in. All other arguments will be passed to the configuration method of the package for that domain, See below.

```
NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE
```

As of VERSION 1.18 all IO::Socket objects have autoflush turned on by default. This was not the case with earlier releases.

```
NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE NOTE
```

METHODS

See *perlfunc* for complete descriptions of each of the following supported `IO::Socket` methods, which are just front ends for the corresponding built–in functions:

```
socket
socketpair
bind
listen
accept
send
recv
peername (getpeername)
sockname (getsockname)
shutdown
```

Some methods take slightly different arguments to those defined in *perlfunc* in attempt to make the interface more flexible. These are

accept([PKG])

perform the system call `accept` on the socket and return a new object. The new object will be created in the same class as the listen socket, unless `PKG` is specified. This object can be used to communicate with the client that was trying to connect. In a scalar context the new socket is returned, or undef upon failure. In a list context a two–element array is returned containing the new socket and the peer address; the list will be empty upon failure.

socketpair(DOMAIN, TYPE, PROTOCOL)

Call `socketpair` and return a list of two sockets created, or an empty list on failure.

Additional methods that are provided are:

timeout([VAL])

Set or get the timeout value associated with this socket. If called without any arguments then the current setting is returned. If called with an argument the current setting is changed and the previous value returned.

sockopt(OPT [, VAL])

Unified method to both set and get options in the SOL_SOCKET level. If called with one argument then getsockopt is called, otherwise setsockopt is called.

sockdomain

Returns the numerical number for the socket domain type. For example, for a AF_INET socket the value of `&AF_INET` will be returned.

socktype

Returns the numerical number for the socket type. For example, for a SOCK_STREAM socket the value of `&SOCK_STREAM` will be returned.

protocol

Returns the numerical number for the protocol being used on the socket, if known. If the protocol is unknown, as with an AF_UNIX socket, zero is returned.

connected

If the socket is in a connected state the the peer address is returned. If the socket is not in a connected state then undef will be returned.

SEE ALSO

Socket, *IO::Handle*, *IO::Socket::INET*, *IO::Socket::UNIX*

AUTHOR

Graham Barr. Currently maintained by the Perl Porters. Please report all bugs to <perl5−porters@perl.org.

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NAME

IPC::Msg – SysV Msg IPC object class

SYNOPSIS

```
use IPC::SysV qw(IPC_PRIVATE S_IRWXU);
use IPC::Msg;

$msg = new IPC::Msg(IPC_PRIVATE, S_IRWXU);

$msg->snd(pack("l! a*",$msgtype,$msg));

$msg->rcv($buf,256);

$ds = $msg->stat;

$msg->remove;
```

DESCRIPTION

METHODS

new (KEY , FLAGS)

Creates a new message queue associated with `KEY`. A new queue is created if

- `KEY` is equal to `IPC_PRIVATE`
- `KEY` does not already have a message queue associated with it, and *`FLAGS`* `&` `IPC_CREAT` is true.

On creation of a new message queue `FLAGS` is used to set the permissions.

id

Returns the system message queue identifier.

rcv (BUF, LEN [, TYPE [, FLAGS]])

Read a message from the queue. Returns the type of the message read. See *msgrcv*. The BUF becomes tainted.

remove

Remove and destroy the message queue from the system.

set (STAT)
set (NAME = VALUE [, NAME = VALUE ...])

`set` will set the following values of the `stat` structure associated with the message queue.

```
uid
gid
mode (oly the permission bits)
qbytes
```

`set` accepts either a stat object, as returned by the `stat` method, or a list of *name–value* pairs.

snd (TYPE, MSG [, FLAGS])

Place a message on the queue with the data from `MSG` and with type `TYPE`. See *msgsnd*.

stat

Returns an object of type `IPC::Msg::stat` which is a sub–class of `Class::Struct`. It provides the following fields. For a description of these fields see you system documentation.

```
uid
gid
cuid
cgid
mode
qnum
```

```
qbytes
lspid
lrpid
stime
rtime
ctime
```

SEE ALSO

IPC::SysV Class::Struct

AUTHOR

Graham Barr <gbarr@pobox.com

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NAME

IPC::Semaphore – SysV Semaphore IPC object class

SYNOPSIS

```
use IPC::SysV qw(IPC_PRIVATE S_IRWXU IPC_CREAT);
use IPC::Semaphore;

$sem = new IPC::Semaphore(IPC_PRIVATE, 10, S_IRWXU | IPC_CREAT);

$sem->setall( (0) x 10);

@sem = $sem->getall;

$ncnt = $sem->getncnt;

$zcnt = $sem->getzcnt;

$ds = $sem->stat;

$sem->remove;
```

DESCRIPTION

METHODS

new (KEY , NSEMS , FLAGS)

Create a new semaphore set associated with `KEY`. `NSEMS` is the number of semaphores in the set. A new set is created if

- `KEY` is equal to `IPC_PRIVATE`
- `KEY` does not already have a semaphore identifier associated with it, and *`FLAGS`* `&` `IPC_CREAT` is true.

On creation of a new semaphore set `FLAGS` is used to set the permissions.

getall

Returns the values of the semaphore set as an array.

getncnt (SEM)

Returns the number of processed waiting for the semaphore `SEM` to become greater than it's current value

getpid (SEM)

Returns the process id of the last process that performed an operation on the semaphore `SEM`.

getval (SEM)

Returns the current value of the semaphore `SEM`.

getzcnt (SEM)

Returns the number of processed waiting for the semaphore `SEM` to become zero.

id

Returns the system identifier for the semaphore set.

op (OPLIST)

`OPLIST` is a list of operations to pass to `semop`. `OPLIST` is a concatenation of smaller lists, each which has three values. The first is the semaphore number, the second is the operation and the last is a flags value. See *semop* for more details. For example

```
$sem->op(
    0, -1, IPC_NOWAIT,
    1,  1, IPC_NOWAIT
);
```

remove

Remove and destroy the semaphore set from the system.

set (STAT)
set (NAME = VALUE [, NAME = VALUE ...])

`set` will set the following values of the `stat` structure associated with the semaphore set.

```
uid
gid
mode (oly the permission bits)
```

`set` accepts either a stat object, as returned by the `stat` method, or a list of *name–value* pairs.

setall (VALUES)

Sets all values in the semaphore set to those given on the `VALUES` list. `VALUES` must contain the correct number of values.

setval (N , VALUE)

Set the `N`th value in the semaphore set to `VALUE`

stat Returns an object of type `IPC::Semaphore::stat` which is a sub–class of `Class::Struct`. It provides the following fields. For a description of these fields see you system documentation.

```
uid
gid
cuid
cgid
mode
ctime
otime
nsems
```

SEE ALSO

IPC::SysV Class::Struct semget semctl semop

AUTHOR

Graham Barr <gbarr@pobox.com

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NAME

IPC::SysV – SysV IPC constants

SYNOPSIS

```
use IPC::SysV qw(IPC_STAT IPC_PRIVATE);
```

DESCRIPTION

`IPC::SysV` defines and conditionally exports all the constants defined in your system include files which are needed by the SysV IPC calls.

ftok(PATH, ID)

Return a key based on PATH and ID, which can be used as a key for `msgget`, `semget` and `shmget`. See *ftok*

SEE ALSO

IPC::Msg, *IPC::Semaphore*, *ftok*

AUTHORS

Graham Barr <gbarr@pobox.com Jarkko Hietaniemi <jhi@iki.fi

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NAME

NDBM_File – Tied access to ndbm files

SYNOPSIS

```
use Fcntl;   # For O_RDWR, O_CREAT, etc.
use NDBM_File;

# Now read and change the hash
$h{newkey} = newvalue;
print $h{oldkey};
...

untie %h;
```

DESCRIPTION

`NDBM_File` establishes a connection between a Perl hash variable and a file in NDBM_File format;. You can manipulate the data in the file just as if it were in a Perl hash, but when your program exits, the data will remain in the file, to be used the next time your program runs.

Use `NDBM_File` with the Perl built–in `tie` function to establish the connection between the variable and the file. The arguments to `tie` should be:

1. The hash variable you want to tie.
2. The string `"NDBM_File"`. (Ths tells Perl to use the `NDBM_File` package to perform the functions of the hash.)
3. The name of the file you want to tie to the hash.
4. Flags. Use one of:

   `O_RDONLY`
   Read–only access to the data in the file.

   `O_WRONLY`
   Write–only access to the data in the file.

   `O_RDWR`
   Both read and write access.

   If you want to create the file if it does not exist, add `O_CREAT` to any of these, as in the example. If you omit `O_CREAT` and the file does not already exist, the `tie` call will fail.
5. The default permissions to use if a new file is created. The actual permissions will be modified by the user‘s umask, so you should probably use 0666 here. (See *umask*.)

DIAGNOSTICS

On failure, the `tie` call returns an undefined value and probably sets `$!` to contain the reason the file could not be tied.

`ndbm store returned -1, errno 22, key "..." at ...`

This warning is emmitted when you try to store a key or a value that is too long. It means that the change was not recorded in the database. See BUGS AND WARNINGS below.

BUGS AND WARNINGS

There are a number of limits on the size of the data that you can store in the NDBM file. The most important is that the length of a key, plus the length of its associated value, may not exceed 1008 bytes.

See *tie*, *perldbmfilter*, *Fcntl*

NAME

ODBM_File – Tied access to odbm files

SYNOPSIS

```
use Fcntl;   # For O_RDWR, O_CREAT, etc.
use ODBM_File;

# Now read and change the hash
$h{newkey} = newvalue;
print $h{oldkey};
...

untie %h;
```

DESCRIPTION

`ODBM_File` establishes a connection between a Perl hash variable and a file in ODBM_File format;. You can manipulate the data in the file just as if it were in a Perl hash, but when your program exits, the data will remain in the file, to be used the next time your program runs.

Use `ODBM_File` with the Perl built–in `tie` function to establish the connection between the variable and the file. The arguments to `tie` should be:

1. The hash variable you want to tie.
2. The string `"ODBM_File"`. (Ths tells Perl to use the `ODBM_File` package to perform the functions of the hash.)
3. The name of the file you want to tie to the hash.
4. Flags. Use one of:

   `O_RDONLY`
   Read–only access to the data in the file.

   `O_WRONLY`
   Write–only access to the data in the file.

   `O_RDWR`
   Both read and write access.

   If you want to create the file if it does not exist, add `O_CREAT` to any of these, as in the example. If you omit `O_CREAT` and the file does not already exist, the `tie` call will fail.
5. The default permissions to use if a new file is created. The actual permissions will be modified by the user's umask, so you should probably use 0666 here. (See *umask*.)

DIAGNOSTICS

On failure, the `tie` call returns an undefined value and probably sets `$!` to contain the reason the file could not be tied.

`odbm store returned -1, errno 22, key "..." at ...`

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BUGS AND WARNINGS

There are a number of limits on the size of the data that you can store in the ODBM file. The most important is that the length of a key, plus the length of its associated value, may not exceed 1008 bytes.

See *tie*, *perldbmfilter*, *Fcntl*

NAME

Opcode – Disable named opcodes when compiling perl code

SYNOPSIS

```
use Opcode;
```

DESCRIPTION

Perl code is always compiled into an internal format before execution.

Evaluating perl code (e.g. via "eval" or "do ‘file‘") causes the code to be compiled into an internal format and then, provided there was no error in the compilation, executed. The internal format is based on many distinct *opcodes*.

By default no opmask is in effect and any code can be compiled.

The Opcode module allow you to define an *operator mask* to be in effect when perl *next* compiles any code. Attempting to compile code which contains a masked opcode will cause the compilation to fail with an error. The code will not be executed.

NOTE

The Opcode module is not usually used directly. See the ops pragma and Safe modules for more typical uses.

WARNING

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Operator Names and Operator Lists

The canonical list of operator names is the contents of the array PL_op_name defined and initialised in file ***opcode.h*** of the Perl source distribution (and installed into the perl library).

Each operator has both a terse name (its opname) and a more verbose or recognisable descriptive name. The opdesc function can be used to return a list of descriptions for a list of operators.

Many of the functions and methods listed below take a list of operators as parameters. Most operator lists can be made up of several types of element. Each element can be one of

an operator name (opname)

Operator names are typically small lowercase words like enterloop, leaveloop, last, next, redo etc. Sometimes they are rather cryptic like gv2cv, i_ncmp and ftsvtx.

an operator tag name (optag)

Operator tags can be used to refer to groups (or sets) of operators. Tag names always begin with a colon. The Opcode module defines several optags and the user can define others using the define_optag function.

a negated opname or optag

An opname or optag can be prefixed with an exclamation mark, e.g., !mkdir. Negating an opname or optag means remove the corresponding ops from the accumulated set of ops at that point.

an operator set (opset)

An *opset* as a binary string of approximately 44 bytes which holds a set or zero or more operators.

The opset and opset_to_ops functions can be used to convert from a list of operators to an opset and *vice versa*.

Wherever a list of operators can be given you can use one or more opsets. See also Manipulating Opsets below.

Opcode Functions

The Opcode package contains functions for manipulating operator names tags and sets. All are available for export by the package.

opcodes In a scalar context opcodes returns the number of opcodes in this version of perl (around 350 for perl−5.7.0).

In a list context it returns a list of all the operator names. (Not yet implemented, use @names = opset_to_ops(full_opset).)

opset (OP, ...)

Returns an opset containing the listed operators.

opset_to_ops (OPSET)

Returns a list of operator names corresponding to those operators in the set.

opset_to_hex (OPSET)

Returns a string representation of an opset. Can be handy for debugging.

full_opset Returns an opset which includes all operators.

empty_opset

Returns an opset which contains no operators.

invert_opset (OPSET)

Returns an opset which is the inverse set of the one supplied.

verify_opset (OPSET, ...)

Returns true if the supplied opset looks like a valid opset (is the right length etc) otherwise it returns false. If an optional second parameter is true then verify_opset will croak on an invalid opset instead of returning false.

Most of the other Opcode functions call verify_opset automatically and will croak if given an invalid opset.

define_optag (OPTAG, OPSET)

Define OPTAG as a symbolic name for OPSET. Optag names always start with a colon `:`.

The optag name used must not be defined already (define_optag will croak if it is already defined). Optag names are global to the perl process and optag definitions cannot be altered or deleted once defined.

It is strongly recommended that applications using Opcode should use a leading capital letter on their tag names since lowercase names are reserved for use by the Opcode module. If using Opcode within a module you should prefix your tags names with the name of your module to ensure uniqueness and thus avoid clashes with other modules.

opmask_add (OPSET)

Adds the supplied opset to the current opmask. Note that there is currently *no* mechanism for unmasking ops once they have been masked. This is intentional.

opmask Returns an opset corresponding to the current opmask.

opdesc (OP, ...)

This takes a list of operator names and returns the corresponding list of operator descriptions.

opdump (PAT)

Dumps to STDOUT a two column list of op names and op descriptions. If an optional pattern is given then only lines which match the (case insensitive) pattern will be output.

It's designed to be used as a handy command line utility:

```
perl -MOpcode=opdump -e opdump
perl -MOpcode=opdump -e 'opdump Eval'
```

Manipulating Opsets

Opsets may be manipulated using the perl bit vector operators & (and), | (or), ^ (xor) and ~ (negate/invert).

However you should never rely on the numerical position of any opcode within the opset. In other words both sides of a bit vector operator should be opsets returned from Opcode functions.

Also, since the number of opcodes in your current version of perl might not be an exact multiple of eight, there may be unused bits in the last byte of an upset. This should not cause any problems (Opcode functions ignore those extra bits) but it does mean that using the ~ operator will typically not produce the same 'physical' opset 'string' as the invert_opset function.

TO DO (maybe)

```
$bool = opset_eq($opset1, $opset2)  true if opsets are logically eqiv

$yes = opset_can($opset, @ops)      true if $opset has all @ops set

@diff = opset_diff($opset1, $opset2) => ('foo', '!bar', ...)
```

Predefined Opcode Tags

:base_core

```
null stub scalar pushmark wantarray const defined undef

rv2sv sassign

rv2av aassign aelem aelemfast aslice av2arylen

rv2hv helem hslice each values keys exists delete

preinc i_preinc predec i_predec postinc i_postinc postdec i_postdec
int hex oct abs pow multiply i_multiply divide i_divide
modulo i_modulo add i_add subtract i_subtract

left_shift right_shift bit_and bit_xor bit_or negate i_negate
not complement

lt i_lt gt i_gt le i_le ge i_ge eq i_eq ne i_ne ncmp i_ncmp
slt sgt sle sge seq sne scmp

substr vec stringify study pos length index rindex ord chr

ucfirst lcfirst uc lc quotemeta trans chop schop chomp schomp

match split qr

list lslice splice push pop shift unshift reverse

cond_expr flip flop andassign orassign and or xor

warn die lineseq nextstate scope enter leave setstate

rv2cv anoncode prototype

entersub leavesub leavesublv return method method_named -- XXX loops via rec

leaveeval -- needed for Safe to operate, is safe without entereval
```

:base_mem

These memory related ops are not included in :base_core because they can easily be used to implement a resource attack (e.g., consume all available memory).

```
concat repeat join range

anonlist anonhash
```

Note that despite the existance of this optag a memory resource attack may still be possible using only :base_core ops.

Disabling these ops is a *very* heavy handed way to attempt to prevent a memory resource attack. It's probable that a specific memory limit mechanism will be added to perl in the near future.

:base_loop

These loop ops are not included in :base_core because they can easily be used to implement a resource attack (e.g., consume all available CPU time).

```
grepstart grepwhile
mapstart mapwhile
enteriter iter
enterloop leaveloop unstack
last next redo
goto
```

:base_io

These ops enable *filehandle* (rather than filename) based input and output. These are safe on the assumption that only pre−existing filehandles are available for use. To create new filehandles other ops such as open would need to be enabled.

```
readline rcatline getc read

formline enterwrite leavewrite

print sysread syswrite send recv

eof tell seek sysseek

readdir telldir seekdir rewinddir
```

:base_orig

These are a hotchpotch of opcodes still waiting to be considered

```
gvsv gv gelem

padsv padav padhv padany

rv2gv refgen srefgen ref

bless -- could be used to change ownership of objects (reblessing)

pushre regcmaybe regcreset regcomp subst substcont

sprintf prtf -- can core dump

crypt

tie untie

dbmopen dbmclose
sselect select
pipe_op sockpair

getppid getpgrp setpgrp getpriority setpriority localtime gmtime
```

```
entertry leavetry -- can be used to 'hide' fatal errors
```

:base_math

These ops are not included in :base_core because of the risk of them being used to generate floating point exceptions (which would have to be caught using a `$SIG{FPE}` handler).

```
atan2 sin cos exp log sqrt
```

These ops are not included in :base_core because they have an effect beyond the scope of the compartment.

```
rand srand
```

:base_thread

These ops are related to multi-threading.

```
lock threadsv
```

:default

A handy tag name for a *reasonable* default set of ops. (The current ops allowed are unstable while development continues. It will change.)

```
:base_core :base_mem :base_loop :base_io :base_orig :base_thread
```

If safety matters to you (and why else would you be using the Opcode module?) then you should not rely on the definition of this, or indeed any other, optag!

:filesys_read

```
stat lstat readlink

ftatime ftblk ftchr ftctime ftdir fteexec fteowned fteread
ftewrite ftfile ftis ftlink ftmtime ftpipe ftrexec ftrowned
ftrread ftsgid ftsize ftsock ftsuid fttty ftzero ftrwrite ftsvtx

fttext ftbinary

fileno
```

:sys_db

```
ghbyname ghbyaddr ghostent shostent ehostent      -- hosts
gnbyname gnbyaddr gnetent snetent enetent         -- networks
gpbyname gpbynumber gprotoent sprotoent eprotoent -- protocols
gsbyname gsbyport gservent sservent eservent      -- services

gpwnam gpwuid gpwent spwent epwent getlogin       -- users
ggrnam ggrgid ggrent sgrent egrent                -- groups
```

:browse

A handy tag name for a *reasonable* default set of ops beyond the :default optag. Like :default (and indeed all the other optags) its current definition is unstable while development continues. It will change.

The :browse tag represents the next step beyond :default. It it a superset of the :default ops and adds :filesys_read the :sys_db. The intent being that scripts can access more (possibly sensitive) information about your system but not be able to change it.

```
:default :filesys_read :sys_db
```

:filesys_open

```
sysopen open close
umask binmode

open_dir closedir -- other dir ops are in :base_io
```

:filesys_write

```
link unlink rename symlink truncate

mkdir rmdir

utime chmod chown

fcntl -- not strictly filesys related, but possibly as dangerous?
```

:subprocess

```
backtick system

fork

wait waitpid

glob -- access to Cshell via <`rm *`>
```

:ownprocess

```
exec exit kill

time tms -- could be used for timing attacks (paranoid?)
```

:others

This tag holds groups of assorted specialist opcodes that don't warrant having optags defined for them.

SystemV Interprocess Communications:

```
msgctl msgget msgrcv msgsnd

semctl semget semop

shmctl shmget shmread shmwrite
```

:still_to_be_decided

```
chdir
flock ioctl

socket getpeername ssockopt
bind connect listen accept shutdown gsockopt getsockname

sleep alarm -- changes global timer state and signal handling
sort -- assorted problems including core dumps
tied -- can be used to access object implementing a tie
pack unpack -- can be used to create/use memory pointers

entereval -- can be used to hide code from initial compile
require dofile

caller -- get info about calling environment and args

reset

dbstate -- perl -d version of nextstate(ment) opcode
```

:dangerous

This tag is simply a bucket for opcodes that are unlikely to be used via a tag name but need to be tagged for completness and documentation.

```
syscall dump chroot
```

SEE ALSO

ops(3) — perl pragma interface to Opcode module.

Safe(3) — Opcode and namespace limited execution compartments

AUTHORS

Originally designed and implemented by Malcolm Beattie, mbeattie@sable.ox.ac.uk as part of Safe version 1.

Split out from Safe module version 1, named opcode tags and other changes added by Tim Bunce.

NAME

ops – Perl pragma to restrict unsafe operations when compiling

SYNOPSIS

```
perl -Mops=:default ...     # only allow reasonably safe operations
perl -M-ops=system ...      # disable the 'system' opcode
```

DESCRIPTION

Since the ops pragma currently has an irreversible global effect, it is only of significant practical use with the `-M` option on the command line.

See the *Opcode* module for information about opcodes, optags, opmasks and important information about safety.

SEE ALSO

Opcode(3), Safe(3), perlrun(3)

NAME

Safe – Compile and execute code in restricted compartments

SYNOPSIS

```
use Safe;

$compartment = new Safe;

$compartment->permit(qw(time sort :browse));

$result = $compartment->reval($unsafe_code);
```

DESCRIPTION

The Safe extension module allows the creation of compartments in which perl code can be evaluated. Each compartment has

a new namespace

The "root" of the namespace (i.e. "main::") is changed to a different package and code evaluated in the compartment cannot refer to variables outside this namespace, even with run–time glob lookups and other tricks.

Code which is compiled outside the compartment can choose to place variables into (or *share* variables with) the compartment's namespace and only that data will be visible to code evaluated in the compartment.

By default, the only variables shared with compartments are the "underscore" variables $_ and @_ (and, technically, the less frequently used %_, the _ filehandle and so on). This is because otherwise perl operators which default to $_ will not work and neither will the assignment of arguments to @_ on subroutine entry.

an operator mask

Each compartment has an associated "operator mask". Recall that perl code is compiled into an internal format before execution. Evaluating perl code (e.g. via "eval" or "do 'file'") causes the code to be compiled into an internal format and then, provided there was no error in the compilation, executed. Code evaluated in a compartment compiles subject to the compartment's operator mask. Attempting to evaluate code in a compartment which contains a masked operator will cause the compilation to fail with an error. The code will not be executed.

The default operator mask for a newly created compartment is the ':default' optag.

It is important that you read the Opcode(3) module documentation for more information, especially for detailed definitions of opnames, optags and opsets.

Since it is only at the compilation stage that the operator mask applies, controlled access to potentially unsafe operations can be achieved by having a handle to a wrapper subroutine (written outside the compartment) placed into the compartment. For example,

```
$cpt = new Safe;
sub wrapper {
    # vet arguments and perform potentially unsafe operations
}
$cpt->share('&wrapper');
```

WARNING

The authors make **no warranty**, implied or otherwise, about the suitability of this software for safety or security purposes.

The authors shall not in any case be liable for special, incidental, consequential, indirect or other similar damages arising from the use of this software.

Your mileage will vary. If in any doubt **do not use it**.

RECENT CHANGES

The interface to the Safe module has changed quite dramatically since version 1 (as supplied with Perl5.002). Study these pages carefully if you have code written to use Safe version 1 because you will need to makes changes.

Methods in class Safe

To create a new compartment, use

```
$cpt = new Safe;
```

Optional argument is (NAMESPACE), where NAMESPACE is the root namespace to use for the compartment (defaults to "Safe::Root0", incremented for each new compartment).

Note that version 1.00 of the Safe module supported a second optional parameter, MASK. That functionality has been withdrawn pending deeper consideration. Use the permit and deny methods described below.

The following methods can then be used on the compartment object returned by the above constructor. The object argument is implicit in each case.

permit (OP, ...)

Permit the listed operators to be used when compiling code in the compartment (in *addition* to any operators already permitted).

permit_only (OP, ...)

Permit *only* the listed operators to be used when compiling code in the compartment (*no* other operators are permitted).

deny (OP, ...)

Deny the listed operators from being used when compiling code in the compartment (other operators may still be permitted).

deny_only (OP, ...)

Deny *only* the listed operators from being used when compiling code in the compartment (*all* other operators will be permitted).

trap (OP, ...)
untrap (OP, ...)

The trap and untrap methods are synonyms for deny and permit respectfully.

share (NAME, ...)

This shares the variable(s) in the argument list with the compartment. This is almost identical to exporting variables using the *Exporter(3)* module.

Each NAME must be the **name** of a variable, typically with the leading type identifier included. A bareword is treated as a function name.

Examples of legal names are '`$foo`' for a scalar, '@foo' for an array, '%foo' for a hash, '`&foo`' or 'foo' for a subroutine and '*foo' for a glob (i.e. all symbol table entries associated with "foo", including scalar, array, hash, sub and filehandle).

Each NAME is assumed to be in the calling package. See share_from for an alternative method (which share uses).

share_from (PACKAGE, ARRAYREF)

This method is similar to `share()` but allows you to explicitly name the package that symbols should be shared from. The symbol names (including type characters) are supplied as an array reference.

```
$safe->share_from('main', [ '$foo', '%bar', 'func' ]);
```

varglob (VARNAME)

This returns a glob reference for the symbol table entry of VARNAME in the package of the compartment. VARNAME must be the **name** of a variable without any leading type marker. For example,

```
$cpt = new Safe 'Root';
$Root::foo = "Hello world";
# Equivalent version which doesn't need to know $cpt's package name:
${$cpt->varglob('foo')} = "Hello world";
```

reval (STRING)

This evaluates STRING as perl code inside the compartment.

The code can only see the compartment's namespace (as returned by the **root** method). The compartment's root package appears to be the `main::` package to the code inside the compartment.

Any attempt by the code in STRING to use an operator which is not permitted by the compartment will cause an error (at run–time of the main program but at compile–time for the code in STRING). The error is of the form "%s trapped by operation mask operation...".

If an operation is trapped in this way, then the code in STRING will not be executed. If such a trapped operation occurs or any other compile–time or return error, then `$@` is set to the error message, just as with an `eval()`.

If there is no error, then the method returns the value of the last expression evaluated, or a return statement may be used, just as with subroutines and **`eval()`**. The context (list or scalar) is determined by the caller as usual.

This behaviour differs from the beta distribution of the Safe extension where earlier versions of perl made it hard to mimic the return behaviour of the `eval()` command and the context was always scalar.

Some points to note:

If the entereval op is permitted then the code can use eval "..." to 'hide' code which might use denied ops. This is not a major problem since when the code tries to execute the eval it will fail because the opmask is still in effect. However this technique would allow clever, and possibly harmful, code to 'probe' the boundaries of what is possible.

Any string eval which is executed by code executing in a compartment, or by code called from code executing in a compartment, will be eval'd in the namespace of the compartment. This is potentially a serious problem.

Consider a function `foo()` in package pkg compiled outside a compartment but shared with it. Assume the compartment has a root package called 'Root'. If `foo()` contains an eval statement like eval '`$foo = 1`' then, normally, `$pkg::foo` will be set to 1. If `foo()` is called from the compartment (by whatever means) then instead of setting `$pkg::foo`, the eval will actually set `$Root::pkg::foo`.

This can easily be demonstrated by using a module, such as the Socket module, which uses eval "..." as part of an AUTOLOAD function. You can 'use' the module outside the compartment and share an (autoloaded) function with the compartment. If an autoload is triggered by code in the compartment, or by any code anywhere that is called by any means from the compartment, then the eval in the Socket module's AUTOLOAD function happens in the namespace of the compartment. Any variables created or used by the eval'd code are now under the control of the code in the compartment.

A similar effect applies to *all* runtime symbol lookups in code called from a compartment but not compiled within it.

rdo (FILENAME)

This evaluates the contents of file FILENAME inside the compartment. See above documentation on the **reval** method for further details.

root (NAMESPACE)

This method returns the name of the package that is the root of the compartment's namespace.

Note that this behaviour differs from version 1.00 of the Safe module where the root module could be used to change the namespace. That functionality has been withdrawn pending deeper consideration.

mask (MASK)

This is a get-or-set method for the compartment's operator mask.

With no MASK argument present, it returns the current operator mask of the compartment.

With the MASK argument present, it sets the operator mask for the compartment (equivalent to calling the deny_only method).

Some Safety Issues

This section is currently just an outline of some of the things code in a compartment might do (intentionally or unintentionally) which can have an effect outside the compartment.

Memory Consuming all (or nearly all) available memory.

CPU Causing infinite loops etc.

Snooping Copying private information out of your system. Even something as simple as your user name is of value to others. Much useful information could be gleaned from your environment variables for example.

Signals Causing signals (especially SIGFPE and SIGALARM) to affect your process.

Setting up a signal handler will need to be carefully considered and controlled. What mask is in effect when a signal handler gets called? If a user can get an imported function to get an exception and call the user's signal handler, does that user's restricted mask get re-instated before the handler is called? Does an imported handler get called with its original mask or the user's one?

State Changes

Ops such as chdir obviously effect the process as a whole and not just the code in the compartment. Ops such as rand and srand have a similar but more subtle effect.

AUTHOR

Originally designed and implemented by Malcolm Beattie, mbeattie@sable.ox.ac.uk.

Reworked to use the Opcode module and other changes added by Tim Bunce ***<Tim.Bunce@ig.co.uk>***.

NAME

re – Perl pragma to alter regular expression behaviour

SYNOPSIS

```
use re 'taint';
($x) = ($^X =~ /^(.*)$/s);     # $x is tainted here

$pat = '(?{ $foo = 1 })';
use re 'eval';
/foo${pat}bar/;                # won't fail (when not under -T switch)

{
    no re 'taint';             # the default
    ($x) = ($^X =~ /^(.*)$/s); # $x is not tainted here

    no re 'eval';              # the default
    /foo${pat}bar/;            # disallowed (with or without -T switch)
}

use re 'debug';                # NOT lexically scoped (as others are)
/^(.*)$/s;                     # output debugging info during
                               #     compile and run time

use re 'debugcolor';           # same as 'debug', but with colored output
...
```

(We use `$^X` in these examples because it's tainted by default.)

DESCRIPTION

When `use re 'taint'` is in effect, and a tainted string is the target of a regex, the regex memories (or values returned by the m// operator in list context) are tainted. This feature is useful when regex operations on tainted data aren't meant to extract safe substrings, but to perform other transformations.

When `use re 'eval'` is in effect, a regex is allowed to contain `(?{ ... })` zero-width assertions even if regular expression contains variable interpolation. That is normally disallowed, since it is a potential security risk. Note that this pragma is ignored when the regular expression is obtained from tainted data, i.e. evaluation is always disallowed with tainted regular expresssions. See *(?{ code })*.

For the purpose of this pragma, interpolation of precompiled regular expressions (i.e., the result of `qr//`) is *not* considered variable interpolation. Thus:

```
/foo${pat}bar/
```

is allowed if `$pat` is a precompiled regular expression, even if `$pat` contains `(?{ ... })` assertions.

When `use re 'debug'` is in effect, perl emits debugging messages when compiling and using regular expressions. The output is the same as that obtained by running a `-DDEBUGGING`-enabled perl interpreter with the **-Dr** switch. It may be quite voluminous depending on the complexity of the match. Using `debugcolor` instead of `debug` enables a form of output that can be used to get a colorful display on terminals that understand termcap color sequences. Set `$ENV{PERL_RE_TC}` to a comma-separated list of `termcap` properties to use for highlighting strings on/off, pre-point part on/off. See *Debugging regular expressions in perldebug* for additional info.

The directive `use re 'debug'` is *not lexically scoped*, as the other directives are. It has both compile-time and run-time effects.

See *Pragmatic Modules*.

NAME

SDBM_File – Tied access to sdbm files

SYNOPSIS

```
use Fcntl;   # For O_RDWR, O_CREAT, etc.
use SDBM_File;

tie(%h, 'SDBM_File', 'filename', O_RDWR|O_CREAT, 0666)
  or die "Couldn't tie SDBM file 'filename': $!; aborting";

# Now read and change the hash
$h{newkey} = newvalue;
print $h{oldkey};
...

untie %h;
```

DESCRIPTION

`SDBM_File` establishes a connection between a Perl hash variable and a file in SDBM_File format;. You can manipulate the data in the file just as if it were in a Perl hash, but when your program exits, the data will remain in the file, to be used the next time your program runs.

Use `SDBM_File` with the Perl built–in `tie` function to establish the connection between the variable and the file. The arguments to `tie` should be:

1. The hash variable you want to tie.
2. The string `"SDBM_File"`. (Ths tells Perl to use the `SDBM_File` package to perform the functions of the hash.)
3. The name of the file you want to tie to the hash.
4. Flags. Use one of:

   `O_RDONLY`
   Read–only access to the data in the file.

   `O_WRONLY`
   Write–only access to the data in the file.

   `O_RDWR`
   Both read and write access.

   If you want to create the file if it does not exist, add `O_CREAT` to any of these, as in the example. If you omit `O_CREAT` and the file does not already exist, the `tie` call will fail.
5. The default permissions to use if a new file is created. The actual permissions will be modified by the user's umask, so you should probably use 0666 here. (See *umask*.)

DIAGNOSTICS

On failure, the `tie` call returns an undefined value and probably sets `$!` to contain the reason the file could not be tied.

`sdbm store returned -1, errno 22, key "..." at ...`

This warning is emmitted when you try to store a key or a value that is too long. It means that the change was not recorded in the database. See BUGS AND WARNINGS below.

BUGS AND WARNINGS

There are a number of limits on the size of the data that you can store in the SDBM file. The most important is that the length of a key, plus the length of its associated value, may not exceed 1008 bytes.

See *tie*, *perldbmfilter*, *Fcntl*

NAME

Socket, sockaddr_in, sockaddr_un, inet_aton, inet_ntoa − load the C socket.h defines and structure manipulators

SYNOPSIS

```
use Socket;

$proto = getprotobyname('udp');
socket(Socket_Handle, PF_INET, SOCK_DGRAM, $proto);
$iaddr = gethostbyname('hishost.com');
$port = getservbyname('time', 'udp');
$sin = sockaddr_in($port, $iaddr);
send(Socket_Handle, 0, 0, $sin);

$proto = getprotobyname('tcp');
socket(Socket_Handle, PF_INET, SOCK_STREAM, $proto);
$port = getservbyname('smtp', 'tcp');
$sin = sockaddr_in($port,inet_aton("127.1"));
$sin = sockaddr_in(7,inet_aton("localhost"));
$sin = sockaddr_in(7,INADDR_LOOPBACK);
connect(Socket_Handle,$sin);

($port, $iaddr) = sockaddr_in(getpeername(Socket_Handle));
$peer_host = gethostbyaddr($iaddr, AF_INET);
$peer_addr = inet_ntoa($iaddr);

$proto = getprotobyname('tcp');
socket(Socket_Handle, PF_UNIX, SOCK_STREAM, $proto);
unlink('/tmp/usock');
$sun = sockaddr_un('/tmp/usock');
connect(Socket_Handle,$sun);
```

DESCRIPTION

This module is just a translation of the C ***socket.h*** file. Unlike the old mechanism of requiring a translated ***socket.ph*** file, this uses the **h2xs** program (see the Perl source distribution) and your native C compiler. This means that it has a far more likely chance of getting the numbers right. This includes all of the commonly used pound−defines like AF_INET, SOCK_STREAM, etc.

Also, some common socket "newline" constants are provided: the constants `CR`, `LF`, and `CRLF`, as well as `$CR`, `$LF`, and `$CRLF`, which map to `\015`, `\012`, and `\015\012`. If you do not want to use the literal characters in your programs, then use the constants provided here. They are not exported by default, but can be imported individually, and with the `:crlf` export tag:

```
use Socket qw(:DEFAULT :crlf);
```

In addition, some structure manipulation functions are available:

inet_aton HOSTNAME

Takes a string giving the name of a host, and translates that to the 4−byte string (structure). Takes arguments of both the 'rtfm.mit.edu' type and '18.181.0.24'. If the host name cannot be resolved, returns undef. For multi−homed hosts (hosts with more than one address), the first address found is returned.

inet_ntoa IP_ADDRESS

Takes a four byte ip address (as returned by `inet_aton()`) and translates it into a string of the form 'd.d.d.d' where the 'd's are numbers less than 256 (the normal readable four dotted number notation for internet addresses).

INADDR_ANY

Note: does not return a number, but a packed string.

Returns the 4−byte wildcard ip address which specifies any of the hosts ip addresses. (A particular machine can have more than one ip address, each address corresponding to a particular network interface. This wildcard address allows you to bind to all of them simultaneously.) Normally equivalent to inet_aton('0.0.0.0').

INADDR_BROADCAST

Note: does not return a number, but a packed string.

Returns the 4−byte 'this−lan' ip broadcast address. This can be useful for some protocols to solicit information from all servers on the same LAN cable. Normally equivalent to inet_aton('255.255.255.255').

INADDR_LOOPBACK

Note − does not return a number.

Returns the 4−byte loopback address. Normally equivalent to inet_aton('localhost').

INADDR_NONE

Note − does not return a number.

Returns the 4−byte 'invalid' ip address. Normally equivalent to inet_aton('255.255.255.255').

sockaddr_in PORT, ADDRESS
sockaddr_in SOCKADDR_IN

In a list context, unpacks its SOCKADDR_IN argument and returns an array consisting of (PORT, ADDRESS). In a scalar context, packs its (PORT, ADDRESS) arguments as a SOCKADDR_IN and returns it. If this is confusing, use `pack_sockaddr_in()` and `unpack_sockaddr_in()` explicitly.

pack_sockaddr_in PORT, IP_ADDRESS

Takes two arguments, a port number and a 4 byte IP_ADDRESS (as returned by `inet_aton()`). Returns the sockaddr_in structure with those arguments packed in with AF_INET filled in. For internet domain sockets, this structure is normally what you need for the arguments in `bind()`, `connect()`, and `send()`, and is also returned by `getpeername()`, `getsockname()` and `recv()`.

unpack_sockaddr_in SOCKADDR_IN

Takes a sockaddr_in structure (as returned by `pack_sockaddr_in()`) and returns an array of two elements: the port and the 4−byte ip−address. Will croak if the structure does not have AF_INET in the right place.

sockaddr_un PATHNAME
sockaddr_un SOCKADDR_UN

In a list context, unpacks its SOCKADDR_UN argument and returns an array consisting of (PATHNAME). In a scalar context, packs its PATHNAME arguments as a SOCKADDR_UN and returns it. If this is confusing, use `pack_sockaddr_un()` and `unpack_sockaddr_un()` explicitly. These are only supported if your system has ***<sys/un.h>***.

pack_sockaddr_un PATH

Takes one argument, a pathname. Returns the sockaddr_un structure with that path packed in with AF_UNIX filled in. For unix domain sockets, this structure is normally what you need for the arguments in `bind()`, `connect()`, and `send()`, and is also returned by `getpeername()`, `getsockname()` and `recv()`.

unpack_sockaddr_un SOCKADDR_UN

Takes a sockaddr_un structure (as returned by `pack_sockaddr_un()`) and returns the pathname. Will croak if the structure does not have AF_UNIX in the right place.

NAME

Storable – persistency for perl data structures

SYNOPSIS

```
use Storable;
store \%table, 'file';
$hashref = retrieve('file');

use Storable qw(nstore store_fd nstore_fd freeze thaw dclone);

# Network order
nstore \%table, 'file';
$hashref = retrieve('file');   # There is NO nretrieve()

# Storing to and retrieving from an already opened file
store_fd \@array, \*STDOUT;
nstore_fd \%table, \*STDOUT;
$aryref = fd_retrieve(\*SOCKET);
$hashref = fd_retrieve(\*SOCKET);

# Serializing to memory
$serialized = freeze \%table;
%table_clone = %{ thaw($serialized) };

# Deep (recursive) cloning
$cloneref = dclone($ref);

# Advisory locking
use Storable qw(lock_store lock_nstore lock_retrieve)
lock_store \%table, 'file';
lock_nstore \%table, 'file';
$hashref = lock_retrieve('file');
```

DESCRIPTION

The Storable package brings persistency to your perl data structures containing SCALAR, ARRAY, HASH or REF objects, i.e. anything that can be conveniently stored to disk and retrieved at a later time.

It can be used in the regular procedural way by calling `store` with a reference to the object to be stored, along with the file name where the image should be written. The routine returns `undef` for I/O problems or other internal error, a true value otherwise. Serious errors are propagated as a `die` exception.

To retrieve data stored to disk, use `retrieve` with a file name, and the objects stored into that file are recreated into memory for you, a *reference* to the root object being returned. In case an I/O error occurs while reading, `undef` is returned instead. Other serious errors are propagated via `die`.

Since storage is performed recursively, you might want to stuff references to objects that share a lot of common data into a single array or hash table, and then store that object. That way, when you retrieve back the whole thing, the objects will continue to share what they originally shared.

At the cost of a slight header overhead, you may store to an already opened file descriptor using the `store_fd` routine, and retrieve from a file via `fd_retrieve`. Those names aren't imported by default, so you will have to do that explicitely if you need those routines. The file descriptor you supply must be already opened, for read if you're going to retrieve and for write if you wish to store.

```
store_fd(\%table, *STDOUT) || die "can't store to stdout\n";
$hashref = fd_retrieve(*STDIN);
```

You can also store data in network order to allow easy sharing across multiple platforms, or when storing on a socket known to be remotely connected. The routines to call have an initial `n` prefix for *network*, as in `nstore` and `nstore_fd`. At retrieval time, your data will be correctly restored so you don't have to know

whether you're restoring from native or network ordered data. Double values are stored stringified to ensure portability as well, at the slight risk of loosing some precision in the last decimals.

When using `fd_retrieve`, objects are retrieved in sequence, one object (i.e. one recursive tree) per associated `store_fd`.

If you're more from the object-oriented camp, you can inherit from Storable and directly store your objects by invoking `store` as a method. The fact that the root of the to-be-stored tree is a blessed reference (i.e. an object) is special-cased so that the retrieve does not provide a reference to that object but rather the blessed object reference itself. (Otherwise, you'd get a reference to that blessed object).

MEMORY STORE

The Storable engine can also store data into a Perl scalar instead, to later retrieve them. This is mainly used to freeze a complex structure in some safe compact memory place (where it can possibly be sent to another process via some IPC, since freezing the structure also serializes it in effect). Later on, and maybe somewhere else, you can thaw the Perl scalar out and recreate the original complex structure in memory.

Surprisingly, the routines to be called are named `freeze` and `thaw`. If you wish to send out the frozen scalar to another machine, use `nfreeze` instead to get a portable image.

Note that freezing an object structure and immediately thawing it actually achieves a deep cloning of that structure:

```
dclone(.) = thaw(freeze(.))
```

Storable provides you with a `dclone` interface which does not create that intermediary scalar but instead freezes the structure in some internal memory space and then immediatly thaws it out.

ADVISORY LOCKING

The `lock_store` and `lock_nstore` routine are equivalent to `store` and `nstore`, only they get an exclusive lock on the file before writing. Likewise, `lock_retrieve` performs as `retrieve`, but also gets a shared lock on the file before reading.

Like with any advisory locking scheme, the protection only works if you systematically use `lock_store` and `lock_retrieve`. If one side of your application uses `store` whilst the other uses `lock_retrieve`, you will get no protection at all.

The internal advisory locking is implemented using Perl's `flock()` routine. If your system does not support any form of `flock()`, or if you share your files across NFS, you might wish to use other forms of locking by using modules like LockFile::Simple which lock a file using a filesystem entry, instead of locking the file descriptor.

SPEED

The heart of Storable is written in C for decent speed. Extra low-level optimization have been made when manipulating perl internals, to sacrifice encapsulation for the benefit of a greater speed.

CANONICAL REPRESENTATION

Normally Storable stores elements of hashes in the order they are stored internally by Perl, i.e. pseudo-randomly. If you set `$Storable::canonical` to some `TRUE` value, Storable will store hashes with the elements sorted by their key. This allows you to compare data structures by comparing their frozen representations (or even the compressed frozen representations), which can be useful for creating lookup tables for complicated queries.

Canonical order does not imply network order, those are two orthogonal settings.

ERROR REPORTING

Storable uses the "exception" paradigm, in that it does not try to workaround failures: if something bad happens, an exception is generated from the caller's perspective (see *Carp* and `croak()`). Use eval {} to trap those exceptions.

When Storable croaks, it tries to report the error via the `logcroak()` routine from the `Log::Agent`

package, if it is available.

Normal errors are reported by having `store()` or `retrieve()` return `undef`. Such errors are usually I/O errors (or truncated stream errors at retrieval).

WIZARDS ONLY

Hooks

Any class may define hooks that will be called during the serialization and deserialization process on objects that are instances of that class. Those hooks can redefine the way serialization is performed (and therefore, how the symetrical deserialization should be conducted).

Since we said earlier:

```
dclone(.) = thaw(freeze(.))
```

everything we say about hooks should also hold for deep cloning. However, hooks get to know whether the operation is a mere serialization, or a cloning.

Therefore, when serializing hooks are involved,

```
dclone(.) <> thaw(freeze(.))
```

Well, you could keep them in sync, but there's no guarantee it will always hold on classes somebody else wrote. Besides, there is little to gain in doing so: a serializing hook could only keep one attribute of an object, which is probably not what should happen during a deep cloning of that same object.

Here is the hooking interface:

`STORABLE_freeze` *obj*, *cloning*

The serializing hook, called on the object during serialization. It can be inherited, or defined in the class itself, like any other method.

Arguments: *obj* is the object to serialize, *cloning* is a flag indicating whether we're in a `dclone()` or a regular serialization via `store()` or `freeze()`.

Returned value: A LIST `($serialized, $ref1, $ref2, ...)` where `$serialized` is the serialized form to be used, and the optional `$ref1, $ref2,` etc... are extra references that you wish to let the Storable engine serialize.

At deserialization time, you will be given back the same LIST, but all the extra references will be pointing into the deserialized structure.

The **first time** the hook is hit in a serialization flow, you may have it return an empty list. That will signal the Storable engine to further discard that hook for this class and to therefore revert to the default serialization of the underlying Perl data. The hook will again be normally processed in the next serialization.

Unless you know better, serializing hook should always say:

```
sub STORABLE_freeze {
    my ($self, $cloning) = @_;
    return if $cloning;         # Regular default serialization
    ....
}
```

in order to keep reasonable `dclone()` semantics.

`STORABLE_thaw` *obj*, *cloning*, *serialized*, ...

The deserializing hook called on the object during deserialization. But wait. If we're deserializing, there's no object yet... right?

Wrong: the Storable engine creates an empty one for you. If you know Eiffel, you can view `STORABLE_thaw` as an alternate creation routine.

This means the hook can be inherited like any other method, and that *obj* is your blessed reference for this particular instance.

The other arguments should look familiar if you know `STORABLE_freeze`: *cloning* is true when we're part of a deep clone operation, *serialized* is the serialized string you returned to the engine in `STORABLE_freeze`, and there may be an optional list of references, in the same order you gave them at serialization time, pointing to the deserialized objects (which have been processed courtesy of the Storable engine).

When the Storable engine does not find any `STORABLE_thaw` hook routine, it tries to load the class by requiring the package dynamically (using the blessed package name), and then re-attempts the lookup. If at that time the hook cannot be located, the engine croaks. Note that this mechanism will fail if you define several classes in the same file, but perlmod(1) warned you.

It is up to you to use these information to populate *obj* the way you want.

Returned value: none.

Predicates

Predicates are not exportable. They must be called by explicitely prefixing them with the Storable package name.

`Storable::last_op_in_netorder`

The `Storable::last_op_in_netorder()` predicate will tell you whether network order was used in the last store or retrieve operation. If you don't know how to use this, just forget about it.

`Storable::is_storing`

Returns true if within a store operation (via STORABLE_freeze hook).

`Storable::is_retrieving`

Returns true if within a retrieve operation, (via STORABLE_thaw hook).

Recursion

With hooks comes the ability to recurse back to the Storable engine. Indeed, hooks are regular Perl code, and Storable is convenient when it comes to serialize and deserialize things, so why not use it to handle the serialization string?

There are a few things you need to know however:

- You can create endless loops if the things you serialize via `freeze()` (for instance) point back to the object we're trying to serialize in the hook.
- Shared references among objects will not stay shared: if we're serializing the list of object [A, C] where both object A and C refer to the SAME object B, and if there is a serializing hook in A that says freeze(B), then when deserializing, we'll get [A', C'] where A' refers to B', but C' refers to D, a deep clone of B'. The topology was not preserved.

That's why `STORABLE_freeze` lets you provide a list of references to serialize. The engine guarantees that those will be serialized in the same context as the other objects, and therefore that shared objects will stay shared.

In the above [A, C] example, the `STORABLE_freeze` hook could return:

```
("something", $self->{B})
```

and the B part would be serialized by the engine. In `STORABLE_thaw`, you would get back the reference to the B' object, deserialized for you.

Therefore, recursion should normally be avoided, but is nonetheless supported.

Deep Cloning

There is a new Clone module available on CPAN which implements deep cloning natively, i.e. without freezing to memory and thawing the result. It is aimed to replace Storable's `dclone()` some day. However, it does not currently support Storable hooks to redefine the way deep cloning is performed.

EXAMPLES

Here are some code samples showing a possible usage of Storable:

```
use Storable qw(store retrieve freeze thaw dclone);

%color = ('Blue' => 0.1, 'Red' => 0.8, 'Black' => 0, 'White' => 1);

store(\%color, '/tmp/colors') or die "Can't store %a in /tmp/colors!\n";

$colref = retrieve('/tmp/colors');
die "Unable to retrieve from /tmp/colors!\n" unless defined $colref;
printf "Blue is still %lf\n", $colref->{'Blue'};

$colref2 = dclone(\%color);

$str = freeze(\%color);
printf "Serialization of %%color is %d bytes long.\n", length($str);
$colref3 = thaw($str);
```

which prints (on my machine):

```
Blue is still 0.100000
Serialization of %color is 102 bytes long.
```

WARNING

If you're using references as keys within your hash tables, you're bound to disapointment when retrieving your data. Indeed, Perl stringifies references used as hash table keys. If you later wish to access the items via another reference stringification (i.e. using the same reference that was used for the key originally to record the value into the hash table), it will work because both references stringify to the same string.

It won't work across a `store` and `retrieve` operations however, because the addresses in the retrieved objects, which are part of the stringified references, will probably differ from the original addresses. The topology of your structure is preserved, but not hidden semantics like those.

On platforms where it matters, be sure to call `binmode()` on the descriptors that you pass to Storable functions.

Storing data canonically that contains large hashes can be significantly slower than storing the same data normally, as temprorary arrays to hold the keys for each hash have to be allocated, populated, sorted and freed. Some tests have shown a halving of the speed of storing — the exact penalty will depend on the complexity of your data. There is no slowdown on retrieval.

BUGS

You can't store GLOB, CODE, FORMLINE, etc... If you can define semantics for those operations, feel free to enhance Storable so that it can deal with them.

The store functions will `croak` if they run into such references unless you set `$Storable::forgive_me` to some `TRUE` value. In that case, the fatal message is turned in a warning and some meaningless string is stored instead.

Setting `$Storable::canonical` may not yield frozen strings that compare equal due to possible stringification of numbers. When the string version of a scalar exists, it is the form stored, therefore if you happen to use your numbers as strings between two freezing operations on the same data structures, you will get different results.

When storing doubles in network order, their value is stored as text. However, you should also not expect non–numeric floating–point values such as infinity and "not a number" to pass successfully through a

`nstore()/retrieve()` pair.

As Storable neither knows nor cares about character sets (although it does know that characters may be more than eight bits wide), any difference in the interpretation of character codes between a host and a target system is your problem. In particular, if host and target use different code points to represent the characters used in the text representation of floating−point numbers, you will not be able be able to exchange floating−point data, even with `nstore()`.

CREDITS

Thank you to (in chronological order):

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for their bug reports, suggestions and contributions.

Benjamin Holzman contributed the tied variable support, Andrew Ford contributed the canonical order for hashes, and Gisle Aas fixed a few misunderstandings of mine regarding the Perl internals, and optimized the emission of "tags" in the output streams by simply counting the objects instead of tagging them (leading to a binary incompatibility for the Storable image starting at version 0.6—older images are of course still properly understood). Murray Nesbitt made Storable thread−safe. Marc Lehmann added overloading and reference to tied items support.

TRANSLATIONS

There is a Japanese translation of this man page available at
http://member.nifty.ne.jp/hippo2000/perltips/storable.htm , courtesy of Kawai, Takanori
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AUTHOR

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SEE ALSO

Clone(3).

NAME

Sys::Hostname – Try every conceivable way to get hostname

SYNOPSIS

```
use Sys::Hostname;
$host = hostname;
```

DESCRIPTION

Attempts several methods of getting the system hostname and then caches the result. It tries the first available of the C library's `gethostname()`, `'$Config{aphostname}'`, uname(2), `syscall(SYS_gethostname)`, `'hostname'`, `'uname -n'`, and the file */com/host*. If all that fails it `croak`s.

All NULs, returns, and newlines are removed from the result.

AUTHOR

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XS code added by Greg Bacon <*gbacon@cs.uah.edu*>

NAME

Sys::Syslog, openlog, closelog, setlogmask, syslog – Perl interface to the UNIX syslog(3) calls

SYNOPSIS

```
use Sys::Syslog;                          # all except setlogsock, or:
use Sys::Syslog qw(:DEFAULT setlogsock);  # default set, plus setlogsock

setlogsock $sock_type;
openlog $ident, $logopt, $facility;
syslog $priority, $format, @args;
$oldmask = setlogmask $mask_priority;
closelog;
```

DESCRIPTION

Sys::Syslog is an interface to the UNIX `syslog(3)` program. Call `syslog()` with a string priority and a list of `printf()` args just like `syslog(3)`.

Syslog provides the functions:

openlog `$ident, $logopt, $facility`

`$ident` is prepended to every message. *`$logopt`* contains zero or more of the words *pid*, *ndelay*, *cons*, *nowait*. *`$facility`* specifies the part of the system

syslog `$priority, $format,` @args

If *`$priority`* permits, logs *`($format, @args)`* printed as by `printf(3V)`, with the addition that *%m* is replaced with `"$!"` (the latest error message).

setlogmask `$mask_priority`

Sets log mask *`$mask_priority`* and returns the old mask.

setlogsock `$sock_type` (added in 5.004_02)

Sets the socket type to be used for the next call to `openlog()` or `syslog()` and returns TRUE on success, undef on failure.

A value of 'unix' will connect to the UNIX domain socket returned by the `_PATH_LOG` macro (if you system defines it) in ***syslog.h***. A value of 'inet' will connect to an INET socket returned by `getservbyname()`. If `_PATH_LOG` is unavailable or if `getservbyname()` fails, returns undef. Any other value croaks.

The default is for the INET socket to be used.

closelog

Closes the log file.

Note that `openlog` now takes three arguments, just like `openlog(3)`.

EXAMPLES

```
openlog($program, 'cons,pid', 'user');
syslog('info', 'this is another test');
syslog('mail|warning', 'this is a better test: %d', time);
closelog();

syslog('debug', 'this is the last test');

setlogsock('unix');
openlog("$program $$", 'ndelay', 'user');
syslog('notice', 'fooprogram: this is really done');

setlogsock('inet');
$! = 55;
```

```
    syslog('info', 'problem was %m'); # %m == $! in syslog(3)
```

SEE ALSO

syslog(3)

AUTHOR

Tom Christiansen <***tchrist@perl.com***> and Larry Wall <***larry@wall.org***>.

UNIX domain sockets added by Sean Robinson <***robinson_s@sc.maricopa.edu***> with support from Tim Bunce <***Tim.Bunce@ig.co.uk***> and the perl5−porters mailing list.

Dependency on ***syslog.ph*** replaced with XS code by Tom Hughes <***tom@compton.nu***>.

NAME

Thread::Queue – thread–safe queues

SYNOPSIS

```
use Thread::Queue;
my $q = new Thread::Queue;
$q->enqueue("foo", "bar");
my $foo = $q->dequeue;    # The "bar" is still in the queue.
my $foo = $q->dequeue_nb; # returns "bar", or undef if the queue was
                          # empty
my $left = $q->pending;   # returns the number of items still in the queue
```

DESCRIPTION

A queue, as implemented by `Thread::Queue` is a thread–safe data structure much like a list. Any number of threads can safely add elements to the end of the list, or remove elements from the head of the list. (Queues don't permit adding or removing elements from the middle of the list)

FUNCTIONS AND METHODS

new The `new` function creates a new empty queue.

enqueue LIST

The `enqueue` method adds a list of scalars on to the end of the queue. The queue will grow as needed to accomodate the list.

dequeue The `dequeue` method removes a scalar from the head of the queue and returns it. If the queue is currently empty, `dequeue` will block the thread until another thread `enqueues` a scalar.

dequeue_nb

The `dequeue_nb` method, like the `dequeue` method, removes a scalar from the head of the queue and returns it. Unlike `dequeue`, though, `dequeue_nb` won't block if the queue is empty, instead returning `undef`.

pending The `pending` method returns the number of items still in the queue. (If there can be multiple readers on the queue it's best to lock the queue before checking to make sure that it stays in a consistent state)

SEE ALSO

Thread

NAME

Thread::Semaphore – thread–safe semaphores

SYNOPSIS

```
use Thread::Semaphore;
my $s = new Thread::Semaphore;
$s->up;     # Also known as the semaphore V -operation.
# The guarded section is here
$s->down;   # Also known as the semaphore P -operation.

# The default semaphore value is 1.
my $s = new Thread::Semaphore($initial_value);
$s->up($up_value);
$s->down($up_value);
```

DESCRIPTION

Semaphores provide a mechanism to regulate access to resources. Semaphores, unlike locks, aren't tied to particular scalars, and so may be used to control access to anything you care to use them for.

Semaphores don't limit their values to zero or one, so they can be used to control access to some resource that may have more than one of. (For example, filehandles) Increment and decrement amounts aren't fixed at one either, so threads can reserve or return multiple resources at once.

FUNCTIONS AND METHODS

new
new NUMBER

`new` creates a new semaphore, and initializes its count to the passed number. If no number is passed, the semaphore's count is set to one.

down
down NUMBER

The `down` method decreases the semaphore's count by the specified number, or one if no number has been specified. If the semaphore's count would drop below zero, this method will block until such time that the semaphore's count is equal to or larger than the amount you're `down`ing the semaphore's count by.

up
up NUMBER

The `up` method increases the semaphore's count by the number specified, or one if no number's been specified. This will unblock any thread blocked trying to `down` the semaphore if the `up` raises the semaphore count above what the `down`s are trying to decrement it by.

NAME

Thread::Signal – Start a thread which runs signal handlers reliably

SYNOPSIS

```
use Thread::Signal;

$SIG{HUP} = \&some_handler;
```

DESCRIPTION

The `Thread::Signal` module starts up a special signal handler thread. All signals to the process are delivered to it and it runs the associated `$SIG{FOO}` handlers for them. Without this module, signals arriving at inopportune moments (such as when perl's internals are in the middle of updating critical structures) cause the perl code of the handler to be run unsafely which can cause memory corruption or worse.

BUGS

This module changes the semantics of signal handling slightly in that the signal handler is run separately from the main thread (and in parallel with it). This means that tricks such as calling `die` from a signal handler behave differently (and, in particular, can't be used to exit directly from a system call).

NAME

Thread::Specific – thread–specific keys

SYNOPSIS

```
use Thread::Specific;
my $k = key_create Thread::Specific;
```

DESCRIPTION

`key_create` returns a unique thread–specific key.

NAME

Thread – manipulate threads in Perl (EXPERIMENTAL, subject to change)

SYNOPSIS

```
use Thread;

my $t = new Thread \&start_sub, @start_args;

$result = $t->join;
$result = $t->eval;
$t->detach;
$flags = $t->flags;

if ($t->done) {
    $t->join;
}

if($t->equal($another_thread)) {
    # ...
}

my $tid = Thread->self->tid;
my $tlist = Thread->list;

lock($scalar);
yield();

use Thread 'async';
```

DESCRIPTION

```
WARNING: Threading is an experimental feature.  Both the interface
and implementation are subject to change drastically.  In fact, this
documentation describes the flavor of threads that was in version
5.005.  Perl 5.6.0 and later have the beginnings of support for
interpreter threads, which (when finished) is expected to be
significantly different from what is described here.  The information
contained here may therefore soon be obsolete.  Use at your own risk!
```

The `Thread` module provides multithreading support for perl.

FUNCTIONS

new \&start_sub
new \&start_sub, LIST

`new` starts a new thread of execution in the referenced subroutine. The optional list is passed as parameters to the subroutine. Execution continues in both the subroutine and the code after the `new` call.

`new Thread` returns a thread object representing the newly created thread.

lock VARIABLE

`lock` places a lock on a variable until the lock goes out of scope. If the variable is locked by another thread, the `lock` call will block until it's available. `lock` is recursive, so multiple calls to `lock` are safe—the variable will remain locked until the outermost lock on the variable goes out of scope.

Locks on variables only affect `lock` calls—they do *not* affect normal access to a variable. (Locks on subs are different, and covered in a bit) If you really, *really* want locks to block access, then go ahead and tie them to something and manage this yourself. This is done on purpose. While managing access to variables is a good thing, perl doesn't force you out of its living room...

If a container object, such as a hash or array, is locked, all the elements of that container are not locked. For example, if a thread does a `lock @a`, any other thread doing a `lock($a[12])` won't block.

You may also `lock` a sub, using `lock &sub`. Any calls to that sub from another thread will block until the lock is released. This behaviour is not equivalent to declaring the sub with the `locked` attribute. The `locked` attribute serializes access to a subroutine, but allows different threads non-simultaneous access. `lock &sub`, on the other hand, will not allow *any* other thread access for the duration of the lock.

Finally, `lock` will traverse up references exactly *one* level. `lock(\$a)` is equivalent to `lock($a)`, while `lock(\\$a)` is not.

async BLOCK;

`async` creates a thread to execute the block immediately following it. This block is treated as an anonymous sub, and so must have a semi-colon after the closing brace. Like `new Thread`, `async` returns a thread object.

Thread-self

The `Thread->self` function returns a thread object that represents the thread making the `Thread->self` call.

Thread-list

`Thread->list` returns a list of thread objects for all running and finished but un-`join`ed threads.

cond_wait VARIABLE

The `cond_wait` function takes a **locked** variable as a parameter, unlocks the variable, and blocks until another thread does a `cond_signal` or `cond_broadcast` for that same locked variable. The variable that `cond_wait` blocked on is relocked after the `cond_wait` is satisfied. If there are multiple threads `cond_wait`ing on the same variable, all but one will reblock waiting to reaquire the lock on the variable. (So if you're only using `cond_wait` for synchronization, give up the lock as soon as possible)

cond_signal VARIABLE

The `cond_signal` function takes a locked variable as a parameter and unblocks one thread that's `cond_wait`ing on that variable. If more than one thread is blocked in a `cond_wait` on that variable, only one (and which one is indeterminate) will be unblocked.

If there are no threads blocked in a `cond_wait` on the variable, the signal is discarded.

cond_broadcast VARIABLE

The `cond_broadcast` function works similarly to `cond_signal`. `cond_broadcast`, though, will unblock **all** the threads that are blocked in a `cond_wait` on the locked variable, rather than only one.

yield The `yield` function allows another thread to take control of the CPU. The exact results are implementation-dependent.

METHODS

join `join` waits for a thread to end and returns any values the thread exited with. `join` will block until the thread has ended, though it won't block if the thread has already terminated.

If the thread being `join`ed `die`d, the error it died with will be returned at this time. If you don't want the thread performing the `join` to die as well, you should either wrap the `join` in an `eval` or use the `eval` thread method instead of `join`.

eval — The `eval` method wraps an `eval` around a `join`, and so waits for a thread to exit, passing along any values the thread might have returned. Errors, of course, get placed into `$@`.

detach — `detach` tells a thread that it is never going to be joined i.e. that all traces of its existence can be removed once it stops running. Errors in detached threads will not be visible anywhere – if you want to catch them, you should use `$SIG{__DIE__}` or something like that.

equal — `equal` tests whether two thread objects represent the same thread and returns true if they do.

tid — The `tid` method returns the tid of a thread. The tid is a monotonically increasing integer assigned when a thread is created. The main thread of a program will have a tid of zero, while subsequent threads will have tids assigned starting with one.

flags — The `flags` method returns the flags for the thread. This is the integer value corresponding to the internal flags for the thread, and the value may not be all that meaningful to you.

done — The `done` method returns true if the thread you're checking has finished, and false otherwise.

LIMITATIONS

The sequence number used to assign tids is a simple integer, and no checking is done to make sure the tid isn't currently in use. If a program creates more than 2^32 – 1 threads in a single run, threads may be assigned duplicate tids. This limitation may be lifted in a future version of Perl.

SEE ALSO

attributes, *Thread::Queue*, *Thread::Semaphore*, *Thread::Specific*.

NAME

JNI – Perl encapsulation of the Java Native Interface

SYNOPSIS

```
use JNI;
```

DESCRIPTION

Exported constants

```
JNI_ABORT
JNI_COMMIT
JNI_ERR
JNI_FALSE
JNI_H
JNI_OK
JNI_TRUE
```

AUTHOR

SEE ALSO

perl(1).

NAME

AnyDBM_File – provide framework for multiple DBMs

NDBM_File, DB_File, GDBM_File, SDBM_File, ODBM_File – various DBM implementations

SYNOPSIS

```
use AnyDBM_File;
```

DESCRIPTION

This module is a "pure virtual base class"—it has nothing of its own. It's just there to inherit from one of the various DBM packages. It prefers ndbm for compatibility reasons with Perl 4, then Berkeley DB (See *DB_File*), GDBM, SDBM (which is always there—it comes with Perl), and finally ODBM. This way old programs that used to use NDBM via `dbmopen()` can still do so, but new ones can reorder @ISA:

```
BEGIN { @AnyDBM_File::ISA = qw(DB_File GDBM_File NDBM_File) }
use AnyDBM_File;
```

Having multiple DBM implementations makes it trivial to copy database formats:

```
use POSIX; use NDBM_File; use DB_File;
tie %newhash,  'DB_File', $new_filename, O_CREAT|O_RDWR;
tie %oldhash,  'NDBM_File', $old_filename, 1, 0;
%newhash = %oldhash;
```

DBM Comparisons

Here's a partial table of features the different packages offer:

	odbm	ndbm	sdbm	gdbm	bsd-db
Linkage comes w/ perl	yes	yes	yes	yes	yes
Src comes w/ perl	no	no	yes	no	no
Comes w/ many unix os	yes	yes[0]	no	no	no
Builds ok on !unix	?	?	yes	yes	?
Code Size	?	?	small	big	big
Database Size	?	?	small	big?	ok[1]
Speed	?	?	slow	ok	fast
FTPable	no	no	yes	yes	yes
Easy to build	N/A	N/A	yes	yes	ok[2]
Size limits	1k	4k	1k[3]	none	none
Byte-order independent	no	no	no	no	yes
Licensing restrictions	?	?	no	yes	no

[0] on mixed universe machines, may be in the bsd compat library, which is often shunned.

[1] Can be trimmed if you compile for one access method.

[2] See *DB_File*. Requires symbolic links.

[3] By default, but can be redefined.

SEE ALSO

dbm(3), ndbm(3), DB_File(3), *perldbmfilter*

NAME

attributes – get/set subroutine or variable attributes

SYNOPSIS

```
sub foo : method ;
my ($x,@y,%z) : Bent ;
my $s = sub : method { ... };

use attributes ();    # optional, to get subroutine declarations
my @attrlist = attributes::get(\&foo);

use attributes 'get'; # import the attributes::get subroutine
my @attrlist = get \&foo;
```

DESCRIPTION

Subroutine declarations and definitions may optionally have attribute lists associated with them. (Variable `my` declarations also may, but see the warning below.) Perl handles these declarations by passing some information about the call site and the thing being declared along with the attribute list to this module. In particular, the first example above is equivalent to the following:

```
use attributes __PACKAGE__, \&foo, 'method';
```

The second example in the synopsis does something equivalent to this:

```
use attributes __PACKAGE__, \$x, 'Bent';
use attributes __PACKAGE__, \@y, 'Bent';
use attributes __PACKAGE__, \%z, 'Bent';
```

Yes, that's three invocations.

WARNING: attribute declarations for variables are an *experimental* feature. The semantics of such declarations could change or be removed in future versions. They are present for purposes of experimentation with what the semantics ought to be. Do not rely on the current implementation of this feature.

There are only a few attributes currently handled by Perl itself (or directly by this module, depending on how you look at it.) However, package–specific attributes are allowed by an extension mechanism. (See *"Package–specific Attribute Handling"* below.)

The setting of attributes happens at compile time. An attempt to set an unrecognized attribute is a fatal error. (The error is trappable, but it still stops the compilation within that `eval`.) Setting an attribute with a name that's all lowercase letters that's not a built–in attribute (such as "foo") will result in a warning with **–w** or `use warnings 'reserved'`.

Built–in Attributes

The following are the built–in attributes for subroutines:

locked

Setting this attribute is only meaningful when the subroutine or method is to be called by multiple threads. When set on a method subroutine (i.e., one marked with the **method** attribute below), Perl ensures that any invocation of it implicitly locks its first argument before execution. When set on a non–method subroutine, Perl ensures that a lock is taken on the subroutine itself before execution. The semantics of the lock are exactly those of one explicitly taken with the `lock` operator immediately after the subroutine is entered.

method

Indicates that the referenced subroutine is a method. This has a meaning when taken together with the **locked** attribute, as described there. It also means that a subroutine so marked will not trigger the "Ambiguous call resolved as CORE::%s" warning.

lvalue

Indicates that the referenced subroutine is a valid lvalue and can be assigned to. The subroutine must return a modifiable value such as a scalar variable, as described in *perlsub*.

There are no built−in attributes for anything other than subroutines.

Available Subroutines

The following subroutines are available for general use once this module has been loaded:

get This routine expects a single parameter—a reference to a subroutine or variable. It returns a list of attributes, which may be empty. If passed invalid arguments, it uses `die()` (via *Carp::croak|Carp*) to raise a fatal exception. If it can find an appropriate package name for a class method lookup, it will include the results from a `FETCH_`*type*`_ATTRIBUTES` call in its return list, as described in *"Package−specific Attribute Handling"* below. Otherwise, only *built−in attributes|"Built−in Attributes"* will be returned.

reftype

This routine expects a single parameter—a reference to a subroutine or variable. It returns the built−in type of the referenced variable, ignoring any package into which it might have been blessed. This can be useful for determining the *type* value which forms part of the method names described in *"Package−specific Attribute Handling"* below.

Note that these routines are *not* exported by default.

Package−specific Attribute Handling

WARNING: the mechanisms described here are still experimental. Do not rely on the current implementation. In particular, there is no provision for applying package attributes to 'cloned' copies of subroutines used as closures. (See *Making References in perlref* for information on closures.) Package−specific attribute handling may change incompatibly in a future release.

When an attribute list is present in a declaration, a check is made to see whether an attribute 'modify' handler is present in the appropriate package (or its @ISA inheritance tree). Similarly, when `attributes::get` is called on a valid reference, a check is made for an appropriate attribute 'fetch' handler. See *"EXAMPLES"* to see how the "appropriate package" determination works.

The handler names are based on the underlying type of the variable being declared or of the reference passed. Because these attributes are associated with subroutine or variable declarations, this deliberately ignores any possibility of being blessed into some package. Thus, a subroutine declaration uses "CODE" as its *type*, and even a blessed hash reference uses "HASH" as its *type*.

The class methods invoked for modifying and fetching are these:

FETCH_*type*_ATTRIBUTES

This method receives a single argument, which is a reference to the variable or subroutine for which package−defined attributes are desired. The expected return value is a list of associated attributes. This list may be empty.

MODIFY_*type*_ATTRIBUTES

This method is called with two fixed arguments, followed by the list of attributes from the relevant declaration. The two fixed arguments are the relevant package name and a reference to the declared subroutine or variable. The expected return value as a list of attributes which were not recognized by this handler. Note that this allows for a derived class to delegate a call to its base class, and then only examine the attributes which the base class didn't already handle for it.

The call to this method is currently made *during* the processing of the declaration. In particular, this means that a subroutine reference will probably be for an undefined subroutine, even if this declaration is actually part of the definition.

Calling `attributes::get()` from within the scope of a null package declaration `package ;` for an

unblessed variable reference will not provide any starting package name for the 'fetch' method lookup. Thus, this circumstance will not result in a method call for package−defined attributes. A named subroutine knows to which symbol table entry it belongs (or originally belonged), and it will use the corresponding package. An anonymous subroutine knows the package name into which it was compiled (unless it was also compiled with a null package declaration), and so it will use that package name.

Syntax of Attribute Lists

An attribute list is a sequence of attribute specifications, separated by whitespace or a colon (with optional whitespace). Each attribute specification is a simple name, optionally followed by a parenthesised parameter list. If such a parameter list is present, it is scanned past as for the rules for the `q()` operator. (See *Quote and Quote−like Operators in perlop*.) The parameter list is passed as it was found, however, and not as per `q()`.

Some examples of syntactically valid attribute lists:

```
switch(10,foo(7,3))  :  expensive
Ugly('\(") :Bad
_5x5
locked method
```

Some examples of syntactically invalid attribute lists (with annotation):

```
switch(10,foo()              # ()-string not balanced
Ugly('(')                    # ()-string not balanced
5x5                          # "5x5" not a valid identifier
Y2::north                    # "Y2::north" not a simple identifier
foo + bar                    # "+" neither a colon nor whitespace
```

EXPORTS

Default exports

None.

Available exports

The routines `get` and `reftype` are exportable.

Export tags defined

The `:ALL` tag will get all of the above exports.

EXAMPLES

Here are some samples of syntactically valid declarations, with annotation as to how they resolve internally into `use attributes` invocations by perl. These examples are primarily useful to see how the "appropriate package" is found for the possible method lookups for package−defined attributes.

1. Code:

```
package Canine;
package Dog;
my Canine $spot : Watchful ;
```

   Effect:

```
use attributes Canine => \$spot, "Watchful";
```

2. Code:

```
package Felis;
my $cat : Nervous;
```

   Effect:

```
use attributes Felis => \$cat, "Nervous";
```

3. Code:

```
package X;
sub foo : locked ;
```

Effect:

```
use attributes X => \&foo, "locked";
```

4. Code:

```
package X;
sub Y::x : locked { 1 }
```

Effect:

```
use attributes Y => \&Y::x, "locked";
```

5. Code:

```
package X;
sub foo { 1 }

package Y;
BEGIN { *bar = \&X::foo; }

package Z;
sub Y::bar : locked ;
```

Effect:

```
use attributes X => \&X::foo, "locked";
```

This last example is purely for purposes of completeness. You should not be trying to mess with the attributes of something in a package that's not your own.

SEE ALSO

"Private Variables via my()" and *Subroutine Attributes in perlsub* for details on the basic declarations; *attrs* for the obsolescent form of subroutine attribute specification which this module replaces; *use* for details on the normal invocation mechanism.

NAME

AutoLoader – load subroutines only on demand

SYNOPSIS

```
package Foo;
use AutoLoader 'AUTOLOAD';   # import the default AUTOLOAD subroutine

package Bar;
use AutoLoader;              # don't import AUTOLOAD, define our own
sub AUTOLOAD {
    ...
    $AutoLoader::AUTOLOAD = "...";
    goto &AutoLoader::AUTOLOAD;
}
```

DESCRIPTION

The **AutoLoader** module works with the **AutoSplit** module and the `__END__` token to defer the loading of some subroutines until they are used rather than loading them all at once.

To use **AutoLoader**, the author of a module has to place the definitions of subroutines to be autoloaded after an `__END__` token. (See *perldata*.) The **AutoSplit** module can then be run manually to extract the definitions into individual files ***auto/funcname.al***.

AutoLoader implements an AUTOLOAD subroutine. When an undefined subroutine in is called in a client module of **AutoLoader**, **AutoLoader**'s AUTOLOAD subroutine attempts to locate the subroutine in a file with a name related to the location of the file from which the client module was read. As an example, if ***POSIX.pm*** is located in ***/usr/local/lib/perl5/POSIX.pm***, **AutoLoader** will look for perl subroutines **POSIX** in ***/usr/local/lib/perl5/auto/POSIX/*.al***, where the `.al` file has the same name as the subroutine, sans package. If such a file exists, AUTOLOAD will read and evaluate it, thus (presumably) defining the needed subroutine. AUTOLOAD will then `goto` the newly defined subroutine.

Once this process completes for a given function, it is defined, so future calls to the subroutine will bypass the AUTOLOAD mechanism.

Subroutine Stubs

In order for object method lookup and/or prototype checking to operate correctly even when methods have not yet been defined it is necessary to "forward declare" each subroutine (as in `sub NAME;`). See *SYNOPSIS in perlsub*. Such forward declaration creates "subroutine stubs", which are place holders with no code.

The AutoSplit and **AutoLoader** modules automate the creation of forward declarations. The AutoSplit module creates an 'index' file containing forward declarations of all the AutoSplit subroutines. When the AutoLoader module is 'use'd it loads these declarations into its callers package.

Because of this mechanism it is important that **AutoLoader** is always `used` and not `required`.

Using AutoLoader's AUTOLOAD Subroutine

In order to use **AutoLoader**'s AUTOLOAD subroutine you *must* explicitly import it:

```
use AutoLoader 'AUTOLOAD';
```

Overriding AutoLoader's AUTOLOAD Subroutine

Some modules, mainly extensions, provide their own AUTOLOAD subroutines. They typically need to check for some special cases (such as constants) and then fallback to **AutoLoader**'s AUTOLOAD for the rest.

Such modules should *not* import **AutoLoader**'s AUTOLOAD subroutine. Instead, they should define their own AUTOLOAD subroutines along these lines:

```
use AutoLoader;
use Carp;

sub AUTOLOAD {
    my $sub = $AUTOLOAD;
    (my $constname = $sub) =~ s/.*::///;
    my $val = constant($constname, @_ ? $_[0] : 0);
    if ($! != 0) {
        if ($! =~ /Invalid/ || $!{EINVAL}) {
            $AutoLoader::AUTOLOAD = $sub;
            goto &AutoLoader::AUTOLOAD;
        }
        else {
            croak "Your vendor has not defined constant $constname";
        }
    }
    *$sub = sub { $val }; # same as: eval "sub $sub { $val }";
    goto &$sub;
}
```

If any module's own AUTOLOAD subroutine has no need to fallback to the AutoLoader's AUTOLOAD subroutine (because it doesn't have any AutoSplit subroutines), then that module should not use **AutoLoader** at all.

Package Lexicals

Package lexicals declared with `my` in the main block of a package using **AutoLoader** will not be visible to auto–loaded subroutines, due to the fact that the given scope ends at the `__END__` marker. A module using such variables as package globals will not work properly under the **AutoLoader**.

The `vars` pragma (see *vars in perlmod*) may be used in such situations as an alternative to explicitly qualifying all globals with the package namespace. Variables pre–declared with this pragma will be visible to any autoloaded routines (but will not be invisible outside the package, unfortunately).

Not Using AutoLoader

You can stop using AutoLoader by simply

```
no AutoLoader;
```

AutoLoader vs. SelfLoader

The **AutoLoader** is similar in purpose to **SelfLoader**: both delay the loading of subroutines.

SelfLoader uses the `__DATA__` marker rather than `__END__`. While this avoids the use of a hierarchy of disk files and the associated open/close for each routine loaded, **SelfLoader** suffers a startup speed disadvantage in the one–time parsing of the lines after `__DATA__`, after which routines are cached. **SelfLoader** can also handle multiple packages in a file.

AutoLoader only reads code as it is requested, and in many cases should be faster, but requires a mechanism like **AutoSplit** be used to create the individual files. *ExtUtils::MakeMaker* will invoke **AutoSplit** automatically if **AutoLoader** is used in a module source file.

CAVEATS

AutoLoaders prior to Perl 5.002 had a slightly different interface. Any old modules which use **AutoLoader** should be changed to the new calling style. Typically this just means changing a require to a use, adding the explicit `'AUTOLOAD'` import if needed, and removing **AutoLoader** from `@ISA`.

On systems with restrictions on file name length, the file corresponding to a subroutine may have a shorter name that the routine itself. This can lead to conflicting file names. The *AutoSplit* package warns of these potential conflicts when used to split a module.

AutoLoader may fail to find the autosplit files (or even find the wrong ones) in cases where `@INC` contains relative paths, **and** the program does `chdir`.

SEE ALSO

SelfLoader – an autoloader that doesn't use external files.

NAME

AutoSplit – split a package for autoloading

SYNOPSIS

```
autosplit($file, $dir, $keep, $check, $modtime);

autosplit_lib_modules(@modules);
```

DESCRIPTION

This function will split up your program into files that the AutoLoader module can handle. It is used by both the standard perl libraries and by the MakeMaker utility, to automatically configure libraries for autoloading.

The `autosplit` interface splits the specified file into a hierarchy rooted at the directory `$dir`. It creates directories as needed to reflect class hierarchy, and creates the file ***autosplit.ix***. This file acts as both forward declaration of all package routines, and as timestamp for the last update of the hierarchy.

The remaining three arguments to `autosplit` govern other options to the autosplitter.

`$keep`

If the third argument, *`$keep`*, is false, then any pre–existing `*.al` files in the autoload directory are removed if they are no longer part of the module (obsoleted functions). `$keep` defaults to 0.

`$check`

The fourth argument, *`$check`*, instructs `autosplit` to check the module currently being split to ensure that it does include a `use` specification for the AutoLoader module, and skips the module if AutoLoader is not detected. `$check` defaults to 1.

`$modtime`

Lastly, the *`$modtime`* argument specifies that `autosplit` is to check the modification time of the module against that of the `autosplit.ix` file, and only split the module if it is newer. `$modtime` defaults to 1.

Typical use of AutoSplit in the perl MakeMaker utility is via the command–line with:

```
perl -e 'use AutoSplit; autosplit($ARGV[0], $ARGV[1], 0, 1, 1)'
```

Defined as a Make macro, it is invoked with file and directory arguments; `autosplit` will split the specified file into the specified directory and delete obsolete `.al` files, after checking first that the module does use the AutoLoader, and ensuring that the module is not already currently split in its current form (the modtime test).

The `autosplit_lib_modules` form is used in the building of perl. It takes as input a list of files (modules) that are assumed to reside in a directory **lib** relative to the current directory. Each file is sent to the autosplitter one at a time, to be split into the directory **lib/auto**.

In both usages of the autosplitter, only subroutines defined following the perl *__END__* token are split out into separate files. Some routines may be placed prior to this marker to force their immediate loading and parsing.

Multiple packages

As of version 1.01 of the AutoSplit module it is possible to have multiple packages within a single file. Both of the following cases are supported:

```
package NAME;
__END__
sub AAA { ... }
package NAME::option1;
sub BBB { ... }
package NAME::option2;
```

```
sub BBB { ... }

package NAME;
__END__
sub AAA { ... }
sub NAME::option1::BBB { ... }
sub NAME::option2::BBB { ... }
```

DIAGNOSTICS

`AutoSplit` will inform the user if it is necessary to create the top−level directory specified in the invocation. It is preferred that the script or installation process that invokes `AutoSplit` have created the full directory path ahead of time. This warning may indicate that the module is being split into an incorrect path.

`AutoSplit` will warn the user of all subroutines whose name causes potential file naming conflicts on machines with drastically limited (8 characters or less) file name length. Since the subroutine name is used as the file name, these warnings can aid in portability to such systems.

Warnings are issued and the file skipped if `AutoSplit` cannot locate either the *__END__* marker or a "package Name;"−style specification.

`AutoSplit` will also emit general diagnostics for inability to create directories or files.

NAME

autouse – postpone load of modules until a function is used

SYNOPSIS

```
use autouse 'Carp' => qw(carp croak);
carp "this carp was predeclared and autoused ";
```

DESCRIPTION

If the module `Module` is already loaded, then the declaration

```
use autouse 'Module' => qw(func1 func2($;$) Module::func3);
```

is equivalent to

```
use Module qw(func1 func2);
```

if `Module` defines `func2()` with prototype `($;$)`, and `func1()` and `func3()` have no prototypes. (At least if `Module` uses `Exporter`'s `import`, otherwise it is a fatal error.)

If the module `Module` is not loaded yet, then the above declaration declares functions `func1()` and `func2()` in the current package, and declares a function `Module::func3()`. When these functions are called, they load the package `Module` if needed, and substitute themselves with the correct definitions.

WARNING

Using `autouse` will move important steps of your program's execution from compile time to runtime. This can

- Break the execution of your program if the module you `autoused` has some initialization which it expects to be done early.
- hide bugs in your code since important checks (like correctness of prototypes) is moved from compile time to runtime. In particular, if the prototype you specified on `autouse` line is wrong, you will not find it out until the corresponding function is executed. This will be very unfortunate for functions which are not always called (note that for such functions `autouse`ing gives biggest win, for a workaround see below).

To alleviate the second problem (partially) it is advised to write your scripts like this:

```
use Module;
use autouse Module => qw(carp($) croak(&$));
carp "this carp was predeclared and autoused ";
```

The first line ensures that the errors in your argument specification are found early. When you ship your application you should comment out the first line, since it makes the second one useless.

AUTHOR

Ilya Zakharevich (ilya@math.ohio–state.edu)

SEE ALSO

perl(1).

NAME

base – Establish IS–A relationship with base class at compile time

SYNOPSIS

```
package Baz;
use base qw(Foo Bar);
```

DESCRIPTION

Roughly similar in effect to

```
BEGIN {
    require Foo;
    require Bar;
    push @ISA, qw(Foo Bar);
}
```

Will also initialize the %FIELDS hash if one of the base classes has it. Multiple inheritance of %FIELDS is not supported. The 'base' pragma will croak if multiple base classes have a %FIELDS hash. See *fields* for a description of this feature.

When strict 'vars' is in scope *base* also let you assign to @ISA without having to declare @ISA with the 'vars' pragma first.

If any of the base classes are not loaded yet, *base* silently `requires` them. Whether to `require` a base class package is determined by the absence of a global `$VERSION` in the base package. If `$VERSION` is not detected even after loading it, <base will define `$VERSION` in the base package, setting it to the string `-1, defined by base.pm`.

HISTORY

This module was introduced with Perl 5.004_04.

SEE ALSO

fields

NAME

Benchmark – benchmark running times of Perl code

SYNOPSIS

```
timethis ($count, "code");

# Use Perl code in strings...
timethese($count, {
    'Name1' => '...code1...',
    'Name2' => '...code2...',
});

# ... or use subroutine references.
timethese($count, {
    'Name1' => sub { ...code1... },
    'Name2' => sub { ...code2... },
});

# cmpthese can be used both ways as well
cmpthese($count, {
    'Name1' => '...code1...',
    'Name2' => '...code2...',
});

cmpthese($count, {
    'Name1' => sub { ...code1... },
    'Name2' => sub { ...code2... },
});

# ...or in two stages
$results = timethese($count,
    {
        'Name1' => sub { ...code1... },
        'Name2' => sub { ...code2... },
    },
    'none'
);
cmpthese( $results ) ;

$t = timeit($count, '...other code...')
print "$count loops of other code took:",timestr($t),"\n";

$t = countit($time, '...other code...')
$count = $t->iters ;
print "$count loops of other code took:",timestr($t),"\n";
```

DESCRIPTION

The Benchmark module encapsulates a number of routines to help you figure out how long it takes to execute some code.

timethis – run a chunk of code several times

timethese – run several chunks of code several times

cmpthese – print results of timethese as a comparison chart

timeit – run a chunk of code and see how long it goes

countit – see how many times a chunk of code runs in a given time

Methods

new Returns the current time. Example:

```
use Benchmark;
$t0 = new Benchmark;
# ... your code here ...
$t1 = new Benchmark;
$td = timediff($t1, $t0);
print "the code took:",timestr($td),"\n";
```

debug Enables or disable debugging by setting the `$Benchmark::Debug` flag:

```
debug Benchmark 1;
$t = timeit(10, ' 5 ** $Global ');
debug Benchmark 0;
```

iters Returns the number of iterations.

Standard Exports

The following routines will be exported into your namespace if you use the Benchmark module:

timeit(COUNT, CODE)

Arguments: COUNT is the number of times to run the loop, and CODE is the code to run. CODE may be either a code reference or a string to be eval'd; either way it will be run in the caller's package.

Returns: a Benchmark object.

timethis (COUNT, CODE, [TITLE, [STYLE]])

Time COUNT iterations of CODE. CODE may be a string to eval or a code reference; either way the CODE will run in the caller's package. Results will be printed to STDOUT as TITLE followed by the times. TITLE defaults to "timethis COUNT" if none is provided. STYLE determines the format of the output, as described for `timestr()` below.

The COUNT can be zero or negative: this means the *minimum number of CPU seconds* to run. A zero signifies the default of 3 seconds. For example to run at least for 10 seconds:

```
timethis(-10, $code)
```

or to run two pieces of code tests for at least 3 seconds:

```
timethese(0, { test1 => '...', test2 => '...'})
```

CPU seconds is, in UNIX terms, the user time plus the system time of the process itself, as opposed to the real (wallclock) time and the time spent by the child processes. Less than 0.1 seconds is not accepted (–0.01 as the count, for example, will cause a fatal runtime exception).

Note that the CPU seconds is the **minimum** time: CPU scheduling and other operating system factors may complicate the attempt so that a little bit more time is spent. The benchmark output will, however, also tell the number of `$code` runs/second, which should be a more interesting number than the actually spent seconds.

Returns a Benchmark object.

timethese (COUNT, CODEHASHREF, [STYLE])

The CODEHASHREF is a reference to a hash containing names as keys and either a string to eval or a code reference for each value. For each (KEY, VALUE) pair in the CODEHASHREF, this routine will call

```
timethis(COUNT, VALUE, KEY, STYLE)
```

The routines are called in string comparison order of KEY.

The COUNT can be zero or negative, see `timethis()`.

Returns a hash of Benchmark objects, keyed by name.

timediff (T1, T2)

Returns the difference between two Benchmark times as a Benchmark object suitable for passing to `timestr()`.

timestr (TIMEDIFF, [STYLE, [FORMAT]])

Returns a string that formats the times in the TIMEDIFF object in the requested STYLE. TIMEDIFF is expected to be a Benchmark object similar to that returned by `timediff()`.

STYLE can be any of 'all', 'none', 'noc', 'nop' or 'auto'. 'all' shows each of the 5 times available ('wallclock' time, user time, system time, user time of children, and system time of children). 'noc' shows all except the two children times. 'nop' shows only wallclock and the two children times. 'auto' (the default) will act as 'all' unless the children times are both zero, in which case it acts as 'noc'. 'none' prevents output.

FORMAT is the *printf(3)*-style format specifier (without the leading '%') to use to print the times. It defaults to '5.2f'.

Optional Exports

The following routines will be exported into your namespace if you specifically ask that they be imported:

clearcache (COUNT)

Clear the cached time for COUNT rounds of the null loop.

clearallcache ( )

Clear all cached times.

cmpthese (COUT, CODEHASHREF, [STYLE])
cmpthese (RESULTSHASHREF)

Optionally calls `timethese()`, then outputs comparison chart. This chart is sorted from slowest to fastest, and shows the percent speed difference between each pair of tests. Can also be passed the data structure that `timethese()` returns:

```
$results = timethese( .... );
cmpthese( $results );
```

Returns the data structure returned by `timethese()` (or passed in).

countit(TIME, CODE)

Arguments: TIME is the minimum length of time to run CODE for, and CODE is the code to run. CODE may be either a code reference or a string to be eval'd; either way it will be run in the caller's package.

TIME is *not* negative. `countit()` will run the loop many times to calculate the speed of CODE before running it for TIME. The actual time run for will usually be greater than TIME due to system clock resolution, so it's best to look at the number of iterations divided by the times that you are concerned with, not just the iterations.

Returns: a Benchmark object.

disablecache ( )

Disable caching of timings for the null loop. This will force Benchmark to recalculate these timings for each new piece of code timed.

enablecache ( )

Enable caching of timings for the null loop. The time taken for COUNT rounds of the null loop will be calculated only once for each different COUNT used.

timesum (T1, T2)

Returns the sum of two Benchmark times as a Benchmark object suitable for passing to `timestr()`.

NOTES

The data is stored as a list of values from the time and times functions:

```
($real, $user, $system, $children_user, $children_system, $iters)
```

in seconds for the whole loop (not divided by the number of rounds).

The timing is done using time(3) and times(3).

Code is executed in the caller's package.

The time of the null loop (a loop with the same number of rounds but empty loop body) is subtracted from the time of the real loop.

The null loop times can be cached, the key being the number of rounds. The caching can be controlled using calls like these:

```
clearcache($key);
clearallcache();

disablecache();
enablecache();
```

Caching is off by default, as it can (usually slightly) decrease accuracy and does not usually noticably affect runtimes.

EXAMPLES

For example,

```
use Benchmark;$x=3;cmpthese(-5,{a=>sub{$x*$x},b=>sub{$x**2}})
```

outputs something like this:

```
Benchmark: running a, b, each for at least 5 CPU seconds...
         a: 10 wallclock secs ( 5.14 usr +  0.13 sys =  5.27 CPU) @ 3835055.60/s (
         b:  5 wallclock secs ( 5.41 usr +  0.00 sys =  5.41 CPU) @ 1574944.92/s (
       Rate    b    a
b 1574945/s   -- -59%
a 3835056/s 144%   --
```

while

```
use Benchmark;
$x=3;
$r=timethese(-5,{a=>sub{$x*$x},b=>sub{$x**2}},'none');
cmpthese($r);
```

outputs something like this:

```
       Rate    b    a
b 1559428/s   -- -62%
a 4152037/s 166%   --
```

INHERITANCE

Benchmark inherits from no other class, except of course for Exporter.

CAVEATS

Comparing eval'd strings with code references will give you inaccurate results: a code reference will show a slightly slower execution time than the equivalent eval'd string.

The real time timing is done using time(2) and the granularity is therefore only one second.

Short tests may produce negative figures because perl can appear to take longer to execute the empty loop than a short test; try:

```
timethis(100,'1');
```

The system time of the null loop might be slightly more than the system time of the loop with the actual code and therefore the difference might end up being < 0.

SEE ALSO

Devel::DProf – a Perl code profiler

AUTHORS

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MODIFICATION HISTORY

September 8th, 1994; by Tim Bunce.

March 28th, 1997; by Hugo van der Sanden: added support for code references and the already documented 'debug' method; revamped documentation.

April 04–07th, 1997: by Jarkko Hietaniemi, added the run–for–some–time functionality.

September, 1999; by Barrie Slaymaker: math fixes and accuracy and efficiency tweaks. Added `cmpthese()`. A result is now returned from `timethese()`. Exposed `countit()` (was `runfor()`).

NAME

blib – Use MakeMaker‘s uninstalled version of a package

SYNOPSIS

```
perl -Mblib script [args...]

perl -Mblib=dir script [args...]
```

DESCRIPTION

Looks for MakeMaker–like *‘blib’* directory structure starting in *dir* (or current directory) and working back up to five levels of ’..’.

Intended for use on command line with **–M** option as a way of testing arbitary scripts against an uninstalled version of a package.

However it is possible to :

```
use blib;
or
use blib '..';
```

etc. if you really must.

BUGS

Pollutes global name space for development only task.

AUTHOR

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NAME

bytes – Perl pragma to force byte semantics rather than character semantics

SYNOPSIS

```
use bytes;
no bytes;
```

DESCRIPTION

WARNING: The implementation of Unicode support in Perl is incomplete. See *perlunicode* for the exact details.

The `use bytes` pragma disables character semantics for the rest of the lexical scope in which it appears. `no bytes` can be used to reverse the effect of `use bytes` within the current lexical scope.

Perl normally assumes character semantics in the presence of character data (i.e. data that has come from a source that has been marked as being of a particular character encoding). When `use bytes` is in effect, the encoding is temporarily ignored, and each string is treated as a series of bytes.

As an example, when Perl sees `$x = chr(400)`, it encodes the character in UTF8 and stores it in `$x`. Then it is marked as character data, so, for instance, `length $x` returns `1`. However, in the scope of the `bytes` pragma, `$x` is treated as a series of bytes – the bytes that make up the UTF8 encoding – and `length $x` returns `2`:

```
$x = chr(400);
print "Length is ", length $x, "\n";     # "Length is 1"
printf "Contents are %vd\n", $x;         # "Contents are 400"
{
    use bytes;
    print "Length is ", length $x, "\n"; # "Length is 2"
    printf "Contents are %vd\n", $x;     # "Contents are 198.144"
}
```

For more on the implications and differences between character semantics and byte semantics, see *perlunicode*.

SEE ALSO

perlunicode, *utf8*

NAME

Carp::Heavy – Carp guts

SYNOPIS

(internal use only)

DESCRIPTION

No user–serviceable parts inside.

NAME

carp – warn of errors (from perspective of caller)

cluck – warn of errors with stack backtrace
(not exported by default)

croak – die of errors (from perspective of caller)

confess – die of errors with stack backtrace

SYNOPSIS

```
use Carp;
croak "We're outta here!";

use Carp qw(cluck);
cluck "This is how we got here!";
```

DESCRIPTION

The Carp routines are useful in your own modules because they act like `die()` or `warn()`, but report where the error was in the code they were called from. Thus if you have a routine `Foo()` that has a `carp()` in it, then the `carp()` will report the error as occurring where `Foo()` was called, not where `carp()` was called.

Forcing a Stack Trace

As a debugging aid, you can force Carp to treat a croak as a confess and a carp as a cluck across *all* modules. In other words, force a detailed stack trace to be given. This can be very helpful when trying to understand why, or from where, a warning or error is being generated.

This feature is enabled by 'importing' the non–existent symbol 'verbose'. You would typically enable it by saying

```
perl -MCarp=verbose script.pl
```

or by including the string `MCarp=verbose` in the *PERL5OPT* environment variable.

BUGS

The Carp routines don't handle exception objects currently. If called with a first argument that is a reference, they simply call `die()` or `warn()`, as appropriate.

NAME

CGI::Apache – Backward compatibility module for CGI.pm

SYNOPSIS

Do not use this module. It is deprecated.

ABSTRACT

DESCRIPTION

AUTHOR INFORMATION

BUGS

SEE ALSO

NAME

CGI::Carp – CGI routines for writing to the HTTPD (or other) error log

SYNOPSIS

```
use CGI::Carp;

croak "We're outta here!";
confess "It was my fault: $!";
carp "It was your fault!";
warn "I'm confused";
die  "I'm dying.\n";

use CGI::Carp qw(cluck);
cluck "I wouldn't do that if I were you";

use CGI::Carp qw(fatalsToBrowser);
die "Fatal error messages are now sent to browser";
```

DESCRIPTION

CGI scripts have a nasty habit of leaving warning messages in the error logs that are neither time stamped nor fully identified. Tracking down the script that caused the error is a pain. This fixes that. Replace the usual

```
use Carp;
```

with

```
use CGI::Carp
```

And the standard `warn()`, die `()`, `croak()`, `confess()` and `carp()` calls will automagically be replaced with functions that write out nicely time–stamped messages to the HTTP server error log.

For example:

```
[Fri Nov 17 21:40:43 1995] test.pl: I'm confused at test.pl line 3.
[Fri Nov 17 21:40:43 1995] test.pl: Got an error message: Permission denied.
[Fri Nov 17 21:40:43 1995] test.pl: I'm dying.
```

REDIRECTING ERROR MESSAGES

By default, error messages are sent to STDERR. Most HTTPD servers direct STDERR to the server's error log. Some applications may wish to keep private error logs, distinct from the server's error log, or they may wish to direct error messages to STDOUT so that the browser will receive them.

The `carpout()` function is provided for this purpose. Since `carpout()` is not exported by default, you must import it explicitly by saying

```
use CGI::Carp qw(carpout);
```

The `carpout()` function requires one argument, which should be a reference to an open filehandle for writing errors. It should be called in a `BEGIN` block at the top of the CGI application so that compiler errors will be caught. Example:

```
BEGIN {
  use CGI::Carp qw(carpout);
  open(LOG, ">>/usr/local/cgi-logs/mycgi-log") or
    die("Unable to open mycgi-log: $!\n");
  carpout(LOG);
}
```

`carpout()` does not handle file locking on the log for you at this point.

The real STDERR is not closed — it is moved to SAVEERR. Some servers, when dealing with CGI scripts,

close their connection to the browser when the script closes STDOUT and STDERR. SAVEERR is used to prevent this from happening prematurely.

You can pass filehandles to `carpout()` in a variety of ways. The "correct" way according to Tom Christiansen is to pass a reference to a filehandle GLOB:

```
carpout(\*LOG);
```

This looks weird to mere mortals however, so the following syntaxes are accepted as well:

```
carpout(LOG);
carpout(main::LOG);
carpout(main'LOG);
carpout(\LOG);
carpout(\'main::LOG');

... and so on
```

FileHandle and other objects work as well.

Use of `carpout()` is not great for performance, so it is recommended for debugging purposes or for moderate−use applications. A future version of this module may delay redirecting STDERR until one of the CGI::Carp methods is called to prevent the performance hit.

MAKING PERL ERRORS APPEAR IN THE BROWSER WINDOW

If you want to send fatal (die, confess) errors to the browser, ask to import the special "fatalsToBrowser" subroutine:

```
use CGI::Carp qw(fatalsToBrowser);
die "Bad error here";
```

Fatal errors will now be echoed to the browser as well as to the log. CGI::Carp arranges to send a minimal HTTP header to the browser so that even errors that occur in the early compile phase will be seen. Nonfatal errors will still be directed to the log file only (unless redirected with carpout).

Changing the default message

By default, the software error message is followed by a note to contact the Webmaster by e−mail with the time and date of the error. If this message is not to your liking, you can change it using the `set_message()` routine. This is not imported by default; you should import it on the `use()` line:

```
use CGI::Carp qw(fatalsToBrowser set_message);
set_message("It's not a bug, it's a feature!");
```

You may also pass in a code reference in order to create a custom error message. At run time, your code will be called with the text of the error message that caused the script to die. Example:

```
use CGI::Carp qw(fatalsToBrowser set_message);
BEGIN {
   sub handle_errors {
      my $msg = shift;
      print "<h1>Oh gosh</h1>";
      print "Got an error: $msg";
  }
  set_message(\&handle_errors);
}
```

In order to correctly intercept compile−time errors, you should call `set_message()` from within a BEGIN{} block.

MAKING WARNINGS APPEAR AS HTML COMMENTS

It is now also possible to make non−fatal errors appear as HTML comments embedded in the output of your program. To enable this feature, export the new "warningsToBrowser" subroutine. Since sending warnings to the browser before the HTTP headers have been sent would cause an error, any warnings are stored in an internal buffer until you call the `warningsToBrowser()` subroutine with a true argument:

```
use CGI::Carp qw(fatalsToBrowser warningsToBrowser);
use CGI qw(:standard);
print header();
warningsToBrowser(1);
```

You may also give a false argument to `warningsToBrowser()` to prevent warnings from being sent to the browser while you are printing some content where HTML comments are not allowed:

```
warningsToBrowser(0);    # disable warnings
print "<SCRIPT type=javascript><!--\n";
print_some_javascript_code();
print "//--></SCRIPT>\n";
warningsToBrowser(1);    # re-enable warnings
```

Note: In this respect `warningsToBrowser()` differs fundamentally from `fatalsToBrowser()`, which you should never call yourself!

CHANGE LOG

1.05 `carpout()` added and minor corrections by Marc Hedlund <hedlund@best.com on 11/26/95.

1.06 `fatalsToBrowser()` no longer aborts for fatal errors within `eval()` statements.

1.08 `set_message()` added and `carpout()` expanded to allow for FileHandle objects.

1.09 `set_message()` now allows users to pass a code REFERENCE for really custom error messages. croak and carp are now exported by default. Thanks to Gunther Birznieks for the patches.

1.10 Patch from Chris Dean (ctdean@cogit.com) to allow module to run correctly under mod_perl.

1.11 Changed order of `>` and `<` escapes.

1.12 Changed `die()` on line 217 to CORE::die to avoid **−w** warning.

1.13 Added `cluck()` to make the module orthogonal with Carp. More mod_perl related fixes.

1.20 Patch from Ilmari Karonen (perl@itz.pp.sci.fi): Added `warningsToBrowser()`. Replaced <CODE tags with <PRE in `fatalsToBrowser()` output.

AUTHORS

Address bug reports and comments to: lstein@cshl.org

SEE ALSO

Carp, CGI::Base, CGI::BasePlus, CGI::Request, CGI::MiniSvr, CGI::Form, CGI::Response

NAME

CGI::Cookie – Interface to Netscape Cookies

SYNOPSIS

```
use CGI qw/:standard/;
use CGI::Cookie;

# Create new cookies and send them
$cookie1 = new CGI::Cookie(-name=>'ID',-value=>123456);
$cookie2 = new CGI::Cookie(-name=>'preferences',
                           -value=>{ font => Helvetica,
                                     size => 12 }
                           );
print header(-cookie=>[$cookie1,$cookie2]);

# fetch existing cookies
%cookies = fetch CGI::Cookie;
$id = $cookies{'ID'}->value;

# create cookies returned from an external source
%cookies = parse CGI::Cookie($ENV{COOKIE});
```

DESCRIPTION

CGI::Cookie is an interface to Netscape (HTTP/1.1) cookies, an innovation that allows Web servers to store persistent information on the browser's side of the connection. Although CGI::Cookie is intended to be used in conjunction with CGI.pm (and is in fact used by it internally), you can use this module independently.

For full information on cookies see

```
http://www.ics.uci.edu/pub/ietf/http/rfc2109.txt
```

USING CGI::Cookie

CGI::Cookie is object oriented. Each cookie object has a name and a value. The name is any scalar value. The value is any scalar or array value (associative arrays are also allowed). Cookies also have several optional attributes, including:

1. expiration date

The expiration date tells the browser how long to hang on to the cookie. If the cookie specifies an expiration date in the future, the browser will store the cookie information in a disk file and return it to the server every time the user reconnects (until the expiration date is reached). If the cookie species an expiration date in the past, the browser will remove the cookie from the disk file. If the expiration date is not specified, the cookie will persist only until the user quits the browser.

2. domain

This is a partial or complete domain name for which the cookie is valid. The browser will return the cookie to any host that matches the partial domain name. For example, if you specify a domain name of ".capricorn.com", then Netscape will return the cookie to Web servers running on any of the machines "www.capricorn.com", "ftp.capricorn.com", "feckless.capricorn.com", etc. Domain names must contain at least two periods to prevent attempts to match on top level domains like ".edu". If no domain is specified, then the browser will only return the cookie to servers on the host the cookie originated from.

3. path

If you provide a cookie path attribute, the browser will check it against your script's URL before returning the cookie. For example, if you specify the path "/cgi–bin", then the cookie will be returned to each of the scripts "/cgi–bin/tally.pl", "/cgi–bin/order.pl", and "/cgi–bin/customer_service/complain.pl", but not to the script "/cgi–private/site_admin.pl". By default, the path is set to "/", so that all scripts at your site will receive the cookie.

4. secure flag

If the "secure" attribute is set, the cookie will only be sent to your script if the CGI request is occurring on a secure channel, such as SSL.

Creating New Cookies

```
$c = new CGI::Cookie(-name    =>  'foo',
                     -value   =>  'bar',
                     -expires =>  '+3M',
                     -domain  =>  '.capricorn.com',
                     -path    =>  '/cgi-bin/database'
                     -secure  =>  1
                    );
```

Create cookies from scratch with the **new** method. The **–name** and **–value** parameters are required. The name must be a scalar value. The value can be a scalar, an array reference, or a hash reference. (At some point in the future cookies will support one of the Perl object serialization protocols for full generality).

–expires accepts any of the relative or absolute date formats recognized by CGI.pm, for example "+3M" for three months in the future. See CGI.pm's documentation for details.

–domain points to a domain name or to a fully qualified host name. If not specified, the cookie will be returned only to the Web server that created it.

–path points to a partial URL on the current server. The cookie will be returned to all URLs beginning with the specified path. If not specified, it defaults to '/', which returns the cookie to all pages at your site.

–secure if set to a true value instructs the browser to return the cookie only when a cryptographic protocol is in use.

Sending the Cookie to the Browser

Within a CGI script you can send a cookie to the browser by creating one or more Set–Cookie: fields in the HTTP header. Here is a typical sequence:

```
my $c = new CGI::Cookie(-name    =>  'foo',
                        -value   =>  ['bar','baz'],
                        -expires =>  '+3M');

print "Set-Cookie: $c\n";
print "Content-Type: text/html\n\n";
```

To send more than one cookie, create several Set–Cookie: fields. Alternatively, you may concatenate the cookies together with "; " and send them in one field.

If you are using CGI.pm, you send cookies by providing a –cookie argument to the `header()` method:

```
print header(-cookie=>$c);
```

Mod_perl users can set cookies using the request object's `header_out()` method:

```
$r->header_out('Set-Cookie',$c);
```

Internally, Cookie overloads the "" operator to call its `as_string()` method when incorporated into the HTTP header. `as_string()` turns the Cookie's internal representation into an RFC–compliant text representation. You may call `as_string()` yourself if you prefer:

```
print "Set-Cookie: ",$c->as_string,"\n";
```

Recovering Previous Cookies

```
%cookies = fetch CGI::Cookie;
```

fetch returns an associative array consisting of all cookies returned by the browser. The keys of the array are the cookie names. You can iterate through the cookies this way:

```
%cookies = fetch CGI::Cookie;
foreach (keys %cookies) {
   do_something($cookies{$_});
}
```

In a scalar context, `fetch()` returns a hash reference, which may be more efficient if you are manipulating multiple cookies.

CGI.pm uses the URL escaping methods to save and restore reserved characters in its cookies. If you are trying to retrieve a cookie set by a foreign server, this escaping method may trip you up. Use `raw_fetch()` instead, which has the same semantics as `fetch()`, but performs no unescaping.

You may also retrieve cookies that were stored in some external form using the `parse()` class method:

```
$COOKIES = `cat /usr/tmp/Cookie_stash`;
%cookies = parse CGI::Cookie($COOKIES);
```

Manipulating Cookies

Cookie objects have a series of accessor methods to get and set cookie attributes. Each accessor has a similar syntax. Called without arguments, the accessor returns the current value of the attribute. Called with an argument, the accessor changes the attribute and returns its new value.

`name()`

Get or set the cookie's name. Example:

```
$name = $c->name;
$new_name = $c->name('fred');
```

`value()`

Get or set the cookie's value. Example:

```
$value = $c->value;
@new_value = $c->value(['a','b','c','d']);
```

`value()` is context sensitive. In a list context it will return the current value of the cookie as an array. In a scalar context it will return the **first** value of a multivalued cookie.

`domain()`

Get or set the cookie's domain.

`path()`

Get or set the cookie's path.

`expires()`

Get or set the cookie's expiration time.

AUTHOR INFORMATION

Address bug reports and comments to: lstein@cshl.org

BUGS

This section intentionally left blank.

SEE ALSO

CGI::Carp, *CGI*

NAME

CGI::Fast – CGI Interface for Fast CGI

SYNOPSIS

```
use CGI::Fast qw(:standard);
$COUNTER = 0;
while (new CGI::Fast) {
    print header;
    print start_html("Fast CGI Rocks");
    print
        h1("Fast CGI Rocks"),
        "Invocation number ",b($COUNTER++),
        " PID ",b($$),".",
        hr;
    print end_html;
}
```

DESCRIPTION

CGI::Fast is a subclass of the CGI object created by CGI.pm. It is specialized to work well with the Open Market FastCGI standard, which greatly speeds up CGI scripts by turning them into persistently running server processes. Scripts that perform time–consuming initialization processes, such as loading large modules or opening persistent database connections, will see large performance improvements.

OTHER PIECES OF THE PUZZLE

In order to use CGI::Fast you'll need a FastCGI–enabled Web server. Open Market's server is FastCGI–savvy. There are also freely redistributable FastCGI modules for NCSA httpd 1.5 and Apache. FastCGI–enabling modules for Microsoft Internet Information Server and Netscape Communications Server have been announced.

In addition, you'll need a version of the Perl interpreter that has been linked with the FastCGI I/O library. Precompiled binaries are available for several platforms, including DEC Alpha, HP–UX and SPARC/Solaris, or you can rebuild Perl from source with patches provided in the FastCGI developer's kit. The FastCGI Perl interpreter can be used in place of your normal Perl without ill consequences.

You can find FastCGI modules for Apache and NCSA httpd, precompiled Perl interpreters, and the FastCGI developer's kit all at URL:

```
http://www.fastcgi.com/
```

WRITING FASTCGI PERL SCRIPTS

FastCGI scripts are persistent: one or more copies of the script are started up when the server initializes, and stay around until the server exits or they die a natural death. After performing whatever one–time initialization it needs, the script enters a loop waiting for incoming connections, processing the request, and waiting some more.

A typical FastCGI script will look like this:

```
#!/usr/local/bin/perl    # must be a FastCGI version of perl!
use CGI::Fast;
&do_some_initialization();
while ($q = new CGI::Fast) {
    &process_request($q);
}
```

Each time there's a new request, CGI::Fast returns a CGI object to your loop. The rest of the time your script waits in the call to `new()`. When the server requests that your script be terminated, `new()` will return undef. You can of course exit earlier if you choose. A new version of the script will be respawned to take its place (this may be necessary in order to avoid Perl memory leaks in long–running scripts).

CGI.pm's default CGI object mode also works. Just modify the loop this way:

```
while (new CGI::Fast) {
    &process_request;
}
```

Calls to `header()`, `start_form()`, etc. will all operate on the current request.

INSTALLING FASTCGI SCRIPTS

See the FastCGI developer's kit documentation for full details. On the Apache server, the following line must be added to srm.conf:

```
AddType application/x-httpd-fcgi .fcgi
```

FastCGI scripts must end in the extension .fcgi. For each script you install, you must add something like the following to srm.conf:

```
AppClass /usr/etc/httpd/fcgi-bin/file_upload.fcgi -processes 2
```

This instructs Apache to launch two copies of file_upload.fcgi at startup time.

USING FASTCGI SCRIPTS AS CGI SCRIPTS

Any script that works correctly as a FastCGI script will also work correctly when installed as a vanilla CGI script. However it will not see any performance benefit.

CAVEATS

I haven't tested this very much.

AUTHOR INFORMATION

Address bug reports and comments to: lstein@cshl.org

BUGS

This section intentionally left blank.

SEE ALSO

CGI::Carp, *CGI*

NAME

CGI::Pretty – module to produce nicely formatted HTML code

SYNOPSIS

```
use CGI::Pretty qw( :html3 );

# Print a table with a single data element
print table( TR( td( "foo" ) ) );
```

DESCRIPTION

CGI::Pretty is a module that derives from CGI. It's sole function is to allow users of CGI to output nicely formatted HTML code.

When using the CGI module, the following code:
print table(TR(td("foo")));

produces the following output:
<TABLE<TR<TDfoo</TD</TR</TABLE

If a user were to create a table consisting of many rows and many columns, the resultant HTML code would be quite difficult to read since it has no carriage returns or indentation.

CGI::Pretty fixes this problem. What it does is add a carriage return and indentation to the HTML code so that one can easily read it.

```
print table( TR( td( "foo" ) ) );
```

now produces the following output:

```
<TABLE
  <TR
    <TD
      foo
    </TD
  </TR
</TABLE
```

Tags that won't be formatted

The <A and <PRE tags are not formatted. If these tags were formatted, the user would see the extra indentation on the web browser causing the page to look different than what would be expected. If you wish to add more tags to the list of tags that are not to be touched, push them onto the `@AS_IS` array:

```
push @CGI::Pretty::AS_IS,qw(CODE XMP);
```

Customizing the Indenting

If you wish to have your own personal style of indenting, you can change the `$INDENT` variable:

```
$CGI::Pretty::INDENT = "\t\t";
```

would cause the indents to be two tabs.

Similarly, if you wish to have more space between lines, you may change the `$LINEBREAK` variable:

```
$CGI::Pretty::LINEBREAK = "\n\n";
```

would create two carriage returns between lines.

If you decide you want to use the regular CGI indenting, you can easily do the following:

```
$CGI::Pretty::INDENT = $CGI::Pretty::LINEBREAK = "";
```

BUGS

This section intentionally left blank.

AUTHOR

Brian Paulsen <Brian@ThePaulsens.com, with minor modifications by Lincoln Stein <lstein@cshl.org for incorporation into the CGI.pm distribution.

Bug reports and comments to Brian@ThePaulsens.com. You can also write to lstein@cshl.org, but this code looks pretty hairy to me and I'm not sure I understand it!

SEE ALSO

CGI

NAME

CGI::Push – Simple Interface to Server Push

SYNOPSIS

```
use CGI::Push qw(:standard);

do_push(-next_page=>\&next_page,
        -last_page=>\&last_page,
        -delay=>0.5);

sub next_page {
    my($q,$counter) = @_;
    return undef if $counter >= 10;
    return start_html('Test'),
           h1('Visible'),"\n",
           "This page has been called ", strong($counter)," times",
           end_html();
  }

 sub last_page {
     my($q,$counter) = @_;
     return start_html('Done'),
            h1('Finished'),
            strong($counter),' iterations.',
            end_html;
 }
```

DESCRIPTION

CGI::Push is a subclass of the CGI object created by CGI.pm. It is specialized for server push operations, which allow you to create animated pages whose content changes at regular intervals.

You provide CGI::Push with a pointer to a subroutine that will draw one page. Every time your subroutine is called, it generates a new page. The contents of the page will be transmitted to the browser in such a way that it will replace what was there beforehand. The technique will work with HTML pages as well as with graphics files, allowing you to create animated GIFs.

Only Netscape Navigator supports server push. Internet Explorer browsers do not.

USING CGI::Push

CGI::Push adds one new method to the standard CGI suite, `do_push()`. When you call this method, you pass it a reference to a subroutine that is responsible for drawing each new page, an interval delay, and an optional subroutine for drawing the last page. Other optional parameters include most of those recognized by the CGI `header()` method.

You may call `do_push()` in the object oriented manner or not, as you prefer:

```
use CGI::Push;
$q = new CGI::Push;
$q->do_push(-next_page=>\&draw_a_page);

    -or-

use CGI::Push qw(:standard);
do_push(-next_page=>\&draw_a_page);
```

Parameters are as follows:

–next_page

```
do_push(-next_page=>\&my_draw_routine);
```

This required parameter points to a reference to a subroutine responsible for drawing each new page. The subroutine should expect two parameters consisting of the CGI object and a counter indicating the number of times the subroutine has been called. It should return the contents of the page as an **array** of one or more items to print. It can return a false value (or an empty array) in order to abort the redrawing loop and print out the final page (if any)

```
sub my_draw_routine {
    my($q,$counter) = @_;
    return undef if $counter > 100;
    return start_html('testing'),
           h1('testing'),
           "This page called $counter times";
}
```

You are of course free to refer to create and use global variables within your draw routine in order to achieve special effects.

–last_page

This optional parameter points to a reference to the subroutine responsible for drawing the last page of the series. It is called after the –next_page routine returns a false value. The subroutine itself should have exactly the same calling conventions as the –next_page routine.

–type

This optional parameter indicates the content type of each page. It defaults to "text/html". Normally the module assumes that each page is of a homogenous MIME type. However if you provide either of the magic values "heterogeneous" or "dynamic" (the latter provided for the convenience of those who hate long parameter names), you can specify the MIME type — and other header fields — on a per–page basis. See "heterogeneous pages" for more details.

–delay

This indicates the delay, in seconds, between frames. Smaller delays refresh the page faster. Fractional values are allowed.

If not specified, –delay will default to 1 second

–cookie, –target, –expires

These have the same meaning as the like–named parameters in `CGI::header()`.

Heterogeneous Pages

Ordinarily all pages displayed by CGI::Push share a common MIME type. However by providing a value of "heterogeneous" or "dynamic" in the `do_push()` –type parameter, you can specify the MIME type of each page on a case–by–case basis.

If you use this option, you will be responsible for producing the HTTP header for each page. Simply modify your draw routine to look like this:

```
sub my_draw_routine {
    my($q,$counter) = @_;
    return header('text/html'),   # note we're producing the header here
           start_html('testing'),
           h1('testing'),
           "This page called $counter times";
}
```

You can add any header fields that you like, but some (cookies and status fields included) may not be interpreted by the browser. One interesting effect is to display a series of pages, then, after the last page, to redirect the browser to a new URL. Because `redirect()` does b<not work, the easiest way is with a –refresh header field, as shown below:

```
sub my_draw_routine {
    my($q,$counter) = @_;
    return undef if $counter > 10;
    return header('text/html'),   # note we're producing the header here
           start_html('testing'),
           h1('testing'),
           "This page called $counter times";
}

sub my_last_page {
    header(-refresh=>'5; URL=http://somewhere.else/finished.html',
           -type=>'text/html'),
    start_html('Moved'),
    h1('This is the last page'),
    'Goodbye!'
     hr,
     end_html;
}
```

Changing the Page Delay on the Fly

If you would like to control the delay between pages on a page-by-page basis, call `push_delay()` from within your draw routine. `push_delay()` takes a single numeric argument representing the number of seconds you wish to delay after the current page is displayed and before displaying the next one. The delay may be fractional. Without parameters, `push_delay()` just returns the current delay.

INSTALLING CGI::Push SCRIPTS

Server push scripts **must** be installed as no-parsed-header (NPH) scripts in order to work correctly. On Unix systems, this is most often accomplished by prefixing the script's name with "nph-". Recognition of NPH scripts happens automatically with WebSTAR and Microsoft IIS. Users of other servers should see their documentation for help.

AUTHOR INFORMATION

Address bug reports and comments to: lstein@cshl.org

BUGS

This section intentionally left blank.

SEE ALSO

CGI::Carp, *CGI*

NAME

CGI::Switch – Backward compatibility module for defunct CGI::Switch

SYNOPSIS

Do not use this module. It is deprecated.

ABSTRACT

DESCRIPTION

AUTHOR INFORMATION

BUGS

SEE ALSO

NAME

CGI – Simple Common Gateway Interface Class

SYNOPSIS

```
# CGI script that creates a fill-out form
# and echoes back its values.

use CGI qw/:standard/;
print header,
      start_html('A Simple Example'),
      h1('A Simple Example'),
      start_form,
      "What's your name? ",textfield('name'),p,
      "What's the combination?", p,
      checkbox_group(-name=>'words',
                     -values=>['eenie','meenie','minie','moe'],
                     -defaults=>['eenie','minie']), p,
      "What's your favorite color? ",
      popup_menu(-name=>'color',
                 -values=>['red','green','blue','chartreuse']),p,
      submit,
      end_form,
      hr;

 if (param()) {
     print "Your name is",em(param('name')),p,
           "The keywords are: ",em(join(", ",param('words'))),p,
           "Your favorite color is ",em(param('color')),
           hr;
 }
```

ABSTRACT

This perl library uses perl5 objects to make it easy to create Web fill–out forms and parse their contents. This package defines CGI objects, entities that contain the values of the current query string and other state variables. Using a CGI object's methods, you can examine keywords and parameters passed to your script, and create forms whose initial values are taken from the current query (thereby preserving state information). The module provides shortcut functions that produce boilerplate HTML, reducing typing and coding errors. It also provides functionality for some of the more advanced features of CGI scripting, including support for file uploads, cookies, cascading style sheets, server push, and frames.

CGI.pm also provides a simple function–oriented programming style for those who don't need its object–oriented features.

The current version of CGI.pm is available at

```
http://www.genome.wi.mit.edu/ftp/pub/software/WWW/cgi_docs.html
ftp://ftp-genome.wi.mit.edu/pub/software/WWW/
```

DESCRIPTION

PROGRAMMING STYLE

There are two styles of programming with CGI.pm, an object–oriented style and a function–oriented style. In the object–oriented style you create one or more CGI objects and then use object methods to create the various elements of the page. Each CGI object starts out with the list of named parameters that were passed to your CGI script by the server. You can modify the objects, save them to a file or database and recreate them. Because each object corresponds to the "state" of the CGI script, and because each object's parameter list is independent of the others, this allows you to save the state of the script and restore it later.

For example, using the object oriented style, here is how you create a simple "Hello World" HTML page:

```
#!/usr/local/bin/perl -w
use CGI;                                # load CGI routines
$q = new CGI;                           # create new CGI object
print $q->header,                       # create the HTTP header
      $q->start_html('hello world'), # start the HTML
      $q->h1('hello world'),         # level 1 header
      $q->end_html;                     # end the HTML
```

In the function−oriented style, there is one default CGI object that you rarely deal with directly. Instead you just call functions to retrieve CGI parameters, create HTML tags, manage cookies, and so on. This provides you with a cleaner programming interface, but limits you to using one CGI object at a time. The following example prints the same page, but uses the function−oriented interface. The main differences are that we now need to import a set of functions into our name space (usually the "standard" functions), and we don't need to create the CGI object.

```
#!/usr/local/bin/perl
use CGI qw/:standard/;           # load standard CGI routines
print header,                    # create the HTTP header
      start_html('hello world'), # start the HTML
      h1('hello world'),         # level 1 header
      end_html;                  # end the HTML
```

The examples in this document mainly use the object−oriented style. See HOW TO IMPORT FUNCTIONS for important information on function−oriented programming in CGI.pm

CALLING CGI.PM ROUTINES

Most CGI.pm routines accept several arguments, sometimes as many as 20 optional ones! To simplify this interface, all routines use a named argument calling style that looks like this:

```
print $q->header(-type=>'image/gif',-expires=>'+3d');
```

Each argument name is preceded by a dash. Neither case nor order matters in the argument list. −type, −Type, and −TYPE are all acceptable. In fact, only the first argument needs to begin with a dash. If a dash is present in the first argument, CGI.pm assumes dashes for the subsequent ones.

Several routines are commonly called with just one argument. In the case of these routines you can provide the single argument without an argument name. `header()` happens to be one of these routines. In this case, the single argument is the document type.

```
print $q->header('text/html');
```

Other such routines are documented below.

Sometimes named arguments expect a scalar, sometimes a reference to an array, and sometimes a reference to a hash. Often, you can pass any type of argument and the routine will do whatever is most appropriate. For example, the `param()` routine is used to set a CGI parameter to a single or a multi−valued value. The two cases are shown below:

```
$q->param(-name=>'veggie',-value=>'tomato');
$q->param(-name=>'veggie',-value=>['tomato','tomahto','potato','potahto']);
```

A large number of routines in CGI.pm actually aren't specifically defined in the module, but are generated automatically as needed. These are the "HTML shortcuts," routines that generate HTML tags for use in dynamically−generated pages. HTML tags have both attributes (the attribute="value" pairs within the tag itself) and contents (the part between the opening and closing pairs.) To distinguish between attributes and contents, CGI.pm uses the convention of passing HTML attributes as a hash reference as the first argument, and the contents, if any, as any subsequent arguments. It works out like this:

```
Code                           Generated HTML
```

```
----                                 --------------
h1()                                 <H1>
h1('some','contents');               <H1>some contents</H1>
h1({-align=>left});                  <H1 ALIGN="LEFT">
h1({-align=>left},'contents');       <H1 ALIGN="LEFT">contents</H1>
```

HTML tags are described in more detail later.

Many newcomers to CGI.pm are puzzled by the difference between the calling conventions for the HTML shortcuts, which require curly braces around the HTML tag attributes, and the calling conventions for other routines, which manage to generate attributes without the curly brackets. Don't be confused. As a convenience the curly braces are optional in all but the HTML shortcuts. If you like, you can use curly braces when calling any routine that takes named arguments. For example:

```
print $q->header( {-type=>'image/gif',-expires=>'+3d'} );
```

If you use the **-w** switch, you will be warned that some CGI.pm argument names conflict with built-in Perl functions. The most frequent of these is the -values argument, used to create multi-valued menus, radio button clusters and the like. To get around this warning, you have several choices:

1. Use another name for the argument, if one is available. For example, -value is an alias for -values.
2. Change the capitalization, e.g. -Values
3. Put quotes around the argument name, e.g. '-values'

Many routines will do something useful with a named argument that it doesn't recognize. For example, you can produce non-standard HTTP header fields by providing them as named arguments:

```
print $q->header(-type  =>  'text/html',
                 -cost  =>  'Three smackers',
                 -annoyance_level => 'high',
                 -complaints_to   => 'bit bucket');
```

This will produce the following nonstandard HTTP header:

```
HTTP/1.0 200 OK
Cost: Three smackers
Annoyance-level: high
Complaints-to: bit bucket
Content-type: text/html
```

Notice the way that underscores are translated automatically into hyphens. HTML-generating routines perform a different type of translation.

This feature allows you to keep up with the rapidly changing HTTP and HTML "standards".

CREATING A NEW QUERY OBJECT (OBJECT-ORIENTED STYLE):

```
$query = new CGI;
```

This will parse the input (from both POST and GET methods) and store it into a perl5 object called `$query`.

CREATING A NEW QUERY OBJECT FROM AN INPUT FILE

```
$query = new CGI(INPUTFILE);
```

If you provide a file handle to the `new()` method, it will read parameters from the file (or STDIN, or whatever). The file can be in any of the forms describing below under debugging (i.e. a series of newline delimited TAG=VALUE pairs will work). Conveniently, this type of file is created by the `save()` method (see below). Multiple records can be saved and restored.

Perl purists will be pleased to know that this syntax accepts references to file handles, or even references to

filehandle globs, which is the "official" way to pass a filehandle:

```
$query = new CGI(\*STDIN);
```

You can also initialize the CGI object with a FileHandle or IO::File object.

If you are using the function−oriented interface and want to initialize CGI state from a file handle, the way to do this is with **`restore_parameters()`**. This will (re)initialize the default CGI object from the indicated file handle.

```
open (IN,"test.in") || die;
restore_parameters(IN);
close IN;
```

You can also initialize the query object from an associative array reference:

```
$query = new CGI( {'dinosaur'=>'barney',
                   'song'=>'I love you',
                   'friends'=>[qw/Jessica George Nancy/]}
                );
```

or from a properly formatted, URL−escaped query string:

```
$query = new CGI('dinosaur=barney&color=purple');
```

or from a previously existing CGI object (currently this clones the parameter list, but none of the other object−specific fields, such as autoescaping):

```
$old_query = new CGI;
$new_query = new CGI($old_query);
```

To create an empty query, initialize it from an empty string or hash:

```
$empty_query = new CGI("");

   -or-

$empty_query = new CGI({});
```

FETCHING A LIST OF KEYWORDS FROM THE QUERY:

```
@keywords = $query->keywords
```

If the script was invoked as the result of an <ISINDEX search, the parsed keywords can be obtained as an array using the `keywords()` method.

FETCHING THE NAMES OF ALL THE PARAMETERS PASSED TO YOUR SCRIPT:

```
@names = $query->param
```

If the script was invoked with a parameter list (e.g. "name1=value1`&name2=value2&name3=value3")`, the `param()` method will return the parameter names as a list. If the script was invoked as an <ISINDEX script and contains a string without ampersands (e.g. "value1+value2+value3") , there will be a single parameter named "keywords" containing the "+"−delimited keywords.

NOTE: As of version 1.5, the array of parameter names returned will be in the same order as they were submitted by the browser. Usually this order is the same as the order in which the parameters are defined in the form (however, this isn't part of the spec, and so isn't guaranteed).

FETCHING THE VALUE OR VALUES OF A SINGLE NAMED PARAMETER:

```
@values = $query->param('foo');

          -or-

$value = $query->param('foo');
```

Pass the `param()` method a single argument to fetch the value of the named parameter. If the parameter is multivalued (e.g. from multiple selections in a scrolling list), you can ask to receive an array. Otherwise the method will return a single value.

If a value is not given in the query string, as in the queries "name1=&name2=" or "name1&name2", it will be returned as an empty string. This feature is new in 2.63.

SETTING THE VALUE(S) OF A NAMED PARAMETER:

```
$query->param('foo','an','array','of','values');
```

This sets the value for the named parameter 'foo' to an array of values. This is one way to change the value of a field AFTER the script has been invoked once before. (Another way is with the –override parameter accepted by all methods that generate form elements.)

`param()` also recognizes a named parameter style of calling described in more detail later:

```
$query->param(-name=>'foo',-values=>['an','array','of','values']);

                                -or-

$query->param(-name=>'foo',-value=>'the value');
```

APPENDING ADDITIONAL VALUES TO A NAMED PARAMETER:

```
$query->append(-name=>'foo',-values=>['yet','more','values']);
```

This adds a value or list of values to the named parameter. The values are appended to the end of the parameter if it already exists. Otherwise the parameter is created. Note that this method only recognizes the named argument calling syntax.

IMPORTING ALL PARAMETERS INTO A NAMESPACE:

```
$query->import_names('R');
```

This creates a series of variables in the 'R' namespace. For example, `$R::foo`, @R:foo. For keyword lists, a variable @R::keywords will appear. If no namespace is given, this method will assume 'Q'. WARNING: don't import anything into 'main'; this is a major security risk!!!!

In older versions, this method was called **`import()`**. As of version 2.20, this name has been removed completely to avoid conflict with the built–in Perl module **import** operator.

DELETING A PARAMETER COMPLETELY:

```
$query->delete('foo');
```

This completely clears a parameter. It sometimes useful for resetting parameters that you don't want passed down between script invocations.

If you are using the function call interface, use `"Delete()"` instead to avoid conflicts with Perl's built–in delete operator.

DELETING ALL PARAMETERS:

```
$query->delete_all();
```

This clears the CGI object completely. It might be useful to ensure that all the defaults are taken when you create a fill–out form.

Use `Delete_all()` instead if you are using the function call interface.

DIRECT ACCESS TO THE PARAMETER LIST:

```
$q->param_fetch('address')->[1] = '1313 Mockingbird Lane';
unshift @{$q->param_fetch(-name=>'address')},'George Munster';
```

If you need access to the parameter list in a way that isn't covered by the methods above, you can obtain a direct reference to it by calling the **`param_fetch()`** method with the name of the . This will return an array reference to the named parameters, which you then can manipulate in any way you like.

You can also use a named argument style using the **–name** argument.

FETCHING THE PARAMETER LIST AS A HASH:

```
$params = $q->Vars;
print $params->{'address'};
@foo = split("\0",$params->{'foo'});
%params = $q->Vars;

use CGI ':cgi-lib';
$params = Vars;
```

Many people want to fetch the entire parameter list as a hash in which the keys are the names of the CGI parameters, and the values are the parameters' values. The `Vars()` method does this. Called in a scalar context, it returns the parameter list as a tied hash reference. Changing a key changes the value of the parameter in the underlying CGI parameter list. Called in a list context, it returns the parameter list as an ordinary hash. This allows you to read the contents of the parameter list, but not to change it.

When using this, the thing you must watch out for are multivalued CGI parameters. Because a hash cannot distinguish between scalar and list context, multivalued parameters will be returned as a packed string, separated by the "\0" (null) character. You must split this packed string in order to get at the individual values. This is the convention introduced long ago by Steve Brenner in his cgi–lib.pl module for Perl version 4.

If you wish to use `Vars()` as a function, import the *:cgi–lib* set of function calls (also see the section on CGI–LIB compatibility).

SAVING THE STATE OF THE SCRIPT TO A FILE:

```
$query->save(FILEHANDLE)
```

This will write the current state of the form to the provided filehandle. You can read it back in by providing a filehandle to the `new()` method. Note that the filehandle can be a file, a pipe, or whatever!

The format of the saved file is:

```
NAME1=VALUE1
NAME1=VALUE1'
NAME2=VALUE2
NAME3=VALUE3
=
```

Both name and value are URL escaped. Multi–valued CGI parameters are represented as repeated names. A session record is delimited by a single = symbol. You can write out multiple records and read them back in with several calls to **new**. You can do this across several sessions by opening the file in append mode, allowing you to create primitive guest books, or to keep a history of users' queries. Here's a short example of creating multiple session records:

```
use CGI;

open (OUT,">>test.out") || die;
$records = 5;
foreach (0..$records) {
    my $q = new CGI;
    $q->param(-name=>'counter',-value=>$_);
    $q->save(OUT);
}
close OUT;

# reopen for reading
open (IN,"test.out") || die;
while (!eof(IN)) {
    my $q = new CGI(IN);
```

```
    print $q->param('counter'),"\n";
}
```

The file format used for save/restore is identical to that used by the Whitehead Genome Center's data exchange format "Boulderio", and can be manipulated and even databased using Boulderio utilities. See

```
http://stein.cshl.org/boulder/
```

for further details.

If you wish to use this method from the function–oriented (non–OO) interface, the exported name for this method is **save_parameters()**.

RETRIEVING CGI ERRORS

Errors can occur while processing user input, particularly when processing uploaded files. When these errors occur, CGI will stop processing and return an empty parameter list. You can test for the existence and nature of errors using the *cgi_error()* function. The error messages are formatted as HTTP status codes. You can either incorporate the error text into an HTML page, or use it as the value of the HTTP status:

```
my $error = $q->cgi_error;
if ($error) {
    print $q->header(-status=>$error),
          $q->start_html('Problems'),
          $q->h2('Request not processed'),
          $q->strong($error);
    exit 0;
}
```

When using the function–oriented interface (see the next section), errors may only occur the first time you call *param()*. Be ready for this!

USING THE FUNCTION–ORIENTED INTERFACE

To use the function–oriented interface, you must specify which CGI.pm routines or sets of routines to import into your script's namespace. There is a small overhead associated with this importation, but it isn't much.

```
use CGI <list of methods>;
```

The listed methods will be imported into the current package; you can call them directly without creating a CGI object first. This example shows how to import the **param()** and **header()** methods, and then use them directly:

```
use CGI 'param','header';
print header('text/plain');
$zipcode = param('zipcode');
```

More frequently, you'll import common sets of functions by referring to the groups by name. All function sets are preceded with a ":" character as in ":html3" (for tags defined in the HTML 3 standard).

Here is a list of the function sets you can import:

:cgi Import all CGI–handling methods, such as **param()**, **path_info()** and the like.

:form

Import all fill–out form generating methods, such as **textfield()**.

:html2

Import all methods that generate HTML 2.0 standard elements.

:html3

Import all methods that generate HTML 3.0 proposed elements (such as <table, <super and <sub).

:netscape

Import all methods that generate Netscape−specific HTML extensions.

:html

Import all HTML−generating shortcuts (i.e. ‘html2’ + ‘html3’ + ‘netscape’)...

:standard

Import "standard" features, ‘html2‘, ‘html3‘, ‘form’ and ‘cgi’.

:all Import all the available methods. For the full list, see the CGI.pm code, where the variable %EXPORT_TAGS is defined.

If you import a function name that is not part of CGI.pm, the module will treat it as a new HTML tag and generate the appropriate subroutine. You can then use it like any other HTML tag. This is to provide for the rapidly−evolving HTML "standard." For example, say Microsoft comes out with a new tag called <GRADIENT (which causes the user‘s desktop to be flooded with a rotating gradient fill until his machine reboots). You don‘t need to wait for a new version of CGI.pm to start using it immediately:

```
use CGI qw/:standard :html3 gradient/;
print gradient({-start=>'red',-end=>'blue'});
```

Note that in the interests of execution speed CGI.pm does **not** use the standard *Exporter* syntax for specifying load symbols. This may change in the future.

If you import any of the state−maintaining CGI or form−generating methods, a default CGI object will be created and initialized automatically the first time you use any of the methods that require one to be present. This includes **`param()`**, **`textfield()`**, **`submit()`** and the like. (If you need direct access to the CGI object, you can find it in the global variable **`$CGI::Q`**). By importing CGI.pm methods, you can create visually elegant scripts:

```
use CGI qw/:standard/;
print
    header,
    start_html('Simple Script'),
    h1('Simple Script'),
    start_form,
    "What's your name? ",textfield('name'),p,
    "What's the combination?",
    checkbox_group(-name=>'words',
                   -values=>['eenie','meenie','minie','moe'],
                   -defaults=>['eenie','moe']),p,
    "What's your favorite color?",
    popup_menu(-name=>'color',
               -values=>['red','green','blue','chartreuse']),p,
    submit,
    end_form,
    hr,"\n";

 if (param) {
    print
        "Your name is ",em(param('name')),p,
        "The keywords are: ",em(join(", ",param('words'))),p,
        "Your favorite color is ",em(param('color')),".\n";
 }
 print end_html;
```

PRAGMAS

In addition to the function sets, there are a number of pragmas that you can import. Pragmas, which are always preceded by a hyphen, change the way that CGI.pm functions in various ways. Pragmas, function sets, and individual functions can all be imported in the same `use()` line. For example, the following use statement imports the standard set of functions and enables debugging mode (pragma –debug):

```
use CGI qw/:standard -debug/;
```

The current list of pragmas is as follows:

–any

When you *use CGI –any*, then any method that the query object doesn't recognize will be interpreted as a new HTML tag. This allows you to support the next *ad hoc* Netscape or Microsoft HTML extension. This lets you go wild with new and unsupported tags:

```
use CGI qw(-any);
$q=new CGI;
print $q->gradient({speed=>'fast',start=>'red',end=>'blue'});
```

Since using <citeany</cite causes any mistyped method name to be interpreted as an HTML tag, use it with care or not at all.

–compile

This causes the indicated autoloaded methods to be compiled up front, rather than deferred to later. This is useful for scripts that run for an extended period of time under FastCGI or mod_perl, and for those destined to be crunched by Malcom Beattie's Perl compiler. Use it in conjunction with the methods or method families you plan to use.

```
use CGI qw(-compile :standard :html3);
```

or even

```
use CGI qw(-compile :all);
```

Note that using the –compile pragma in this way will always have the effect of importing the compiled functions into the current namespace. If you want to compile without importing use the `compile()` method instead (see below).

–nosticky

This makes CGI.pm not generating the hidden fields .submit and .cgifields. It is very useful if you don't want to have the hidden fields appear in the querystring in a GET method. For example, a search script generated this way will have a very nice url with search parameters for bookmarking.

–no_xhtml

By default, CGI.pm versions 2.69 and higher emit XHTML (http://www.w3.org/TR/xhtml1/). The –no_xhtml pragma disables this feature. Thanks to Michalis Kabrianis <kabrianis@hellug.gr for this feature.

–nph

This makes CGI.pm produce a header appropriate for an NPH (no parsed header) script. You may need to do other things as well to tell the server that the script is NPH. See the discussion of NPH scripts below.

–newstyle_urls

Separate the name=value pairs in CGI parameter query strings with semicolons rather than ampersands. For example:

```
?name=fred;age=24;favorite_color=3
```

Semicolon–delimited query strings are always accepted, but will not be emitted by `self_url()` and `query_string()` unless the –newstyle_urls pragma is specified.

This became the default in version 2.64.

–oldstyle_urls

Separate the name=value pairs in CGI parameter query strings with ampersands rather than semicolons. This is no longer the default.

–autoload

This overrides the autoloader so that any function in your program that is not recognized is referred to CGI.pm for possible evaluation. This allows you to use all the CGI.pm functions without adding them to your symbol table, which is of concern for mod_perl users who are worried about memory consumption. *Warning:* when *–autoload* is in effect, you cannot use "poetry mode" (functions without the parenthesis). Use `hr()` rather than *hr*, or add something like *use subs qw/hr p header/* to the top of your script.

–no_debug

This turns off the command–line processing features. If you want to run a CGI.pm script from the command line to produce HTML, and you don't want it to read CGI parameters from the command line or STDIN, then use this pragma:

```
use CGI qw(-no_debug :standard);
```

–debug

This turns on full debugging. In addition to reading CGI arguments from the command–line processing, CGI.pm will pause and try to read arguments from STDIN, producing the message "(offline mode: enter name=value pairs on standard input)" features.

See the section on debugging for more details.

–private_tempfiles

CGI.pm can process uploaded file. Ordinarily it spools the uploaded file to a temporary directory, then deletes the file when done. However, this opens the risk of eavesdropping as described in the file upload section. Another CGI script author could peek at this data during the upload, even if it is confidential information. On Unix systems, the –private_tempfiles pragma will cause the temporary file to be unlinked as soon as it is opened and before any data is written into it, reducing, but not eliminating the risk of eavesdropping (there is still a potential race condition). To make life harder for the attacker, the program chooses tempfile names by calculating a 32 bit checksum of the incoming HTTP headers.

To ensure that the temporary file cannot be read by other CGI scripts, use suEXEC or a CGI wrapper program to run your script. The temporary file is created with mode 0600 (neither world nor group readable).

The temporary directory is selected using the following algorithm:

```
1. if the current user (e.g. "nobody") has a directory named
"tmp" in its home directory, use that (Unix systems only).

2. if the environment variable TMPDIR exists, use the location
indicated.

3. Otherwise try the locations /usr/tmp, /var/tmp, C:\temp,
/tmp, /temp, ::Temporary Items, and \WWW_ROOT.
```

Each of these locations is checked that it is a directory and is writable. If not, the algorithm tries the next choice.

SPECIAL FORMS FOR IMPORTING HTML–TAG FUNCTIONS

Many of the methods generate HTML tags. As described below, tag functions automatically generate both the opening and closing tags. For example:

```
print h1('Level 1 Header');
```

produces

```
<H1>Level 1 Header</H1>
```

There will be some times when you want to produce the start and end tags yourself. In this case, you can use the form start_*tag_name* and end_*tag_name*, as in:

```
print start_h1,'Level 1 Header',end_h1;
```

With a few exceptions (described below), start_*tag_name* and end_*tag_name* functions are not generated automatically when you *use CGI*. However, you can specify the tags you want to generate *start/end* functions for by putting an asterisk in front of their name, or, alternatively, requesting either "start_*tag_name*" or "end_*tag_name*" in the import list.

Example:

```
use CGI qw/:standard *table start_ul/;
```

In this example, the following functions are generated in addition to the standard ones:

1. `start_table()` (generates a <TABLE tag)
2. `end_table()` (generates a </TABLE tag)
3. `start_ul()` (generates a <UL tag)
4. `end_ul()` (generates a </UL tag)

GENERATING DYNAMIC DOCUMENTS

Most of CGI.pm's functions deal with creating documents on the fly. Generally you will produce the HTTP header first, followed by the document itself. CGI.pm provides functions for generating HTTP headers of various types as well as for generating HTML. For creating GIF images, see the GD.pm module.

Each of these functions produces a fragment of HTML or HTTP which you can print out directly so that it displays in the browser window, append to a string, or save to a file for later use.

CREATING A STANDARD HTTP HEADER:

Normally the first thing you will do in any CGI script is print out an HTTP header. This tells the browser what type of document to expect, and gives other optional information, such as the language, expiration date, and whether to cache the document. The header can also be manipulated for special purposes, such as server push and pay per view pages.

```
print $query->header;

     -or-

print $query->header('image/gif');

     -or-

print $query->header('text/html','204 No response');

     -or-

print $query->header(-type=>'image/gif',
                     -nph=>1,
                     -status=>'402 Payment required',
                     -expires=>'+3d',
                     -cookie=>$cookie,
                     -charset=>'utf-7',
                     -attachment=>'foo.gif',
                     -Cost=>'$2.00');
```

`header()` returns the Content-type: header. You can provide your own MIME type if you choose, otherwise it defaults to text/html. An optional second parameter specifies the status code and a

human−readable message. For example, you can specify 204, "No response" to create a script that tells the browser to do nothing at all.

The last example shows the named argument style for passing arguments to the CGI methods using named parameters. Recognized parameters are **−type**, **−status**, **−expires**, and **−cookie**. Any other named parameters will be stripped of their initial hyphens and turned into header fields, allowing you to specify any HTTP header you desire. Internal underscores will be turned into hyphens:

```
print $query->header(-Content_length=>3002);
```

Most browsers will not cache the output from CGI scripts. Every time the browser reloads the page, the script is invoked anew. You can change this behavior with the **−expires** parameter. When you specify an absolute or relative expiration interval with this parameter, some browsers and proxy servers will cache the script's output until the indicated expiration date. The following forms are all valid for the −expires field:

```
+30s                              30 seconds from now
+10m                              ten minutes from now
+1h                               one hour from now
-1d                               yesterday (i.e. "ASAP!")
now                               immediately
+3M                               in three months
+10y                              in ten years time
Thursday, 25-Apr-1999 00:40:33 GMT  at the indicated time & date
```

The **−cookie** parameter generates a header that tells the browser to provide a "magic cookie" during all subsequent transactions with your script. Netscape cookies have a special format that includes interesting attributes such as expiration time. Use the `cookie()` method to create and retrieve session cookies.

The **−nph** parameter, if set to a true value, will issue the correct headers to work with a NPH (no−parse−header) script. This is important to use with certain servers that expect all their scripts to be NPH.

The **−charset** parameter can be used to control the character set sent to the browser. If not provided, defaults to ISO−8859−1. As a side effect, this sets the `charset()` method as well.

The **−attachment** parameter can be used to turn the page into an attachment. Instead of displaying the page, some browsers will prompt the user to save it to disk. The value of the argument is the suggested name for the saved file. In order for this to work, you may have to set the **−type** to "application/octet−stream".

GENERATING A REDIRECTION HEADER

```
print $query->redirect('http://somewhere.else/in/movie/land');
```

Sometimes you don't want to produce a document yourself, but simply redirect the browser elsewhere, perhaps choosing a URL based on the time of day or the identity of the user.

The `redirect()` function redirects the browser to a different URL. If you use redirection like this, you should **not** print out a header as well.

One hint I can offer is that relative links may not work correctly when you generate a redirection to another document on your site. This is due to a well−intentioned optimization that some servers use. The solution to this is to use the full URL (including the http: part) of the document you are redirecting to.

You can also use named arguments:

```
print $query->redirect(-uri=>'http://somewhere.else/in/movie/land',
                       -nph=>1);
```

The **−nph** parameter, if set to a true value, will issue the correct headers to work with a NPH (no−parse−header) script. This is important to use with certain servers, such as Microsoft Internet Explorer, which expect all their scripts to be NPH.

CREATING THE HTML DOCUMENT HEADER

```
print $query->start_html(-title=>'Secrets of the Pyramids',
                         -author=>'fred@capricorn.org',
                         -base=>'true',
                         -target=>'_blank',
                         -meta=>{'keywords'=>'pharaoh secret mummy',
                                 'copyright'=>'copyright 1996 King Tut'},
                         -style=>{'src'=>'/styles/style1.css'},
                         -BGCOLOR=>'blue');
```

After creating the HTTP header, most CGI scripts will start writing out an HTML document. The `start_html()` routine creates the top of the page, along with a lot of optional information that controls the page's appearance and behavior.

This method returns a canned HTML header and the opening <BODY tag. All parameters are optional. In the named parameter form, recognized parameters are –title, –author, –base, –xbase, –dtd, –lang and –target (see below for the explanation). Any additional parameters you provide, such as the Netscape unofficial BGCOLOR attribute, are added to the <BODY tag. Additional parameters must be proceeded by a hyphen.

The argument **–xbase** allows you to provide an HREF for the <BASE tag different from the current location, as in

```
-xbase=>"http://home.mcom.com/"
```

All relative links will be interpreted relative to this tag.

The argument **–target** allows you to provide a default target frame for all the links and fill–out forms on the page. **This is a non–standard HTTP feature which only works with Netscape browsers!** See the Netscape documentation on frames for details of how to manipulate this.

```
-target=>"answer_window"
```

All relative links will be interpreted relative to this tag. You add arbitrary meta information to the header with the **–meta** argument. This argument expects a reference to an associative array containing name/value pairs of meta information. These will be turned into a series of header <META tags that look something like this:

```
<META NAME="keywords" CONTENT="pharaoh secret mummy">
<META NAME="description" CONTENT="copyright 1996 King Tut">
```

To create an HTTP–EQUIV type of <META tag, use **–head**, described below.

The **–style** argument is used to incorporate cascading stylesheets into your code. See the section on CASCADING STYLESHEETS for more information.

The **–lang** argument is used to incorporate a language attribute into the <HTML tag. The default if not specified is "en–US" for US English. For example:

```
print $q->header(-lang=>'fr-CA');
```

You can place other arbitrary HTML elements to the <HEAD section with the **–head** tag. For example, to place the rarely–used <LINK element in the head section, use this:

```
print start_html(-head=>Link({-rel=>'next',
                              -href=>'http://www.capricorn.com/s2.html'}));
```

To incorporate multiple HTML elements into the <HEAD section, just pass an array reference:

```
print start_html(-head=>[
                         Link({-rel=>'next',
                               -href=>'http://www.capricorn.com/s2.html'}),
                         Link({-rel=>'previous',
```

```
                                        -href=>'http://www.capricorn.com/s1.html'})
                                ]
                        );
```

And here's how to create an HTTP–EQUIV <META tag:

```
print header(-head=>meta({-http_equiv => 'Content-Type',
                          -content    => 'text/html'}))
```

JAVASCRIPTING: The **–script**, **–noScript**, **–onLoad**, **–onMouseOver**, **–onMouseOut** and **–onUnload** parameters are used to add Netscape JavaScript calls to your pages. **–script** should point to a block of text containing JavaScript function definitions. This block will be placed within a <SCRIPT block inside the HTML (not HTTP) header. The block is placed in the header in order to give your page a fighting chance of having all its JavaScript functions in place even if the user presses the stop button before the page has loaded completely. CGI.pm attempts to format the script in such a way that JavaScript–naive browsers will not choke on the code: unfortunately there are some browsers, such as Chimera for Unix, that get confused by it nevertheless.

The **–onLoad** and **–onUnload** parameters point to fragments of JavaScript code to execute when the page is respectively opened and closed by the browser. Usually these parameters are calls to functions defined in the **–script** field:

```
$query = new CGI;
print $query->header;
$JSCRIPT=<<END;
// Ask a silly question
function riddle_me_this() {
   var r = prompt("What walks on four legs in the morning, " +
                  "two legs in the afternoon, " +
                  "and three legs in the evening?");
   response(r);
}
// Get a silly answer
function response(answer) {
   if (answer == "man")
      alert("Right you are!");
   else
      alert("Wrong!  Guess again.");
}
END
print $query->start_html(-title=>'The Riddle of the Sphinx',
                         -script=>$JSCRIPT);
```

Use the **–noScript** parameter to pass some HTML text that will be displayed on browsers that do not have JavaScript (or browsers where JavaScript is turned off).

Netscape 3.0 recognizes several attributes of the <SCRIPT tag, including LANGUAGE and SRC. The latter is particularly interesting, as it allows you to keep the JavaScript code in a file or CGI script rather than cluttering up each page with the source. To use these attributes pass a HASH reference in the **–script** parameter containing one or more of –language, –src, or –code:

```
print $q->start_html(-title=>'The Riddle of the Sphinx',
                     -script=>{-language=>'JAVASCRIPT',
                               -src=>'/javascript/sphinx.js'}
                     );

print $q->(-title=>'The Riddle of the Sphinx',
           -script=>{-language=>'PERLSCRIPT',
                     -code=>'print "hello world!\n;"'}
```

```
                );
```

A final feature allows you to incorporate multiple <SCRIPT sections into the header. Just pass the list of script sections as an array reference. this allows you to specify different source files for different dialects of JavaScript. Example:

```
print $q->start_html(-title=>'The Riddle of the Sphinx',
                     -script=>[
                               { -language => 'JavaScript1.0',
                                 -src      => '/javascript/utilities10.js'
                               },
                               { -language => 'JavaScript1.1',
                                 -src      => '/javascript/utilities11.js'
                               },
                               { -language => 'JavaScript1.2',
                                 -src      => '/javascript/utilities12.js'
                               },
                               { -language => 'JavaScript28.2',
                                 -src      => '/javascript/utilities219.js'
                               }
                             ]
                          );
</pre>
```

If this looks a bit extreme, take my advice and stick with straight CGI scripting.

See

```
http://home.netscape.com/eng/mozilla/2.0/handbook/javascript/
```

for more information about JavaScript.

The old−style positional parameters are as follows:

Parameters:

1. The title
2. The author's e−mail address (will create a <LINK REV="MADE" tag if present
3. A 'true' flag if you want to include a <BASE tag in the header. This helps resolve relative addresses to absolute ones when the document is moved, but makes the document hierarchy non−portable. Use with care!

4, 5, 6...

Any other parameters you want to include in the <BODY tag. This is a good place to put Netscape extensions, such as colors and wallpaper patterns.

ENDING THE HTML DOCUMENT:

```
print $query->end_html
```

This ends an HTML document by printing the </BODY</HTML tags.

CREATING A SELF−REFERENCING URL THAT PRESERVES STATE INFORMATION:

```
$myself = $query->self_url;
print q(<A HREF="$myself">I'm talking to myself.</A>);
```

`self_url()` will return a URL, that, when selected, will reinvoke this script with all its state information intact. This is most useful when you want to jump around within the document using internal anchors but you don't want to disrupt the current contents of the form(s). Something like this will do the trick.

```
$myself = $query->self_url;
print "<A HREF=$myself#table1>See table 1</A>";
```

```
print "<A HREF=$myself#table2>See table 2</A>";
print "<A HREF=$myself#yourself>See for yourself</A>";
```

If you want more control over what's returned, using the **url()** method instead.

You can also retrieve the unprocessed query string with query_string():

```
$the_string = $query->query_string;
```

OBTAINING THE SCRIPT'S URL

```
$full_url      = $query->url();
$full_url      = $query->url(-full=>1);  #alternative syntax
$relative_url  = $query->url(-relative=>1);
$absolute_url  = $query->url(-absolute=>1);
$url_with_path = $query->url(-path_info=>1);
$url_with_path_and_query = $query->url(-path_info=>1,-query=>1);
$netloc        = $query->url(-base => 1);
```

url() returns the script's URL in a variety of formats. Called without any arguments, it returns the full form of the URL, including host name and port number

```
http://your.host.com/path/to/script.cgi
```

You can modify this format with the following named arguments:

–absolute

If true, produce an absolute URL, e.g.

```
/path/to/script.cgi
```

–relative

Produce a relative URL. This is useful if you want to reinvoke your script with different parameters. For example:

```
script.cgi
```

–full

Produce the full URL, exactly as if called without any arguments. This overrides the –relative and –absolute arguments.

–path (–path_info)

Append the additional path information to the URL. This can be combined with **–full**, **–absolute** or **–relative**. **–path_info** is provided as a synonym.

–query (–query_string)

Append the query string to the URL. This can be combined with **–full**, **–absolute** or **–relative**. **–query_string** is provided as a synonym.

–base

Generate just the protocol and net location, as in http://www.foo.com:8000

MIXING POST AND URL PARAMETERS

```
$color = $query-&gt;url_param('color');
```

It is possible for a script to receive CGI parameters in the URL as well as in the fill–out form by creating a form that POSTs to a URL containing a query string (a "?" mark followed by arguments). The **param()** method will always return the contents of the POSTed fill–out form, ignoring the URL's query string. To retrieve URL parameters, call the **url_param()** method. Use it in the same way as **param()**. The main difference is that it allows you to read the parameters, but not set them.

Under no circumstances will the contents of the URL query string interfere with similarly–named CGI parameters in POSTed forms. If you try to mix a URL query string with a form submitted with the GET

method, the results will not be what you expect.

CREATING STANDARD HTML ELEMENTS:

CGI.pm defines general HTML shortcut methods for most, if not all of the HTML 3 and HTML 4 tags. HTML shortcuts are named after a single HTML element and return a fragment of HTML text that you can then print or manipulate as you like. Each shortcut returns a fragment of HTML code that you can append to a string, save to a file, or, most commonly, print out so that it displays in the browser window.

This example shows how to use the HTML methods:

```
$q = new CGI;
print $q->blockquote(
                   "Many years ago on the island of",
                   $q->a({href=>"http://crete.org/"},"Crete"),
                   "there lived a Minotaur named",
                   $q->strong("Fred."),
                  ),
    $q->hr;
```

This results in the following HTML code (extra newlines have been added for readability):

```
<blockquote>
Many years ago on the island of
<a HREF="http://crete.org/">Crete</a> there lived
a minotaur named <strong>Fred.</strong>
</blockquote>
<hr>
```

If you find the syntax for calling the HTML shortcuts awkward, you can import them into your namespace and dispense with the object syntax completely (see the next section for more details):

```
use CGI ':standard';
print blockquote(
   "Many years ago on the island of",
   a({href=>"http://crete.org/"},"Crete"),
   "there lived a minotaur named",
   strong("Fred."),
   ),
   hr;
```

PROVIDING ARGUMENTS TO HTML SHORTCUTS

The HTML methods will accept zero, one or multiple arguments. If you provide no arguments, you get a single tag:

```
print hr;    #  <HR>
```

If you provide one or more string arguments, they are concatenated together with spaces and placed between opening and closing tags:

```
print h1("Chapter","1"); # <H1>Chapter 1</H1>"
```

If the first argument is an associative array reference, then the keys and values of the associative array become the HTML tag's attributes:

```
print a({-href=>'fred.html',-target=>'_new'},
   "Open a new frame");

         <A HREF="fred.html",TARGET="_new">Open a new frame</A>
```

You may dispense with the dashes in front of the attribute names if you prefer:

```
print img {src=>'fred.gif',align=>'LEFT'};
```

```
<IMG ALIGN="LEFT" SRC="fred.gif">
```

Sometimes an HTML tag attribute has no argument. For example, ordered lists can be marked as COMPACT. The syntax for this is an argument that that points to an undef string:

```
print ol({compact=>undef},li('one'),li('two'),li('three'));
```

Prior to CGI.pm version 2.41, providing an empty ('') string as an attribute argument was the same as providing undef. However, this has changed in order to accommodate those who want to create tags of the form <IMG ALT="">. The difference is shown in these two pieces of code:

```
CODE                    RESULT
img({alt=>undef})       <IMG ALT>
img({alt=>''})          <IMT ALT="">
```

THE DISTRIBUTIVE PROPERTY OF HTML SHORTCUTS

One of the cool features of the HTML shortcuts is that they are distributive. If you give them an argument consisting of a **reference** to a list, the tag will be distributed across each element of the list. For example, here's one way to make an ordered list:

```
print ul(
          li({-type=>'disc'},['Sneezy','Doc','Sleepy','Happy'])
        );
```

This example will result in HTML output that looks like this:

```
<UL>
  <LI TYPE="disc">Sneezy</LI>
  <LI TYPE="disc">Doc</LI>
  <LI TYPE="disc">Sleepy</LI>
  <LI TYPE="disc">Happy</LI>
</UL>
```

This is extremely useful for creating tables. For example:

```
print table({-border=>undef},
        caption('When Should You Eat Your Vegetables?'),
        Tr({-align=>CENTER,-valign=>TOP},
        [
           th(['Vegetable', 'Breakfast','Lunch','Dinner']),
           td(['Tomatoes' , 'no', 'yes', 'yes']),
           td(['Broccoli' , 'no', 'no',  'yes']),
           td(['Onions'   , 'yes','yes', 'yes'])
        ]
        )
     );
```

HTML SHORTCUTS AND LIST INTERPOLATION

Consider this bit of code:

```
print blockquote(em('Hi'),'mom!'));
```

It will ordinarily return the string that you probably expect, namely:

```
<BLOCKQUOTE><EM>Hi</EM> mom!</BLOCKQUOTE>
```

Note the space between the element "Hi" and the element "mom!". CGI.pm puts the extra space there using array interpolation, which is controlled by the magic `$"` variable. Sometimes this extra space is not what you want, for example, when you are trying to align a series of images. In this case, you can simply change the value of `$"` to an empty string.

```
{
```

```
    local($") = '';
    print blockquote(em('Hi'),'mom!'));
}
```

I suggest you put the code in a block as shown here. Otherwise the change to `$"` will affect all subsequent code until you explicitly reset it.

NON–STANDARD HTML SHORTCUTS

A few HTML tags don't follow the standard pattern for various reasons.

`comment()` generates an HTML comment (<!— comment —). Call it like

```
print comment('here is my comment');
```

Because of conflicts with built–in Perl functions, the following functions begin with initial caps:

```
Select
Tr
Link
Delete
Accept
Sub
```

In addition, `start_html()`, `end_html()`, `start_form()`, `end_form()`, `start_multipart_form()` and all the fill–out form tags are special. See their respective sections.

AUTOESCAPING HTML

By default, all HTML that is emitted by the form–generating functions is passed through a function called `escapeHTML()`:

`$escaped_string` = escapeHTML("unescaped string");

Escape HTML formatting characters in a string.

Provided that you have specified a character set of ISO–8859–1 (the default), the standard HTML escaping rules will be used. The "<" character becomes `"<"`, ">" becomes `">"`, "&" becomes `"&"`, and the quote character becomes `"""`. In addition, the hexadecimal 0x8b and 0x9b characters, which many windows–based browsers interpret as the left and right angle–bracket characters, are replaced by their numeric HTML entities (`"&#139"` and `"›"`). If you manually change the charset, either by calling the `charset()` method explicitly or by passing a –charset argument to `header()`, then **all** characters will be replaced by their numeric entities, since CGI.pm has no lookup table for all the possible encodings.

The automatic escaping does not apply to other shortcuts, such as `h1()`. You should call `escapeHTML()` yourself on untrusted data in order to protect your pages against nasty tricks that people may enter into guestbooks, etc.. To change the character set, use `charset()`. To turn autoescaping off completely, use `autoescape()`:

`$charset` = charset([`$charset`]);

Get or set the current character set.

`$flag` = autoEscape([`$flag`]);

Get or set the value of the autoescape flag.

PRETTY–PRINTING HTML

By default, all the HTML produced by these functions comes out as one long line without carriage returns or indentation. This is yuck, but it does reduce the size of the documents by 10–20%. To get pretty–printed output, please use *CGI::Pretty*, a subclass contributed by Brian Paulsen.

CREATING FILL–OUT FORMS:

General note The various form–creating methods all return strings to the caller, containing the tag or tags that will create the requested form element. You are responsible for actually printing out these strings. It's set up this way so that you can place formatting tags around the form elements.

Another note The default values that you specify for the forms are only used the **first** time the script is invoked (when there is no query string). On subsequent invocations of the script (when there is a query string), the former values are used even if they are blank.

If you want to change the value of a field from its previous value, you have two choices:

(1) call the `param()` method to set it.

(2) use the –override (alias –force) parameter (a new feature in version 2.15). This forces the default value to be used, regardless of the previous value:

```
print $query->textfield(-name=>'field_name',
                        -default=>'starting value',
                        -override=>1,
                        -size=>50,
                        -maxlength=>80);
```

Yet another note By default, the text and labels of form elements are escaped according to HTML rules. This means that you can safely use "<CLICK ME" as the label for a button. However, it also interferes with your ability to incorporate special HTML character sequences, such as `Á`, into your fields. If you wish to turn off automatic escaping, call the `autoEscape()` method with a false value immediately after creating the CGI object:

```
$query = new CGI;
$query->autoEscape(undef);
```

CREATING AN ISINDEX TAG

```
print $query->isindex(-action=>$action);

      -or-

print $query->isindex($action);
```

Prints out an <ISINDEX tag. Not very exciting. The parameter –action specifies the URL of the script to process the query. The default is to process the query with the current script.

STARTING AND ENDING A FORM

```
print $query->start_form(-method=>$method,
                         -action=>$action,
                         -enctype=>$encoding);
  <... various form stuff ...>
print $query->endform;

    -or-

print $query->start_form($method,$action,$encoding);
  <... various form stuff ...>
print $query->endform;
```

`start_form()` will return a <FORM tag with the optional method, action and form encoding that you specify. The defaults are:

```
method: POST
action: this script
enctype: application/x-www-form-urlencoded
```

endform() returns the closing </FORM tag.

Start_form()'s enctype argument tells the browser how to package the various fields of the form before sending the form to the server. Two values are possible:

Note: This method was previously named startform(), and startform() is still recognized as an alias.

application/x-www-form-urlencoded

This is the older type of encoding used by all browsers prior to Netscape 2.0. It is compatible with many CGI scripts and is suitable for short fields containing text data. For your convenience, CGI.pm stores the name of this encoding type in **&CGI::URL_ENCODED.**

multipart/form-data

This is the newer type of encoding introduced by Netscape 2.0. It is suitable for forms that contain very large fields or that are intended for transferring binary data. Most importantly, it enables the "file upload" feature of Netscape 2.0 forms. For your convenience, CGI.pm stores the name of this encoding type in **&CGI::MULTIPART**

Forms that use this type of encoding are not easily interpreted by CGI scripts unless they use CGI.pm or another library designed to handle them.

For compatibility, the start_form() method uses the older form of encoding by default. If you want to use the newer form of encoding by default, you can call **start_multipart_form()** instead of **start_form()**.

JAVASCRIPTING: The **-name** and **-onSubmit** parameters are provided for use with JavaScript. The -name parameter gives the form a name so that it can be identified and manipulated by JavaScript functions. -onSubmit should point to a JavaScript function that will be executed just before the form is submitted to your server. You can use this opportunity to check the contents of the form for consistency and completeness. If you find something wrong, you can put up an alert box or maybe fix things up yourself. You can abort the submission by returning false from this function.

Usually the bulk of JavaScript functions are defined in a <SCRIPT block in the HTML header and -onSubmit points to one of these function call. See start_html() for details.

CREATING A TEXT FIELD

```
print $query->textfield(-name=>'field_name',
                        -default=>'starting value',
                        -size=>50,
                        -maxlength=>80);
    -or-
print $query->textfield('field_name','starting value',50,80);
```

textfield() will return a text input field.

Parameters

1. The first parameter is the required name for the field (-name).
2. The optional second parameter is the default starting value for the field contents (-default).
3. The optional third parameter is the size of the field in characters (-size).
4. The optional fourth parameter is the maximum number of characters the field will accept (-maxlength).

As with all these methods, the field will be initialized with its previous contents from earlier invocations of the script. When the form is processed, the value of the text field can be retrieved with:

```
$value = $query->param('foo');
```

If you want to reset it from its initial value after the script has been called once, you can do so like this:

```
$query->param('foo',"I'm taking over this value!");
```

NEW AS OF VERSION 2.15: If you don't want the field to take on its previous value, you can force its current value by using the -override (alias -force) parameter:

```
print $query->textfield(-name=>'field_name',
                        -default=>'starting value',
                        -override=>1,
                        -size=>50,
                        -maxlength=>80);
```

JAVASCRIPTING: You can also provide **-onChange**, **-onFocus**, **-onBlur**, **-onMouseOver**, **-onMouseOut** and **-onSelect** parameters to register JavaScript event handlers. The onChange handler will be called whenever the user changes the contents of the text field. You can do text validation if you like. onFocus and onBlur are called respectively when the insertion point moves into and out of the text field. onSelect is called when the user changes the portion of the text that is selected.

CREATING A BIG TEXT FIELD

```
print $query->textarea(-name=>'foo',
                       -default=>'starting value',
                       -rows=>10,
                       -columns=>50);
```

-or

```
print $query->textarea('foo','starting value',10,50);
```

`textarea()` is just like textfield, but it allows you to specify rows and columns for a multiline text entry box. You can provide a starting value for the field, which can be long and contain multiple lines.

JAVASCRIPTING: The **-onChange**, **-onFocus**, **-onBlur** , **-onMouseOver**, **-onMouseOut**, and **-onSelect** parameters are recognized. See `textfield()`.

CREATING A PASSWORD FIELD

```
print $query->password_field(-name=>'secret',
                             -value=>'starting value',
                             -size=>50,
                             -maxlength=>80);
```

-or-

```
print $query->password_field('secret','starting value',50,80);
```

`password_field()` is identical to `textfield()`, except that its contents will be starred out on the web page.

JAVASCRIPTING: The **-onChange**, **-onFocus**, **-onBlur**, **-onMouseOver**, **-onMouseOut** and **-onSelect** parameters are recognized. See `textfield()`.

CREATING A FILE UPLOAD FIELD

```
print $query->filefield(-name=>'uploaded_file',
                        -default=>'starting value',
                        -size=>50,
                        -maxlength=>80);
```

-or-

```
print $query->filefield('uploaded_file','starting value',50,80);
```

`filefield()` will return a file upload field for Netscape 2.0 browsers. In order to take full advantage of this *you must use the new multipart encoding scheme* for the form. You can do this either by calling **`start_form()`** with an encoding type of **`&CGI::MULTIPART`**, or by calling the new method

start_multipart_form() instead of vanilla **start_form()**.

Parameters

1. The first parameter is the required name for the field (−name).
2. The optional second parameter is the starting value for the field contents to be used as the default file name (−default).

   For security reasons, browsers don't pay any attention to this field, and so the starting value will always be blank. Worse, the field loses its "sticky" behavior and forgets its previous contents. The starting value field is called for in the HTML specification, however, and possibly some browser will eventually provide support for it.
3. The optional third parameter is the size of the field in characters (−size).
4. The optional fourth parameter is the maximum number of characters the field will accept (−maxlength).

When the form is processed, you can retrieve the entered filename by calling `param()`:

```
$filename = $query->param('uploaded_file');
```

Different browsers will return slightly different things for the name. Some browsers return the filename only. Others return the full path to the file, using the path conventions of the user's machine. Regardless, the name returned is always the name of the file on the *user's* machine, and is unrelated to the name of the temporary file that CGI.pm creates during upload spooling (see below).

The filename returned is also a file handle. You can read the contents of the file using standard Perl file reading calls:

```
# Read a text file and print it out
while (<$filename>) {
   print;
}

# Copy a binary file to somewhere safe
open (OUTFILE,">>/usr/local/web/users/feedback");
while ($bytesread=read($filename,$buffer,1024)) {
   print OUTFILE $buffer;
}
```

However, there are problems with the dual nature of the upload fields. If you `use strict`, then Perl will complain when you try to use a string as a filehandle. You can get around this by placing the file reading code in a block containing the `no strict` pragma. More seriously, it is possible for the remote user to type garbage into the upload field, in which case what you get from `param()` is not a filehandle at all, but a string.

To be safe, use the *`upload()`* function (new in version 2.47). When called with the name of an upload field, *`upload()`* returns a filehandle, or undef if the parameter is not a valid filehandle.

```
$fh = $query->upload('uploaded_file');
while (<$fh>) {
      print;
}
```

This is the recommended idiom.

When a file is uploaded the browser usually sends along some information along with it in the format of headers. The information usually includes the MIME content type. Future browsers may send other information as well (such as modification date and size). To retrieve this information, call `uploadInfo()`. It returns a reference to an associative array containing all the document headers.

```
$filename = $query->param('uploaded_file');
$type = $query->uploadInfo($filename)->{'Content-Type'};
unless ($type eq 'text/html') {
   die "HTML FILES ONLY!";
}
```

If you are using a machine that recognizes "text" and "binary" data modes, be sure to understand when and how to use them (see the Camel book). Otherwise you may find that binary files are corrupted during file uploads.

There are occasionally problems involving parsing the uploaded file. This usually happens when the user presses "Stop" before the upload is finished. In this case, CGI.pm will return undef for the name of the uploaded file and set *cgi_error()* to the string "400 Bad request (malformed multipart POST)". This error message is designed so that you can incorporate it into a status code to be sent to the browser. Example:

```
$file = $query->upload('uploaded_file');
if (!$file && $query->cgi_error) {
   print $query->header(-status=>$query->cgi_error);
   exit 0;
}
```

You are free to create a custom HTML page to complain about the error, if you wish.

JAVASCRIPTING: The **–onChange**, **–onFocus**, **–onBlur**, **–onMouseOver**, **–onMouseOut** and **–onSelect** parameters are recognized. See `textfield()` for details.

CREATING A POPUP MENU

```
print $query->popup_menu('menu_name',
                         ['eenie','meenie','minie'],
                         'meenie');

   -or-

%labels = ('eenie'=>'your first choice',
           'meenie'=>'your second choice',
           'minie'=>'your third choice');
print $query->popup_menu('menu_name',
                         ['eenie','meenie','minie'],
                         'meenie',\%labels);

     -or (named parameter style)-

print $query->popup_menu(-name=>'menu_name',
                         -values=>['eenie','meenie','minie'],
                         -default=>'meenie',
                         -labels=>\%labels);
```

`popup_menu()` creates a menu.

1. The required first argument is the menu's name (–name).
2. The required second argument (–values) is an array **reference** containing the list of menu items in the menu. You can pass the method an anonymous array, as shown in the example, or a reference to a named array, such as "\@foo".
3. The optional third parameter (–default) is the name of the default menu choice. If not specified, the first item will be the default. The values of the previous choice will be maintained across queries.
4. The optional fourth parameter (–labels) is provided for people who want to use different values for the user–visible label inside the popup menu nd the value returned to your script. It's a pointer to an associative array relating menu values to user–visible labels. If you leave this parameter blank, the

menu values will be displayed by default. (You can also leave a label undefined if you want to).

When the form is processed, the selected value of the popup menu can be retrieved using:

```
$popup_menu_value = $query->param('menu_name');
```

JAVASCRIPTING: `popup_menu()` recognizes the following event handlers: **–onChange**, **–onFocus**, **–onMouseOver**, **–onMouseOut**, and **–onBlur**. See the `textfield()` section for details on when these handlers are called.

CREATING A SCROLLING LIST

```
print $query->scrolling_list('list_name',
                             ['eenie','meenie','minie','moe'],
                             ['eenie','moe'],5,'true');
   -or-
print $query->scrolling_list('list_name',
                             ['eenie','meenie','minie','moe'],
                             ['eenie','moe'],5,'true',
                             \%labels);

     -or-

print $query->scrolling_list(-name=>'list_name',
                             -values=>['eenie','meenie','minie','moe'],
                             -default=>['eenie','moe'],
                             -size=>5,
                             -multiple=>'true',
                             -labels=>\%labels);
```

`scrolling_list()` creates a scrolling list.

Parameters:

1. The first and second arguments are the list name (–name) and values (–values). As in the popup menu, the second argument should be an array reference.
2. The optional third argument (–default) can be either a reference to a list containing the values to be selected by default, or can be a single value to select. If this argument is missing or undefined, then nothing is selected when the list first appears. In the named parameter version, you can use the synonym "–defaults" for this parameter.
3. The optional fourth argument is the size of the list (–size).
4. The optional fifth argument can be set to true to allow multiple simultaneous selections (–multiple). Otherwise only one selection will be allowed at a time.
5. The optional sixth argument is a pointer to an associative array containing long user–visible labels for the list items (–labels). If not provided, the values will be displayed.

   When this form is processed, all selected list items will be returned as a list under the parameter name 'list_name'. The values of the selected items can be retrieved with:

   ```
   @selected = $query->param('list_name');
   ```

JAVASCRIPTING: `scrolling_list()` recognizes the following event handlers: **–onChange**, **–onFocus**, **–onMouseOver**, **–onMouseOut** and **–onBlur**. See `textfield()` for the description of when these handlers are called.

CREATING A GROUP OF RELATED CHECKBOXES

```
print $query->checkbox_group(-name=>'group_name',
                             -values=>['eenie','meenie','minie','moe'],
                             -default=>['eenie','moe'],
                             -linebreak=>'true',
```

```
                                -labels=>\%labels);

    print $query->checkbox_group('group_name',
                                ['eenie','meenie','minie','moe'],
                                ['eenie','moe'],'true',\%labels);

    HTML3-COMPATIBLE BROWSERS ONLY:

    print $query->checkbox_group(-name=>'group_name',
                                -values=>['eenie','meenie','minie','moe'],
                                -rows=2,-columns=>2);
```

`checkbox_group()` creates a list of checkboxes that are related by the same name.

Parameters:

1. The first and second arguments are the checkbox name and values, respectively (–name and –values). As in the popup menu, the second argument should be an array reference. These values are used for the user–readable labels printed next to the checkboxes as well as for the values passed to your script in the query string.

2. The optional third argument (–default) can be either a reference to a list containing the values to be checked by default, or can be a single value to checked. If this argument is missing or undefined, then nothing is selected when the list first appears.

3. The optional fourth argument (–linebreak) can be set to true to place line breaks between the checkboxes so that they appear as a vertical list. Otherwise, they will be strung together on a horizontal line.

4. The optional fifth argument is a pointer to an associative array relating the checkbox values to the user–visible labels that will be printed next to them (–labels). If not provided, the values will be used as the default.

5. **HTML3–compatible browsers** (such as Netscape) can take advantage of the optional parameters **–rows**, and **–columns**. These parameters cause `checkbox_group()` to return an HTML3 compatible table containing the checkbox group formatted with the specified number of rows and columns. You can provide just the –columns parameter if you wish; checkbox_group will calculate the correct number of rows for you.

   To include row and column headings in the returned table, you can use the **–rowheaders** and **–colheaders** parameters. Both of these accept a pointer to an array of headings to use. The headings are just decorative. They don‘t reorganize the interpretation of the checkboxes — they‘re still a single named unit.

When the form is processed, all checked boxes will be returned as a list under the parameter name ‘group_name’. The values of the "on" checkboxes can be retrieved with:

```
    @turned_on = $query->param('group_name');
```

The value returned by `checkbox_group()` is actually an array of button elements. You can capture them and use them within tables, lists, or in other creative ways:

```
    @h = $query->checkbox_group(-name=>'group_name',-values=>\@values);
    &use_in_creative_way(@h);
```

JAVASCRIPTING: `checkbox_group()` recognizes the **–onClick** parameter. This specifies a JavaScript code fragment or function call to be executed every time the user clicks on any of the buttons in the group. You can retrieve the identity of the particular button clicked on using the "this" variable.

CREATING A STANDALONE CHECKBOX

```
    print $query->checkbox(-name=>'checkbox_name',
                           -checked=>'checked',
                           -value=>'ON',
```

```
                                -label=>'CLICK ME');

        -or-

    print $query->checkbox('checkbox_name','checked','ON','CLICK ME');
```

`checkbox()` is used to create an isolated checkbox that isn't logically related to any others.

Parameters:

1. The first parameter is the required name for the checkbox (–name). It will also be used for the user–readable label printed next to the checkbox.
2. The optional second parameter (–checked) specifies that the checkbox is turned on by default. Synonyms are –selected and –on.
3. The optional third parameter (–value) specifies the value of the checkbox when it is checked. If not provided, the word "on" is assumed.
4. The optional fourth parameter (–label) is the user–readable label to be attached to the checkbox. If not provided, the checkbox name is used.

The value of the checkbox can be retrieved using:

```
    $turned_on = $query->param('checkbox_name');
```

JAVASCRIPTING: `checkbox()` recognizes the **–onClick** parameter. See `checkbox_group()` for further details.

CREATING A RADIO BUTTON GROUP

```
    print $query->radio_group(-name=>'group_name',
                              -values=>['eenie','meenie','minie'],
                              -default=>'meenie',
                              -linebreak=>'true',
                              -labels=>\%labels);

        -or-

    print $query->radio_group('group_name',['eenie','meenie','minie'],
                                           'meenie','true',\%labels);

    HTML3-COMPATIBLE BROWSERS ONLY:

    print $query->radio_group(-name=>'group_name',
                              -values=>['eenie','meenie','minie','moe'],
                              -rows=2,-columns=>2);
```

`radio_group()` creates a set of logically–related radio buttons (turning one member of the group on turns the others off)

Parameters:

1. The first argument is the name of the group and is required (–name).
2. The second argument (–values) is the list of values for the radio buttons. The values and the labels that appear on the page are identical. Pass an array *reference* in the second argument, either using an anonymous array, as shown, or by referencing a named array as in "\@foo".
3. The optional third parameter (–default) is the name of the default button to turn on. If not specified, the first item will be the default. You can provide a nonexistent button name, such as "–" to start up with no buttons selected.
4. The optional fourth parameter (–linebreak) can be set to 'true' to put line breaks between the buttons, creating a vertical list.

5. The optional fifth parameter (–labels) is a pointer to an associative array relating the radio button values to user–visible labels to be used in the display. If not provided, the values themselves are displayed.

6. **HTML3–compatible browsers** (such as Netscape) can take advantage of the optional parameters **–rows**, and **–columns**. These parameters cause `radio_group()` to return an HTML3 compatible table containing the radio group formatted with the specified number of rows and columns. You can provide just the –columns parameter if you wish; radio_group will calculate the correct number of rows for you.

   To include row and column headings in the returned table, you can use the **–rowheader** and **–colheader** parameters. Both of these accept a pointer to an array of headings to use. The headings are just decorative. They don't reorganize the interpretation of the radio buttons — they're still a single named unit.

When the form is processed, the selected radio button can be retrieved using:

```
$which_radio_button = $query->param('group_name');
```

The value returned by `radio_group()` is actually an array of button elements. You can capture them and use them within tables, lists, or in other creative ways:

```
@h = $query->radio_group(-name=>'group_name',-values=>\@values);
&use_in_creative_way(@h);
```

CREATING A SUBMIT BUTTON

```
print $query->submit(-name=>'button_name',
                     -value=>'value');

    -or-

print $query->submit('button_name','value');
```

`submit()` will create the query submission button. Every form should have one of these.

Parameters:

1. The first argument (–name) is optional. You can give the button a name if you have several submission buttons in your form and you want to distinguish between them. The name will also be used as the user–visible label. Be aware that a few older browsers don't deal with this correctly and **never** send back a value from a button.

2. The second argument (–value) is also optional. This gives the button a value that will be passed to your script in the query string.

You can figure out which button was pressed by using different values for each one:

```
$which_one = $query->param('button_name');
```

JAVASCRIPTING: `radio_group()` recognizes the **–onClick** parameter. See `checkbox_group()` for further details.

CREATING A RESET BUTTON

```
print $query->reset
```

`reset()` creates the "reset" button. Note that it restores the form to its value from the last time the script was called, NOT necessarily to the defaults.

Note that this conflicts with the Perl `reset()` built–in. Use `CORE::reset()` to get the original reset function.

CREATING A DEFAULT BUTTON

```
print $query->defaults('button_label')
```

`defaults()` creates a button that, when invoked, will cause the form to be completely reset to its defaults, wiping out all the changes the user ever made.

CREATING A HIDDEN FIELD

```
print $query->hidden(-name=>'hidden_name',
                     -default=>['value1','value2'...]);

        -or-

print $query->hidden('hidden_name','value1','value2'...);
```

`hidden()` produces a text field that can't be seen by the user. It is useful for passing state variable information from one invocation of the script to the next.

Parameters:

1. The first argument is required and specifies the name of this field (-name).
2. The second argument is also required and specifies its value (-default). In the named parameter style of calling, you can provide a single value here or a reference to a whole list

Fetch the value of a hidden field this way:

```
$hidden_value = $query->param('hidden_name');
```

Note, that just like all the other form elements, the value of a hidden field is "sticky". If you want to replace a hidden field with some other values after the script has been called once you'll have to do it manually:

```
$query->param('hidden_name','new','values','here');
```

CREATING A CLICKABLE IMAGE BUTTON

```
print $query->image_button(-name=>'button_name',
                           -src=>'/source/URL',
                           -align=>'MIDDLE');

   -or-

print $query->image_button('button_name','/source/URL','MIDDLE');
```

`image_button()` produces a clickable image. When it's clicked on the position of the click is returned to your script as "button_name.x" and "button_name.y", where "button_name" is the name you've assigned to it.

JAVASCRIPTING: `image_button()` recognizes the **-onClick** parameter. See `checkbox_group()` for further details.

Parameters:

1. The first argument (-name) is required and specifies the name of this field.
2. The second argument (-src) is also required and specifies the URL
3. The third option (-align, optional) is an alignment type, and may be TOP, BOTTOM or MIDDLE

Fetch the value of the button this way:
$x = $query-param('button_name.x');
$y = $query-param('button_name.y');

CREATING A JAVASCRIPT ACTION BUTTON

```
print $query->button(-name=>'button_name',
                     -value=>'user visible label',
                     -onClick=>"do_something()");

   -or-

print $query->button('button_name',"do_something()");
```

`button()` produces a button that is compatible with Netscape 2.0's JavaScript. When it's pressed the fragment of JavaScript code pointed to by the **–onClick** parameter will be executed. On non–Netscape browsers this form element will probably not even display.

HTTP COOKIES

Netscape browsers versions 1.1 and higher, and all versions of Internet Explorer, support a so–called "cookie" designed to help maintain state within a browser session. CGI.pm has several methods that support cookies.

A cookie is a name=value pair much like the named parameters in a CGI query string. CGI scripts create one or more cookies and send them to the browser in the HTTP header. The browser maintains a list of cookies that belong to a particular Web server, and returns them to the CGI script during subsequent interactions.

In addition to the required name=value pair, each cookie has several optional attributes:

1. an expiration time

   This is a time/date string (in a special GMT format) that indicates when a cookie expires. The cookie will be saved and returned to your script until this expiration date is reached if the user exits the browser and restarts it. If an expiration date isn't specified, the cookie will remain active until the user quits the browser.

2. a domain

   This is a partial or complete domain name for which the cookie is valid. The browser will return the cookie to any host that matches the partial domain name. For example, if you specify a domain name of ".capricorn.com", then the browser will return the cookie to Web servers running on any of the machines "www.capricorn.com", "www2.capricorn.com", "feckless.capricorn.com", etc. Domain names must contain at least two periods to prevent attempts to match on top level domains like ".edu". If no domain is specified, then the browser will only return the cookie to servers on the host the cookie originated from.

3. a path

   If you provide a cookie path attribute, the browser will check it against your script's URL before returning the cookie. For example, if you specify the path "/cgi–bin", then the cookie will be returned to each of the scripts "/cgi–bin/tally.pl", "/cgi–bin/order.pl", and "/cgi–bin/customer_service/complain.pl", but not to the script "/cgi–private/site_admin.pl". By default, path is set to "/", which causes the cookie to be sent to any CGI script on your site.

4. a "secure" flag

   If the "secure" attribute is set, the cookie will only be sent to your script if the CGI request is occurring on a secure channel, such as SSL.

The interface to HTTP cookies is the **`cookie()`** method:

```
$cookie = $query->cookie(-name=>'sessionID',
                         -value=>'xyzzy',
                         -expires=>'+1h',
                         -path=>'/cgi-bin/database',
                         -domain=>'.capricorn.org',
                         -secure=>1);
print $query->header(-cookie=>$cookie);
```

`cookie()` creates a new cookie. Its parameters include:

–name

The name of the cookie (required). This can be any string at all. Although browsers limit their cookie names to non–whitespace alphanumeric characters, CGI.pm removes this restriction by escaping and unescaping cookies behind the scenes.

–value

The value of the cookie. This can be any scalar value, array reference, or even associative array reference. For example, you can store an entire associative array into a cookie this way:

```
$cookie=$query->cookie(-name=>'family information',
                       -value=>\%childrens_ages);
```

–path

The optional partial path for which this cookie will be valid, as described above.

–domain

The optional partial domain for which this cookie will be valid, as described above.

–expires

The optional expiration date for this cookie. The format is as described in the section on the **header()** method:

```
"+1h"  one hour from now
```

–secure

If set to true, this cookie will only be used within a secure SSL session.

The cookie created by `cookie()` must be incorporated into the HTTP header within the string returned by the `header()` method:

```
print $query->header(-cookie=>$my_cookie);
```

To create multiple cookies, give `header()` an array reference:

```
$cookie1 = $query->cookie(-name=>'riddle_name',
                          -value=>"The Sphynx's Question");
$cookie2 = $query->cookie(-name=>'answers',
                          -value=>\%answers);
print $query->header(-cookie=>[$cookie1,$cookie2]);
```

To retrieve a cookie, request it by name by calling `cookie()` method without the **–value** parameter:

```
use CGI;
$query = new CGI;
$riddle = $query->cookie('riddle_name');
%answers = $query->cookie('answers');
```

Cookies created with a single scalar value, such as the "riddle_name" cookie, will be returned in that form. Cookies with array and hash values can also be retrieved.

The cookie and CGI namespaces are separate. If you have a parameter named 'answers' and a cookie named 'answers', the values retrieved by `param()` and `cookie()` are independent of each other. However, it's simple to turn a CGI parameter into a cookie, and vice–versa:

```
# turn a CGI parameter into a cookie
$c=$q->cookie(-name=>'answers',-value=>[$q->param('answers')]);
# vice-versa
$q->param(-name=>'answers',-value=>[$q->cookie('answers')]);
```

See the **cookie.cgi** example script for some ideas on how to use cookies effectively.

WORKING WITH FRAMES

It's possible for CGI.pm scripts to write into several browser panels and windows using the HTML 4 frame mechanism. There are three techniques for defining new frames programmatically:

1. Create a <Frameset **document**

   After writing out the HTTP header, instead of creating a standard HTML document using the `start_html()` call, create a <FRAMESET document that defines the frames on the page. Specify your script(s) (with appropriate parameters) as the SRC for each of the frames.

   There is no specific support for creating <FRAMESET sections in CGI.pm, but the HTML is very simple to write. See the frame documentation in Netscape's home pages for details

   ```
   http://home.netscape.com/assist/net_sites/frames.html
   ```

2. Specify the destination for the document in the HTTP header

   You may provide a **–target** parameter to the `header()` method:

   ```
   print $q->header(-target=>'ResultsWindow');
   ```

   This will tell the browser to load the output of your script into the frame named "ResultsWindow". If a frame of that name doesn't already exist, the browser will pop up a new window and load your script's document into that. There are a number of magic names that you can use for targets. See the frame documents on Netscape's home pages for details.

3. Specify the destination for the document in the <FORM tag

   You can specify the frame to load in the FORM tag itself. With CGI.pm it looks like this:

   ```
   print $q->start_form(-target=>'ResultsWindow');
   ```

   When your script is reinvoked by the form, its output will be loaded into the frame named "ResultsWindow". If one doesn't already exist a new window will be created.

The script "frameset.cgi" in the examples directory shows one way to create pages in which the fill–out form and the response live in side–by–side frames.

LIMITED SUPPORT FOR CASCADING STYLE SHEETS

CGI.pm has limited support for HTML3's cascading style sheets (css). To incorporate a stylesheet into your document, pass the `start_html()` method a **–style** parameter. The value of this parameter may be a scalar, in which case it is incorporated directly into a <STYLE section, or it may be a hash reference. In the latter case you should provide the hash with one or more of **–src** or **–code**. **–src** points to a URL where an externally–defined stylesheet can be found. **–code** points to a scalar value to be incorporated into a <STYLE section. Style definitions in **–code** override similarly–named ones in **–src**, hence the name "cascading."

You may also specify the type of the stylesheet by adding the optional **–type** parameter to the hash pointed to by **–style**. If not specified, the style defaults to 'text/css'.

To refer to a style within the body of your document, add the **–class** parameter to any HTML element:

```
print h1({-class=>'Fancy'},'Welcome to the Party');
```

Or define styles on the fly with the **–style** parameter:

```
print h1({-style=>'Color: red;'},'Welcome to Hell');
```

You may also use the new **`span()`** element to apply a style to a section of text:

```
print span({-style=>'Color: red;'},
           h1('Welcome to Hell'),
           "Where did that handbasket get to?"
           );
```

Note that you must import the ":html3" definitions to have the **`span()`** method available. Here's a quick and dirty example of using CSS's. See the CSS specification at http://www.w3.org/pub/WWW/TR/Wd–css–1.html for more information.

```
use CGI qw/:standard :html3/;

#here's a stylesheet incorporated directly into the page
$newStyle=<<END;
<!--
P.Tip {
    margin-right: 50pt;
    margin-left: 50pt;
    color: red;
}
P.Alert {
    font-size: 30pt;
    font-family: sans-serif;
  color: red;
}
-->
END
print header();
print start_html( -title=>'CGI with Style',
                  -style=>{-src=>'http://www.capricorn.com/style/st1.css',
                           -code=>$newStyle}
                );
print h1('CGI with Style'),
      p({-class=>'Tip'},
        "Better read the cascading style sheet spec before playing with this!"),
      span({-style=>'color: magenta'},
           "Look Mom, no hands!",
           p(),
           "Whooo wee!"
           );
print end_html;
```

Pass an array reference to **–style** in order to incorporate multiple stylesheets into your document.

DEBUGGING

If you are running the script from the command line or in the perl debugger, you can pass the script a list of keywords or parameter=value pairs on the command line or from standard input (you don't have to worry about tricking your script into reading from environment variables). You can pass keywords like this:

```
your_script.pl keyword1 keyword2 keyword3
```

or this:

```
your_script.pl keyword1+keyword2+keyword3
```

or this:

```
your_script.pl name1=value1 name2=value2
```

or this:

```
your_script.pl name1=value1&name2=value2
```

To turn off this feature, use the –no_debug pragma.

To test the POST method, you may enable full debugging with the –debug pragma. This will allow you to feed newline–delimited name=value pairs to the script on standard input.

When debugging, you can use quotes and backslashes to escape characters in the familiar shell manner, letting you place spaces and other funny characters in your parameter=value pairs:

```
your_script.pl "name1='I am a long value'" "name2=two\ words"
```

DUMPING OUT ALL THE NAME/VALUE PAIRS

The `Dump()` method produces a string consisting of all the query's name/value pairs formatted nicely as a nested list. This is useful for debugging purposes:

```
print $query->Dump
```

Produces something that looks like:

```
<UL>
<LI>name1
    <UL>
    <LI>value1
    <LI>value2
    </UL>
<LI>name2
    <UL>
    <LI>value1
    </UL>
</UL>
```

As a shortcut, you can interpolate the entire CGI object into a string and it will be replaced with the a nice HTML dump shown above:

```
$query=new CGI;
print "<H2>Current Values</H2> $query\n";
```

FETCHING ENVIRONMENT VARIABLES

Some of the more useful environment variables can be fetched through this interface. The methods are as follows:

`Accept()`

Return a list of MIME types that the remote browser accepts. If you give this method a single argument corresponding to a MIME type, as in `$query->Accept('text/html')`, it will return a floating point value corresponding to the browser's preference for this type from 0.0 (don't want) to 1.0. Glob types (e.g. text/*) in the browser's accept list are handled correctly.

Note that the capitalization changed between version 2.43 and 2.44 in order to avoid conflict with Perl's `accept()` function.

`raw_cookie()`

Returns the HTTP_COOKIE variable, an HTTP extension implemented by Netscape browsers version 1.1 and higher, and all versions of Internet Explorer. Cookies have a special format, and this method call just returns the raw form (?cookie dough). See `cookie()` for ways of setting and retrieving cooked cookies.

Called with no parameters, `raw_cookie()` returns the packed cookie structure. You can separate it into individual cookies by splitting on the character sequence "; ". Called with the name of a cookie, retrieves the **unescaped** form of the cookie. You can use the regular `cookie()` method to get the names, or use the `raw_fetch()` method from the CGI::Cookie module.

`user_agent()`

Returns the HTTP_USER_AGENT variable. If you give this method a single argument, it will attempt to pattern match on it, allowing you to do something like `$query->user_agent(netscape);`

`path_info()`

Returns additional path information from the script URL. E.G. fetching /cgi-bin/your_script/additional/stuff will result in `$query->path_info()` returning "/additional/stuff".

NOTE: The Microsoft Internet Information Server is broken with respect to additional path information. If you use the Perl DLL library, the IIS server will attempt to execute the additional path information as a Perl script. If you use the ordinary file associations mapping, the path information will be present in the environment, but incorrect. The best thing to do is to avoid using additional path information in CGI scripts destined for use with IIS.

path_translated()

As per `path_info()` but returns the additional path information translated into a physical path, e.g. "/usr/local/etc/httpd/htdocs/additional/stuff".

The Microsoft IIS is broken with respect to the translated path as well.

remote_host()

Returns either the remote host name or IP address. if the former is unavailable.

script_name()

Return the script name as a partial URL, for self−refering scripts.

referer()

Return the URL of the page the browser was viewing prior to fetching your script. Not available for all browsers.

auth_type ()

Return the authorization/verification method in use for this script, if any.

server_name ()

Returns the name of the server, usually the machine‘s host name.

virtual_host ()

When using virtual hosts, returns the name of the host that the browser attempted to contact

server_port ()

Return the port that the server is listening on.

server_software ()

Returns the server software and version number.

remote_user ()

Return the authorization/verification name used for user verification, if this script is protected.

user_name ()

Attempt to obtain the remote user‘s name, using a variety of different techniques. This only works with older browsers such as Mosaic. Newer browsers do not report the user name for privacy reasons!

request_method()

Returns the method used to access your script, usually one of ‘POST‘, ‘GET’ or ‘HEAD’.

content_type()

Returns the content_type of data submitted in a POST, generally multipart/form−data or application/x−www−form−urlencoded

http()

Called with no arguments returns the list of HTTP environment variables, including such things as HTTP_USER_AGENT, HTTP_ACCEPT_LANGUAGE, and HTTP_ACCEPT_CHARSET, corresponding to the like−named HTTP header fields in the request. Called with the name of an HTTP header field, returns its value. Capitalization and the use of hyphens versus underscores are not significant.

For example, all three of these examples are equivalent:

```
$requested_language = $q->http('Accept-language');
$requested_language = $q->http('Accept_language');
$requested_language = $q->http('HTTP_ACCEPT_LANGUAGE');
```

https()

The same as *http()*, but operates on the HTTPS environment variables present when the SSL protocol is in effect. Can be used to determine whether SSL is turned on.

USING NPH SCRIPTS

NPH, or "no−parsed−header", scripts bypass the server completely by sending the complete HTTP header directly to the browser. This has slight performance benefits, but is of most use for taking advantage of HTTP extensions that are not directly supported by your server, such as server push and PICS headers.

Servers use a variety of conventions for designating CGI scripts as NPH. Many Unix servers look at the beginning of the script's name for the prefix "nph−". The Macintosh WebSTAR server and Microsoft's Internet Information Server, in contrast, try to decide whether a program is an NPH script by examining the first line of script output.

CGI.pm supports NPH scripts with a special NPH mode. When in this mode, CGI.pm will output the necessary extra header information when the `header()` and `redirect()` methods are called.

The Microsoft Internet Information Server requires NPH mode. As of version 2.30, CGI.pm will automatically detect when the script is running under IIS and put itself into this mode. You do not need to do this manually, although it won't hurt anything if you do.

There are a number of ways to put CGI.pm into NPH mode:

In the **use** statement

Simply add the "−nph" pragmato the list of symbols to be imported into your script:

```
use CGI qw(:standard -nph)
```

By calling the **nph()** method:

Call **nph()** with a non−zero parameter at any point after using CGI.pm in your program.

```
CGI->nph(1)
```

By using **−nph** parameters in the **header()** and **redirect()** statements:

```
print $q->header(-nph=>1);
```

Server Push

CGI.pm provides three simple functions for producing multipart documents of the type needed to implement server push. These functions were graciously provided by Ed Jordan <ed@fidalgo.net. To import these into your namespace, you must import the ":push" set. You are also advised to put the script into NPH mode and to set `$|` to 1 to avoid buffering problems.

Here is a simple script that demonstrates server push:

```
#!/usr/local/bin/perl
use CGI qw/:push -nph/;
$| = 1;
print multipart_init(-boundary=>'----------------here we go!');
while (1) {
    print multipart_start(-type=>'text/plain'),
          "The current time is ",scalar(localtime),"\n",
          multipart_end;
    sleep 1;
}
```

This script initializes server push by calling **multipart_init()**. It then enters an infinite loop in which it begins a new multipart section by calling **multipart_start()**, prints the current local time, and ends

a multipart section with **multipart_end()**. It then sleeps a second, and begins again.

multipart_init()

```
multipart_init(-boundary=>$boundary);
```

Initialize the multipart system. The -boundary argument specifies what MIME boundary string to use to separate parts of the document. If not provided, CGI.pm chooses a reasonable boundary for you.

multipart_start()

```
multipart_start(-type=>$type)
```

Start a new part of the multipart document using the specified MIME type. If not specified, text/html is assumed.

multipart_end()

```
multipart_end()
```

End a part. You must remember to call multipart_end() once for each multipart_start().

Users interested in server push applications should also have a look at the CGI::Push module.

Avoiding Denial of Service Attacks

A potential problem with CGI.pm is that, by default, it attempts to process form POSTings no matter how large they are. A wily hacker could attack your site by sending a CGI script a huge POST of many megabytes. CGI.pm will attempt to read the entire POST into a variable, growing hugely in size until it runs out of memory. While the script attempts to allocate the memory the system may slow down dramatically. This is a form of denial of service attack.

Another possible attack is for the remote user to force CGI.pm to accept a huge file upload. CGI.pm will accept the upload and store it in a temporary directory even if your script doesn't expect to receive an uploaded file. CGI.pm will delete the file automatically when it terminates, but in the meantime the remote user may have filled up the server's disk space, causing problems for other programs.

The best way to avoid denial of service attacks is to limit the amount of memory, CPU time and disk space that CGI scripts can use. Some Web servers come with built-in facilities to accomplish this. In other cases, you can use the shell *limit* or *ulimit* commands to put ceilings on CGI resource usage.

CGI.pm also has some simple built-in protections against denial of service attacks, but you must activate them before you can use them. These take the form of two global variables in the CGI name space:

$CGI::POST_MAX

If set to a non-negative integer, this variable puts a ceiling on the size of POSTings, in bytes. If CGI.pm detects a POST that is greater than the ceiling, it will immediately exit with an error message. This value will affect both ordinary POSTs and multipart POSTs, meaning that it limits the maximum size of file uploads as well. You should set this to a reasonably high value, such as 1 megabyte.

$CGI::DISABLE_UPLOADS

If set to a non-zero value, this will disable file uploads completely. Other fill-out form values will work as usual.

You can use these variables in either of two ways.

1. On a script-by-script basis

Set the variable at the top of the script, right after the "use" statement:

```
use CGI qw/:standard/;
use CGI::Carp 'fatalsToBrowser';
$CGI::POST_MAX=1024 * 100;  # max 100K posts
$CGI::DISABLE_UPLOADS = 1;  # no uploads
```

2. Globally for all scripts

Open up CGI.pm, find the definitions for `$POST_MAX` and `$DISABLE_UPLOADS`, and set them to the desired values. You'll find them towards the top of the file in a subroutine named `initialize_globals()`.

An attempt to send a POST larger than `$POST_MAX` bytes will cause *`param()`* to return an empty CGI parameter list. You can test for this event by checking *`cgi_error()`*, either after you create the CGI object or, if you are using the function−oriented interface, call `<param()` for the first time. If the POST was intercepted, then `cgi_error()` will return the message "413 POST too large".

This error message is actually defined by the HTTP protocol, and is designed to be returned to the browser as the CGI script's status
code. For example:

```
$uploaded_file = param('upload');
if (!$uploaded_file && cgi_error()) {
   print header(-status=>cgi_error());
   exit 0;
}
```

However it isn't clear that any browser currently knows what to do with this status code. It might be better just to create an HTML page that warns the user of the problem.

COMPATIBILITY WITH CGI−LIB.PL

To make it easier to port existing programs that use cgi−lib.pl the compatibility routine "ReadParse" is provided. Porting is simple:

OLD VERSION
```
require "cgi−lib.pl";
&ReadParse;
print "The value of the antique is $in{antique}.\n";
```

NEW VERSION
```
use CGI;
CGI::ReadParse
print "The value of the antique is $in{antique}.\n";
```

CGI.pm's `ReadParse()` routine creates a tied variable named %in, which can be accessed to obtain the query variables. Like ReadParse, you can also provide your own variable. Infrequently used features of ReadParse, such as the creation of @in and `$in` variables, are not supported.

Once you use ReadParse, you can retrieve the query object itself this way:

```
$q = $in{CGI};
print $q->textfield(-name=>'wow',
                    -value=>'does this really work?');
```

This allows you to start using the more interesting features of CGI.pm without rewriting your old scripts from scratch.

AUTHOR INFORMATION

Address bug reports and comments to: lstein@cshl.org. When sending bug reports, please provide the version of CGI.pm, the version of Perl, the name and version of your Web server, and the name and version of the operating system you are using. If the problem is even remotely browser dependent, please provide information about the affected browers as well.

CREDITS

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for suggestions and bug fixes.

A COMPLETE EXAMPLE OF A SIMPLE FORM–BASED SCRIPT

```
#!/usr/local/bin/perl

use CGI;

$query = new CGI;

print $query->header;
print $query->start_html("Example CGI.pm Form");
print "<H1> Example CGI.pm Form</H1>\n";
&print_prompt($query);
&do_work($query);
&print_tail;
print $query->end_html;

sub print_prompt {
   my($query) = @_;

   print $query->start_form;
   print "<EM>What's your name?</EM><BR>";
   print $query->textfield('name');
   print $query->checkbox('Not my real name');

   print "<P><EM>Where can you find English Sparrows?</EM><BR>";
   print $query->checkbox_group(
                          -name=>'Sparrow locations',
                          -values=>[England,France,Spain,Asia,Hoboken],
                          -linebreak=>'yes',
                          -defaults=>[England,Asia]);

   print "<P><EM>How far can they fly?</EM><BR>",
        $query->radio_group(
```

```
                    -name=>'how far',
                    -values=>['10 ft','1 mile','10 miles','real far'],
                    -default=>'1 mile');

   print "<P><EM>What's your favorite color?</EM>  ";
   print $query->popup_menu(-name=>'Color',
                            -values=>['black','brown','red','yellow'],
                            -default=>'red');

   print $query->hidden('Reference','Monty Python and the Holy Grail');

   print "<P><EM>What have you got there?</EM><BR>";
   print $query->scrolling_list(
                 -name=>'possessions',
                 -values=>['A Coconut','A Grail','An Icon',
                           'A Sword','A Ticket'],
                 -size=>5,
                 -multiple=>'true');

   print "<P><EM>Any parting comments?</EM><BR>";
   print $query->textarea(-name=>'Comments',
                          -rows=>10,
                          -columns=>50);

   print "<P>",$query->reset;
   print $query->submit('Action','Shout');
   print $query->submit('Action','Scream');
   print $query->endform;
   print "<HR>\n";
}

sub do_work {
   my($query) = @_;
   my(@values,$key);

   print "<H2>Here are the current settings in this form</H2>";

   foreach $key ($query->param) {
      print "<STRONG>$key</STRONG> -> ";
      @values = $query->param($key);
      print join(", ",@values),"<BR>\n";
  }
}

sub print_tail {
   print <<END;
<HR>
<ADDRESS>Lincoln D. Stein</ADDRESS><BR>
<A HREF="/">Home Page</A>
END
}
```

BUGS

This module has grown large and monolithic. Furthermore it's doing many things, such as handling URLs, parsing CGI input, writing HTML, etc., that are also done in the LWP modules. It should be discarded in favor of the CGI::* modules, but somehow I continue to work on it.

Note that the code is truly contorted in order to avoid spurious warnings when programs are run with the **-w** switch.

SEE ALSO

CGI::Carp, *URI::URL*, *CGI::Request*, *CGI::MiniSvr*, *CGI::Base*, *CGI::Form*, *CGI::Push*, *CGI::Fast*, *CGI::Pretty*

NAME

charnames – define character names for \N{named} string literal escape.

SYNOPSIS

```
use charnames ':full';
print "\N{GREEK SMALL LETTER SIGMA} is called sigma.\n";

use charnames ':short';
print "\N{greek:Sigma} is an upper-case sigma.\n";

use charnames qw(cyrillic greek);
print "\N{sigma} is Greek sigma, and \N{be} is Cyrillic b.\n";
```

DESCRIPTION

Pragma `use charnames` supports arguments `:full`, `:short` and script names. If `:full` is present, for expansion of \N{CHARNAME}} string CHARNAME is first looked in the list of standard Unicode names of chars. If `:short` is present, and CHARNAME has the form SCRIPT:CNAME, then CNAME is looked up as a letter in script SCRIPT. If pragma `use charnames` is used with script name arguments, then for \N{CHARNAME}} the name CHARNAME is looked up as a letter in the given scripts (in the specified order).

For lookup of CHARNAME inside a given script SCRIPTNAME this pragma looks for the names

```
SCRIPTNAME CAPITAL LETTER CHARNAME
SCRIPTNAME SMALL LETTER CHARNAME
SCRIPTNAME LETTER CHARNAME
```

in the table of standard Unicode names. If CHARNAME is lowercase, then the CAPITAL variant is ignored, otherwise the SMALL variant is ignored.

CUSTOM TRANSLATORS

The mechanism of translation of \N{...} escapes is general and not hardwired into ***charnames.pm***. A module can install custom translations (inside the scope which uses the module) with the following magic incantation:

```
use charnames ();           # for $charnames::hint_bits
sub import {
    shift;
    $^H |= $charnames::hint_bits;
    $^H{charnames} = \&translator;
}
```

Here `translator()` is a subroutine which takes CHARNAME as an argument, and returns text to insert into the string instead of the \N{CHARNAME} escape. Since the text to insert should be different in `bytes` mode and out of it, the function should check the current state of `bytes`-flag as in:

```
use bytes ();                       # for $bytes::hint_bits
sub translator {
    if ($^H & $bytes::hint_bits) {
        return bytes_translator(@_);
    }
    else {
        return utf8_translator(@_);
    }
}
```

BUGS

Since evaluation of the translation function happens in a middle of compilation (of a string literal), the translation function should not do any `evals` or `requires`. This restriction should be lifted in a future version of Perl.

NAME

Class::Struct – declare struct–like datatypes as Perl classes

SYNOPSIS

```
use Class::Struct;
        # declare struct, based on array:
struct( CLASS_NAME => [ ELEMENT_NAME => ELEMENT_TYPE, ... ]);
        # declare struct, based on hash:
struct( CLASS_NAME => { ELEMENT_NAME => ELEMENT_TYPE, ... });

package CLASS_NAME;
use Class::Struct;
        # declare struct, based on array, implicit class name:
struct( ELEMENT_NAME => ELEMENT_TYPE, ... );

# Declare struct at compile time
use Class::Struct CLASS_NAME => [ ELEMENT_NAME => ELEMENT_TYPE, ... ];
use Class::Struct CLASS_NAME => { ELEMENT_NAME => ELEMENT_TYPE, ... };

package Myobj;
use Class::Struct;
        # declare struct with four types of elements:
struct( s => '$', a => '@', h => '%', c => 'My_Other_Class' );

$obj = new Myobj;               # constructor

                                # scalar type accessor:
$element_value = $obj->s;           # element value
$obj->s('new value');               # assign to element

                                # array type accessor:
$ary_ref = $obj->a;                 # reference to whole array
$ary_element_value = $obj->a(2);    # array element value
$obj->a(2, 'new value');            # assign to array element

                                # hash type accessor:
$hash_ref = $obj->h;                # reference to whole hash
$hash_element_value = $obj->h('x'); # hash element value
$obj->h('x', 'new value');        # assign to hash element

                                # class type accessor:
$element_value = $obj->c;           # object reference
$obj->c->method(...);               # call method of object
$obj->c(new My_Other_Class);        # assign a new object
```

DESCRIPTION

`Class::Struct` exports a single function, `struct`. Given a list of element names and types, and optionally a class name, `struct` creates a Perl 5 class that implements a "struct–like" data structure.

The new class is given a constructor method, `new`, for creating struct objects.

Each element in the struct data has an accessor method, which is used to assign to the element and to fetch its value. The default accessor can be overridden by declaring a `sub` of the same name in the package. (See Example 2.)

Each element's type can be scalar, array, hash, or class.

The `struct()` function

The `struct` function has three forms of parameter–list.

```
struct( CLASS_NAME => [ ELEMENT_LIST ]);
struct( CLASS_NAME => { ELEMENT_LIST });
struct( ELEMENT_LIST );
```

The first and second forms explicitly identify the name of the class being created. The third form assumes the current package name as the class name.

An object of a class created by the first and third forms is based on an array, whereas an object of a class created by the second form is based on a hash. The array–based forms will be somewhat faster and smaller; the hash–based forms are more flexible.

The class created by `struct` must not be a subclass of another class other than `UNIVERSAL`.

It can, however, be used as a superclass for other classes. To facilitate this, the generated constructor method uses a two–argument blessing. Furthermore, if the class is hash–based, the key of each element is prefixed with the class name (see *Perl Cookbook*, Recipe 13.12).

A function named `new` must not be explicitly defined in a class created by `struct`.

The *ELEMENT_LIST* has the form

```
NAME => TYPE, ...
```

Each name–type pair declares one element of the struct. Each element name will be defined as an accessor method unless a method by that name is explicitly defined; in the latter case, a warning is issued if the warning flag (**–w**) is set.

Class Creation at Compile Time

`Class::Struct` can create your class at compile time. The main reason for doing this is obvious, so your class acts like every other class in Perl. Creating your class at compile time will make the order of events similar to using any other class (or Perl module).

There is no significant speed gain between compile time and run time class creation, there is just a new, more standard order of events.

Element Types and Accessor Methods

The four element types — scalar, array, hash, and class — are represented by strings — `'$'`, `'@'`, `'%'`, and a class name — optionally preceded by a `'*'`.

The accessor method provided by `struct` for an element depends on the declared type of the element.

Scalar (`'$'` or `'*$'`)

The element is a scalar, and by default is initialized to `undef` (but see *Initializing with new*).

The accessor's argument, if any, is assigned to the element.

If the element type is `'$'`, the value of the element (after assignment) is returned. If the element type is `'*$'`, a reference to the element is returned.

Array (`'@'` or `'*@'`)

The element is an array, initialized by default to `()`.

With no argument, the accessor returns a reference to the element's whole array (whether or not the element was specified as `'@'` or `'*@'`).

With one or two arguments, the first argument is an index specifying one element of the array; the second argument, if present, is assigned to the array element. If the element type is `'@'`, the accessor returns the array element value. If the element type is `'*@'`, a reference to the array element is returned.

Hash (`'%'` or `'*%'`)

The element is a hash, initialized by default to `()`.

With no argument, the accessor returns a reference to the element's whole hash (whether or not the element was specified as `'%'` or `'*%'`).

With one or two arguments, the first argument is a key specifying one element of the hash; the second argument, if present, is assigned to the hash element. If the element type is `'%'`, the accessor returns the hash element value. If the element type is `'*%'`, a reference to the hash element is returned.

Class (`'Class_Name'` or `'*Class_Name'`)

The element's value must be a reference blessed to the named class or to one of its subclasses. The element is initialized to the result of calling the `new` constructor of the named class.

The accessor's argument, if any, is assigned to the element. The accessor will `croak` if this is not an appropriate object reference.

If the element type does not start with a `'*'`, the accessor returns the element value (after assignment). If the element type starts with a `'*'`, a reference to the element itself is returned.

Initializing with `new`

`struct` always creates a constructor called `new`. That constructor may take a list of initializers for the various elements of the new struct.

Each initializer is a pair of values: *element name* `=>` *value*. The initializer value for a scalar element is just a scalar value. The initializer for an array element is an array reference. The initializer for a hash is a hash reference.

The initializer for a class element is also a hash reference, and the contents of that hash are passed to the element's own constructor.

See Example 3 below for an example of initialization.

EXAMPLES

Example 1

Giving a struct element a class type that is also a struct is how structs are nested. Here, `timeval` represents a time (seconds and microseconds), and `rusage` has two elements, each of which is of type `timeval`.

```
use Class::Struct;

struct( rusage => {
    ru_utime => timeval,  # seconds
    ru_stime => timeval,  # microseconds
});

struct( timeval => [
    tv_secs  => '$',
    tv_usecs => '$',
]);

    # create an object:
my $t = new rusage;

    # $t->ru_utime and $t->ru_stime are objects of type timeval.
    # set $t->ru_utime to 100.0 sec and $t->ru_stime to 5.0 sec.
$t->ru_utime->tv_secs(100);
$t->ru_utime->tv_usecs(0);
$t->ru_stime->tv_secs(5);
$t->ru_stime->tv_usecs(0);
```

Example 2

An accessor function can be redefined in order to provide additional checking of values, etc. Here, we want the `count` element always to be nonnegative, so we redefine the `count` accessor accordingly.

```
package MyObj;
use Class::Struct;

# declare the struct
struct ( 'MyObj', { count => '$', stuff => '%' } );

# override the default accessor method for 'count'
sub count {
    my $self = shift;
    if ( @_ ) {
        die 'count must be nonnegative' if $_[0] < 0;
        $self->{'count'} = shift;
        warn "Too many args to count" if @_;
    }
    return $self->{'count'};
}

package main;
$x = new MyObj;
print "\$x->count(5) = ", $x->count(5), "\n";
                         # prints '$x->count(5) = 5'

print "\$x->count = ", $x->count, "\n";
                         # prints '$x->count = 5'

print "\$x->count(-5) = ", $x->count(-5), "\n";
                         # dies due to negative argument!
```

Example 3

The constructor of a generated class can be passed a list of *element=value* pairs, with which to initialize the struct. If no initializer is specified for a particular element, its default initialization is performed instead. Initializers for non−existent elements are silently ignored.

Note that the initializer for a nested struct is specified as an anonymous hash of initializers, which is passed on to the nested struct's constructor.

```
use Class::Struct;

struct Breed =>
{
    name  => '$',
    cross => '$',
};

struct Cat =>
[
    name     => '$',
    kittens  => '@',
    markings => '%',
    breed    => 'Breed',
];

my $cat = Cat->new( name     => 'Socks',
                    kittens  => ['Monica', 'Kenneth'],
                    markings => { socks=>1, blaze=>"white" },
                    breed    => { name=>'short-hair', cross=>1 },
                  );

print "Once a cat called ", $cat->name, "\n";
print "(which was a ", $cat->breed->name, ")\n";
```

```
    print "had two kittens: ", join(' and ', @{$cat->kittens}), "\n";
```

Author and Modification History

Modified by Casey Tweten, 2000–11–08, v0.59.

```
Added the ability for compile time class creation.
```

Modified by Damian Conway, 1999–03–05, v0.58.

```
Added handling of hash-like arg list to class ctor.

Changed to two-argument blessing in ctor to support
derivation from created classes.

Added classname prefixes to keys in hash-based classes
(refer to "Perl Cookbook", Recipe 13.12 for rationale).

Corrected behaviour of accessors for '*@' and '*%' struct
elements.  Package now implements documented behaviour when
returning a reference to an entire hash or array element.
Previously these were returned as a reference to a reference
to the element.
```

Renamed to `Class::Struct` and modified by Jim Miner, 1997–04–02.

```
members() function removed.
Documentation corrected and extended.
Use of struct() in a subclass prohibited.
User definition of accessor allowed.
Treatment of '*' in element types corrected.
Treatment of classes as element types corrected.
Class name to struct() made optional.
Diagnostic checks added.
```

Originally `Class::Template` by Dean Roehrich.

```
# Template.pm   --- struct/member template builder
#   12mar95
#   Dean Roehrich
#
# changes/bugs fixed since 28nov94 version:
#  - podified
# changes/bugs fixed since 21nov94 version:
#  - Fixed examples.
# changes/bugs fixed since 02sep94 version:
#  - Moved to Class::Template.
# changes/bugs fixed since 20feb94 version:
#  - Updated to be a more proper module.
#  - Added "use strict".
#  - Bug in build_methods, was using @var when @$var needed.
#  - Now using my() rather than local().
#
# Uses perl5 classes to create nested data types.
# This is offered as one implementation of Tom Christiansen's "structs.pl"
# idea.
```

NAME

constant – Perl pragma to declare constants

SYNOPSIS

```
use constant BUFFER_SIZE    => 4096;
use constant ONE_YEAR       => 365.2425 * 24 * 60 * 60;
use constant PI             => 4 * atan2 1, 1;
use constant DEBUGGING      => 0;
use constant ORACLE         => 'oracle@cs.indiana.edu';
use constant USERNAME       => scalar getpwuid($<);
use constant USERINFO       => getpwuid($<);

sub deg2rad { PI * $_[0] / 180 }

print "This line does nothing"              unless DEBUGGING;

# references can be constants
use constant CHASH          => { foo => 42 };
use constant CARRAY         => [ 1,2,3,4 ];
use constant CPSEUDOHASH    => [ { foo => 1}, 42 ];
use constant CCODE          => sub { "bite $_[0]\n" };

print CHASH->{foo};
print CARRAY->[$i];
print CPSEUDOHASH->{foo};
print CCODE->("me");
print CHASH->[10];                  # compile-time error
```

DESCRIPTION

This will declare a symbol to be a constant with the given scalar or list value.

When you declare a constant such as `PI` using the method shown above, each machine your script runs upon can have as many digits of accuracy as it can use. Also, your program will be easier to read, more likely to be maintained (and maintained correctly), and far less likely to send a space probe to the wrong planet because nobody noticed the one equation in which you wrote `3.14195`.

NOTES

The value or values are evaluated in a list context. You may override this with `scalar` as shown above.

These constants do not directly interpolate into double–quotish strings, although you may do so indirectly. (See *perlref* for details about how this works.)

```
print "The value of PI is @{[ PI ]}.\n";
```

List constants are returned as lists, not as arrays.

```
$homedir = USERINFO[7];             # WRONG
$homedir = (USERINFO)[7];           # Right
```

The use of all caps for constant names is merely a convention, although it is recommended in order to make constants stand out and to help avoid collisions with other barewords, keywords, and subroutine names. Constant names must begin with a letter or underscore. Names beginning with a double underscore are reserved. Some poor choices for names will generate warnings, if warnings are enabled at compile time.

Constant symbols are package scoped (rather than block scoped, as `use strict` is). That is, you can refer to a constant from package Other as `Other::CONST`.

As with all `use` directives, defining a constant happens at compile time. Thus, it's probably not correct to put a constant declaration inside of a conditional statement (like `if ($foo) { use constant ... }`).

Omitting the value for a symbol gives it the value of `undef` in a scalar context or the empty list, `()`, in a list context. This isn't so nice as it may sound, though, because in this case you must either quote the symbol name, or use a big arrow, (`=>`), with nothing to point to. It is probably best to declare these explicitly.

```
use constant UNICORNS       => ();
use constant LOGFILE        => undef;
```

The result from evaluating a list constant in a scalar context is not documented, and is **not** guaranteed to be any particular value in the future. In particular, you should not rely upon it being the number of elements in the list, especially since it is not **necessarily** that value in the current implementation.

Magical values, tied values, and references can be made into constants at compile time, allowing for way cool stuff like this. (These error numbers aren't totally portable, alas.)

```
use constant E2BIG => ($! = 7);
print   E2BIG, "\n";        # something like "Arg list too long"
print 0+E2BIG, "\n";        # "7"
```

Dereferencing constant references incorrectly (such as using an array subscript on a constant hash reference, or vice versa) will be trapped at compile time.

In the rare case in which you need to discover at run time whether a particular constant has been declared via this module, you may use this function to examine the hash `%constant::declared`. If the given constant name does not include a package name, the current package is used.

```
sub declared ($) {
    use constant 1.01;              # don't omit this!
    my $name = shift;
    $name =~ s/^::/main::/;
    my $pkg = caller;
    my $full_name = $name =~ /::/ ? $name : "${pkg}::$name";
    $constant::declared{$full_name};
}
```

TECHNICAL NOTE

In the current implementation, scalar constants are actually inlinable subroutines. As of version 5.004 of Perl, the appropriate scalar constant is inserted directly in place of some subroutine calls, thereby saving the overhead of a subroutine call. See *Constant Functions in perlsub* for details about how and when this happens.

BUGS

In the current version of Perl, list constants are not inlined and some symbols may be redefined without generating a warning.

It is not possible to have a subroutine or keyword with the same name as a constant in the same package. This is probably a Good Thing.

A constant with a name in the list `STDIN STDOUT STDERR ARGV ARGVOUT ENV INC SIG` is not allowed anywhere but in package `main::`, for technical reasons.

Even though a reference may be declared as a constant, the reference may point to data which may be changed, as this code shows.

```
use constant CARRAY         => [ 1,2,3,4 ];
print CARRAY->[1];
CARRAY->[1] = " be changed";
print CARRAY->[1];
```

Unlike constants in some languages, these cannot be overridden on the command line or via environment variables.

You can get into trouble if you use constants in a context which automatically quotes barewords (as is true for any subroutine call). For example, you can't say `$hash{CONSTANT}` because `CONSTANT` will be interpreted as a string. Use `$hash{CONSTANT()}` or `$hash{+CONSTANT}` to prevent the bareword quoting mechanism from kicking in. Similarly, since the `=>` operator quotes a bareword immediately to its left, you have to say `CONSTANT() => 'value'` (or simply use a comma in place of the big arrow) instead of `CONSTANT => 'value'`.

AUTHOR

Tom Phoenix, ***<rootbeer@redcat.com>***, with help from many other folks.

COPYRIGHT

NAME

CPAN::FirstTime – Utility for CPAN::Config file Initialization

SYNOPSIS

```
CPAN::FirstTime::init()
```

DESCRIPTION

The init routine asks a few questions and writes a CPAN::Config file. Nothing special.

NAME

CPAN::Nox – Wrapper around CPAN.pm without using any XS module

SYNOPSIS

Interactive mode:

```
perl –MCPAN::Nox –e shell;
```

DESCRIPTION

This package has the same functionality as CPAN.pm, but tries to prevent the usage of compiled extensions during it‘s own execution. It‘s primary purpose is a rescue in case you upgraded perl and broke binary compatibility somehow.

SEE ALSO

CPAN(3)

NAME

CPAN – query, download and build perl modules from CPAN sites

SYNOPSIS

Interactive mode:

```
perl -MCPAN -e shell;
```

Batch mode:

```
use CPAN;

autobundle, clean, install, make, recompile, test
```

DESCRIPTION

The CPAN module is designed to automate the make and install of perl modules and extensions. It includes some searching capabilities and knows how to use Net::FTP or LWP (or lynx or an external ftp client) to fetch the raw data from the net.

Modules are fetched from one or more of the mirrored CPAN (Comprehensive Perl Archive Network) sites and unpacked in a dedicated directory.

The CPAN module also supports the concept of named and versioned *bundles* of modules. Bundles simplify the handling of sets of related modules. See Bundles below.

The package contains a session manager and a cache manager. There is no status retained between sessions. The session manager keeps track of what has been fetched, built and installed in the current session. The cache manager keeps track of the disk space occupied by the make processes and deletes excess space according to a simple FIFO mechanism.

For extended searching capabilities there's a plugin for CPAN available, *CPAN::WAIT*. `CPAN::WAIT` is a full–text search engine that indexes all documents available in CPAN authors directories. If `CPAN::WAIT` is installed on your system, the interactive shell of <CPAN.pm will enable the `wq`, `wr`, `wd`, `wl`, and `wh` commands which send queries to the WAIT server that has been configured for your installation.

All other methods provided are accessible in a programmer style and in an interactive shell style.

Interactive Mode

The interactive mode is entered by running

```
perl -MCPAN -e shell
```

which puts you into a readline interface. You will have the most fun if you install Term::ReadKey and Term::ReadLine to enjoy both history and command completion.

Once you are on the command line, type 'h' and the rest should be self–explanatory.

The function call `shell` takes two optional arguments, one is the prompt, the second is the default initial command line (the latter only works if a real ReadLine interface module is installed).

The most common uses of the interactive modes are

Searching for authors, bundles, distribution files and modules

There are corresponding one–letter commands `a`, `b`, `d`, and `m` for each of the four categories and another, `i` for any of the mentioned four. Each of the four entities is implemented as a class with slightly differing methods for displaying an object.

Arguments you pass to these commands are either strings exactly matching the identification string of an object or regular expressions that are then matched case–insensitively against various attributes of the objects. The parser recognizes a regular expression only if you enclose it between two slashes.

The principle is that the number of found objects influences how an item is displayed. If the search finds one item, the result is displayed with the rather verbose method `as_string`, but if we find more than

one, we display each object with the terse method <as_glimpse.

make, test, install, clean modules or distributions

These commands take any number of arguments and investigate what is necessary to perform the action. If the argument is a distribution file name (recognized by embedded slashes), it is processed. If it is a module, CPAN determines the distribution file in which this module is included and processes that, following any dependencies named in the module's Makefile.PL (this behavior is controlled by *prerequisites_policy*.)

Any `make` or `test` are run unconditionally. An

```
install <distribution_file>
```

also is run unconditionally. But for

```
install <module>
```

CPAN checks if an install is actually needed for it and prints *module up to date* in the case that the distribution file containing the module doesn't need to be updated.

CPAN also keeps track of what it has done within the current session and doesn't try to build a package a second time regardless if it succeeded or not. The `force` command takes as a first argument the method to invoke (currently: `make`, `test`, or `install`) and executes the command from scratch.

Example:

```
cpan> install OpenGL
OpenGL is up to date.
cpan> force install OpenGL
Running make
OpenGL-0.4/
OpenGL-0.4/COPYRIGHT
[...]
```

A `clean` command results in a

```
make clean
```

being executed within the distribution file's working directory.

get, readme, look module or distribution

`get` downloads a distribution file without further action. `readme` displays the README file of the associated distribution. `Look` gets and untars (if not yet done) the distribution file, changes to the appropriate directory and opens a subshell process in that directory.

Signals

CPAN.pm installs signal handlers for SIGINT and SIGTERM. While you are in the cpan-shell it is intended that you can press `^C` anytime and return to the cpan-shell prompt. A SIGTERM will cause the cpan-shell to clean up and leave the shell loop. You can emulate the effect of a SIGTERM by sending two consecutive SIGINTs, which usually means by pressing `^C` twice.

CPAN.pm ignores a SIGPIPE. If the user sets inactivity_timeout, a SIGALRM is used during the run of the `perl Makefile.PL` subprocess.

CPAN::Shell

The commands that are available in the shell interface are methods in the package CPAN::Shell. If you enter the shell command, all your input is split by the `Text::ParseWords::shellwords()` routine which acts like most shells do. The first word is being interpreted as the method to be called and the rest of the words are treated as arguments to this method. Continuation lines are supported if a line ends with a literal backslash.

autobundle

`autobundle` writes a bundle file into the `$CPAN::Config->{cpan_home}/Bundle` directory. The file contains a list of all modules that are both available from CPAN and currently installed within @INC. The name of the bundle file is based on the current date and a counter.

recompile

`recompile()` is a very special command in that it takes no argument and runs the make/test/install cycle with brute force over all installed dynamically loadable extensions (aka XS modules) with 'force' in effect. The primary purpose of this command is to finish a network installation. Imagine, you have a common source tree for two different architectures. You decide to do a completely independent fresh installation. You start on one architecture with the help of a Bundle file produced earlier. CPAN installs the whole Bundle for you, but when you try to repeat the job on the second architecture, CPAN responds with a `"Foo up to date"` message for all modules. So you invoke CPAN's recompile on the second architecture and you're done.

Another popular use for `recompile` is to act as a rescue in case your perl breaks binary compatibility. If one of the modules that CPAN uses is in turn depending on binary compatibility (so you cannot run CPAN commands), then you should try the CPAN::Nox module for recovery.

The four `CPAN::*` Classes: Author, Bundle, Module, Distribution

Although it may be considered internal, the class hierarchy does matter for both users and programmer. CPAN.pm deals with above mentioned four classes, and all those classes share a set of methods. A classical single polymorphism is in effect. A metaclass object registers all objects of all kinds and indexes them with a string. The strings referencing objects have a separated namespace (well, not completely separated):

```
        Namespace                         Class

  words containing a "/" (slash)      Distribution
   words starting with Bundle::           Bundle
         everything else             Module or Author
```

Modules know their associated Distribution objects. They always refer to the most recent official release. Developers may mark their releases as unstable development versions (by inserting an underbar into the visible version number), so the really hottest and newest distribution file is not always the default. If a module Foo circulates on CPAN in both version 1.23 and 1.23_90, CPAN.pm offers a convenient way to install version 1.23 by saying

```
install Foo
```

This would install the complete distribution file (say BAR/Foo-1.23.tar.gz) with all accompanying material. But if you would like to install version 1.23_90, you need to know where the distribution file resides on CPAN relative to the authors/id/ directory. If the author is BAR, this might be BAR/Foo-1.23_90.tar.gz; so you would have to say

```
install BAR/Foo-1.23_90.tar.gz
```

The first example will be driven by an object of the class CPAN::Module, the second by an object of class CPAN::Distribution.

Programmer's interface

If you do not enter the shell, the available shell commands are both available as methods (`CPAN::Shell->install(...)`) and as functions in the calling package (`install(...)`).

There's currently only one class that has a stable interface - CPAN::Shell. All commands that are available in the CPAN shell are methods of the class CPAN::Shell. Each of the commands that produce listings of modules (`r`, `autobundle`, `u`) also return a list of the IDs of all modules within the list.

expand(`$type,@things`)

The IDs of all objects available within a program are strings that can be expanded to the corresponding real objects with the `CPAN::Shell->expand("Module",@things)` method. Expand returns a list

of CPAN::Module objects according to the `@things` arguments given. In scalar context it only returns the first element of the list.

Programming Examples

This enables the programmer to do operations that combine functionalities that are available in the shell.

```
# install everything that is outdated on my disk:
perl -MCPAN -e 'CPAN::Shell->install(CPAN::Shell->r)'

# install my favorite programs if necessary:
for $mod (qw(Net::FTP MD5 Data::Dumper)){
    my $obj = CPAN::Shell->expand('Module',$mod);
    $obj->install;
}

# list all modules on my disk that have no VERSION number
for $mod (CPAN::Shell->expand("Module","/./")){
    next unless $mod->inst_file;
    # MakeMaker convention for undefined $VERSION:
    next unless $mod->inst_version eq "undef";
    print "No VERSION in ", $mod->id, "\n";
}

# find out which distribution on CPAN contains a module:
print CPAN::Shell->expand("Module","Apache::Constants")->cpan_file
```

Or if you want to write a cronjob to watch The CPAN, you could list all modules that need updating. First a quick and dirty way:

```
perl -e 'use CPAN; CPAN::Shell->r;'
```

If you don‘t want to get any output in the case that all modules are up to date, you can parse the output of above command for the regular expression //modules are up to date// and decide to mail the output only if it doesn‘t match. Ick?

If you prefer to do it more in a programmer style in one single process, maybe something like this suites you better:

```
# list all modules on my disk that have newer versions on CPAN
for $mod (CPAN::Shell->expand("Module","/./")){
  next unless $mod->inst_file;
  next if $mod->uptodate;
  printf "Module %s is installed as %s, could be updated to %s from CPAN\n",
      $mod->id, $mod->inst_version, $mod->cpan_version;
}
```

If that gives you too much output every day, you maybe only want to watch for three modules. You can write

```
for $mod (CPAN::Shell->expand("Module","/Apache|LWP|CGI/")){
```

as the first line instead. Or you can combine some of the above tricks:

```
# watch only for a new mod_perl module
$mod = CPAN::Shell->expand("Module","mod_perl");
exit if $mod->uptodate;
# new mod_perl arrived, let me know all update recommendations
CPAN::Shell->r;
```

Methods in the four Classes

Cache Manager

Currently the cache manager only keeps track of the build directory (`$CPAN::Config->{build_dir}`). It is a simple FIFO mechanism that deletes complete directories below `build_dir` as soon as the size of all directories there gets bigger than `$CPAN::Config->{build_cache}` (in MB). The contents of this cache may be used for later re-installations that you intend to do manually, but will never be trusted by CPAN itself. This is due to the fact that the user might use these directories for building modules on different architectures.

There is another directory (`$CPAN::Config->{keep_source_where}`) where the original distribution files are kept. This directory is not covered by the cache manager and must be controlled by the user. If you choose to have the same directory as build_dir and as keep_source_where directory, then your sources will be deleted with the same fifo mechanism.

Bundles

A bundle is just a perl module in the namespace Bundle:: that does not define any functions or methods. It usually only contains documentation.

It starts like a perl module with a package declaration and a `$VERSION` variable. After that the pod section looks like any other pod with the only difference being that *one special pod section* exists starting with (verbatim):

```
=head1 CONTENTS
```

In this pod section each line obeys the format

```
Module_Name [Version_String] [- optional text]
```

The only required part is the first field, the name of a module (e.g. Foo::Bar, ie. *not* the name of the distribution file). The rest of the line is optional. The comment part is delimited by a dash just as in the man page header.

The distribution of a bundle should follow the same convention as other distributions.

Bundles are treated specially in the CPAN package. If you say 'install Bundle::Tkkit' (assuming such a bundle exists), CPAN will install all the modules in the CONTENTS section of the pod. You can install your own Bundles locally by placing a conformant Bundle file somewhere into your @INC path. The `autobundle()` command which is available in the shell interface does that for you by including all currently installed modules in a snapshot bundle file.

Prerequisites

If you have a local mirror of CPAN and can access all files with "file:" URLs, then you only need a perl better than perl5.003 to run this module. Otherwise Net::FTP is strongly recommended. LWP may be required for non-UNIX systems or if your nearest CPAN site is associated with an URL that is not `ftp:`.

If you have neither Net::FTP nor LWP, there is a fallback mechanism implemented for an external ftp command or for an external lynx command.

Finding packages and VERSION

This module presumes that all packages on CPAN

- declare their `$VERSION` variable in an easy to parse manner. This prerequisite can hardly be relaxed because it consumes far too much memory to load all packages into the running program just to determine the `$VERSION` variable. Currently all programs that are dealing with version use something like this

  ```
  perl -MExtUtils::MakeMaker -le \
      'print MM->parse_version(shift)' filename
  ```

  If you are author of a package and wonder if your `$VERSION` can be parsed, please try the above method.

- come as compressed or gzipped tarfiles or as zip files and contain a Makefile.PL (well, we try to handle a bit more, but without much enthusiasm).

Debugging

The debugging of this module is a bit complex, because we have interferences of the software producing the indices on CPAN, of the mirroring process on CPAN, of packaging, of configuration, of synchronicity, and of bugs within CPAN.pm.

For code debugging in interactive mode you can try "o debug" which will list options for debugging the various parts of the code. You should know that "o debug" has built−in completion support.

For data debugging there is the `dump` command which takes the same arguments as make/test/install and outputs the object's Data::Dumper dump.

Floppy, Zip, Offline Mode

CPAN.pm works nicely without network too. If you maintain machines that are not networked at all, you should consider working with file: URLs. Of course, you have to collect your modules somewhere first. So you might use CPAN.pm to put together all you need on a networked machine. Then copy the `$CPAN::Config−{keep_source_where}` (but not `$CPAN::Config−{build_dir}`) directory on a floppy. This floppy is kind of a personal CPAN. CPAN.pm on the non−networked machines works nicely with this floppy. See also below the paragraph about CD−ROM support.

CONFIGURATION

When the CPAN module is installed, a site wide configuration file is created as CPAN/Config.pm. The default values defined there can be overridden in another configuration file: CPAN/MyConfig.pm. You can store this file in `$HOME/.cpan/CPAN/MyConfig.pm` if you want, because `$HOME/.cpan` is added to the search path of the CPAN module before the `use()` or `require()` statements.

Currently the following keys in the hash reference `$CPAN::Config` are defined:

```
build_cache         size of cache for directories to build modules
build_dir           locally accessible directory to build modules
index_expire        after this many days refetch index files
cache_metadata      use serializer to cache metadata
cpan_home           local directory reserved for this package
dontload_hash       anonymous hash: modules in the keys will not be
                    loaded by the CPAN::has_inst() routine
gzip                location of external program gzip
inactivity_timeout breaks interactive Makefile.PLs after this
                    many seconds inactivity. Set to 0 to never break.
inhibit_startup_message
                    if true, does not print the startup message
keep_source_where   directory in which to keep the source (if we do)
make                location of external make program
make_arg            arguments that should always be passed to 'make'
make_install_arg    same as make_arg for 'make install'
makepl_arg          arguments passed to 'perl Makefile.PL'
pager               location of external program more (or any pager)
prerequisites_policy
                    what to do if you are missing module prerequisites
                    ('follow' automatically, 'ask' me, or 'ignore')
scan_cache          controls scanning of cache ('atstart' or 'never')
tar                 location of external program tar
term_is_latin       if true internal UTF-8 is translated to ISO-8859-1
                    (and nonsense for characters outside latin range)
unzip               location of external program unzip
urllist             arrayref to nearby CPAN sites (or equivalent locations)
```

```
  wait_list           arrayref to a wait server to try (See CPAN::WAIT)
  ftp_proxy,       }  the three usual variables for configuring
    http_proxy,    }  proxy requests. Both as CPAN::Config variables
    no_proxy       }  and as environment variables configurable.
```

You can set and query each of these options interactively in the cpan shell with the command set defined within the `o conf` command:

`o conf <scalar option>`
prints the current value of the *scalar option*

`o conf <scalar option> <value>`
Sets the value of the *scalar option* to *value*

`o conf <list option>`
prints the current value of the *list option* in MakeMaker's neatvalue format.

`o conf <list option> [shift|pop]`
shifts or pops the array in the *list option* variable

`o conf <list option> [unshift|push|splice] <list>`
works like the corresponding perl commands.

Note on urllist parameter's format

urllist parameters are URLs according to RFC 1738. We do a little guessing if your URL is not compliant, but if you have problems with file URLs, please try the correct format. Either:

```
file://localhost/whatever/ftp/pub/CPAN/
```

or

```
file:///home/ftp/pub/CPAN/
```

urllist parameter has CD–ROM support

The `urllist` parameter of the configuration table contains a list of URLs that are to be used for downloading. If the list contains any `file` URLs, CPAN always tries to get files from there first. This feature is disabled for index files. So the recommendation for the owner of a CD–ROM with CPAN contents is: include your local, possibly outdated CD–ROM as a `file` URL at the end of urllist, e.g.

```
o conf urllist push file://localhost/CDROM/CPAN
```

CPAN.pm will then fetch the index files from one of the CPAN sites that come at the beginning of urllist. It will later check for each module if there is a local copy of the most recent version.

Another peculiarity of urllist is that the site that we could successfully fetch the last file from automatically gets a preference token and is tried as the first site for the next request. So if you add a new site at runtime it may happen that the previously preferred site will be tried another time. This means that if you want to disallow a site for the next transfer, it must be explicitly removed from urllist.

SECURITY

There's no strong security layer in CPAN.pm. CPAN.pm helps you to install foreign, unmasked, unsigned code on your machine. We compare to a checksum that comes from the net just as the distribution file itself. If somebody has managed to tamper with the distribution file, they may have as well tampered with the CHECKSUMS file. Future development will go towards strong authentication.

EXPORT

Most functions in package CPAN are exported per default. The reason for this is that the primary use is intended for the cpan shell or for oneliners.

POPULATE AN INSTALLATION WITH LOTS OF MODULES

To populate a freshly installed perl with my favorite modules is pretty easiest by maintaining a private bundle definition file. To get a useful blueprint of a bundle definition file, the command autobundle can be used on the CPAN shell command line. This command writes a bundle definition file for all modules that are installed for the currently running perl interpreter. It's recommended to run this command only once and from then on maintain the file manually under a private name, say Bundle/my_bundle.pm. With a clever bundle file you can then simply say

```
cpan> install Bundle::my_bundle
```

then answer a few questions and then go out for a coffee.

Maintaining a bundle definition file means to keep track of two things: dependencies and interactivity. CPAN.pm sometimes fails on calculating dependencies because not all modules define all MakeMaker attributes correctly, so a bundle definition file should specify prerequisites as early as possible. On the other hand, it's a bit annoying that many distributions need some interactive configuring. So what I try to accomplish in my private bundle file is to have the packages that need to be configured early in the file and the gentle ones later, so I can go out after a few minutes and leave CPAN.pm unattained.

WORKING WITH CPAN.pm BEHIND FIREWALLS

Thanks to Graham Barr for contributing the following paragraphs about the interaction between perl, and various firewall configurations. For further informations on firewalls, it is recommended to consult the documentation that comes with the ncftp program. If you are unable to go through the firewall with a simple Perl setup, it is very likely that you can configure ncftp so that it works for your firewall.

Three basic types of firewalls

Firewalls can be categorized into three basic types.

http firewall

This is where the firewall machine runs a web server and to access the outside world you must do it via the web server. If you set environment variables like http_proxy or ftp_proxy to a values beginning with http:// or in your web browser you have to set proxy information then you know you are running a http firewall.

To access servers outside these types of firewalls with perl (even for ftp) you will need to use LWP.

ftp firewall

This where the firewall machine runs a ftp server. This kind of firewall will only let you access ftp servers outside the firewall. This is usually done by connecting to the firewall with ftp, then entering a username like "user@outside.host.com"

To access servers outside these type of firewalls with perl you will need to use Net::FTP.

One way visibility

I say one way visibility as these firewalls try to make themselve look invisible to the users inside the firewall. An FTP data connection is normally created by sending the remote server your IP address and then listening for the connection. But the remote server will not be able to connect to you because of the firewall. So for these types of firewall FTP connections need to be done in a passive mode.

There are two that I can think off.

SOCKS

If you are using a SOCKS firewall you will need to compile perl and link it with the SOCKS library, this is what is normally called a 'socksified' perl. With this executable you will be able to connect to servers outside the firewall as if it is not there.

IP Masquerade

This is the firewall implemented in the Linux kernel, it allows you to hide a complete network behind one IP address. With this firewall no special compiling is need as you can access hosts

directly.

Configuring lynx or ncftp for going through a firewall

If you can go through your firewall with e.g. lynx, presumably with a command such as

```
/usr/local/bin/lynx -pscott:tiger
```

then you would configure CPAN.pm with the command

```
o conf lynx "/usr/local/bin/lynx -pscott:tiger"
```

That's all. Similarly for ncftp or ftp, you would configure something like

```
o conf ncftp "/usr/bin/ncftp -f /home/scott/ncftplogin.cfg"
```

Your milage may vary...

FAQ

1) I installed a new version of module X but CPAN keeps saying,

```
I have the old version installed
```

Most probably you **do** have the old version installed. This can happen if a module installs itself into a different directory in the @INC path than it was previously installed. This is not really a CPAN.pm problem, you would have the same problem when installing the module manually. The easiest way to prevent this behaviour is to add the argument `UNINST=1` to the `make install` call, and that is why many people add this argument permanently by configuring

```
o conf make_install_arg UNINST=1
```

2) So why is UNINST=1 not the default?

Because there are people who have their precise expectations about who may install where in the @INC path and who uses which @INC array. In fine tuned environments `UNINST=1` can cause damage.

3) I want to clean up my mess, and install a new perl along with

```
all modules I have. How do I go about it?
```

Run the autobundle command for your old perl and optionally rename the resulting bundle file (e.g. Bundle/mybundle.pm), install the new perl with the Configure option prefix, e.g.

```
./Configure -Dprefix=/usr/local/perl-5.6.78.9
```

Install the bundle file you produced in the first step with something like

```
cpan> install Bundle::mybundle
```

and you're done.

4) When I install bundles or multiple modules with one command

```
there is too much output to keep track of
```

You may want to configure something like

```
o conf make_arg "| tee -ai /root/.cpan/logs/make.out"
o conf make_install_arg "| tee -ai /root/.cpan/logs/make_install.out"
```

so that STDOUT is captured in a file for later inspection.

5) I am not root, how can I install a module in a personal

```
directory?
```

You will most probably like something like this:

```
o conf makepl_arg "LIB=~/myperl/lib \
                   INSTALLMAN1DIR=~/myperl/man/man1 \
```

```
                    INSTALLMAN3DIR=~/myperl/man/man3"
  install Sybase::Sybperl
```

You can make this setting permanent like all `o conf` settings with `o conf commit`.

You will have to add ~/myperl/man to the MANPATH environment variable and also tell your perl programs to look into ~/myperl/lib, e.g. by including

```
use lib "$ENV{HOME}/myperl/lib";
```

or setting the PERL5LIB environment variable.

Another thing you should bear in mind is that the UNINST parameter should never be set if you are not root.

6) How to get a package, unwrap it, and make a change before

```
building it?
```

```
look Sybase::Sybperl
```

7) I installed a Bundle and had a couple of fails. When I

```
retried, everything resolved nicely. Can this be fixed to work
on first try?
```

The reason for this is that CPAN does not know the dependencies of all modules when it starts out. To decide about the additional items to install, it just uses data found in the generated Makefile. An undetected missing piece breaks the process. But it may well be that your Bundle installs some prerequisite later than some depending item and thus your second try is able to resolve everything. Please note, CPAN.pm does not know the dependency tree in advance and cannot sort the queue of things to install in a topologically correct order. It resolves perfectly well IFF all modules declare the prerequisites correctly with the PREREQ_PM attribute to MakeMaker. For bundles which fail and you need to install often, it is recommended sort the Bundle definition file manually. It is planned to improve the metadata situation for dependencies on CPAN in general, but this will still take some time.

8) In our intranet we have many modules for internal use. How

```
can I integrate these modules with CPAN.pm but without uploading
the modules to CPAN?
```

Have a look at the CPAN::Site module.

9) When I run CPAN's shell, I get error msg about line 1 to 4,

```
setting meta input/output via the /etc/inputrc file.
```

I guess, /etc/inputrc interacts with Term::ReadLine somehow. Maybe just remove /etc/inputrc or set the INPUTRC environment variable (see the readline documentation).

BUGS

We should give coverage for **all** of the CPAN and not just the PAUSE part, right? In this discussion CPAN and PAUSE have become equal — but they are not. PAUSE is authors/, modules/ and scripts/. CPAN is PAUSE plus the clpa/, doc/, misc/, ports/, and src/.

Future development should be directed towards a better integration of the other parts.

If a Makefile.PL requires special customization of libraries, prompts the user for special input, etc. then you may find CPAN is not able to build the distribution. In that case, you should attempt the traditional method of building a Perl module package from a shell.

AUTHOR

Andreas Koenig <andreas.koenig@anima.de>

SEE ALSO

perl(1), CPAN::Nox(3)

NAME

getcwd – get pathname of current working directory

SYNOPSIS

```
use Cwd;
$dir = cwd;

use Cwd;
$dir = getcwd;

use Cwd;
$dir = fastgetcwd;

use Cwd 'chdir';
chdir "/tmp";
print $ENV{'PWD'};

use Cwd 'abs_path';     # aka realpath()
print abs_path($ENV{'PWD'});

use Cwd 'fast_abs_path';
print fast_abs_path($ENV{'PWD'});
```

DESCRIPTION

The `getcwd()` function re–implements the getcwd(3) (or getwd(3)) functions in Perl.

The `abs_path()` function takes a single argument and returns the absolute pathname for that argument. It uses the same algorithm as `getcwd()`. (Actually, `getcwd()` is abs_path(".")) Symbolic links and relative–path components ("." and "..") are resolved to return the canonical pathname, just like realpath(3). Also callable as `realpath()`.

The `fastcwd()` function looks the same as `getcwd()`, but runs faster. It's also more dangerous because it might conceivably `chdir()` you out of a directory that it can't `chdir()` you back into. If fastcwd encounters a problem it will return undef but will probably leave you in a different directory. For a measure of extra security, if everything appears to have worked, the `fastcwd()` function will check that it leaves you in the same directory that it started in. If it has changed it will `die` with the message "Unstable directory path, current directory changed unexpectedly". That should never happen.

The `fast_abs_path()` function looks the same as `abs_path()`, but runs faster. And like `fastcwd()` is more dangerous.

The `cwd()` function looks the same as getcwd and fastgetcwd but is implemented using the most natural and safe form for the current architecture. For most systems it is identical to 'pwd' (but without the trailing line terminator).

It is recommended that cwd (or another `*cwd()` function) is used in *all* code to ensure portability.

If you ask to override your `chdir()` built–in function, then your PWD environment variable will be kept up to date. (See *Overriding Builtin Functions*.) Note that it will only be kept up to date if all packages which use chdir import it from Cwd.

NAME

DB − programmatic interface to the Perl debugging API (draft, subject to change)

SYNOPSIS

```
package CLIENT;
use DB;
@ISA = qw(DB);

# these (inherited) methods can be called by the client

CLIENT->register()      # register a client package name
CLIENT->done()          # de-register from the debugging API
CLIENT->skippkg('hide::hide')  # ask DB not to stop in this package
CLIENT->cont([WHERE])       # run some more (until BREAK or another breakpt)
CLIENT->step()              # single step
CLIENT->next()              # step over
CLIENT->ret()               # return from current subroutine
CLIENT->backtrace()         # return the call stack description
CLIENT->ready()             # call when client setup is done
CLIENT->trace_toggle()      # toggle subroutine call trace mode
CLIENT->subs([SUBS])        # return subroutine information
CLIENT->files()             # return list of all files known to DB
CLIENT->lines()             # return lines in currently loaded file
CLIENT->loadfile(FILE,LINE) # load a file and let other clients know
CLIENT->lineevents()        # return info on lines with actions
CLIENT->set_break([WHERE],[COND])
CLIENT->set_tbreak([WHERE])
CLIENT->clr_breaks([LIST])
CLIENT->set_action(WHERE,ACTION)
CLIENT->clr_actions([LIST])
CLIENT->evalcode(STRING)  # eval STRING in executing code's context
CLIENT->prestop([STRING]) # execute in code context before stopping
CLIENT->poststop([STRING])# execute in code context before resuming

# These methods will be called at the appropriate times.
# Stub versions provided do nothing.
# None of these can block.

CLIENT->init()          # called when debug API inits itself
CLIENT->stop(FILE,LINE) # when execution stops
CLIENT->idle()          # while stopped (can be a client event loop)
CLIENT->cleanup()       # just before exit
CLIENT->output(LIST)    # called to print any output that API must show
```

DESCRIPTION

Perl debug information is frequently required not just by debuggers, but also by modules that need some "special" information to do their job properly, like profilers.

This module abstracts and provides all of the hooks into Perl internal debugging functionality, so that various implementations of Perl debuggers (or packages that want to simply get at the "privileged" debugging data) can all benefit from the development of this common code. Currently used by Swat, the perl/Tk GUI debugger.

Note that multiple "front−ends" can latch into this debugging API simultaneously. This is intended to facilitate things like debugging with a command line and GUI at the same time, debugging debuggers etc. [Sounds nice, but this needs some serious support — GSAR]

In particular, this API does **not** provide the following functions:

- data display
- command processing
- command alias management
- user interface (tty or graphical)

These are intended to be services performed by the clients of this API.

This module attempts to be squeaky clean w.r.t `use strict;` and when warnings are enabled.

Global Variables

The following "public" global names can be read by clients of this API. Beware that these should be considered "readonly".

`$DB::sub`

Name of current executing subroutine.

%DB::sub

The keys of this hash are the names of all the known subroutines. Each value is an encoded string that has the sprintf(3) format `("%s:%d-%d", filename, fromline, toline)`.

`$DB::single`

Single-step flag. Will be true if the API will stop at the next statement.

`$DB::signal`

Signal flag. Will be set to a true value if a signal was caught. Clients may check for this flag to abort time-consuming operations.

`$DB::trace`

This flag is set to true if the API is tracing through subroutine calls.

@DB::args

Contains the arguments of current subroutine, or the `@ARGV` array if in the toplevel context.

@DB::dbline

List of lines in currently loaded file.

%DB::dbline

Actions in current file (keys are line numbers). The values are strings that have the sprintf(3) format `("%s\000%s", breakcondition, actioncode)`.

`$DB::package`

Package namespace of currently executing code.

`$DB::filename`

Currently loaded filename.

`$DB::subname`

Fully qualified name of currently executing subroutine.

`$DB::lineno`

Line number that will be executed next.

API Methods

The following are methods in the DB base class. A client must access these methods by inheritance (*not* by calling them directly), since the API keeps track of clients through the inheritance mechanism.

CLIENT–register()

register a client object/package

CLIENT–evalcode(STRING)

eval STRING in executing code context

CLIENT–skippkg('D::hide')

ask DB not to stop in these packages

CLIENT–run()

run some more (until a breakpt is reached)

CLIENT–step()

single step

CLIENT–next()

step over

CLIENT–done()

de–register from the debugging API

Client Callback Methods

The following "virtual" methods can be defined by the client. They will be called by the API at appropriate points. Note that unless specified otherwise, the debug API only defines empty, non–functional default versions of these methods.

CLIENT–init()

Called after debug API inits itself.

CLIENT–prestop([STRING])

Usually inherited from DB package. If no arguments are passed, returns the prestop action string.

CLIENT–stop()

Called when execution stops (w/ args file, line).

CLIENT–idle()

Called while stopped (can be a client event loop).

CLIENT–poststop([STRING])

Usually inherited from DB package. If no arguments are passed, returns the poststop action string.

CLIENT–evalcode(STRING)

Usually inherited from DB package. Ask for a STRING to be `eval`–ed in executing code context.

CLIENT–cleanup()

Called just before exit.

CLIENT–output(LIST)

Called when API must show a message (warnings, errors etc.).

BUGS

The interface defined by this module is missing some of the later additions to perl's debugging functionality. As such, this interface should be considered highly experimental and subject to change.

AUTHOR

Gurusamy Sarathy gsar@activestate.com

This code heavily adapted from an early version of perl5db.pl attributable to Larry Wall and the Perl Porters.

NAME

Devel::SelfStubber – generate stubs for a SelfLoading module

SYNOPSIS

To generate just the stubs:

```
use Devel::SelfStubber;
Devel::SelfStubber->stub('MODULENAME','MY_LIB_DIR');
```

or to generate the whole module with stubs inserted correctly

```
use Devel::SelfStubber;
$Devel::SelfStubber::JUST_STUBS=0;
Devel::SelfStubber->stub('MODULENAME','MY_LIB_DIR');
```

MODULENAME is the Perl module name, e.g. Devel::SelfStubber, NOT 'Devel/SelfStubber' or 'Devel/SelfStubber.pm'.

MY_LIB_DIR defaults to '.' if not present.

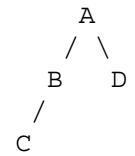
DESCRIPTION

Devel::SelfStubber prints the stubs you need to put in the module before the __DATA__ token (or you can get it to print the entire module with stubs correctly placed). The stubs ensure that if a method is called, it will get loaded. They are needed specifically for inherited autoloaded methods.

This is best explained using the following example:

Assume four classes, A,B,C & D.

A is the root class, B is a subclass of A, C is a subclass of B, and D is another subclass of A.



If D calls an autoloaded method 'foo' which is defined in class A, then the method is loaded into class A, then executed. If C then calls method 'foo', and that method was reimplemented in class B, but set to be autoloaded, then the lookup mechanism never gets to the AUTOLOAD mechanism in B because it first finds the method already loaded in A, and so erroneously uses that. If the method foo had been stubbed in B, then the lookup mechanism would have found the stub, and correctly loaded and used the sub from B.

So, for classes and subclasses to have inheritance correctly work with autoloading, you need to ensure stubs are loaded.

The SelfLoader can load stubs automatically at module initialization with the statement `'SelfLoader->load_stubs()';`, but you may wish to avoid having the stub loading overhead associated with your initialization (though note that the SelfLoader::load_stubs method will be called sooner or later – at latest when the first sub is being autoloaded). In this case, you can put the sub stubs before the __DATA__ token. This can be done manually, but this module allows automatic generation of the stubs.

By default it just prints the stubs, but you can set the global `$Devel::SelfStubber::JUST_STUBS` to 0 and it will print out the entire module with the stubs positioned correctly.

At the very least, this is useful to see what the SelfLoader thinks are stubs – in order to ensure future versions of the SelfStubber remain in step with the SelfLoader, the SelfStubber actually uses the SelfLoader to determine which stubs are needed.

NAME

diagnostics – Perl compiler pragma to force verbose warning diagnostics

splain – standalone program to do the same thing

SYNOPSIS

As a pragma:

```
use diagnostics;
use diagnostics -verbose;

enable  diagnostics;
disable diagnostics;
```

Aa a program:

```
perl program 2>diag.out
splain [-v] [-p] diag.out
```

DESCRIPTION

The `diagnostics` Pragma

This module extends the terse diagnostics normally emitted by both the perl compiler and the perl interpreter, augmenting them with the more explicative and endearing descriptions found in *perldiag*. Like the other pragmata, it affects the compilation phase of your program rather than merely the execution phase.

To use in your program as a pragma, merely invoke

```
use diagnostics;
```

at the start (or near the start) of your program. (Note that this *does* enable perl's **-w** flag.) Your whole compilation will then be subject(ed :-) to the enhanced diagnostics. These still go out **STDERR**.

Due to the interaction between runtime and compiletime issues, and because it's probably not a very good idea anyway, you may not use `no diagnostics` to turn them off at compiletime. However, you may control their behaviour at runtime using the `disable()` and `enable()` methods to turn them off and on respectively.

The **-verbose** flag first prints out the *perldiag* introduction before any other diagnostics. The `$diagnostics::PRETTY` variable can generate nicer escape sequences for pagers.

Warnings dispatched from perl itself (or more accurately, those that match descriptions found in *perldiag*) are only displayed once (no duplicate descriptions). User code generated warnings ala `warn()` are unaffected, allowing duplicate user messages to be displayed.

The *splain* Program

While apparently a whole nuther program, *splain* is actually nothing more than a link to the (executable) ***diagnostics.pm*** module, as well as a link to the ***diagnostics.pod*** documentation. The **-v** flag is like the `use diagnostics -verbose` directive. The **-p** flag is like the `$diagnostics::PRETTY` variable. Since you're post-processing with *splain*, there's no sense in being able to `enable()` or `disable()` processing.

Output from *splain* is directed to **STDOUT**, unlike the pragma.

EXAMPLES

The following file is certain to trigger a few errors at both runtime and compiletime:

```
use diagnostics;
print NOWHERE "nothing\n";
print STDERR "\n\tThis message should be unadorned.\n";
warn "\tThis is a user warning";
print "\nDIAGNOSTIC TESTER: Please enter a <CR> here: ";
```

```
my $a, $b = scalar <STDIN>;
print "\n";
print $x/$y;
```

If you prefer to run your program first and look at its problem afterwards, do this:

```
perl -w test.pl 2>test.out
./splain < test.out
```

Note that this is not in general possible in shells of more dubious heritage, as the theoretical

```
(perl -w test.pl >/dev/tty) >& test.out
./splain < test.out
```

Because you just moved the existing **stdout** to somewhere else.

If you don't want to modify your source code, but still have on-the-fly warnings, do this:

```
exec 3>&1; perl -w test.pl 2>&1 1>&3 3>&- | splain 1>&2 3>&-
```

Nifty, eh?

If you want to control warnings on the fly, do something like this. Make sure you do the `use` first, or you won't be able to get at the `enable()` or `disable()` methods.

```
use diagnostics; # checks entire compilation phase
    print "\ntime for 1st bogus diags: SQUAWKINGS\n";
    print BOGUS1 'nada';
    print "done with 1st bogus\n";

disable diagnostics; # only turns off runtime warnings
    print "\ntime for 2nd bogus: (squelched)\n";
    print BOGUS2 'nada';
    print "done with 2nd bogus\n";

enable diagnostics; # turns back on runtime warnings
    print "\ntime for 3rd bogus: SQUAWKINGS\n";
    print BOGUS3 'nada';
    print "done with 3rd bogus\n";

disable diagnostics;
    print "\ntime for 4th bogus: (squelched)\n";
    print BOGUS4 'nada';
    print "done with 4th bogus\n";
```

INTERNALS

Diagnostic messages derive from the ***perldiag.pod*** file when available at runtime. Otherwise, they may be embedded in the file itself when the splain package is built. See the ***Makefile*** for details.

If an extant `$SIG{__WARN__}` handler is discovered, it will continue to be honored, but only after the `diagnostics::splainthis()` function (the module's `$SIG{__WARN__}` interceptor) has had its way with your warnings.

There is a `$diagnostics::DEBUG` variable you may set if you're desperately curious what sorts of things are being intercepted.

```
BEGIN { $diagnostics::DEBUG = 1 }
```

BUGS

Not being able to say "no diagnostics" is annoying, but may not be insurmountable.

The `-pretty` directive is called too late to affect matters. You have to do this instead, and *before* you load the module.

```
BEGIN { $diagnostics::PRETTY = 1 }
```

I could start up faster by delaying compilation until it should be needed, but this gets a "panic: top_level" when using the pragma form in Perl 5.001e.

While it's true that this documentation is somewhat subserious, if you use a program named *splain*, you should expect a bit of whimsy.

AUTHOR

Tom Christiansen ***<tchrist@mox.perl.com***, 25 June 1995.

NAME

DirHandle – supply object methods for directory handles

SYNOPSIS

```
use DirHandle;
$d = new DirHandle ".";
if (defined $d) {
    while (defined($_ = $d->read)) { something($_); }
    $d->rewind;
    while (defined($_ = $d->read)) { something_else($_); }
    undef $d;
}
```

DESCRIPTION

The `DirHandle` method provide an alternative interface to the `opendir()`, `closedir()`, `readdir()`, and `rewinddir()` functions.

The only objective benefit to using `DirHandle` is that it avoids namespace pollution by creating globs to hold directory handles.

NAME

Dumpvalue – provides screen dump of Perl data.

SYNOPSIS

```
use Dumpvalue;
my $dumper = new Dumpvalue;
$dumper->set(globPrint => 1);
$dumper->dumpValue(\*::);
$dumper->dumpvars('main');
```

DESCRIPTION

Creation

A new dumper is created by a call

```
$d = new Dumpvalue(option1 => value1, option2 => value2)
```

Recognized options:

`arrayDepth`, `hashDepth`

Print only first N elements of arrays and hashes. If false, prints all the elements.

`compactDump`, `veryCompact`

Change style of array and hash dump. If true, short array may be printed on one line.

`globPrint`

Whether to print contents of globs.

`DumpDBFiles`

Dump arrays holding contents of debugged files.

`DumpPackages`

Dump symbol tables of packages.

`DumpReused`

Dump contents of "reused" addresses.

`tick`, `HighBit`, `printUndef`

Change style of string dump. Default value of `tick` is `auto`, one can enable either double–quotish dump, or single–quotish by setting it to `"` or `'`. By default, characters with high bit set are printed *as is*.

`UsageOnly`

very rudimentally per–package memory usage dump. If set, `dumpvars` calculates total size of strings in variables in the package.

unctrl

Changes the style of printout of strings. Possible values are `unctrl` and `quote`.

subdump

Whether to try to find the subroutine name given the reference.

bareStringify

Whether to write the non–overloaded form of the stringify–overloaded objects.

quoteHighBit

Whether to print chars with high bit set in binary or "as is".

stopDbSignal

Whether to abort printing if debugger signal flag is raised.

Later in the life of the object the methods may be queries with `get()` method and `set()` method (which accept multiple arguments).

Methods

dumpValue

```
$dumper->dumpValue($value);
$dumper->dumpValue([$value1, $value2]);
```

dumpValues

```
$dumper->dumpValues($value1, $value2);
```

dumpvars

```
$dumper->dumpvars('my_package');
$dumper->dumpvars('my_package', 'foo', '~bar$', '!.....');
```

The optional arguments are considered as literal strings unless they start with `~` or `!`, in which case they are interpreted as regular expressions (possibly negated).

The second example prints entries with names `foo`, and also entries with names which ends on `bar`, or are shorter than 5 chars.

set_quote

```
$d->set_quote('"');
```

Sets `tick` and `unctrl` options to suitable values for printout with the given quote char. Possible values are `auto`, `'` and `"`.

set_unctrl

```
$d->set_unctrl('"');
```

Sets `unctrl` option with checking for an invalid argument. Possible values are `unctrl` and `quote`.

compactDump

```
$d->compactDump(1);
```

Sets `compactDump` option. If the value is 1, sets to a reasonable big number.

veryCompact

```
$d->veryCompact(1);
```

Sets `compactDump` and `veryCompact` options simultaneously.

set

```
$d->set(option1 => value1, option2 => value2);
```

get

```
@values = $d->get('option1', 'option2');
```

NAME

English – use nice English (or awk) names for ugly punctuation variables

SYNOPSIS

```
use English qw( -no_match_vars ) ;  # Avoids regex performance penalty
use English;
...
if ($ERRNO =~ /denied/) { ... }
```

DESCRIPTION

This module provides aliases for the built–in variables whose names no one seems to like to read. Variables with side–effects which get triggered just by accessing them (like `$0`) will still be affected.

For those variables that have an **awk** version, both long and short English alternatives are provided. For example, the `$/` variable can be referred to either `$RS` or `$INPUT_RECORD_SEPARATOR` if you are using the English module.

See *perlvar* for a complete list of these.

PERFORMANCE

This module can provoke sizeable inefficiencies for regular expressions, due to unfortunate implementation details. If performance matters in your application and you don't need `$PREMATCH`, `$MATCH`, or `$POSTMATCH`, try doing

```
use English qw( -no_match_vars ) ;
```

. **It is especially important to do this in modules to avoid penalizing all applications which use them.**

NAME

Env – perl module that imports environment variables as scalars or arrays

SYNOPSIS

```
use Env;
use Env qw(PATH HOME TERM);
use Env qw($SHELL @LD_LIBRARY_PATH);
```

DESCRIPTION

Perl maintains environment variables in a special hash named `%ENV`. For when this access method is inconvenient, the Perl module `Env` allows environment variables to be treated as scalar or array variables.

The `Env::import()` function ties environment variables with suitable names to global Perl variables with the same names. By default it ties all existing environment variables (`keys %ENV`) to scalars. If the `import` function receives arguments, it takes them to be a list of variables to tie; it's okay if they don't yet exist. The scalar type prefix '`$`' is inferred for any element of this list not prefixed by '`$`' or '@'. Arrays are implemented in terms of `split` and `join`, using `$Config::Config{path_sep}` as the delimiter.

After an environment variable is tied, merely use it like a normal variable. You may access its value

```
@path = split(/:/, $PATH);
print join("\n", @LD_LIBRARY_PATH), "\n";
```

or modify it

```
$PATH .= ":.";
push @LD_LIBRARY_PATH, $dir;
```

however you'd like. Bear in mind, however, that each access to a tied array variable requires splitting the environment variable's string anew.

The code:

```
use Env qw(@PATH);
push @PATH, '.';
```

is equivalent to:

```
use Env qw(PATH);
$PATH .= ":.";
```

except that if `$ENV{PATH}` started out empty, the second approach leaves it with the (odd) value "`:.`", but the first approach leaves it with "`.`".

To remove a tied environment variable from the environment, assign it the undefined value

```
undef $PATH;
undef @LD_LIBRARY_PATH;
```

LIMITATIONS

On VMS systems, arrays tied to environment variables are read–only. Attempting to change anything will cause a warning.

AUTHOR

Chip Salzenberg <***chip@fin.uucp***> and Gregor N. Purdy <***gregor@focusresearch.com***>

NAME

Exporter::Heavy – Exporter guts

SYNOPIS

(internal use only)

DESCRIPTION

No user–serviceable parts inside.

NAME

Exporter – Implements default import method for modules

SYNOPSIS

In module ModuleName.pm:

```
package ModuleName;
require Exporter;
@ISA = qw(Exporter);

@EXPORT = qw(...);            # symbols to export by default
@EXPORT_OK = qw(...);         # symbols to export on request
%EXPORT_TAGS = tag => [...];  # define names for sets of symbols
```

In other files which wish to use ModuleName:

```
use ModuleName;               # import default symbols into my package

use ModuleName qw(...);       # import listed symbols into my package

use ModuleName ();            # do not import any symbols
```

DESCRIPTION

The Exporter module implements a default `import` method which many modules choose to inherit rather than implement their own.

Perl automatically calls the `import` method when processing a `use` statement for a module. Modules and `use` are documented in *perlfunc* and *perlmod*. Understanding the concept of modules and how the `use` statement operates is important to understanding the Exporter.

How to Export

The arrays `@EXPORT` and `@EXPORT_OK` in a module hold lists of symbols that are going to be exported into the users name space by default, or which they can request to be exported, respectively. The symbols can represent functions, scalars, arrays, hashes, or typeglobs. The symbols must be given by full name with the exception that the ampersand in front of a function is optional, e.g.

```
@EXPORT    = qw(afunc $scalar @array);   # afunc is a function
@EXPORT_OK = qw(&bfunc %hash *typeglob); # explicit prefix on &bfunc
```

Selecting What To Export

Do **not** export method names!

Do **not** export anything else by default without a good reason!

Exports pollute the namespace of the module user. If you must export try to use @EXPORT_OK in preference to @EXPORT and avoid short or common symbol names to reduce the risk of name clashes.

Generally anything not exported is still accessible from outside the module using the ModuleName::item_name (or `$blessed_ref->method`) syntax. By convention you can use a leading underscore on names to informally indicate that they are ‘internal’ and not for public use.

(It is actually possible to get private functions by saying:

```
my $subref = sub { ... };
&$subref;
```

But there‘s no way to call that directly as a method, since a method must have a name in the symbol table.)

As a general rule, if the module is trying to be object oriented then export nothing. If it‘s just a collection of functions then @EXPORT_OK anything but use @EXPORT with caution.

Other module design guidelines can be found in *perlmod*.

Specialised Import Lists

If the first entry in an import list begins with !, : or / then the list is treated as a series of specifications which either add to or delete from the list of names to import. They are processed left to right. Specifications are in the form:

```
[!]name         This name only
[!]:DEFAULT     All names in @EXPORT
[!]:tag         All names in $EXPORT_TAGS{tag} anonymous list
[!]/pattern/    All names in @EXPORT and @EXPORT_OK which match
```

A leading ! indicates that matching names should be deleted from the list of names to import. If the first specification is a deletion it is treated as though preceded by :DEFAULT. If you just want to import extra names in addition to the default set you will still need to include :DEFAULT explicitly.

e.g., Module.pm defines:

```
@EXPORT      = qw(A1 A2 A3 A4 A5);
@EXPORT_OK   = qw(B1 B2 B3 B4 B5);
%EXPORT_TAGS = (T1 => [qw(A1 A2 B1 B2)], T2 => [qw(A1 A2 B3 B4)]);

Note that you cannot use tags in @EXPORT or @EXPORT_OK.
Names in EXPORT_TAGS must also appear in @EXPORT or @EXPORT_OK.
```

An application using Module can say something like:

```
use Module qw(:DEFAULT :T2 !B3 A3);
```

Other examples include:

```
use Socket qw(!/^[AP]F_/ !SOMAXCONN !SOL_SOCKET);
use POSIX  qw(:errno_h :termios_h !TCSADRAIN !/^EXIT/);
```

Remember that most patterns (using //) will need to be anchored with a leading ^, e.g., `/^EXIT/` rather than `/EXIT/`.

You can say `BEGIN { $Exporter::Verbose=1 }` to see how the specifications are being processed and what is actually being imported into modules.

Exporting without using Export‘s import method

Exporter has a special method, ‘export_to_level’ which is used in situations where you can‘t directly call Export‘s import method. The export_to_level method looks like:

MyPackage–export_to_level($where_to_export, $package, @what_to_export);

where `$where_to_export` is an integer telling how far up the calling stack to export your symbols, and @what_to_export is an array telling what symbols *to* export (usually this is @_). The `$package` argument is currently unused.

For example, suppose that you have a module, A, which already has an import function:

package A;

@ISA = qw(Exporter); @EXPORT_OK = qw ($b);

sub import {
  $A::b = 1; # not a very useful import method
}

and you want to Export symbol `$A::b` back to the module that called package A. Since Exporter relies on the import method to work, via inheritance, as it stands `Exporter::import()` will never get called. Instead, say the following:

package A; @ISA = qw(Exporter); @EXPORT_OK = qw ($b);

```
sub import {
  $A::b = 1;
  A–export_to_level(1, @_);
}
```

This will export the symbols one level 'above' the current package – ie: to the program or module that used package A.

Note: Be careful not to modify '@_' at all before you call export_to_level – or people using your package will get very unexplained results!

Module Version Checking

The Exporter module will convert an attempt to import a number from a module into a call to `$module_name–>require_version($value)`. This can be used to validate that the version of the module being used is greater than or equal to the required version.

The Exporter module supplies a default require_version method which checks the value of `$VERSION` in the exporting module.

Since the default require_version method treats the `$VERSION` number as a simple numeric value it will regard version 1.10 as lower than 1.9. For this reason it is strongly recommended that you use numbers with at least two decimal places, e.g., 1.09.

Managing Unknown Symbols

In some situations you may want to prevent certain symbols from being exported. Typically this applies to extensions which have functions or constants that may not exist on some systems.

The names of any symbols that cannot be exported should be listed in the `@EXPORT_FAIL` array.

If a module attempts to import any of these symbols the Exporter will give the module an opportunity to handle the situation before generating an error. The Exporter will call an export_fail method with a list of the failed symbols:

```
@failed_symbols = $module_name–>export_fail(@failed_symbols);
```

If the export_fail method returns an empty list then no error is recorded and all the requested symbols are exported. If the returned list is not empty then an error is generated for each symbol and the export fails. The Exporter provides a default export_fail method which simply returns the list unchanged.

Uses for the export_fail method include giving better error messages for some symbols and performing lazy architectural checks (put more symbols into @EXPORT_FAIL by default and then take them out if someone actually tries to use them and an expensive check shows that they are usable on that platform).

Tag Handling Utility Functions

Since the symbols listed within %EXPORT_TAGS must also appear in either @EXPORT or @EXPORT_OK, two utility functions are provided which allow you to easily add tagged sets of symbols to @EXPORT or @EXPORT_OK:

```
%EXPORT_TAGS = (foo => [qw(aa bb cc)], bar => [qw(aa cc dd)]);

Exporter::export_tags('foo');     # add aa, bb and cc to @EXPORT
Exporter::export_ok_tags('bar');  # add aa, cc and dd to @EXPORT_OK
```

Any names which are not tags are added to @EXPORT or @EXPORT_OK unchanged but will trigger a warning (with `–w`) to avoid misspelt tags names being silently added to @EXPORT or @EXPORT_OK. Future versions may make this a fatal error.

NAME

ExtUtils::Command – utilities to replace common UNIX commands in Makefiles etc.

SYNOPSIS

```
perl -MExtUtils::Command -e cat files... > destination
perl -MExtUtils::Command -e mv source... destination
perl -MExtUtils::Command -e cp source... destination
perl -MExtUtils::Command -e touch files...
perl -MExtUtils::Command -e rm_f file...
perl -MExtUtils::Command -e rm_rf directories...
perl -MExtUtils::Command -e mkpath directories...
perl -MExtUtils::Command -e eqtime source destination
perl -MExtUtils::Command -e chmod mode files...
perl -MExtUtils::Command -e test_f file
```

DESCRIPTION

The module is used in the Win32 port to replace common UNIX commands. Most commands are wrappers on generic modules File::Path and File::Basename.

cat Concatenates all files mentioned on command line to STDOUT.

eqtime src dst

Sets modified time of dst to that of src

rm_f files....

Removes directories – recursively (even if readonly)

rm_f files....

Removes files (even if readonly)

touch files ...

Makes files exist, with current timestamp

mv source... destination

Moves source to destination. Multiple sources are allowed if destination is an existing directory.

cp source... destination

Copies source to destination. Multiple sources are allowed if destination is an existing directory.

chmod mode files...

Sets UNIX like permissions ‘mode’ on all the files.

mkpath directory...

Creates directory, including any parent directories.

test_f file

Tests if a file exists

BUGS

Should probably be Auto/Self loaded.

SEE ALSO

ExtUtils::MakeMaker, ExtUtils::MM_Unix, ExtUtils::MM_Win32

AUTHOR

Nick Ing–Simmons ***<nick@ni–s.u–net.com>***.

NAME

ExtUtils::Embed − Utilities for embedding Perl in C/C++ applications

SYNOPSIS

```
perl -MExtUtils::Embed -e xsinit
perl -MExtUtils::Embed -e ldopts
```

DESCRIPTION

ExtUtils::Embed provides utility functions for embedding a Perl interpreter and extensions in your C/C++ applications. Typically, an application **Makefile** will invoke ExtUtils::Embed functions while building your application.

@EXPORT

ExtUtils::Embed exports the following functions:

`xsinit()`, `ldopts()`, `ccopts()`, `perl_inc()`, `ccflags()`, `ccdlflags()`, `xsi_header()`, `xsi_protos()`, `xsi_body()`

FUNCTIONS

`xsinit()`

Generate C/C++ code for the XS initializer function.

When invoked as `'perl -MExtUtils::Embed -e xsinit −'` the following options are recognized:

−o <output filename> (Defaults to **perlxsi.c**)

−o STDOUT will print to STDOUT.

−std (Write code for extensions that are linked with the current Perl.)

Any additional arguments are expected to be names of modules to generate code for.

When invoked with parameters the following are accepted and optional:

```
xsinit($filename,$std,[@modules])
```

Where,

`$filename` is equivalent to the **−o** option.

`$std` is boolean, equivalent to the **−std** option.

[@modules] is an array ref, same as additional arguments mentioned above.

Examples

```
perl -MExtUtils::Embed -e xsinit -- -o xsinit.c Socket
```

This will generate code with an **xs_init** function that glues the perl **Socket::bootstrap** function to the C **boot_Socket** function and writes it to a file named ***xsinit.c***.

Note that **DynaLoader** is a special case where it must call **boot_DynaLoader** directly.

```
perl -MExtUtils::Embed -e xsinit
```

This will generate code for linking with **DynaLoader** and each static extension found in **`$Config{static_ext}`.** The code is written to the default file name **perlxsi.c**.

```
perl -MExtUtils::Embed -e xsinit -- -o xsinit.c -std DBI DBD::Oracle
```

Here, code is written for all the currently linked extensions along with code for **DBI** and **DBD::Oracle**.

If you have a working **DynaLoader** then there is rarely any need to statically link in any other

extensions.

`ldopts()`

Output arguments for linking the Perl library and extensions to your application.

When invoked as `'perl -MExtUtils::Embed -e ldopts -'` the following options are recognized:

-std

Output arguments for linking the Perl library and any extensions linked with the current Perl.

-I <path1:path2>

Search path for ModuleName.a archives. Default path is **@INC**. Library archives are expected to be found as **/some/path/auto/ModuleName/ModuleName.a** For example, when looking for **Socket.a** relative to a search path, we should find **auto/Socket/Socket.a**

When looking for **DBD::Oracle** relative to a search path, we should find **auto/DBD/Oracle/Oracle.a**

Keep in mind that you can always supply **/my/own/path/ModuleName.a** as an additional linker argument.

— <list of linker args>

Additional linker arguments to be considered.

Any additional arguments found before the **—** token are expected to be names of modules to generate code for.

When invoked with parameters the following are accepted and optional:

```
ldopts($std,[@modules],[@link_args],$path)
```

Where:

$std is boolean, equivalent to the **-std** option.

[@modules] is equivalent to additional arguments found before the **—** token.

[@link_args] is equivalent to arguments found after the **—** token.

$path is equivalent to the **-I** option.

In addition, when ldopts is called with parameters, it will return the argument string rather than print it to STDOUT.

Examples

```
perl -MExtUtils::Embed -e ldopts
```

This will print arguments for linking with **libperl.a**, **DynaLoader** and extensions found in **$Config{static_ext}**. This includes libraries found in **$Config{libs}** and the first ModuleName.a library for each extension that is found by searching **@INC** or the path specified by the **-I** option. In addition, when ModuleName.a is found, additional linker arguments are picked up from the **extralibs.ld** file in the same directory.

```
perl -MExtUtils::Embed -e ldopts -- -std Socket
```

This will do the same as the above example, along with printing additional arguments for linking with the **Socket** extension.

```
perl -MExtUtils::Embed -e ldopts -- DynaLoader
```

This will print arguments for linking with just the **DynaLoader** extension and **libperl.a**.

```
perl -MExtUtils::Embed -e ldopts -- -std Msql -- -L/usr/msql/lib -lmsql
```

Any arguments after the second '—' token are additional linker arguments that will be examined for potential conflict. If there is no conflict, the additional arguments will be part of the output.

`perl_inc()`

For including perl header files this function simply prints:

```
-I$Config{archlibexp}/CORE
```

So, rather than having to say:

```
perl -MConfig -e 'print "-I$Config{archlibexp}/CORE"'
```

Just say:

```
perl -MExtUtils::Embed -e perl_inc
```

`ccflags()`, `ccdlflags()`

These functions simply print `$Config{ccflags}` and `$Config{ccdlflags}`

`ccopts()`

This function combines `perl_inc()`, `ccflags()` and `ccdlflags()` into one.

`xsi_header()`

This function simply returns a string defining the same **EXTERN_C** macro as **perlmain.c** along with #including **perl.h** and **EXTERN.h**.

xsi_protos(@modules)

This function returns a string of **boot_$ModuleName** prototypes for each @modules.

xsi_body(@modules)

This function returns a string of calls to **newXS()** that glue the module **bootstrap** function to **boot_ModuleName** for each @modules.

xsinit() uses the xsi_* functions to generate most of it's code.

EXAMPLES

For examples on how to use **ExtUtils::Embed** for building C/C++ applications with embedded perl, see *perlembed*.

SEE ALSO

perlembed

AUTHOR

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Based on ideas from Tim Bunce *<Tim.Bunce@ig.co.uk>* and **minimod.pl** by Andreas Koenig *<k@anna.in-berlin.de>* and Tim Bunce.

NAME

ExtUtils::Install – install files from here to there

SYNOPSIS

use ExtUtils::Install;

install($hashref,$verbose,$nonono);

uninstall($packlistfile,$verbose,$nonono);

pm_to_blib($hashref);

DESCRIPTION

Both `install()` and `uninstall()` are specific to the way ExtUtils::MakeMaker handles the installation and deinstallation of perl modules. They are not designed as general purpose tools.

`install()` takes three arguments. A reference to a hash, a verbose switch and a don't–really–do–it switch. The hash ref contains a mapping of directories: each key/value pair is a combination of directories to be copied. Key is a directory to copy from, value is a directory to copy to. The whole tree below the "from" directory will be copied preserving timestamps and permissions.

There are two keys with a special meaning in the hash: "read" and "write". After the copying is done, install will write the list of target files to the file named by `$hashref->{write}`. If there is another file named by `$hashref->{read}`, the contents of this file will be merged into the written file. The read and the written file may be identical, but on AFS it is quite likely that people are installing to a different directory than the one where the files later appear.

`install_default()` takes one or less arguments. If no arguments are specified, it takes `$ARGV[0]` as if it was specified as an argument. The argument is the value of MakeMaker's `FULLEXT` key, like ***Tk/Canvas***. This function calls `install()` with the same arguments as the defaults the MakeMaker would use.

The argument–less form is convenient for install scripts like

```
perl -MExtUtils::Install -e install_default Tk/Canvas
```

Assuming this command is executed in a directory with a populated ***blib*** directory, it will proceed as if the ***blib*** was build by MakeMaker on this machine. This is useful for binary distributions.

`uninstall()` takes as first argument a file containing filenames to be unlinked. The second argument is a verbose switch, the third is a no–don't–really–do–it–now switch.

`pm_to_blib()` takes a hashref as the first argument and copies all keys of the hash to the corresponding values efficiently. Filenames with the extension pm are autosplit. Second argument is the autosplit directory.

You can have an environment variable PERL_INSTALL_ROOT set which will be prepended as a directory to each installed file (and directory).

NAME

ExtUtils::Installed – Inventory management of installed modules

SYNOPSIS

```
use ExtUtils::Installed;
my ($inst) = ExtUtils::Installed->new();
my (@modules) = $inst->modules();
my (@missing) = $inst->validate("DBI");
my $all_files = $inst->files("DBI");
my $files_below_usr_local = $inst->files("DBI", "all", "/usr/local");
my $all_dirs = $inst->directories("DBI");
my $dirs_below_usr_local = $inst->directory_tree("DBI", "prog");
my $packlist = $inst->packlist("DBI");
```

DESCRIPTION

ExtUtils::Installed provides a standard way to find out what core and module files have been installed. It uses the information stored in .packlist files created during installation to provide this information. In addition it provides facilities to classify the installed files and to extract directory information from the .packlist files.

USAGE

The `new()` function searches for all the installed .packlists on the system, and stores their contents. The .packlists can be queried with the functions described below.

FUNCTIONS

`new()`

This takes no parameters, and searches for all the installed .packlists on the system. The packlists are read using the ExtUtils::packlist module.

`modules()`

This returns a list of the names of all the installed modules. The perl 'core' is given the special name 'Perl'.

`files()`

This takes one mandatory parameter, the name of a module. It returns a list of all the filenames from the package. To obtain a list of core perl files, use the module name 'Perl'. Additional parameters are allowed. The first is one of the strings "prog", "man" or "all", to select either just program files, just manual files or all files. The remaining parameters are a list of directories. The filenames returned will be restricted to those under the specified directories.

`directories()`

This takes one mandatory parameter, the name of a module. It returns a list of all the directories from the package. Additional parameters are allowed. The first is one of the strings "prog", "man" or "all", to select either just program directories, just manual directories or all directories. The remaining parameters are a list of directories. The directories returned will be restricted to those under the specified directories. This method returns only the leaf directories that contain files from the specified module.

`directory_tree()`

This is identical in operation to `directory()`, except that it includes all the intermediate directories back up to the specified directories.

`validate()`

This takes one mandatory parameter, the name of a module. It checks that all the files listed in the modules .packlist actually exist, and returns a list of any missing files. If an optional second argument which evaluates to true is given any missing files will be removed from the .packlist

packlist()

This returns the ExtUtils::Packlist object for the specified module.

`version()`

This returns the version number for the specified module.

EXAMPLE

See the example in *ExtUtils::Packlist*.

AUTHOR

Alan Burlison <Alan.Burlison@uk.sun.com

NAME

ExtUtils::Liblist – determine libraries to use and how to use them

SYNOPSIS

```
require ExtUtils::Liblist;

ExtUtils::Liblist::ext($self, $potential_libs, $verbose);
```

DESCRIPTION

This utility takes a list of libraries in the form `-llib1 -llib2 -llib3` and prints out lines suitable for inclusion in an extension Makefile. Extra library paths may be included with the form `-L/another/path` this will affect the searches for all subsequent libraries.

It returns an array of four scalar values: EXTRALIBS, BSLOADLIBS, LDLOADLIBS, and LD_RUN_PATH. Some of these don't mean anything on VMS and Win32. See the details about those platform specifics below.

Dependent libraries can be linked in one of three ways:

- For static extensions

  by the ld command when the perl binary is linked with the extension library. See EXTRALIBS below.

- For dynamic extensions

  by the ld command when the shared object is built/linked. See LDLOADLIBS below.

- For dynamic extensions

  by the DynaLoader when the shared object is loaded. See BSLOADLIBS below.

EXTRALIBS

List of libraries that need to be linked with when linking a perl binary which includes this extension. Only those libraries that actually exist are included. These are written to a file and used when linking perl.

LDLOADLIBS and LD_RUN_PATH

List of those libraries which can or must be linked into the shared library when created using ld. These may be static or dynamic libraries. LD_RUN_PATH is a colon separated list of the directories in LDLOADLIBS. It is passed as an environment variable to the process that links the shared library.

BSLOADLIBS

List of those libraries that are needed but can be linked in dynamically at run time on this platform. SunOS/Solaris does not need this because ld records the information (from LDLOADLIBS) into the object file. This list is used to create a .bs (bootstrap) file.

PORTABILITY

This module deals with a lot of system dependencies and has quite a few architecture specific `ifs` in the code.

VMS implementation

The version of `ext()` which is executed under VMS differs from the Unix–OS/2 version in several respects:

- Input library and path specifications are accepted with or without the `-l` and `-L` prefixes used by Unix linkers. If neither prefix is present, a token is considered a directory to search if it is in fact a directory, and a library to search for otherwise. Authors who wish their extensions to be portable to Unix or OS/2 should use the Unix prefixes, since the Unix–OS/2 version of `ext()` requires them.

- Wherever possible, shareable images are preferred to object libraries, and object libraries to plain object files. In accordance with VMS naming conventions, `ext()` looks for files named *lib*shr and *lib*rtl; it also looks for *lib*lib and lib*lib* to accommodate Unix conventions used in some ported software.

- For each library that is found, an appropriate directive for a linker options file is generated. The return values are space−separated strings of these directives, rather than elements used on the linker command line.
- LDLOADLIBS contains both the libraries found based on `$potential_libs` and the CRTLs, if any, specified in Config.pm. EXTRALIBS contains just those libraries found based on `$potential_libs`. BSLOADLIBS and LD_RUN_PATH are always empty.

In addition, an attempt is made to recognize several common Unix library names, and filter them out or convert them to their VMS equivalents, as appropriate.

In general, the VMS version of `ext()` should properly handle input from extensions originally designed for a Unix or VMS environment. If you encounter problems, or discover cases where the search could be improved, please let us know.

Win32 implementation

The version of `ext()` which is executed under Win32 differs from the Unix−OS/2 version in several respects:

- If `$potential_libs` is empty, the return value will be empty. Otherwise, the libraries specified by `$Config{perllibs}` (see Config.pm) will be appended to the list of `$potential_libs`. The libraries will be searched for in the directories specified in `$potential_libs`, `$Config{libpth}`, and in `$Config{installarchlib}/CORE`. For each library that is found, a space−separated list of fully qualified library pathnames is generated.
- Input library and path specifications are accepted with or without the `-l` and `-L` prefixes used by Unix linkers.

  An entry of the form `-La:\foo` specifies the `a:\foo` directory to look for the libraries that follow.

  An entry of the form `-lfoo` specifies the library `foo`, which may be spelled differently depending on what kind of compiler you are using. If you are using GCC, it gets translated to `libfoo.a`, but for other win32 compilers, it becomes `foo.lib`. If no files are found by those translated names, one more attempt is made to find them using either `foo.a` or `libfoo.lib`, depending on whether GCC or some other win32 compiler is being used, respectively.

  If neither the `-L` or `-l` prefix is present in an entry, the entry is considered a directory to search if it is in fact a directory, and a library to search for otherwise. The `$Config{lib_ext}` suffix will be appended to any entries that are not directories and don't already have the suffix.

  Note that the `-L` and `-l` prefixes are **not required**, but authors who wish their extensions to be portable to Unix or OS/2 should use the prefixes, since the Unix−OS/2 version of `ext()` requires them.
- Entries cannot be plain object files, as many Win32 compilers will not handle object files in the place of libraries.
- Entries in `$potential_libs` beginning with a colon and followed by alphanumeric characters are treated as flags. Unknown flags will be ignored.

  An entry that matches `/:nodefault/i` disables the appending of default libraries found in `$Config{perllibs}` (this should be only needed very rarely).

  An entry that matches `/:nosearch/i` disables all searching for the libraries specified after it. Translation of `-Lfoo` and `-lfoo` still happens as appropriate (depending on compiler being used, as reflected by `$Config{cc}`), but the entries are not verified to be valid files or directories.

  An entry that matches `/:search/i` reenables searching for the libraries specified after it. You can put it at the end to enable searching for default libraries specified by `$Config{perllibs}`.
- The libraries specified may be a mixture of static libraries and import libraries (to link with DLLs). Since both kinds are used pretty transparently on the Win32 platform, we do not attempt to distinguish between them.

- LDLOADLIBS and EXTRALIBS are always identical under Win32, and BSLOADLIBS and LD_RUN_PATH are always empty (this may change in future).
- You must make sure that any paths and path components are properly surrounded with double–quotes if they contain spaces. For example, `$potential_libs` could be (literally):

  ```
  "-Lc:\Program Files\vc\lib" msvcrt.lib "la test\foo bar.lib"
  ```

  Note how the first and last entries are protected by quotes in order to protect the spaces.
- Since this module is most often used only indirectly from extension `Makefile.PL` files, here is an example `Makefile.PL` entry to add a library to the build process for an extension:

  ```
  LIBS => ['-lgl']
  ```

  When using GCC, that entry specifies that MakeMaker should first look for `libgl.a` (followed by `gl.a`) in all the locations specified by `$Config{libpth}`.

  When using a compiler other than GCC, the above entry will search for `gl.lib` (followed by `libgl.lib`).

  If the library happens to be in a location not in `$Config{libpth}`, you need:

  ```
  LIBS => ['-Lc:\gllibs -lgl']
  ```

  Here is a less often used example:

  ```
  LIBS => ['-lgl', ':nosearch -Ld:\mesalibs -lmesa -luser32']
  ```

  This specifies a search for library `gl` as before. If that search fails to find the library, it looks at the next item in the list. The `:nosearch` flag will prevent searching for the libraries that follow, so it simply returns the value as `-Ld:\mesalibs -lmesa -luser32`, since GCC can use that value as is with its linker.

  When using the Visual C compiler, the second item is returned as `-libpath:d:\mesalibs mesa.lib user32.lib`.

  When using the Borland compiler, the second item is returned as `-Ld:\mesalibs mesa.lib user32.lib`, and MakeMaker takes care of moving the `-Ld:\mesalibs` to the correct place in the linker command line.

SEE ALSO

ExtUtils::MakeMaker

NAME

ExtUtils::MakeMaker – create an extension Makefile

SYNOPSIS

```
use ExtUtils::MakeMaker;

WriteMakefile( ATTRIBUTE => VALUE [, ...] );
```

which is really

```
MM->new(\%att)->flush;
```

DESCRIPTION

This utility is designed to write a Makefile for an extension module from a Makefile.PL. It is based on the Makefile.SH model provided by Andy Dougherty and the perl5–porters.

It splits the task of generating the Makefile into several subroutines that can be individually overridden. Each subroutine returns the text it wishes to have written to the Makefile.

MakeMaker is object oriented. Each directory below the current directory that contains a Makefile.PL. Is treated as a separate object. This makes it possible to write an unlimited number of Makefiles with a single invocation of `WriteMakefile()`.

How To Write A Makefile.PL

The short answer is: Don‘t.

```
Always begin with h2xs.
Always begin with h2xs!
ALWAYS BEGIN WITH H2XS!
```

even if you‘re not building around a header file, and even if you don‘t have an XS component.

Run h2xs(1) before you start thinking about writing a module. For so called pm–only modules that consist of `*.pm` files only, h2xs has the `–X` switch. This will generate dummy files of all kinds that are useful for the module developer.

The medium answer is:

```
use ExtUtils::MakeMaker;
WriteMakefile( NAME => "Foo::Bar" );
```

The long answer is the rest of the manpage :–)

Default Makefile Behaviour

The generated Makefile enables the user of the extension to invoke

```
perl Makefile.PL # optionally "perl Makefile.PL verbose"
make
make test        # optionally set TEST_VERBOSE=1
make install     # See below
```

The Makefile to be produced may be altered by adding arguments of the form `KEY=VALUE`. E.g.

```
perl Makefile.PL PREFIX=/tmp/myperl5
```

Other interesting targets in the generated Makefile are

```
make config     # to check if the Makefile is up-to-date
make clean      # delete local temp files (Makefile gets renamed)
make realclean  # delete derived files (including ./blib)
make ci         # check in all the files in the MANIFEST file
make dist       # see below the Distribution Support section
```

make test

MakeMaker checks for the existence of a file named ***test.pl*** in the current directory and if it exists it adds commands to the test target of the generated Makefile that will execute the script with the proper set of perl `-I` options.

MakeMaker also checks for any files matching glob("t/*.t"). It will add commands to the test target of the generated Makefile that execute all matching files via the *Test::Harness* module with the `-I` switches set correctly.

make testdb

A useful variation of the above is the target `testdb`. It runs the test under the Perl debugger (see *perldebug*). If the file ***test.pl*** exists in the current directory, it is used for the test.

If you want to debug some other testfile, set `TEST_FILE` variable thusly:

```
make testdb TEST_FILE=t/mytest.t
```

By default the debugger is called using `-d` option to perl. If you want to specify some other option, set `TESTDB_SW` variable:

```
make testdb TESTDB_SW=-Dx
```

make install

make alone puts all relevant files into directories that are named by the macros INST_LIB, INST_ARCHLIB, INST_SCRIPT, INST_HTMLLIBDIR, INST_HTMLSCRIPTDIR, INST_MAN1DIR, and INST_MAN3DIR. All these default to something below ./blib if you are *not* building below the perl source directory. If you *are* building below the perl source, INST_LIB and INST_ARCHLIB default to ../../lib, and INST_SCRIPT is not defined.

The *install* target of the generated Makefile copies the files found below each of the INST_* directories to their INSTALL* counterparts. Which counterparts are chosen depends on the setting of INSTALLDIRS according to the following table:

```
                              INSTALLDIRS set to
                           perl                 site

INST_ARCHLIB         INSTALLARCHLIB         INSTALLSITEARCH
INST_LIB             INSTALLPRIVLIB         INSTALLSITELIB
INST_HTMLLIBDIR      INSTALLHTMLPRIVLIBDIR  INSTALLHTMLSITELIBDIR
INST_HTMLSCRIPTDIR             INSTALLHTMLSCRIPTDIR
INST_BIN                       INSTALLBIN
INST_SCRIPT                    INSTALLSCRIPT
INST_MAN1DIR                   INSTALLMAN1DIR
INST_MAN3DIR                   INSTALLMAN3DIR
```

The INSTALL... macros in turn default to their %Config (`$Config{installprivlib}`, `$Config{installarchlib}`, etc.) counterparts.

You can check the values of these variables on your system with

```
perl '-V:install.*'
```

And to check the sequence in which the library directories are searched by perl, run

```
perl -le 'print join $/, @INC'
```

PREFIX and LIB attribute

PREFIX and LIB can be used to set several INSTALL* attributes in one go. The quickest way to install a module in a non-standard place might be

```
perl Makefile.PL LIB=~/lib
```

This will install the module's architecture−independent files into ~/lib, the architecture−dependent files into ~/lib/$archname.

Another way to specify many INSTALL directories with a single parameter is PREFIX.

```
perl Makefile.PL PREFIX=~
```

This will replace the string specified by $Config{prefix} in all $Config{install*} values.

Note, that in both cases the tilde expansion is done by MakeMaker, not by perl by default, nor by make.

Conflicts between parameters LIB, PREFIX and the various INSTALL* arguments are resolved so that:

- setting LIB overrides any setting of INSTALLPRIVLIB, INSTALLARCHLIB, INSTALLSITELIB, INSTALLSITEARCH (and they are not affected by PREFIX);
- without LIB, setting PREFIX replaces the initial $Config{prefix} part of those INSTALL* arguments, even if the latter are explicitly set (but are set to still start with $Config{prefix}).

If the user has superuser privileges, and is not working on AFS or relatives, then the defaults for INSTALLPRIVLIB, INSTALLARCHLIB, INSTALLSCRIPT, etc. will be appropriate, and this incantation will be the best:

```
perl Makefile.PL; make; make test
make install
```

make install per default writes some documentation of what has been done into the file $(INSTALLARCHLIB)/perllocal.pod. This feature can be bypassed by calling make pure_install.

AFS users

will have to specify the installation directories as these most probably have changed since perl itself has been installed. They will have to do this by calling

```
perl Makefile.PL INSTALLSITELIB=/afs/here/today \
    INSTALLSCRIPT=/afs/there/now INSTALLMAN3DIR=/afs/for/manpages
make
```

Be careful to repeat this procedure every time you recompile an extension, unless you are sure the AFS installation directories are still valid.

Static Linking of a new Perl Binary

An extension that is built with the above steps is ready to use on systems supporting dynamic loading. On systems that do not support dynamic loading, any newly created extension has to be linked together with the available resources. MakeMaker supports the linking process by creating appropriate targets in the Makefile whenever an extension is built. You can invoke the corresponding section of the makefile with

```
make perl
```

That produces a new perl binary in the current directory with all extensions linked in that can be found in INST_ARCHLIB , SITELIBEXP, and PERL_ARCHLIB. To do that, MakeMaker writes a new Makefile, on UNIX, this is called Makefile.aperl (may be system dependent). If you want to force the creation of a new perl, it is recommended, that you delete this Makefile.aperl, so the directories are searched−through for linkable libraries again.

The binary can be installed into the directory where perl normally resides on your machine with

```
make inst_perl
```

To produce a perl binary with a different name than perl, either say

```
perl Makefile.PL MAP_TARGET=myperl
make myperl
make inst_perl
```

or say

```
perl Makefile.PL
make myperl MAP_TARGET=myperl
make inst_perl MAP_TARGET=myperl
```

In any case you will be prompted with the correct invocation of the `inst_perl` target that installs the new binary into INSTALLBIN.

make inst_perl per default writes some documentation of what has been done into the file `$(INSTALLARCHLIB)/perllocal.pod`. This can be bypassed by calling make pure_inst_perl.

Warning: the inst_perl: target will most probably overwrite your existing perl binary. Use with care!

Sometimes you might want to build a statically linked perl although your system supports dynamic loading. In this case you may explicitly set the linktype with the invocation of the Makefile.PL or make:

```
perl Makefile.PL LINKTYPE=static    # recommended
```

or

```
make LINKTYPE=static                # works on most systems
```

Determination of Perl Library and Installation Locations

MakeMaker needs to know, or to guess, where certain things are located. Especially INST_LIB and INST_ARCHLIB (where to put the files during the make(1) run), PERL_LIB and PERL_ARCHLIB (where to read existing modules from), and PERL_INC (header files and `libperl*.*`).

Extensions may be built either using the contents of the perl source directory tree or from the installed perl library. The recommended way is to build extensions after you have run 'make install' on perl itself. You can do that in any directory on your hard disk that is not below the perl source tree. The support for extensions below the ext directory of the perl distribution is only good for the standard extensions that come with perl.

If an extension is being built below the `ext/` directory of the perl source then MakeMaker will set PERL_SRC automatically (e.g., `../..`). If PERL_SRC is defined and the extension is recognized as a standard extension, then other variables default to the following:

```
PERL_INC     = PERL_SRC
PERL_LIB     = PERL_SRC/lib
PERL_ARCHLIB = PERL_SRC/lib
INST_LIB     = PERL_LIB
INST_ARCHLIB = PERL_ARCHLIB
```

If an extension is being built away from the perl source then MakeMaker will leave PERL_SRC undefined and default to using the installed copy of the perl library. The other variables default to the following:

```
PERL_INC     = $archlibexp/CORE
PERL_LIB     = $privlibexp
PERL_ARCHLIB = $archlibexp
INST_LIB     = ./blib/lib
INST_ARCHLIB = ./blib/arch
```

If perl has not yet been installed then PERL_SRC can be defined on the command line as shown in the previous section.

Which architecture dependent directory?

If you don't want to keep the defaults for the INSTALL* macros, MakeMaker helps you to minimize the typing needed: the usual relationship between INSTALLPRIVLIB and INSTALLARCHLIB is determined by Configure at perl compilation time. MakeMaker supports the user who sets INSTALLPRIVLIB. If INSTALLPRIVLIB is set, but INSTALLARCHLIB not, then MakeMaker defaults the latter to be the same subdirectory of INSTALLPRIVLIB as Configure decided for the counterparts in %Config , otherwise it defaults to INSTALLPRIVLIB. The same relationship holds for INSTALLSITELIB and

INSTALLSITEARCH.

MakeMaker gives you much more freedom than needed to configure internal variables and get different results. It is worth to mention, that make(1) also lets you configure most of the variables that are used in the Makefile. But in the majority of situations this will not be necessary, and should only be done if the author of a package recommends it (or you know what you're doing).

Using Attributes and Parameters

The following attributes can be specified as arguments to `WriteMakefile()` or as NAME=VALUE pairs on the command line:

ABSTRACT

One line description of the module. Will be included in PPD file.

ABSTRACT_FROM

Name of the file that contains the package description. MakeMaker looks for a line in the POD matching `/^($package\s-\s)(.*)/`. This is typically the first line in the "=head1 NAME" section. `$2` becomes the abstract.

AUTHOR

String containing name (and email address) of package author(s). Is used in PPD (Perl Package Description) files for PPM (Perl Package Manager).

BINARY_LOCATION

Used when creating PPD files for binary packages. It can be set to a full or relative path or URL to the binary archive for a particular architecture. For example:

```
perl Makefile.PL BINARY_LOCATION=x86/Agent.tar.gz
```

builds a PPD package that references a binary of the `Agent` package, located in the `x86` directory relative to the PPD itself.

C

Ref to array of *.c file names. Initialised from a directory scan and the values portion of the XS attribute hash. This is not currently used by MakeMaker but may be handy in Makefile.PLs.

CAPI

[This attribute is obsolete in Perl 5.6. PERL_OBJECT builds are C−compatible by default.]

Switch to force usage of the Perl C API even when compiling for PERL_OBJECT.

Note that this attribute is passed through to any recursive build, but if and only if the submodule's Makefile.PL itself makes no mention of the 'CAPI' attribute.

CCFLAGS

String that will be included in the compiler call command line between the arguments INC and OPTIMIZE.

CONFIG

Arrayref. E.g. [qw(archname manext)] defines ARCHNAME & MANEXT from config.sh. MakeMaker will add to CONFIG the following values anyway: ar cc cccdlflags ccdlflags dlext dlsrc ld lddlflags ldflags libc lib_ext obj_ext ranlib sitelibexp sitearchexp so

CONFIGURE

CODE reference. The subroutine should return a hash reference. The hash may contain further attributes, e.g. {LIBS => ...}, that have to be determined by some evaluation method.

DEFINE

Something like `"-DHAVE_UNISTD_H"`

DIR

Ref to array of subdirectories containing Makefile.PLs e.g. ['sdbm'] in ext/SDBM_File

DISTNAME

Your name for distributing the package (by tar file). This defaults to NAME above.

DL_FUNCS

Hashref of symbol names for routines to be made available as universal symbols. Each key/value pair consists of the package name and an array of routine names in that package. Used only under AIX, OS/2, VMS and Win32 at present. The routine names supplied will be expanded in the same way as XSUB names are expanded by the `XS()` macro. Defaults to

```
{"$(NAME)" => ["boot_$(NAME)" ] }
```

e.g.

```
{"RPC" => [qw( boot_rpcb rpcb_gettime getnetconfigent )],
 "NetconfigPtr" => [ 'DESTROY'] }
```

Please see the *ExtUtils::Mksymlists* documentation for more information about the DL_FUNCS, DL_VARS and FUNCLIST attributes.

DL_VARS

Array of symbol names for variables to be made available as universal symbols. Used only under AIX, OS/2, VMS and Win32 at present. Defaults to []. (e.g. [qw(Foo_version Foo_numstreams Foo_tree)])

EXCLUDE_EXT

Array of extension names to exclude when doing a static build. This is ignored if INCLUDE_EXT is present. Consult INCLUDE_EXT for more details. (e.g. [qw(Socket POSIX)])

This attribute may be most useful when specified as a string on the command line: perl Makefile.PL EXCLUDE_EXT='Socket Safe'

EXE_FILES

Ref to array of executable files. The files will be copied to the INST_SCRIPT directory. Make realclean will delete them from there again.

FIRST_MAKEFILE

The name of the Makefile to be produced. Defaults to the contents of MAKEFILE, but can be overridden. This is used for the second Makefile that will be produced for the MAP_TARGET.

FULLPERL

Perl binary able to run this extension.

FUNCLIST

This provides an alternate means to specify function names to be exported from the extension. Its value is a reference to an array of function names to be exported by the extension. These names are passed through unaltered to the linker options file.

H

Ref to array of *.h file names. Similar to C.

HTMLLIBPODS

Hashref of .pm and .pod files. MakeMaker will default this to all
.pod and any .pm files that include POD directives. The files listed
here will be converted to HTML format and installed as was requested at Configure time.

HTMLSCRIPTPODS

Hashref of pod-containing files. MakeMaker will default this to all EXE_FILES files that include POD directives. The files listed here will be converted to HTML format and installed as was requested at Configure time.

IMPORTS

This attribute is used to specify names to be imported into the extension. It is only used on OS/2 and Win32.

INC

Include file dirs eg: `"-I/usr/5include -I/path/to/inc"`

INCLUDE_EXT

Array of extension names to be included when doing a static build. MakeMaker will normally build with all of the installed extensions when doing a static build, and that is usually the desired behavior. If INCLUDE_EXT is present then MakeMaker will build only with those extensions which are explicitly mentioned. (e.g. [qw(Socket POSIX)])

It is not necessary to mention DynaLoader or the current extension when filling in INCLUDE_EXT. If the INCLUDE_EXT is mentioned but is empty then only DynaLoader and the current extension will be included in the build.

This attribute may be most useful when specified as a string on the command line: perl Makefile.PL INCLUDE_EXT='POSIX Socket Devel::Peek'

INSTALLARCHLIB

Used by 'make install', which copies files from INST_ARCHLIB to this directory if INSTALLDIRS is set to perl.

INSTALLBIN

Directory to install binary files (e.g. tkperl) into.

INSTALLDIRS

Determines which of the two sets of installation directories to choose: installprivlib and installarchlib versus installsitelib and installsitearch. The first pair is chosen with INSTALLDIRS=perl, the second with INSTALLDIRS=site. Default is site.

INSTALLHTMLPRIVLIBDIR

This directory gets the HTML pages at 'make install' time. Defaults to `$Config{installhtmlprivlibdir}`.

INSTALLHTMLSCRIPTDIR

This directory gets the HTML pages at 'make install' time. Defaults to `$Config{installhtmlscriptdir}`.

INSTALLHTMLSITELIBDIR

This directory gets the HTML pages at 'make install' time. Defaults to `$Config{installhtmlsitelibdir}`.

INSTALLMAN1DIR

This directory gets the man pages at 'make install' time. Defaults to `$Config{installman1dir}`.

INSTALLMAN3DIR

This directory gets the man pages at 'make install' time. Defaults to `$Config{installman3dir}`.

INSTALLPRIVLIB

Used by 'make install', which copies files from INST_LIB to this directory if INSTALLDIRS is set to perl.

INSTALLSCRIPT

Used by 'make install' which copies files from INST_SCRIPT to this directory.

INSTALLSITEARCH

Used by ‘make install‘, which copies files from INST_ARCHLIB to this directory if INSTALLDIRS is set to site (default).

INSTALLSITELIB

Used by ‘make install‘, which copies files from INST_LIB to this directory if INSTALLDIRS is set to site (default).

INST_ARCHLIB

Same as INST_LIB for architecture dependent files.

INST_BIN

Directory to put real binary files during ‘make’. These will be copied to INSTALLBIN during ‘make install’

INST_EXE

Old name for INST_SCRIPT. Deprecated. Please use INST_SCRIPT if you need to use it.

INST_HTMLLIBDIR

Directory to hold the man pages in HTML format at ‘make’ time

INST_HTMLSCRIPTDIR

Directory to hold the man pages in HTML format at ‘make’ time

INST_LIB

Directory where we put library files of this extension while building it.

INST_MAN1DIR

Directory to hold the man pages at ‘make’ time

INST_MAN3DIR

Directory to hold the man pages at ‘make’ time

INST_SCRIPT

Directory, where executable files should be installed during ‘make’. Defaults to "./blib/script", just to have a dummy location during testing. make install will copy the files in INST_SCRIPT to INSTALLSCRIPT.

LDFROM

defaults to "`$(OBJECT)`" and is used in the ld command to specify what files to link/load from (also see dynamic_lib below for how to specify ld flags)

LIB

LIB should only be set at `perl Makefile.PL` time but is allowed as a MakeMaker argument. It has the effect of setting both INSTALLPRIVLIB and INSTALLSITELIB to that value regardless any explicit setting of those arguments (or of PREFIX). INSTALLARCHLIB and INSTALLSITEARCH are set to the corresponding architecture subdirectory.

LIBPERL_A

The filename of the perllibrary that will be used together with this extension. Defaults to libperl.a.

LIBS

An anonymous array of alternative library specifications to be searched for (in order) until at least one library is found. E.g.

```
'LIBS' => ["-lgdbm", "-ldbm -lfoo", "-L/path -ldbm.nfs"]
```

Mind, that any element of the array contains a complete set of arguments for the ld command. So do not specify

```
'LIBS' => ["-ltcl", "-ltk", "-lX11"]
```

See ODBM_File/Makefile.PL for an example, where an array is needed. If you specify a scalar as in

```
'LIBS' => "-ltcl -ltk -lX11"
```

MakeMaker will turn it into an array with one element.

LINKTYPE

'static' or 'dynamic' (default unless usedl=undef in config.sh). Should only be used to force static linking (also see linkext below).

MAKEAPERL

Boolean which tells MakeMaker, that it should include the rules to make a perl. This is handled automatically as a switch by MakeMaker. The user normally does not need it.

MAKEFILE

The name of the Makefile to be produced.

MAN1PODS

Hashref of pod-containing files. MakeMaker will default this to all EXE_FILES files that include POD directives. The files listed here will be converted to man pages and installed as was requested at Configure time.

MAN3PODS

Hashref of .pm and .pod files. MakeMaker will default this to all
.pod and any .pm files that include POD directives. The files listed
here will be converted to man pages and installed as was requested at Configure time.

MAP_TARGET

If it is intended, that a new perl binary be produced, this variable may hold a name for that binary. Defaults to perl

MYEXTLIB

If the extension links to a library that it builds set this to the name of the library (see SDBM_File)

NAME

Perl module name for this extension (DBD::Oracle). This will default to the directory name but should be explicitly defined in the Makefile.PL.

NEEDS_LINKING

MakeMaker will figure out if an extension contains linkable code anywhere down the directory tree, and will set this variable accordingly, but you can speed it up a very little bit if you define this boolean variable yourself.

NOECHO

Defaults to @. By setting it to an empty string you can generate a Makefile that echos all commands. Mainly used in debugging MakeMaker itself.

NORECURS

Boolean. Attribute to inhibit descending into subdirectories.

NO_VC

In general, any generated Makefile checks for the current version of MakeMaker and the version the Makefile was built under. If NO_VC is set, the version check is neglected. Do not write this into your Makefile.PL, use it interactively instead.

OBJECT

List of object files, defaults to '$(BASEEXT)$(OBJ_EXT)', but can be a long string containing all object files, e.g. "tkpBind.o tkpButton.o tkpCanvas.o"

(Where BASEEXT is the last component of NAME, and OBJ_EXT is `$Config{obj_ext}.`)

OPTIMIZE

Defaults to `-O`. Set it to `-g` to turn debugging on. The flag is passed to subdirectory makes.

PERL

Perl binary for tasks that can be done by miniperl

PERLMAINCC

The call to the program that is able to compile perlmain.c. Defaults to `$(CC)`.

PERL_ARCHLIB

Same as below, but for architecture dependent files.

PERL_LIB

Directory containing the Perl library to use.

PERL_MALLOC_OK

defaults to 0. Should be set to TRUE if the extension can work with the memory allocation routines substituted by the Perl `malloc()` subsystem. This should be applicable to most extensions with exceptions of those

- with bugs in memory allocations which are caught by Perl's `malloc()`;
- which interact with the memory allocator in other ways than via `malloc()`, `realloc()`, `free()`, `calloc()`, `sbrk()` and `brk()`;
- which rely on special alignment which is not provided by Perl's `malloc()`.

NOTE. Negligence to set this flag in *any one* of loaded extension nullifies many advantages of Perl's `malloc()`, such as better usage of system resources, error detection, memory usage reporting, catchable failure of memory allocations, etc.

PERL_SRC

Directory containing the Perl source code (use of this should be avoided, it may be undefined)

PERM_RW

Desired permission for read/writable files. Defaults to `644`. See also *perm_rw*.

PERM_RWX

Desired permission for executable files. Defaults to `755`. See also *perm_rwx*.

PL_FILES

Ref to hash of files to be processed as perl programs. MakeMaker will default to any found *.PL file (except Makefile.PL) being keys and the basename of the file being the value. E.g.

```
{'foobar.PL' => 'foobar'}
```

The *.PL files are expected to produce output to the target files themselves. If multiple files can be generated from the same *.PL file then the value in the hash can be a reference to an array of target file names. E.g.

```
{'foobar.PL' => ['foobar1','foobar2']}
```

PM

Hashref of .pm files and *.pl files to be installed. e.g.

```
{'name_of_file.pm' => '$(INST_LIBDIR)/install_as.pm'}
```

By default this will include *.pm and *.pl and the files found in the PMLIBDIRS directories. Defining PM in the Makefile.PL will override PMLIBDIRS.

PMLIBDIRS

Ref to array of subdirectories containing library files. Defaults to ['lib', `$(BASEEXT)`]. The directories will be scanned and *any* files they contain will be installed in the corresponding location in the library. A `libscan()` method can be used to alter the behaviour. Defining PM in the Makefile.PL will override PMLIBDIRS.

(Where BASEEXT is the last component of NAME.)

POLLUTE

Release 5.005 grandfathered old global symbol names by providing preprocessor macros for extension source compatibility. As of release 5.6, these preprocessor definitions are not available by default. The POLLUTE flag specifies that the old names should still be defined:

```
perl Makefile.PL POLLUTE=1
```

Please inform the module author if this is necessary to successfully install a module under 5.6 or later.

PPM_INSTALL_EXEC

Name of the executable used to run `PPM_INSTALL_SCRIPT` below. (e.g. perl)

PPM_INSTALL_SCRIPT

Name of the script that gets executed by the Perl Package Manager after the installation of a package.

PREFIX

Can be used to set the three INSTALL* attributes in one go (except for probably INSTALLMAN1DIR, if it is not below PREFIX according to %Config). They will have PREFIX as a common directory node and will branch from that node into lib/, lib/ARCHNAME or whatever Configure decided at the build time of your perl (unless you override one of them, of course).

PREREQ_PM

Hashref: Names of modules that need to be available to run this extension (e.g. Fcntl for SDBM_File) are the keys of the hash and the desired version is the value. If the required version number is 0, we only check if any version is installed already.

SKIP

Arryref. E.g. [qw(name1 name2)] skip (do not write) sections of the Makefile. Caution! Do not use the SKIP attribute for the negligible speedup. It may seriously damage the resulting Makefile. Only use it if you really need it.

TYPEMAPS

Ref to array of typemap file names. Use this when the typemaps are in some directory other than the current directory or when they are not named **typemap**. The last typemap in the list takes precedence. A typemap in the current directory has highest precedence, even if it isn't listed in TYPEMAPS. The default system typemap has lowest precedence.

VERSION

Your version number for distributing the package. This defaults to 0.1.

VERSION_FROM

Instead of specifying the VERSION in the Makefile.PL you can let MakeMaker parse a file to determine the version number. The parsing routine requires that the file named by VERSION_FROM contains one single line to compute the version number. The first line in the file that contains the regular expression

```
/([\$*])(([\w\:\']*)\bVERSION)\b.*\=/
```

will be evaluated with `eval()` and the value of the named variable **after** the `eval()` will be assigned to the VERSION attribute of the MakeMaker object. The following lines will be parsed o.k.:

```
$VERSION = '1.00';
*VERSION = \'1.01';
```

```
( $VERSION ) = '$Revision: 1.222 $ ' =~ /\$Revision:\s+([^\s]+)/;
$FOO::VERSION = '1.10';
*FOO::VERSION = \'1.11';
our $VERSION = 1.2.3# new for perl5.6.0
```

but these will fail:

```
my $VERSION = '1.01';
local $VERSION = '1.02';
local $FOO::VERSION = '1.30';
```

(Putting my or local on the preceding line will work o.k.)

The file named in VERSION_FROM is not added as a dependency to Makefile. This is not really correct, but it would be a major pain during development to have to rewrite the Makefile for any smallish change in that file. If you want to make sure that the Makefile contains the correct VERSION macro after any change of the file, you would have to do something like

```
depend => { Makefile => '$(VERSION_FROM)' }
```

See attribute depend below.

XS

Hashref of .xs files. MakeMaker will default this. e.g.

```
{'name_of_file.xs' => 'name_of_file.c'}
```

The .c files will automatically be included in the list of files deleted by a make clean.

XSOPT

String of options to pass to xsubpp. This might include -C++ or -extern. Do not include typemaps here; the TYPEMAP parameter exists for that purpose.

XSPROTOARG

May be set to an empty string, which is identical to -prototypes, or -noprototypes. See the xsubpp documentation for details. MakeMaker defaults to the empty string.

XS_VERSION

Your version number for the .xs file of this package. This defaults to the value of the VERSION attribute.

Additional lowercase attributes

can be used to pass parameters to the methods which implement that part of the Makefile.

clean

```
{FILES => "*.xyz foo"}
```

depend

```
{ANY_TARGET => ANY_DEPENDECY, ...}
```

(ANY_TARGET must not be given a double–colon rule by MakeMaker.)

dist

```
{TARFLAGS => 'cvfF', COMPRESS => 'gzip', SUFFIX => '.gz',
SHAR => 'shar -m', DIST_CP => 'ln', ZIP => '/bin/zip',
ZIPFLAGS => '-rl', DIST_DEFAULT => 'private tardist' }
```

If you specify COMPRESS, then SUFFIX should also be altered, as it is needed to tell make the target file of the compression. Setting DIST_CP to ln can be useful, if you need to preserve the timestamps on your files. DIST_CP can take the values 'cp', which copies the file, 'ln', which links the file, and 'best' which copies symbolic links and links the rest. Default is 'best'.

dynamic_lib

```
{ARMAYBE => 'ar', OTHERLDFLAGS => '...', INST_DYNAMIC_DEP => '...'}
```

linkext

```
{LINKTYPE => 'static', 'dynamic' or ''}
```

NB: Extensions that have nothing but *.pm files had to say

```
{LINKTYPE => ''}
```

with Pre−5.0 MakeMakers. Since version 5.00 of MakeMaker such a line can be deleted safely. MakeMaker recognizes when there's nothing to be linked.

macro

```
{ANY_MACRO => ANY_VALUE, ...}
```

realclean

```
{FILES => '$(INST_ARCHAUTODIR)/*.xyz'}
```

test

```
{TESTS => 't/*.t'}
```

tool_autosplit

```
{MAXLEN => 8}
```

Overriding MakeMaker Methods

If you cannot achieve the desired Makefile behaviour by specifying attributes you may define private subroutines in the Makefile.PL. Each subroutines returns the text it wishes to have written to the Makefile. To override a section of the Makefile you can either say:

```
sub MY::c_o { "new literal text" }
```

or you can edit the default by saying something like:

```
sub MY::c_o {
    package MY; # so that "SUPER" works right
    my $inherited = shift->SUPER::c_o(@_);
    $inherited =~ s/old text/new text/;
    $inherited;
}
```

If you are running experiments with embedding perl as a library into other applications, you might find MakeMaker is not sufficient. You'd better have a look at ExtUtils::Embed which is a collection of utilities for embedding.

If you still need a different solution, try to develop another subroutine that fits your needs and submit the diffs to ***perl5−porters@perl.org*** or ***comp.lang.perl.moderated*** as appropriate.

For a complete description of all MakeMaker methods see *ExtUtils::MM_Unix*.

Here is a simple example of how to add a new target to the generated Makefile:

```
sub MY::postamble {
    '
$(MYEXTLIB): sdbm/Makefile
        cd sdbm && $(MAKE) all
';
}
```

Hintsfile support

MakeMaker.pm uses the architecture specific information from Config.pm. In addition it evaluates architecture specific hints files in a `hints/` directory. The hints files are expected to be named like their counterparts in `PERL_SRC/hints`, but with an `.pl` file name extension (eg. `next_3_2.pl`). They are simply `eval`ed by MakeMaker within the `WriteMakefile()` subroutine, and can be used to execute commands as well as to include special variables. The rules which hintsfile is chosen are the same as in Configure.

The hintsfile is `eval()`ed immediately after the arguments given to WriteMakefile are stuffed into a hash reference `$self` but before this reference becomes blessed. So if you want to do the equivalent to override or create an attribute you would say something like

```
$self->{LIBS} = ['-ldbm -lucb -lc'];
```

Distribution Support

For authors of extensions MakeMaker provides several Makefile targets. Most of the support comes from the ExtUtils::Manifest module, where additional documentation can be found.

make distcheck

reports which files are below the build directory but not in the MANIFEST file and vice versa. (See `ExtUtils::Manifest::fullcheck()` for details)

make skipcheck

reports which files are skipped due to the entries in the `MANIFEST.SKIP` file (See `ExtUtils::Manifest::skipcheck()` for details)

make distclean

does a realclean first and then the distcheck. Note that this is not needed to build a new distribution as long as you are sure that the MANIFEST file is ok.

make manifest

rewrites the MANIFEST file, adding all remaining files found (See `ExtUtils::Manifest::mkmanifest()` for details)

make distdir

Copies all the files that are in the MANIFEST file to a newly created directory with the name `$(DISTNAME)-$(VERSION)`. If that directory exists, it will be removed first.

make disttest

Makes a distdir first, and runs a `perl Makefile.PL`, a make, and a make test in that directory.

make tardist

First does a distdir. Then a command `$(PREOP)` which defaults to a null command, followed by `$(TOUNIX)`, which defaults to a null command under UNIX, and will convert files in distribution directory to UNIX format otherwise. Next it runs `tar` on that directory into a tarfile and deletes the directory. Finishes with a command `$(POSTOP)` which defaults to a null command.

make dist

Defaults to `$(DIST_DEFAULT)` which in turn defaults to tardist.

make uutardist

Runs a tardist first and uuencodes the tarfile.

make shdist

First does a distdir. Then a command `$(PREOP)` which defaults to a null command. Next it runs `shar` on that directory into a sharfile and deletes the intermediate directory again. Finishes with a command `$(POSTOP)` which defaults to a null command. Note: For shdist to work properly a `shar` program that can handle directories is mandatory.

make zipdist

First does a distdir. Then a command `$(PREOP)` which defaults to a null command. Runs `$(ZIP) $(ZIPFLAGS)` on that directory into a zipfile. Then deletes that directory. Finishes with a command `$(POSTOP)` which defaults to a null command.

make ci

Does a `$(CI)` and a `$(RCS_LABEL)` on all files in the MANIFEST file.

Customization of the dist targets can be done by specifying a hash reference to the dist attribute of the WriteMakefile call. The following parameters are recognized:

```
CI           ('ci -u')
COMPRESS     ('gzip --best')
POSTOP       ('@ :')
PREOP        ('@ :')
TO_UNIX      (depends on the system)
RCS_LABEL    ('rcs -q -Nv$(VERSION_SYM):')
SHAR         ('shar')
SUFFIX       ('.gz')
TAR          ('tar')
TARFLAGS     ('cvf')
ZIP          ('zip')
ZIPFLAGS     ('-r')
```

An example:

```
WriteMakefile( 'dist' => { COMPRESS=>"bzip2", SUFFIX=>".bz2" })
```

Disabling an extension

If some events detected in ***Makefile.PL*** imply that there is no way to create the Module, but this is a normal state of things, then you can create a ***Makefile*** which does nothing, but succeeds on all the "usual" build targets. To do so, use

```
ExtUtils::MakeMaker::WriteEmptyMakefile();
```

instead of `WriteMakefile()`.

This may be useful if other modules expect this module to be *built* OK, as opposed to *work* OK (say, this system-dependent module builds in a subdirectory of some other distribution, or is listed as a dependency in a CPAN::Bundle, but the functionality is supported by different means on the current architecture).

ENVIRONMENT

PERL_MM_OPT

Command line options used by `MakeMaker->new()`, and thus by `WriteMakefile()`. The string is split on whitespace, and the result is processed before any actual command line arguments are processed.

SEE ALSO

ExtUtils::MM_Unix, ExtUtils::Manifest, ExtUtils::testlib, ExtUtils::Install, ExtUtils::Embed

AUTHORS

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NAME

ExtUtils::Manifest – utilities to write and check a MANIFEST file

SYNOPSIS

```
require ExtUtils::Manifest;

ExtUtils::Manifest::mkmanifest;

ExtUtils::Manifest::manicheck;

ExtUtils::Manifest::filecheck;

ExtUtils::Manifest::fullcheck;

ExtUtils::Manifest::skipcheck;

ExtUtils::Manifest::manifind();

ExtUtils::Manifest::maniread($file);

ExtUtils::Manifest::manicopy($read,$target,$how);
```

DESCRIPTION

`mkmanifest()` writes all files in and below the current directory to a file named in the global variable `$ExtUtils::Manifest::MANIFEST` (which defaults to `MANIFEST`) in the current directory. It works similar to

```
find . -print
```

but in doing so checks each line in an existing `MANIFEST` file and includes any comments that are found in the existing `MANIFEST` file in the new one. Anything between white space and an end of line within a `MANIFEST` file is considered to be a comment. Filenames and comments are separated by one or more TAB characters in the output. All files that match any regular expression in a file `MANIFEST.SKIP` (if such a file exists) are ignored.

`manicheck()` checks if all the files within a `MANIFEST` in the current directory really do exist. It only reports discrepancies and exits silently if MANIFEST and the tree below the current directory are in sync.

`filecheck()` finds files below the current directory that are not mentioned in the `MANIFEST` file. An optional file `MANIFEST.SKIP` will be consulted. Any file matching a regular expression in such a file will not be reported as missing in the `MANIFEST` file.

`fullcheck()` does both a `manicheck()` and a `filecheck()`.

`skipcheck()` lists all the files that are skipped due to your `MANIFEST.SKIP` file.

`manifind()` returns a hash reference. The keys of the hash are the files found below the current directory.

maniread(`$file`) reads a named `MANIFEST` file (defaults to `MANIFEST` in the current directory) and returns a HASH reference with files being the keys and comments being the values of the HASH. Blank lines and lines which start with # in the `MANIFEST` file are discarded.

`manicopy($read,$target,$how)` copies the files that are the keys in the HASH *`%$read`* to the named target directory. The HASH reference `$read` is typically returned by the `maniread()` function. This function is useful for producing a directory tree identical to the intended distribution tree. The third parameter `$how` can be used to specify a different methods of "copying". Valid values are `cp`, which actually copies the files, `ln` which creates hard links, and `best` which mostly links the files but copies any symbolic link to make a tree without any symbolic link. Best is the default.

MANIFEST.SKIP

The file MANIFEST.SKIP may contain regular expressions of files that should be ignored by `mkmanifest()` and `filecheck()`. The regular expressions should appear one on each line. Blank lines and lines which start with # are skipped. Use `\#` if you need a regular expression to start with a sharp

character. A typical example:

```
\bRCS\b
^MANIFEST\.
^Makefile$
~$
\.html$
\.old$
^blib/
^MakeMaker-\d
```

EXPORT_OK

`&mkmanifest`, `&manicheck`, `&filecheck`, `&fullcheck`, `&maniread`, and `&manicopy` are exportable.

GLOBAL VARIABLES

`$ExtUtils::Manifest::MANIFEST` defaults to `MANIFEST`. Changing it results in both a different `MANIFEST` and a different `MANIFEST.SKIP` file. This is useful if you want to maintain different distributions for different audiences (say a user version and a developer version including RCS).

`$ExtUtils::Manifest::Quiet` defaults to 0. If set to a true value, all functions act silently.

DIAGNOSTICS

All diagnostic output is sent to `STDERR`.

`Not in MANIFEST:` *file*

is reported if a file is found, that is missing in the `MANIFEST` file which is excluded by a regular expression in the file `MANIFEST.SKIP`.

`No such file:` *file*

is reported if a file mentioned in a `MANIFEST` file does not exist.

`MANIFEST:` *`$!`*

is reported if `MANIFEST` could not be opened.

`Added to MANIFEST:` *file*

is reported by `mkmanifest()` if `$Verbose` is set and a file is added to MANIFEST. `$Verbose` is set to 1 by default.

SEE ALSO

ExtUtils::MakeMaker which has handy targets for most of the functionality.

AUTHOR

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NAME

ExtUtils::Mkbootstrap – make a bootstrap file for use by DynaLoader

SYNOPSIS

```
mkbootstrap
```

DESCRIPTION

Mkbootstrap typically gets called from an extension Makefile.

There is no `*.bs` file supplied with the extension. Instead, there may be a `*_BS` file which has code for the special cases, like posix for berkeley db on the NeXT.

This file will get parsed, and produce a maybe empty `@DynaLoader::dl_resolve_using` array for the current architecture. That will be extended by `$BSLOADLIBS`, which was computed by `ExtUtils::Liblist::ext()`. If this array still is empty, we do nothing, else we write a .bs file with an `@DynaLoader::dl_resolve_using` array.

The `*_BS` file can put some code into the generated `*.bs` file by placing it in `$bscode`. This is a handy 'escape' mechanism that may prove useful in complex situations.

If @DynaLoader::dl_resolve_using contains `-L*` or `-l*` entries then Mkbootstrap will automatically add a `dl_findfile()` call to the generated `*.bs` file.

NAME

ExtUtils::Mksymlists – write linker options files for dynamic extension

SYNOPSIS

```
use ExtUtils::Mksymlists;
Mksymlists({ NAME     => $name ,
             DL_VARS  => [ $var1, $var2, $var3 ],
             DL_FUNCS => { $pkg1 => [ $func1, $func2 ],
                           $pkg2 => [ $func3 ] });
```

DESCRIPTION

`ExtUtils::Mksymlists` produces files used by the linker under some OSs during the creation of shared libraries for dynamic extensions. It is normally called from a MakeMaker–generated Makefile when the extension is built. The linker option file is generated by calling the function `Mksymlists`, which is exported by default from `ExtUtils::Mksymlists`. It takes one argument, a list of key–value pairs, in which the following keys are recognized:

DLBASE

This item specifies the name by which the linker knows the extension, which may be different from the name of the extension itself (for instance, some linkers add an '_' to the name of the extension). If it is not specified, it is derived from the NAME attribute. It is presently used only by OS2 and Win32.

DL_FUNCS

This is identical to the DL_FUNCS attribute available via MakeMaker, from which it is usually taken. Its value is a reference to an associative array, in which each key is the name of a package, and each value is an a reference to an array of function names which should be exported by the extension. For instance, one might say `DL_FUNCS => { Homer::Iliad => [ qw(trojans greeks) ], Homer::Odyssey => [ qw(travellers family suitors) ] }`. The function names should be identical to those in the XSUB code; `Mksymlists` will alter the names written to the linker option file to match the changes made by ***xsubpp***. In addition, if none of the functions in a list begin with the string **boot_**, `Mksymlists` will add a bootstrap function for that package, just as xsubpp does. (If a **boot_<pkg>** function is present in the list, it is passed through unchanged.) If DL_FUNCS is not specified, it defaults to the bootstrap function for the extension specified in NAME.

DL_VARS

This is identical to the DL_VARS attribute available via MakeMaker, and, like DL_FUNCS, it is usually specified via MakeMaker. Its value is a reference to an array of variable names which should be exported by the extension.

FILE

This key can be used to specify the name of the linker option file (minus the OS–specific extension), if for some reason you do not want to use the default value, which is the last word of the NAME attribute (*e.g.* for `Tk::Canvas`, FILE defaults to `Canvas`).

FUNCLIST

This provides an alternate means to specify function names to be exported from the extension. Its value is a reference to an array of function names to be exported by the extension. These names are passed through unaltered to the linker options file. Specifying a value for the FUNCLIST attribute suppresses automatic generation of the bootstrap function for the package. To still create the bootstrap name you have to specify the package name in the DL_FUNCS hash:

```
Mksymlists({ NAME     => $name ,
             FUNCLIST => [ $func1, $func2 ],
             DL_FUNCS => { $pkg => [] } });
```

IMPORTS

This attribute is used to specify names to be imported into the extension. It is currently only used by OS/2 and Win32.

NAME

This gives the name of the extension (*e.g.* `Tk::Canvas`) for which the linker option file will be produced.

When calling `Mksymlists`, one should always specify the NAME attribute. In most cases, this is all that's necessary. In the case of unusual extensions, however, the other attributes can be used to provide additional information to the linker.

AUTHOR

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REVISION

Last revised 14–Feb–1996, for Perl 5.002.

NAME

ExtUtils::MM_Cygwin – methods to override UN*X behaviour in ExtUtils::MakeMaker

SYNOPSIS

```
use ExtUtils::MM_Cygwin; # Done internally by ExtUtils::MakeMaker if needed
```

DESCRIPTION

See ExtUtils::MM_Unix for a documentation of the methods provided there.

canonpath

replaces backslashes with forward ones. then acts as *nixish.

cflags

if configured for dynamic loading, triggers #define EXT in EXTERN.h

manifypods

replaces strings '::' with '.' in man page names

perl_archive

points to libperl.a

NAME

ExtUtils::MM_OS2 – methods to override UN*X behaviour in ExtUtils::MakeMaker

SYNOPSIS

```
use ExtUtils::MM_OS2; # Done internally by ExtUtils::MakeMaker if needed
```

DESCRIPTION

See ExtUtils::MM_Unix for a documentation of the methods provided there. This package overrides the implementation of these methods, not the semantics.

NAME

ExtUtils::MM_Unix – methods used by ExtUtils::MakeMaker

SYNOPSIS

```
require ExtUtils::MM_Unix;
```

DESCRIPTION

The methods provided by this package are designed to be used in conjunction with ExtUtils::MakeMaker. When MakeMaker writes a Makefile, it creates one or more objects that inherit their methods from a package `MM`. MM itself doesn't provide any methods, but it ISA ExtUtils::MM_Unix class. The inheritance tree of MM lets operating specific packages take the responsibility for all the methods provided by MM_Unix. We are trying to reduce the number of the necessary overrides by defining rather primitive operations within ExtUtils::MM_Unix.

If you are going to write a platform specific MM package, please try to limit the necessary overrides to primitive methods, and if it is not possible to do so, let's work out how to achieve that gain.

If you are overriding any of these methods in your Makefile.PL (in the MY class), please report that to the makemaker mailing list. We are trying to minimize the necessary method overrides and switch to data driven Makefile.PLs wherever possible. In the long run less methods will be overridable via the MY class.

METHODS

The following description of methods is still under development. Please refer to the code for not suitably documented sections and complain loudly to the makemaker mailing list.

Not all of the methods below are overridable in a Makefile.PL. Overridable methods are marked as (o). All methods are overridable by a platform specific MM_*.pm file (See *ExtUtils::MM_VMS*) and *ExtUtils::MM_OS2*).

Preloaded methods

canonpath

No physical check on the filesystem, but a logical cleanup of a path. On UNIX eliminated successive slashes and successive "/.".

catdir

Concatenate two or more directory names to form a complete path ending with a directory. But remove the trailing slash from the resulting string, because it doesn't look good, isn't necessary and confuses OS2. Of course, if this is the root directory, don't cut off the trailing slash :–)

catfile

Concatenate one or more directory names and a filename to form a complete path ending with a filename

curdir

Returns a string representing of the current directory. "." on UNIX.

rootdir

Returns a string representing of the root directory. "/" on UNIX.

updir

Returns a string representing of the parent directory. ".." on UNIX.

SelfLoaded methods

c_o (o)

Defines the suffix rules to compile different flavors of C files to object files.

cflags (o)

Does very much the same as the cflags script in the perl distribution. It doesn't return the whole compiler command line, but initializes all of its parts. The const_cccmd method then actually returns the definition

of the CCCMD macro which uses these parts.

clean (o)

Defines the clean target.

const_cccmd (o)

Returns the full compiler call for C programs and stores the definition in CONST_CCCMD.

const_config (o)

Defines a couple of constants in the Makefile that are imported from %Config.

const_loadlibs (o)

Defines EXTRALIBS, LDLOADLIBS, BSLOADLIBS, LD_RUN_PATH. See *ExtUtils::Liblist* for details.

constants (o)

Initializes lots of constants and .SUFFIXES and .PHONY

depend (o)

Same as macro for the depend attribute.

dir_target (o)

Takes an array of directories that need to exist and returns a Makefile entry for a .exists file in these directories. Returns nothing, if the entry has already been processed. We're helpless though, if the same directory comes as `$(FOO)` _and_ as "bar". Both of them get an entry, that's why we use "::".

dist (o)

Defines a lot of macros for distribution support.

dist_basics (o)

Defines the targets distclean, distcheck, skipcheck, manifest, veryclean.

dist_ci (o)

Defines a check in target for RCS.

dist_core (o)

Defines the targets dist, tardist, zipdist, uutardist, shdist

dist_dir (o)

Defines the scratch directory target that will hold the distribution before tar–ing (or shar–ing).

dist_test (o)

Defines a target that produces the distribution in the scratchdirectory, and runs 'perl Makefile.PL; make ;make test' in that subdirectory.

dlsyms (o)

Used by AIX and VMS to define DL_FUNCS and DL_VARS and write the *.exp files.

dynamic (o)

Defines the dynamic target.

dynamic_bs (o)

Defines targets for bootstrap files.

dynamic_lib (o)

Defines how to produce the *.so (or equivalent) files.

exescan

Deprecated method. Use libscan instead.

extliblist

Called by init_others, and calls ext ExtUtils::Liblist. See *ExtUtils::Liblist* for details.

file_name_is_absolute

Takes as argument a path and returns true, if it is an absolute path.

find_perl

Finds the executables PERL and FULLPERL

Methods to actually produce chunks of text for the Makefile

The methods here are called for each MakeMaker object in the order specified by @ExtUtils::MakeMaker::MM_Sections.

fixin

Inserts the sharpbang or equivalent magic number to a script

force (o)

Just writes FORCE:

guess_name

Guess the name of this package by examining the working directory's name. MakeMaker calls this only if the developer has not supplied a NAME attribute.

has_link_code

Returns true if C, XS, MYEXTLIB or similar objects exist within this object that need a compiler. Does not descend into subdirectories as `needs_linking()` does.

htmlifypods (o)

Defines targets and routines to translate the pods into HTML manpages and put them into the INST_HTMLLIBDIR and INST_HTMLSCRIPTDIR directories.

init_dirscan

Initializes DIR, XS, PM, C, O_FILES, H, PL_FILES, HTML*PODS, MAN*PODS, EXE_FILES.

init_main

Initializes NAME, FULLEXT, BASEEXT, PARENT_NAME, DLBASE, PERL_SRC, PERL_LIB, PERL_ARCHLIB, PERL_INC, INSTALLDIRS, INST_*, INSTALL*, PREFIX, CONFIG, AR, AR_STATIC_ARGS, LD, OBJ_EXT, LIB_EXT, EXE_EXT, MAP_TARGET, LIBPERL_A, VERSION_FROM, VERSION, DISTNAME, VERSION_SYM.

init_others

Initializes EXTRALIBS, BSLOADLIBS, LDLOADLIBS, LIBS, LD_RUN_PATH, OBJECT, BOOTDEP, PERLMAINCC, LDFROM, LINKTYPE, NOOP, FIRST_MAKEFILE, MAKEFILE, NOECHO, RM_F, RM_RF, TEST_F, TOUCH, CP, MV, CHMOD, UMASK_NULL

install (o)

Defines the install target.

installbin (o)

Defines targets to make and to install EXE_FILES.

libscan (o)

Takes a path to a file that is found by init_dirscan and returns false if we don't want to include this file in the library. Mainly used to exclude RCS, CVS, and SCCS directories from installation.

linkext (o)

Defines the linkext target which in turn defines the LINKTYPE.

lsdir

Takes as arguments a directory name and a regular expression. Returns all entries in the directory that match the regular expression.

macro (o)

Simple subroutine to insert the macros defined by the macro attribute into the Makefile.

makeaperl (o)

Called by staticmake. Defines how to write the Makefile to produce a static new perl.

By default the Makefile produced includes all the static extensions in the perl library. (Purified versions of library files, e.g., DynaLoader_pure_p1_c0_032.a are automatically ignored to avoid link errors.)

makefile (o)

Defines how to rewrite the Makefile.

manifypods (o)

Defines targets and routines to translate the pods into manpages and put them into the INST_* directories.

maybe_command

Returns true, if the argument is likely to be a command.

maybe_command_in_dirs

method under development. Not yet used. Ask Ilya :–)

needs_linking (o)

Does this module need linking? Looks into subdirectory objects (see also `has_link_code()`)

nicetext

misnamed method (will have to be changed). The MM_Unix method just returns the argument without further processing.

On VMS used to insure that colons marking targets are preceded by space – most Unix Makes don't need this, but it's necessary under VMS to distinguish the target delimiter from a colon appearing as part of a filespec.

parse_version

parse a file and return what you think is `$VERSION` in this file set to. It will return the string "undef" if it can't figure out what `$VERSION` is.

parse_abstract

parse a file and return what you think is the ABSTRACT

pasthru (o)

Defines the string that is passed to recursive make calls in subdirectories.

path

Takes no argument, returns the environment variable PATH as an array.

perl_script

Takes one argument, a file name, and returns the file name, if the argument is likely to be a perl script. On MM_Unix this is true for any ordinary, readable file.

perldepend (o)

Defines the dependency from all *.h files that come with the perl distribution.

ppd

Defines target that creates a PPD (Perl Package Description) file for a binary distribution.

perm_rw (o)

Returns the attribute `PERM_RW` or the string `644`. Used as the string that is passed to the `chmod` command to set the permissions for read/writeable files. MakeMaker chooses `644` because it has turned out in the past that relying on the umask provokes hard–to–track bug reports. When the return value is used by the perl function `chmod`, it is interpreted as an octal value.

perm_rwx (o)

Returns the attribute `PERM_RWX` or the string `755`, i.e. the string that is passed to the `chmod` command to set the permissions for executable files. See also perl_rw.

pm_to_blib

Defines target that copies all files in the hash PM to their destination and autosplits them. See *ExtUtils::Install/DESCRIPTION*

post_constants (o)

Returns an empty string per default. Dedicated to overrides from within Makefile.PL after all constants have been defined.

post_initialize (o)

Returns an empty string per default. Used in Makefile.PLs to add some chunk of text to the Makefile after the object is initialized.

postamble (o)

Returns an empty string. Can be used in Makefile.PLs to write some text to the Makefile at the end.

prefixify

Check a path variable in `$self` from %Config, if it contains a prefix, and replace it with another one.

Takes as arguments an attribute name, a search prefix and a replacement prefix. Changes the attribute in the object.

processPL (o)

Defines targets to run *.PL files.

realclean (o)

Defines the realclean target.

replace_manpage_separator

Takes the name of a package, which may be a nested package, in the form Foo/Bar and replaces the slash with `::`. Returns the replacement.

static (o)

Defines the static target.

static_lib (o)

Defines how to produce the *.a (or equivalent) files.

staticmake (o)

Calls makeaperl.

subdir_x (o)

Helper subroutine for subdirs

subdirs (o)

Defines targets to process subdirectories.

test (o)

Defines the test targets.

test_via_harness (o)

Helper method to write the test targets

test_via_script (o)

Other helper method for test.

tool_autosplit (o)

Defines a simple perl call that runs autosplit. May be deprecated by pm_to_blib soon.

tools_other (o)

Defines SHELL, LD, TOUCH, CP, MV, RM_F, RM_RF, CHMOD, UMASK_NULL in the Makefile. Also defines the perl programs MKPATH, WARN_IF_OLD_PACKLIST, MOD_INSTALL. DOC_INSTALL, and UNINSTALL.

tool_xsubpp (o)

Determines typemaps, xsubpp version, prototype behaviour.

top_targets (o)

Defines the targets all, subdirs, config, and O_FILES

writedoc

Obsolete, deprecated method. Not used since Version 5.21.

xs_c (o)

Defines the suffix rules to compile XS files to C.

xs_cpp (o)

Defines the suffix rules to compile XS files to C++.

xs_o (o)

Defines suffix rules to go from XS to object files directly. This is only intended for broken make implementations.

perl_archive

This is internal method that returns path to libperl.a equivalent to be linked to dynamic extensions. UNIX does not have one but OS2 and Win32 do.

export_list

This is internal method that returns name of a file that is passed to linker to define symbols to be exported. UNIX does not have one but OS2 and Win32 do.

SEE ALSO

ExtUtils::MakeMaker

NAME

ExtUtils::MM_VMS − methods to override UN*X behaviour in ExtUtils::MakeMaker

SYNOPSIS

```
use ExtUtils::MM_VMS; # Done internally by ExtUtils::MakeMaker if needed
```

DESCRIPTION

See ExtUtils::MM_Unix for a documentation of the methods provided there. This package overrides the implementation of these methods, not the semantics.

Methods always loaded

wraplist

Converts a list into a string wrapped at approximately 80 columns.

rootdir (override)

Returns a string representing of the root directory.

SelfLoaded methods

Those methods which override default MM_Unix methods are marked "(override)", while methods unique to MM_VMS are marked "(specific)". For overridden methods, documentation is limited to an explanation of why this method overrides the MM_Unix method; see the ExtUtils::MM_Unix documentation for more details.

guess_name (override)

Try to determine name of extension being built. We begin with the name of the current directory. Since VMS filenames are case−insensitive, however, we look for a ***.pm*** file whose name matches that of the current directory (presumably the 'main' ***.pm*** file for this extension), and try to find a `package` statement from which to obtain the Mixed::Case package name.

find_perl (override)

Use VMS file specification syntax and CLI commands to find and invoke Perl images.

path (override)

Translate logical name DCL`$PATH` as a searchlist, rather than trying to `split` string value of `$ENV{'PATH'}`.

maybe_command (override)

Follows VMS naming conventions for executable files. If the name passed in doesn't exactly match an executable file, appends ***.Exe*** (or equivalent) to check for executable image, and ***.Com*** to check for DCL procedure. If this fails, checks directories in DCL`$PATH` and finally ***Sys$System:*** for an executable file having the name specified, with or without the ***.Exe***−equivalent suffix.

maybe_command_in_dirs (override)

Uses DCL argument quoting on test command line.

perl_script (override)

If name passed in doesn't specify a readable file, appends ***.com*** or ***.pl*** and tries again, since it's customary to have file types on all files under VMS.

file_name_is_absolute (override)

Checks for VMS directory spec as well as Unix separators.

replace_manpage_separator

Use as separator a character which is legal in a VMS−syntax file name.

init_others (override)

Provide VMS−specific forms of various utility commands, then hand off to the default MM_Unix method.

constants (override)

Fixes up numerous file and directory macros to insure VMS syntax regardless of input syntax. Also adds a few VMS−specific macros and makes lists of files comma−separated.

cflags (override)

Bypass shell script and produce qualifiers for CC directly (but warn user if a shell script for this extension exists). Fold multiple /Defines into one, since some C compilers pay attention to only one instance of this qualifier on the command line.

const_cccmd (override)

Adds directives to point C preprocessor to the right place when handling #include <sys/foo.h> directives. Also constructs CC command line a bit differently than MM_Unix method.

pm_to_blib (override)

DCL *still* accepts a maximum of 255 characters on a command line, so we write the (potentially) long list of file names to a temp file, then persuade Perl to read it instead of the command line to find args.

tool_autosplit (override)

Use VMS−style quoting on command line.

tool_sxubpp (override)

Use VMS−style quoting on xsubpp command line.

xsubpp_version (override)

Test xsubpp exit status according to VMS rules (`$sts & 1` ==> good) rather than Unix rules (`$sts == 0` ==> good).

tools_other (override)

Adds a few MM[SK] macros, and shortens some the installatin commands, in order to stay under DCL's 255−character limit. Also changes EQUALIZE_TIMESTAMP to set revision date of target file to one second later than source file, since MMK interprets precisely equal revision dates for a source and target file as a sign that the target needs to be updated.

dist (override)

Provide VMSish defaults for some values, then hand off to default MM_Unix method.

c_o (override)

Use VMS syntax on command line. In particular, `$(DEFINE)` and `$(PERL_INC)` have been pulled into `$(CCCMD)`. Also use MM[SK] macros.

xs_c (override)

Use MM[SK] macros.

xs_o (override)

Use MM[SK] macros, and VMS command line for C compiler.

top_targets (override)

Use VMS quoting on command line for Version_check.

dlsyms (override)

Create VMS linker options files specifying universal symbols for this extension's shareable image, and listing other shareable images or libraries to which it should be linked.

dynamic_lib (override)

Use VMS Link command.

dynamic_bs (override)

Use VMS−style quoting on Mkbootstrap command line.

static_lib (override)

Use VMS commands to manipulate object library.

manifypods (override)

Use VMS−style quoting on command line, and VMS logical name to specify fallback location at build time if we can't find pod2man.

processPL (override)

Use VMS−style quoting on command line.

installbin (override)

Stay under DCL's 255 character command line limit once again by splitting potentially long list of files across multiple lines in `realclean` target.

subdir_x (override)

Use VMS commands to change default directory.

clean (override)

Split potentially long list of files across multiple commands (in order to stay under the magic command line limit). Also use MM[SK] commands for handling subdirectories.

realclean (override)

Guess what we're working around? Also, use MM[SK] for subdirectories.

dist_basics (override)

Use VMS−style quoting on command line.

dist_core (override)

Syntax for invoking ***VMS_Share*** differs from that for Unix ***shar***, so `shdist` target actions are VMS−specific.

dist_dir (override)

Use VMS−style quoting on command line.

dist_test (override)

Use VMS commands to change default directory, and use VMS−style quoting on command line.

install (override)

Work around DCL's 255 character limit several times,and use VMS−style command line quoting in a few cases.

perldepend (override)

Use VMS−style syntax for files; it's cheaper to just do it directly here than to have the MM_Unix method call `catfile` repeatedly. Also, if we have to rebuild Config.pm, use MM[SK] to do it.

makefile (override)

Use VMS commands and quoting.

test (override)

Use VMS commands for handling subdirectories.

test_via_harness (override)

Use VMS−style quoting on command line.

test_via_script (override)

Use VMS−style quoting on command line.

makeaperl (override)

Undertake to build a new set of Perl images using VMS commands. Since VMS does dynamic loading, it‘s not necessary to statically link each extension into the Perl image, so this isn‘t the normal build path. Consequently, it hasn‘t really been tested, and may well be incomplete.

nicetext (override)

Insure that colons marking targets are preceded by space, in order to distinguish the target delimiter from a colon appearing as part of a filespec.

NAME

ExtUtils::MM_Win32 – methods to override UN*X behaviour in ExtUtils::MakeMaker

SYNOPSIS

```
use ExtUtils::MM_Win32; # Done internally by ExtUtils::MakeMaker if needed
```

DESCRIPTION

See ExtUtils::MM_Unix for a documentation of the methods provided there. This package overrides the implementation of these methods, not the semantics.

catfile

Concatenate one or more directory names and a filename to form a complete path ending with a filename

constants (o)

Initializes lots of constants and .SUFFIXES and .PHONY

static_lib (o)

Defines how to produce the *.a (or equivalent) files.

dynamic_bs (o)

Defines targets for bootstrap files.

dynamic_lib (o)

Defines how to produce the *.so (or equivalent) files.

canonpath

No physical check on the filesystem, but a logical cleanup of a path. On UNIX eliminated successive slashes and successive "/.".

perl_script

Takes one argument, a file name, and returns the file name, if the argument is likely to be a perl script. On MM_Unix this is true for any ordinary, readable file.

pm_to_blib

Defines target that copies all files in the hash PM to their destination and autosplits them. See *ExtUtils::Install/DESCRIPTION*

test_via_harness (o)

Helper method to write the test targets

tool_autosplit (override)

Use Win32 quoting on command line.

tools_other (o)

Win32 overrides.

Defines SHELL, LD, TOUCH, CP, MV, RM_F, RM_RF, CHMOD, UMASK_NULL in the Makefile. Also defines the perl programs MKPATH, WARN_IF_OLD_PACKLIST, MOD_INSTALL. DOC_INSTALL, and UNINSTALL.

xs_o (o)

Defines suffix rules to go from XS to object files directly. This is only intended for broken make implementations.

top_targets (o)

Defines the targets all, subdirs, config, and O_FILES

htmlifypods (o)

Defines targets and routines to translate the pods into HTML manpages and put them into the INST_HTMLLIBDIR and INST_HTMLSCRIPTDIR directories.

Same as MM_Unix version (changes command−line quoting).

manifypods (o)

We don't want manpage process.

dist_ci (o)

Same as MM_Unix version (changes command−line quoting).

dist_core (o)

Same as MM_Unix version (changes command−line quoting).

pasthru (o)

Defines the string that is passed to recursive make calls in subdirectories.

NAME

ExtUtils::Packlist – manage .packlist files

SYNOPSIS

```
use ExtUtils::Packlist;
my ($pl) = ExtUtils::Packlist->new('.packlist');
$pl->read('/an/old/.packlist');
my @missing_files = $pl->validate();
$pl->write('/a/new/.packlist');

$pl->{'/some/file/name'}++;
   or
$pl->{'/some/other/file/name'} = { type => 'file',
                                   from => '/some/file' };
```

DESCRIPTION

ExtUtils::Packlist provides a standard way to manage .packlist files. Functions are provided to read and write .packlist files. The original .packlist format is a simple list of absolute pathnames, one per line. In addition, this package supports an extended format, where as well as a filename each line may contain a list of attributes in the form of a space separated list of key=value pairs. This is used by the installperl script to differentiate between files and links, for example.

USAGE

The hash reference returned by the `new()` function can be used to examine and modify the contents of the .packlist. Items may be added/deleted from the .packlist by modifying the hash. If the value associated with a hash key is a scalar, the entry written to the .packlist by any subsequent `write()` will be a simple filename. If the value is a hash, the entry written will be the filename followed by the key=value pairs from the hash. Reading back the .packlist will recreate the original entries.

FUNCTIONS

`new()`

This takes an optional parameter, the name of a .packlist. If the file exists, it will be opened and the contents of the file will be read. The `new()` method returns a reference to a hash. This hash holds an entry for each line in the .packlist. In the case of old−style .packlists, the value associated with each key is undef. In the case of new−style .packlists, the value associated with each key is a hash containing the key=value pairs following the filename in the .packlist.

`read()`

This takes an optional parameter, the name of the .packlist to be read. If no file is specified, the .packlist specified to `new()` will be read. If the .packlist does not exist, Carp::croak will be called.

`write()`

This takes an optional parameter, the name of the .packlist to be written. If no file is specified, the .packlist specified to `new()` will be overwritten.

`validate()`

This checks that every file listed in the .packlist actually exists. If an argument which evaluates to true is given, any missing files will be removed from the internal hash. The return value is a list of the missing files, which will be empty if they all exist.

`packlist_file()`

This returns the name of the associated .packlist file

EXAMPLE

Here's `modrm`, a little utility to cleanly remove an installed module.

```
#!/usr/local/bin/perl -w
```

```
use strict;
use IO::Dir;
use ExtUtils::Packlist;
use ExtUtils::Installed;

sub emptydir($) {
    my ($dir) = @_;
    my $dh = IO::Dir->new($dir) || return(0);
    my @count = $dh->read();
    $dh->close();
    return(@count == 2 ? 1 : 0);
}

# Find all the installed packages
print("Finding all installed modules...\n");
my $installed = ExtUtils::Installed->new();

foreach my $module (grep(!/^Perl$/, $installed->modules())) {
   my $version = $installed->version($module) || "???";
   print("Found module $module Version $version\n");
   print("Do you want to delete $module? [n] ");
   my $r = <STDIN>; chomp($r);
   if ($r && $r =~ /^y/i) {
      # Remove all the files
      foreach my $file (sort($installed->files($module))) {
         print("rm $file\n");
         unlink($file);
      }
      my $pf = $installed->packlist($module)->packlist_file();
      print("rm $pf\n");
      unlink($pf);
      foreach my $dir (sort($installed->directory_tree($module))) {
         if (emptydir($dir)) {
            print("rmdir $dir\n");
            rmdir($dir);
         }
      }
   }
}
```

AUTHOR

Alan Burlison <Alan.Burlison@uk.sun.com

NAME

ExtUtils::testlib – add blib/* directories to @INC

SYNOPSIS

```
use ExtUtils::testlib;
```

DESCRIPTION

After an extension has been built and before it is installed it may be desirable to test it bypassing `make test`. By adding

```
use ExtUtils::testlib;
```

to a test program the intermediate directories used by `make` are added to @INC.

NAME

Fatal – replace functions with equivalents which succeed or die

SYNOPSIS

```
use Fatal qw(open close);

sub juggle { . . . }
import Fatal 'juggle';
```

DESCRIPTION

`Fatal` provides a way to conveniently replace functions which normally return a false value when they fail with equivalents which raise exceptions if they are not successful. This lets you use these functions without having to test their return values explicitly on each call. Exceptions can be caught using `eval{}`. See *perlfunc* and *perlvar* for details.

The do–or–die equivalents are set up simply by calling Fatal's `import` routine, passing it the names of the functions to be replaced. You may wrap both user–defined functions and overridable CORE operators (except `exec`, `system` which cannot be expressed via prototypes) in this way.

If the symbol `:void` appears in the import list, then functions named later in that import list raise an exception only when these are called in void context—that is, when their return values are ignored. For example

```
use Fatal qw/:void open close/;

# properly checked, so no exception raised on error
if(open(FH, "< /bogotic") {
        warn "bogo file, dude: $!";
}

# not checked, so error raises an exception
close FH;
```

AUTHOR

Lionel.Cons@cern.ch

prototype updates by Ilya Zakharevich ilya@math.ohio–state.edu

NAME

fields – compile–time class fields

SYNOPSIS

```
{
    package Foo;
    use fields qw(foo bar _Foo_private);
    sub new {
        my Foo $self = shift;
        unless (ref $self) {
            $self = fields::new($self);
            $self->{_Foo_private} = "this is Foo's secret";
        }
        $self->{foo} = 10;
        $self->{bar} = 20;
        return $self;
    }
}

my Foo $var = Foo::->new;
$var->{foo} = 42;

# this will generate a compile-time error
$var->{zap} = 42;

# subclassing
{
    package Bar;
    use base 'Foo';
    use fields qw(baz _Bar_private);        # not shared with Foo
    sub new {
        my $class = shift;
        my $self = fields::new($class);
        $self->SUPER::new();                # init base fields
        $self->{baz} = 10;                  # init own fields
        $self->{_Bar_private} = "this is Bar's secret";
        return $self;
    }
}
```

DESCRIPTION

The `fields` pragma enables compile–time verified class fields.

NOTE: The current implementation keeps the declared fields in the %FIELDS hash of the calling package, but this may change in future versions. Do **not** update the %FIELDS hash directly, because it must be created at compile–time for it to be fully useful, as is done by this pragma.

If a typed lexical variable holding a reference is used to access a hash element and a package with the same name as the type has declared class fields using this pragma, then the operation is turned into an array access at compile time.

The related `base` pragma will combine fields from base classes and any fields declared using the `fields` pragma. This enables field inheritance to work properly.

Field names that start with an underscore character are made private to the class and are not visible to subclasses. Inherited fields can be overridden but will generate a warning if used together with the `–w` switch.

The effect of all this is that you can have objects with named fields which are as compact and as fast arrays to access. This only works as long as the objects are accessed through properly typed variables. If the objects are not typed, access is only checked at run time.

The following functions are supported:

new `fields::new()` creates and blesses a pseudo–hash comprised of the fields declared using the `fields` pragma into the specified class. This makes it possible to write a constructor like this:

```
package Critter::Sounds;
use fields qw(cat dog bird);

sub new {
    my Critter::Sounds $self = shift;
    $self = fields::new($self) unless ref $self;
    $self->{cat} = 'meow';                          # scalar element
    @$self{'dog','bird'} = ('bark','tweet');        # slice
    return $self;
}
```

phash `fields::phash()` can be used to create and initialize a plain (unblessed) pseudo–hash. This function should always be used instead of creating pseudo–hashes directly.

If the first argument is a reference to an array, the pseudo–hash will be created with keys from that array. If a second argument is supplied, it must also be a reference to an array whose elements will be used as the values. If the second array contains less elements than the first, the trailing elements of the pseudo–hash will not be initialized. This makes it particularly useful for creating a pseudo–hash from subroutine arguments:

```
sub dogtag {
    my $tag = fields::phash([qw(name rank ser_num)], [@_]);
}
```

`fields::phash()` also accepts a list of key–value pairs that will be used to construct the pseudo hash. Examples:

```
my $tag = fields::phash(name => "Joe",
                        rank => "captain",
                        ser_num => 42);

my $pseudohash = fields::phash(%args);
```

SEE ALSO

base, *Pseudo–hashes: Using an array as a hash*

NAME

fileparse – split a pathname into pieces

basename – extract just the filename from a path

dirname – extract just the directory from a path

SYNOPSIS

```
use File::Basename;

($name,$path,$suffix) = fileparse($fullname,@suffixlist)
fileparse_set_fstype($os_string);
$basename = basename($fullname,@suffixlist);
$dirname = dirname($fullname);

($name,$path,$suffix) = fileparse("lib/File/Basename.pm","\.pm");
fileparse_set_fstype("VMS");
$basename = basename("lib/File/Basename.pm",".pm");
$dirname = dirname("lib/File/Basename.pm");
```

DESCRIPTION

These routines allow you to parse file specifications into useful pieces using the syntax of different operating systems.

fileparse_set_fstype

You select the syntax via the routine `fileparse_set_fstype()`.

If the argument passed to it contains one of the substrings "VMS", "MSDOS", "MacOS", "AmigaOS" or "MSWin32", the file specification syntax of that operating system is used in future calls to `fileparse()`, `basename()`, and `dirname()`. If it contains none of these substrings, Unix syntax is used. This pattern matching is case-insensitive. If you've selected VMS syntax, and the file specification you pass to one of these routines contains a "/", they assume you are using Unix emulation and apply the Unix syntax rules instead, for that function call only.

If the argument passed to it contains one of the substrings "VMS", "MSDOS", "MacOS", "AmigaOS", "os2", "MSWin32" or "RISCOS", then the pattern matching for suffix removal is performed without regard for case, since those systems are not case-sensitive when opening existing files (though some of them preserve case on file creation).

If you haven't called `fileparse_set_fstype()`, the syntax is chosen by examining the builtin variable `$^O` according to these rules.

fileparse

The `fileparse()` routine divides a file specification into three parts: a leading **path**, a file **name**, and a **suffix**. The **path** contains everything up to and including the last directory separator in the input file specification. The remainder of the input file specification is then divided into **name** and **suffix** based on the optional patterns you specify in `@suffixlist`. Each element of this list is interpreted as a regular expression, and is matched against the end of **name**. If this succeeds, the matching portion of **name** is removed and prepended to **suffix**. By proper use of `@suffixlist`, you can remove file types or versions for examination.

You are guaranteed that if you concatenate **path**, **name**, and **suffix** together in that order, the result will denote the same file as the input file specification.

EXAMPLES

Using Unix file syntax:

```
($base,$path,$type) = fileparse('/virgil/aeneid/draft.book7',
                                '\.book\d+');
```

would yield

```
$base eq 'draft'
$path eq '/virgil/aeneid/',
$type eq '.book7'
```

Similarly, using VMS syntax:

```
($name,$dir,$type) = fileparse('Doc_Root:[Help]Rhetoric.Rnh',
                               '\..*');
```

would yield

```
$name eq 'Rhetoric'
$dir  eq 'Doc_Root:[Help]'
$type eq '.Rnh'
```

`basename`

The `basename()` routine returns the first element of the list produced by calling `fileparse()` with the same arguments, except that it always quotes metacharacters in the given suffixes. It is provided for programmer compatibility with the Unix shell command basename(1).

`dirname`

The `dirname()` routine returns the directory portion of the input file specification. When using VMS or MacOS syntax, this is identical to the second element of the list produced by calling `fileparse()` with the same input file specification. (Under VMS, if there is no directory information in the input file specification, then the current default device and directory are returned.) When using Unix or MSDOS syntax, the return value conforms to the behavior of the Unix shell command dirname(1). This is usually the same as the behavior of `fileparse()`, but differs in some cases. For example, for the input file specification ***lib/***, `fileparse()` considers the directory name to be ***lib/***, while `dirname()` considers the directory name to be **.**).

NAME

validate – run many filetest checks on a tree

SYNOPSIS

```
use File::CheckTree;

$warnings += validate( q{
    /vmunix                 -e || die
    /boot                   -e || die
    /bin                    cd
        csh                 -ex
        csh                 !-ug
        sh                  -ex
        sh                  !-ug
    /usr                    -d || warn "What happened to $file?\n"
});
```

DESCRIPTION

The `validate()` routine takes a single multiline string consisting of lines containing a filename plus a file test to try on it. (The file test may also be a "cd", causing subsequent relative filenames to be interpreted relative to that directory.) After the file test you may put `|| die` to make it a fatal error if the file test fails. The default is `|| warn`. The file test may optionally have a "!' prepended to test for the opposite condition. If you do a cd and then list some relative filenames, you may want to indent them slightly for readability. If you supply your own `die()` or `warn()` message, you can use `$file` to interpolate the filename.

Filetests may be bunched: "–rwx" tests for all of `-r`, `-w`, and `-x`. Only the first failed test of the bunch will produce a warning.

The routine returns the number of warnings issued.

NAME

File::Compare – Compare files or filehandles

SYNOPSIS

```
use File::Compare;

if (compare("file1","file2") == 0) {
    print "They're equal\n";
}
```

DESCRIPTION

The File::Compare::compare function compares the contents of two sources, each of which can be a file or a file handle. It is exported from File::Compare by default.

File::Compare::cmp is a synonym for File::Compare::compare. It is exported from File::Compare only by request.

File::Compare::compare_text does a line by line comparison of the two files. It stops as soon as a difference is detected. `compare_text()` accepts an optional third argument: This must be a CODE reference to a line comparison function, which returns 0 when both lines are considered equal. For example:

```
compare_text($file1, $file2)
```

is basically equivalent to

```
compare_text($file1, $file2, sub {$_[0] ne $_[1]} )
```

RETURN

File::Compare::compare return 0 if the files are equal, 1 if the files are unequal, or −1 if an error was encountered.

AUTHOR

File::Compare was written by Nick Ing−Simmons. Its original documentation was written by Chip Salzenberg.

NAME

File::Copy – Copy files or filehandles

SYNOPSIS

```
use File::Copy;

copy("file1","file2");
copy("Copy.pm",\*STDOUT);'
move("/dev1/fileA","/dev2/fileB");

use POSIX;
use File::Copy cp;

$n = FileHandle->new("/a/file","r");
cp($n,"x");'
```

DESCRIPTION

The File::Copy module provides two basic functions, `copy` and `move`, which are useful for getting the contents of a file from one place to another.

- The `copy` function takes two parameters: a file to copy from and a file to copy to. Either argument may be a string, a FileHandle reference or a FileHandle glob. Obviously, if the first argument is a filehandle of some sort, it will be read from, and if it is a file *name* it will be opened for reading. Likewise, the second argument will be written to (and created if need be).

  Note that passing in files as handles instead of names may lead to loss of information on some operating systems; it is recommended that you use file names whenever possible. Files are opened in binary mode where applicable. To get a consistent behaviour when copying from a filehandle to a file, use `binmode` on the filehandle.

  An optional third parameter can be used to specify the buffer size used for copying. This is the number of bytes from the first file, that wil be held in memory at any given time, before being written to the second file. The default buffer size depends upon the file, but will generally be the whole file (up to 2Mb), or 1k for filehandles that do not reference files (eg. sockets).

  You may use the syntax `use File::Copy "cp"` to get at the "cp" alias for this function. The syntax is *exactly* the same.

- The `move` function also takes two parameters: the current name and the intended name of the file to be moved. If the destination already exists and is a directory, and the source is not a directory, then the source file will be renamed into the directory specified by the destination.

  If possible, `move()` will simply rename the file. Otherwise, it copies the file to the new location and deletes the original. If an error occurs during this copy–and–delete process, you may be left with a (possibly partial) copy of the file under the destination name.

  You may use the "mv" alias for this function in the same way that you may use the "cp" alias for `copy`.

File::Copy also provides the `syscopy` routine, which copies the file specified in the first parameter to the file specified in the second parameter, preserving OS–specific attributes and file structure. For Unix systems, this is equivalent to the simple `copy` routine. For VMS systems, this calls the `rmscopy` routine (see below). For OS/2 systems, this calls the `syscopy` XSUB directly. For Win32 systems, this calls `Win32::CopyFile`.

Special behaviour if `syscopy` is defined (OS/2, VMS and Win32)

If both arguments to `copy` are not file handles, then `copy` will perform a "system copy" of the input file to a new output file, in order to preserve file attributes, indexed file structure, *etc.* The buffer size parameter is ignored. If either argument to `copy` is a handle to an opened file, then data is copied using Perl operators, and no effort is made to preserve file attributes or record structure.

The system copy routine may also be called directly under VMS and OS/2 as `File::Copy::syscopy` (or under VMS as `File::Copy::rmscopy`, which is the routine that does the actual work for syscopy).

rmscopy(`$from,$to[,$date_flag]`)

The first and second arguments may be strings, typeglobs, typeglob references, or objects inheriting from IO::Handle; they are used in all cases to obtain the *filespec* of the input and output files, respectively. The name and type of the input file are used as defaults for the output file, if necessary.

A new version of the output file is always created, which inherits the structure and RMS attributes of the input file, except for owner and protections (and possibly timestamps; see below). All data from the input file is copied to the output file; if either of the first two parameters to `rmscopy` is a file handle, its position is unchanged. (Note that this means a file handle pointing to the output file will be associated with an old version of that file after `rmscopy` returns, not the newly created version.)

The third parameter is an integer flag, which tells `rmscopy` how to handle timestamps. If it is < 0, none of the input file's timestamps are propagated to the output file. If it is > 0, then it is interpreted as a bitmask: if bit 0 (the LSB) is set, then timestamps other than the revision date are propagated; if bit 1 is set, the revision date is propagated. If the third parameter to `rmscopy` is 0, then it behaves much like the DCL COPY command: if the name or type of the output file was explicitly specified, then no timestamps are propagated, but if they were taken implicitly from the input filespec, then all timestamps other than the revision date are propagated. If this parameter is not supplied, it defaults to 0.

Like `copy`, `rmscopy` returns 1 on success. If an error occurs, it sets `$!`, deletes the output file, and returns 0.

RETURN

All functions return 1 on success, 0 on failure. `$!` will be set if an error was encountered.

AUTHOR

File::Copy was written by Aaron Sherman <*ajs@ajs.com*> in 1995, and updated by Charles Bailey <*bailey@newman.upenn.edu*> in 1996.

NAME

File::DosGlob – DOS like globbing and then some

SYNOPSIS

```
require 5.004;

# override CORE::glob in current package
use File::DosGlob 'glob';

# override CORE::glob in ALL packages (use with extreme caution!)
use File::DosGlob 'GLOBAL_glob';

@perlfiles = glob  "..\\pe?l/*.p?";
print <..\\pe?l/*.p?>;

# from the command line (overrides only in main::)
> perl -MFile::DosGlob=glob -e "print <../pe*/*p?>"
```

DESCRIPTION

A module that implements DOS–like globbing with a few enhancements. It is largely compatible with perlglob.exe (the M$ setargv.obj version) in all but one respect—it understands wildcards in directory components.

For example, `<..\\l*b\\file/*glob.p?` will work as expected (in that it will find something like '..\lib\File/DosGlob.pm' alright). Note that all path components are case–insensitive, and that backslashes and forward slashes are both accepted, and preserved. You may have to double the backslashes if you are putting them in literally, due to double–quotish parsing of the pattern by perl.

Spaces in the argument delimit distinct patterns, so `glob('*.exe *.dll')` globs all filenames that end in `.exe` or `.dll`. If you want to put in literal spaces in the glob pattern, you can escape them with either double quotes, or backslashes. e.g. `glob('c:/"Program Files"/*/*.dll')`, or `glob('c:/Program\ Files/*/*.dll')`. The argument is tokenized using `Text::ParseWords::parse_line()`, so see *Text::ParseWords* for details of the quoting rules used.

Extending it to csh patterns is left as an exercise to the reader.

EXPORTS (by request only)

`glob()`

BUGS

Should probably be built into the core, and needs to stop pandering to DOS habits. Needs a dose of optimizium too.

AUTHOR

Gurusamy Sarathy <gsar@activestate.com

HISTORY

- Support for globally overriding `glob()` (GSAR 3–JUN–98)
- Scalar context, independent iterator context fixes (GSAR 15–SEP–97)
- A few dir–vs–file optimizations result in glob importation being 10 times faster than using perlglob.exe, and using perlglob.bat is only twice as slow as perlglob.exe (GSAR 28–MAY–97)
- Several cleanups prompted by lack of compatible perlglob.exe under Borland (GSAR 27–MAY–97)
- Initial version (GSAR 20–FEB–97)

SEE ALSO

perl

perlglob.bat

Text::ParseWords

NAME

find – traverse a file tree

finddepth – traverse a directory structure depth–first

SYNOPSIS

```
use File::Find;
find(\&wanted, '/foo', '/bar');
sub wanted { ... }

use File::Find;
finddepth(\&wanted, '/foo', '/bar');
sub wanted { ... }

use File::Find;
find({ wanted => \&process, follow => 1 }, '.');
```

DESCRIPTION

The first argument to `find()` is either a hash reference describing the operations to be performed for each file, or a code reference.

Here are the possible keys for the hash:

`wanted`

The value should be a code reference. This code reference is called *the `wanted()` function* below.

`bydepth`

Reports the name of a directory only AFTER all its entries have been reported. Entry point `finddepth()` is a shortcut for specifying `{ bydepth = 1 }` in the first argument of `find()`.

`preprocess`

The value should be a code reference. This code reference is used to preprocess a directory; it is called after `readdir()` but before the loop that calls the `wanted()` function. It is called with a list of strings and is expected to return a list of strings. The code can be used to sort the strings alphabetically, numerically, or to filter out directory entries based on their name alone.

`postprocess`

The value should be a code reference. It is invoked just before leaving the current directory. It is called in void context with no arguments. The name of the current directory is in `$File::Find::dir`. This hook is handy for summarizing a directory, such as calculating its disk usage.

`follow`

Causes symbolic links to be followed. Since directory trees with symbolic links (followed) may contain files more than once and may even have cycles, a hash has to be built up with an entry for each file. This might be expensive both in space and time for a large directory tree. See *follow_fast* and *follow_skip* below. If either *follow* or *follow_fast* is in effect:

- It is guaranteed that an *lstat* has been called before the user's *`wanted()`* function is called. This enables fast file checks involving `_`.
- There is a variable `$File::Find::fullname` which holds the absolute pathname of the file with all symbolic links resolved

`follow_fast`

This is similar to *follow* except that it may report some files more than once. It does detect cycles, however. Since only symbolic links have to be hashed, this is much cheaper both in space and time. If processing a file more than once (by the user's *`wanted()`* function) is worse than just taking time, the option *follow* should be used.

follow_skip

follow_skip==1, which is the default, causes all files which are neither directories nor symbolic links to be ignored if they are about to be processed a second time. If a directory or a symbolic link are about to be processed a second time, File::Find dies. follow_skip==0 causes File::Find to die if any file is about to be processed a second time. follow_skip==2 causes File::Find to ignore any duplicate files and dirctories but to proceed normally otherwise.

no_chdir

Does not chdir() to each directory as it recurses. The wanted() function will need to be aware of this, of course. In this case, $_ will be the same as $File::Find::name.

untaint

If find is used in taint–mode (–T command line switch or if EUID != UID or if EGID != GID) then internally directory names have to be untainted before they can be cd'ed to. Therefore they are checked against a regular expression *untaint_pattern*. Note that all names passed to the user's *wanted()* function are still tainted.

untaint_pattern

See above. This should be set using the qr quoting operator. The default is set to qr|^([-+@\w./]+)$|. Note that the parantheses are vital.

untaint_skip

If set, directories (subtrees) which fail the *untaint_pattern* are skipped. The default is to 'die' in such a case.

The wanted() function does whatever verifications you want. $File::Find::dir contains the current directory name, and $_ the current filename within that directory. $File::Find::name contains the complete pathname to the file. You are chdir()'d to $File::Find::dir when the function is called, unless no_chdir was specified. When <follow or <follow_fast are in effect, there is also a $File::Find::fullname. The function may set $File::Find::prune to prune the tree unless bydepth was specified. Unless follow or follow_fast is specified, for compatibility reasons (find.pl, find2perl) there are in addition the following globals available: $File::Find::topdir, $File::Find::topdev, $File::Find::topino, $File::Find::topmode and $File::Find::topnlink.

This library is useful for the find2perl tool, which when fed,

```
find2perl / -name .nfs\* -mtime +7 \
    -exec rm -f {} \; -o -fstype nfs -prune
```

produces something like:

```
sub wanted {
    /^\.nfs.*\z/s &&
    (($dev, $ino, $mode, $nlink, $uid, $gid) = lstat($_)) &&
    int(-M _) > 7 &&
    unlink($_)
    ||
    ($nlink || (($dev, $ino, $mode, $nlink, $uid, $gid) = lstat($_))) &&
    $dev < 0 &&
    ($File::Find::prune = 1);
}
```

Set the variable $File::Find::dont_use_nlink if you're using AFS, since AFS cheats.

Here's another interesting wanted function. It will find all symlinks that don't resolve:

```
sub wanted {
     -l && !-e && print "bogus link: $File::Find::name\n";
```

```
}
```

See also the script `pfind` on CPAN for a nice application of this module.

CAVEAT

Be aware that the option to follow symbolic links can be dangerous. Depending on the structure of the directory tree (including symbolic links to directories) you might traverse a given (physical) directory more than once (only if `follow_fast` is in effect). Furthermore, deleting or changing files in a symbolically linked directory might cause very unpleasant surprises, since you delete or change files in an unknown directory.

NAME

File::Path – create or remove directory trees

SYNOPSIS

```
use File::Path;

mkpath(['/foo/bar/baz', 'blurfl/quux'], 1, 0711);
rmtree(['foo/bar/baz', 'blurfl/quux'], 1, 1);
```

DESCRIPTION

The `mkpath` function provides a convenient way to create directories, even if your `mkdir` kernel call won't create more than one level of directory at a time. `mkpath` takes three arguments:

- the name of the path to create, or a reference to a list of paths to create,
- a boolean value, which if TRUE will cause `mkpath` to print the name of each directory as it is created (defaults to FALSE), and
- the numeric mode to use when creating the directories (defaults to 0777)

It returns a list of all directories (including intermediates, determined using the Unix '/' separator) created.

Similarly, the `rmtree` function provides a convenient way to delete a subtree from the directory structure, much like the Unix command `rm -r`. `rmtree` takes three arguments:

- the root of the subtree to delete, or a reference to a list of roots. All of the files and directories below each root, as well as the roots themselves, will be deleted.
- a boolean value, which if TRUE will cause `rmtree` to print a message each time it examines a file, giving the name of the file, and indicating whether it's using `rmdir` or `unlink` to remove it, or that it's skipping it. (defaults to FALSE)
- a boolean value, which if TRUE will cause `rmtree` to skip any files to which you do not have delete access (if running under VMS) or write access (if running under another OS). This will change in the future when a criterion for 'delete permission' under OSs other than VMS is settled. (defaults to FALSE)

It returns the number of files successfully deleted. Symlinks are simply deleted and not followed.

NOTE: If the third parameter is not TRUE, `rmtree` is **unsecure** in the face of failure or interruption. Files and directories which were not deleted may be left with permissions reset to allow world read and write access. Note also that the occurrence of errors in rmtree can be determined *only* by trapping diagnostic messages using `$SIG{__WARN__};` it is not apparent from the return value. Therefore, you must be extremely careful about using `rmtree($foo,$bar,0` in situations where security is an issue.

AUTHORS

Tim Bunce ***<Tim.Bunce@ig.co.uk*** and Charles Bailey ***<bailey@newman.upenn.edu***

NAME

File::Spec::Functions – portably perform operations on file names

SYNOPSIS

```
use File::Spec::Functions;
$x = catfile('a','b');
```

DESCRIPTION

This module exports convenience functions for all of the class methods provided by File::Spec.

For a reference of available functions, please consult *File::Spec::Unix*, which contains the entire set, and which is inherited by the modules for other platforms. For further information, please see *File::Spec::Mac*, *File::Spec::OS2*, *File::Spec::Win32*, or *File::Spec::VMS*.

Exports

The following functions are exported by default.

```
canonpath
catdir
catfile
curdir
rootdir
updir
no_upwards
file_name_is_absolute
path
```

The following functions are exported only by request.

```
devnull
tmpdir
splitpath
splitdir
catpath
abs2rel
rel2abs
```

All the functions may be imported using the `:ALL` tag.

SEE ALSO

File::Spec, File::Spec::Unix, File::Spec::Mac, File::Spec::OS2, File::Spec::Win32, File::Spec::VMS, ExtUtils::MakeMaker

NAME

File::Spec::Mac – File::Spec for MacOS

SYNOPSIS

```
require File::Spec::Mac; # Done internally by File::Spec if needed
```

DESCRIPTION

Methods for manipulating file specifications.

METHODS

canonpath

On MacOS, there's nothing to be done. Returns what it's given.

catdir

Concatenate two or more directory names to form a complete path ending with a directory. Put a trailing : on the end of the complete path if there isn't one, because that's what's done in MacPerl's environment.

The fundamental requirement of this routine is that

```
File::Spec->catdir(split(":",$path)) eq $path
```

But because of the nature of Macintosh paths, some additional possibilities are allowed to make using this routine give reasonable results for some common situations. Here are the rules that are used. Each argument has its trailing ":" removed. Each argument, except the first, has its leading ":" removed. They are then joined together by a ":".

So

```
File::Spec->catdir("a","b") = "a:b:"
File::Spec->catdir("a:",":b") = "a:b:"
File::Spec->catdir("a:","b") = "a:b:"
File::Spec->catdir("a",":b") = "a:b"
File::Spec->catdir("a","","b") = "a::b"
```

etc.

To get a relative path (one beginning with :), begin the first argument with : or put a "" as the first argument.

If you don't want to worry about these rules, never allow a ":" on the ends of any of the arguments except at the beginning of the first.

Under MacPerl, there is an additional ambiguity. Does the user intend that

```
File::Spec->catfile("LWP","Protocol","http.pm")
```

be relative or absolute? There's no way of telling except by checking for the existence of LWP: or :LWP, and even there he may mean a dismounted volume or a relative path in a different directory (like in @INC). So those checks aren't done here. This routine will treat this as absolute.

catfile

Concatenate one or more directory names and a filename to form a complete path ending with a filename. Since this uses catdir, the same caveats apply. Note that the leading : is removed from the filename, so that

```
File::Spec->catfile($ENV{HOME},"file");
```

and

```
File::Spec->catfile($ENV{HOME},":file");
```

give the same answer, as one might expect.

curdir

Returns a string representing the current directory.

devnull

Returns a string representing the null device.

rootdir

Returns a string representing the root directory. Under MacPerl, returns the name of the startup volume, since that's the closest in concept, although other volumes aren't rooted there.

tmpdir

Returns a string representation of the first existing directory from the following list or '' if none exist:

```
$ENV{TMPDIR}
```

updir

Returns a string representing the parent directory.

file_name_is_absolute

Takes as argument a path and returns true, if it is an absolute path. In the case where a name can be either relative or absolute (for example, a folder named "HD" in the current working directory on a drive named "HD"), relative wins. Use ":" in the appropriate place in the path if you want to distinguish unambiguously.

As a special case, the file name '' is always considered to be absolute.

path

Returns the null list for the MacPerl application, since the concept is usually meaningless under MacOS. But if you're using the MacPerl tool under MPW, it gives back `$ENV{Commands}` suitably split, as is done in :lib:ExtUtils:MM_Mac.pm.

splitpath
splitdir
catpath
abs2rel

See *File::Spec::Unix/abs2rel* for general documentation.

Unlike `File::Spec::Unix-abs2rel()`, this function will make checks against the local filesystem if necessary. See */file_name_is_absolute* for details.

rel2abs

See *File::Spec::Unix/rel2abs* for general documentation.

Unlike `File::Spec::Unix-rel2abs()`, this function will make checks against the local filesystem if necessary. See */file_name_is_absolute* for details.

SEE ALSO

File::Spec

NAME

File::Spec::OS2 – methods for OS/2 file specs

SYNOPSIS

```
require File::Spec::OS2; # Done internally by File::Spec if needed
```

DESCRIPTION

See File::Spec::Unix for a documentation of the methods provided there. This package overrides the implementation of these methods, not the semantics.

NAME

File::Spec::Unix – methods used by File::Spec

SYNOPSIS

```
require File::Spec::Unix; # Done automatically by File::Spec
```

DESCRIPTION

Methods for manipulating file specifications.

METHODS

canonpath

No physical check on the filesystem, but a logical cleanup of a path. On UNIX eliminated successive slashes and successive "/.".

```
$cpath = File::Spec->canonpath( $path ) ;
```

catdir

Concatenate two or more directory names to form a complete path ending with a directory. But remove the trailing slash from the resulting string, because it doesn't look good, isn't necessary and confuses OS2. Of course, if this is the root directory, don't cut off the trailing slash :–)

catfile

Concatenate one or more directory names and a filename to form a complete path ending with a filename

curdir

Returns a string representation of the current directory. "." on UNIX.

devnull

Returns a string representation of the null device. "/dev/null" on UNIX.

rootdir

Returns a string representation of the root directory. "/" on UNIX.

tmpdir

Returns a string representation of the first writable directory from the following list or "" if none are writable:

```
$ENV{TMPDIR}
/tmp
```

updir

Returns a string representation of the parent directory. ".." on UNIX.

no_upwards

Given a list of file names, strip out those that refer to a parent directory. (Does not strip symlinks, only '.', '..', and equivalents.)

case_tolerant

Returns a true or false value indicating, respectively, that alphabetic is not or is significant when comparing file specifications.

file_name_is_absolute

Takes as argument a path and returns true if it is an absolute path.

This does not consult the local filesystem on Unix, Win32, or OS/2. It does sometimes on MacOS (see *File::Spec::MacOS/file_name_is_absolute*). It does consult the working environment for VMS (see *File::Spec::VMS/file_name_is_absolute*).

path

Takes no argument, returns the environment variable PATH as an array.

join

join is the same as catfile.

splitpath

```
($volume,$directories,$file) = File::Spec->splitpath( $path );
($volume,$directories,$file) = File::Spec->splitpath( $path, $no_file );
```

Splits a path in to volume, directory, and filename portions. On systems with no concept of volume, returns undef for volume.

For systems with no syntax differentiating filenames from directories, assumes that the last file is a path unless `$no_file` is true or a trailing separator or /. or /.. is present. On Unix this means that `$no_file` true makes this return ('', `$path`, '').

The directory portion may or may not be returned with a trailing '/'.

The results can be passed to */catpath()* to get back a path equivalent to (usually identical to) the original path.

splitdir

The opposite of */catdir()*.

```
@dirs = File::Spec->splitdir( $directories );
```

`$directories` must be only the directory portion of the path on systems that have the concept of a volume or that have path syntax that differentiates files from directories.

Unlike just splitting the directories on the separator, empty directory names (`''`) can be returned, because these are significant on some OSs (e.g. MacOS).

On Unix,

```
File::Spec->splitdir( "/a/b//c/" );
```

Yields:

```
( '', 'a', 'b', '', 'c', '' )
```

catpath

Takes volume, directory and file portions and returns an entire path. Under Unix, `$volume` is ignored, and directory and file are catenated. A '/' is inserted if need be. On other OSs, `$volume` is significant.

abs2rel

Takes a destination path and an optional base path returns a relative path from the base path to the destination path:

```
$rel_path = File::Spec->abs2rel( $path ) ;
$rel_path = File::Spec->abs2rel( $path, $base ) ;
```

If `$base` is not present or '', then *cwd()* is used. If `$base` is relative, then it is converted to absolute form using */rel2abs()*. This means that it is taken to be relative to *cwd()*.

On systems with the concept of a volume, this assumes that both paths are on the `$destination` volume, and ignores the `$base` volume.

On systems that have a grammar that indicates filenames, this ignores the `$base` filename as well. Otherwise all path components are assumed to be directories.

If `$path` is relative, it is converted to absolute form using */rel2abs()*. This means that it is taken to be relative to *cwd()*.

No checks against the filesystem are made on most systems. On MacOS, the filesystem may be consulted (see *File::Spec::MacOS/file_name_is_absolute*). On VMS, there is interaction with the working environment, as logicals and macros are expanded.

Based on code written by Shigio Yamaguchi.

rel2abs

Converts a relative path to an absolute path.

```
$abs_path = File::Spec->rel2abs( $path ) ;
$abs_path = File::Spec->rel2abs( $path, $base ) ;
```

If `$base` is not present or '', then *cwd()* is used. If `$base` is relative, then it is converted to absolute form using */rel2abs()*. This means that it is taken to be relative to *cwd()*.

On systems with the concept of a volume, this assumes that both paths are on the `$base` volume, and ignores the `$path` volume.

On systems that have a grammar that indicates filenames, this ignores the `$base` filename as well. Otherwise all path components are assumed to be directories.

If `$path` is absolute, it is cleaned up and returned using */canonpath()*.

No checks against the filesystem are made on most systems. On MacOS, the filesystem may be consulted (see *File::Spec::MacOS/file_name_is_absolute*). On VMS, there is interaction with the working environment, as logicals and macros are expanded.

Based on code written by Shigio Yamaguchi.

SEE ALSO

File::Spec

NAME

File::Spec::VMS − methods for VMS file specs

SYNOPSIS

```
require File::Spec::VMS; # Done internally by File::Spec if needed
```

DESCRIPTION

See File::Spec::Unix for a documentation of the methods provided there. This package overrides the implementation of these methods, not the semantics.

eliminate_macros

Expands MM[KS]/Make macros in a text string, using the contents of identically named elements of `%$self`, and returns the result as a file specification in Unix syntax.

fixpath

Catchall routine to clean up problem MM[SK]/Make macros. Expands macros in any directory specification, in order to avoid juxtaposing two VMS−syntax directories when MM[SK] is run. Also expands expressions which are all macro, so that we can tell how long the expansion is, and avoid overrunning DCL's command buffer when MM[KS] is running.

If optional second argument has a TRUE value, then the return string is a VMS−syntax directory specification, if it is FALSE, the return string is a VMS−syntax file specification, and if it is not specified, `fixpath()` checks to see whether it matches the name of a directory in the current default directory, and returns a directory or file specification accordingly.

Methods always loaded

canonpath (override)

Removes redundant portions of file specifications according to VMS syntax.

catdir

Concatenates a list of file specifications, and returns the result as a VMS−syntax directory specification. No check is made for "impossible" cases (e.g. elements other than the first being absolute filespecs).

catfile

Concatenates a list of file specifications, and returns the result as a VMS−syntax file specification.

curdir (override)

Returns a string representation of the current directory: '[]'

devnull (override)

Returns a string representation of the null device: '_NLA0:'

rootdir (override)

Returns a string representation of the root directory: 'SYS$DISK:[000000]'

tmpdir (override)

Returns a string representation of the first writable directory from the following list or '' if none are writable:

```
sys$scratch:
$ENV{TMPDIR}
```

updir (override)

Returns a string representation of the parent directory: '[−]'

case_tolerant (override)

VMS file specification syntax is case–tolerant.

path (override)

Translate logical name DCL$PATH as a searchlist, rather than trying to `split` string value of `$ENV{'PATH'}`.

file_name_is_absolute (override)

Checks for VMS directory spec as well as Unix separators.

splitpath (override)

Splits using VMS syntax.

splitdir (override)

Split dirspec using VMS syntax.

catpath (override)

Construct a complete filespec using VMS syntax

abs2rel (override)

Use VMS syntax when converting filespecs.

rel2abs (override)

Use VMS syntax when converting filespecs.

SEE ALSO

File::Spec

NAME

File::Spec::Win32 – methods for Win32 file specs

SYNOPSIS

```
require File::Spec::Win32; # Done internally by File::Spec if needed
```

DESCRIPTION

See File::Spec::Unix for a documentation of the methods provided there. This package overrides the implementation of these methods, not the semantics.

devnull

Returns a string representation of the null device.

tmpdir

Returns a string representation of the first existing directory from the following list:

```
$ENV{TMPDIR}
$ENV{TEMP}
$ENV{TMP}
/tmp
/
```

catfile

Concatenate one or more directory names and a filename to form a complete path ending with a filename

canonpath

No physical check on the filesystem, but a logical cleanup of a path. On UNIX eliminated successive slashes and successive "/.".

splitpath

```
($volume,$directories,$file) = File::Spec->splitpath( $path );
($volume,$directories,$file) = File::Spec->splitpath( $path, $no_file );
```

Splits a path in to volume, directory, and filename portions. Assumes that the last file is a path unless the path ends in '\\', '\\.', '\\..' or `$no_file` is true. On Win32 this means that `$no_file` true makes this return (`$volume, $path,` undef).

Separators accepted are \ and /.

Volumes can be drive letters or UNC sharenames (\\server\share).

The results can be passed to *`/catpath`* to get back a path equivalent to (usually identical to) the original path.

splitdir

The opposite of *`/catdir()`*.

```
@dirs = File::Spec->splitdir( $directories );
```

`$directories` must be only the directory portion of the path on systems that have the concept of a volume or that have path syntax that differentiates files from directories.

Unlike just splitting the directories on the separator, leading empty and trailing directory entries can be returned, because these are significant on some OSs. So,

```
File::Spec->splitdir( "/a/b/c" );
```

Yields:

```
( '', 'a', 'b', '', 'c', '' )
```

catpath

Takes volume, directory and file portions and returns an entire path. Under Unix, `$volume` is ignored, and this is just like `catfile()`. On other OSs, the `$volume` become significant.

SEE ALSO

File::Spec

NAME

File::Spec – portably perform operations on file names

SYNOPSIS

```
use File::Spec;

$x=File::Spec->catfile('a', 'b', 'c');
```

which returns 'a/b/c' under Unix. Or:

```
use File::Spec::Functions;

$x = catfile('a', 'b', 'c');
```

DESCRIPTION

This module is designed to support operations commonly performed on file specifications (usually called "file names", but not to be confused with the contents of a file, or Perl's file handles), such as concatenating several directory and file names into a single path, or determining whether a path is rooted. It is based on code directly taken from MakeMaker 5.17, code written by Andreas König, Andy Dougherty, Charles Bailey, Ilya Zakharevich, Paul Schinder, and others.

Since these functions are different for most operating systems, each set of OS specific routines is available in a separate module, including:

```
File::Spec::Unix
File::Spec::Mac
File::Spec::OS2
File::Spec::Win32
File::Spec::VMS
```

The module appropriate for the current OS is automatically loaded by File::Spec. Since some modules (like VMS) make use of facilities available only under that OS, it may not be possible to load all modules under all operating systems.

Since File::Spec is object oriented, subroutines should not called directly, as in:

```
File::Spec::catfile('a','b');
```

but rather as class methods:

```
File::Spec->catfile('a','b');
```

For simple uses, *File::Spec::Functions* provides convenient functional forms of these methods.

For a list of available methods, please consult *File::Spec::Unix*, which contains the entire set, and which is inherited by the modules for other platforms. For further information, please see *File::Spec::Mac*, *File::Spec::OS2*, *File::Spec::Win32*, or *File::Spec::VMS*.

SEE ALSO

File::Spec::Unix, File::Spec::Mac, File::Spec::OS2, File::Spec::Win32, File::Spec::VMS, File::Spec::Functions, ExtUtils::MakeMaker

AUTHORS

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NAME

File::stat – by–name interface to Perl's built–in `stat()` functions

SYNOPSIS

```
use File::stat;
$st = stat($file) or die "No $file: $!";
if ( ($st->mode & 0111) && $st->nlink > 1) ) {
    print "$file is executable with lotsa links\n";
}

use File::stat qw(:FIELDS);
stat($file) or die "No $file: $!";
if ( ($st_mode & 0111) && $st_nlink > 1) ) {
    print "$file is executable with lotsa links\n";
}
```

DESCRIPTION

This module's default exports override the core `stat()` and `lstat()` functions, replacing them with versions that return "File::stat" objects. This object has methods that return the similarly named structure field name from the stat(2) function; namely, dev, ino, mode, nlink, uid, gid, rdev, size, atime, mtime, ctime, blksize, and blocks.

You may also import all the structure fields directly into your namespace as regular variables using the :FIELDS import tag. (Note that this still overrides your `stat()` and `lstat()` functions.) Access these fields as variables named with a preceding `st_` in front their method names. Thus, `$stat_obj->dev()` corresponds to `$st_dev` if you import the fields.

To access this functionality without the core overrides, pass the `use` an empty import list, and then access function functions with their full qualified names. On the other hand, the built–ins are still available via the `CORE::` pseudo–package.

NOTE

While this class is currently implemented using the Class::Struct module to build a struct–like class, you shouldn't rely upon this.

AUTHOR

Tom Christiansen

NAME

File::Temp – return name and handle of a temporary file safely

=begin __INTERNALS

PORTABILITY

This module is designed to be portable across operating systems and it currently supports Unix, VMS, DOS, OS/2 and Windows. When porting to a new OS there are generally three main issues that have to be solved:

- Can the OS unlink an open file? If it can't then the `_can_unlink_opened_file` method should be modified.
- Are the return values from `stat` reliable? By default all the return values from `stat` are compared when unlinking a temporary file using the filename and the handle. Operating systems other than unix do not always have valid entries in all fields. If `unlink0` fails then the `stat` comparison should be modified accordingly.
- Security. Systems that can not support a test for the sticky bit on a directory can not use the MEDIUM and HIGH security tests. The `_can_do_level` method should be modified accordingly.

=end __INTERNALS

SYNOPSIS

```
use File::Temp qw/ tempfile tempdir /;

$dir = tempdir( CLEANUP => 1 );
($fh, $filename) = tempfile( DIR => $dir );

($fh, $filename) = tempfile( $template, DIR => $dir);
($fh, $filename) = tempfile( $template, SUFFIX => '.dat');

$fh = tempfile();
```

MkTemp family:

```
use File::Temp qw/ :mktemp  /;

($fh, $file) = mkstemp( "tmpfileXXXXX" );
($fh, $file) = mkstemps( "tmpfileXXXXXX", $suffix);

$tmpdir = mkdtemp( $template );

$unopened_file = mktemp( $template );
```

POSIX functions:

```
use File::Temp qw/ :POSIX /;

$file = tmpnam();
$fh = tmpfile();

($fh, $file) = tmpnam();
($fh, $file) = tmpfile();
```

Compatibility functions:

```
$unopened_file = File::Temp::tempnam( $dir, $pfx );
```

=begin later

Objects (NOT YET IMPLEMENTED):

```
require File::Temp;

$fh = new File::Temp($template);
$fname = $fh->filename;
```

=end later

DESCRIPTION

File::Temp can be used to create and open temporary files in a safe way. The tempfile() function can be used to return the name and the open filehandle of a temporary file. The tempdir() function can be used to create a temporary directory.

The security aspect of temporary file creation is emphasized such that a filehandle and filename are returned together. This helps guarantee that a race condition can not occur where the temporary file is created by another process between checking for the existence of the file and its opening. Additional security levels are provided to check, for example, that the sticky bit is set on world writable directories. See *"safe_level"* for more information.

For compatibility with popular C library functions, Perl implementations of the mkstemp() family of functions are provided. These are, mkstemp(), mkstemps(), mkdtemp() and mktemp().

Additionally, implementations of the standard *POSIX\|POSIX* tmpnam() and tmpfile() functions are provided if required.

Implementations of mktemp(), tmpnam(), and tempnam() are provided, but should be used with caution since they return only a filename that was valid when function was called, so cannot guarantee that the file will not exist by the time the caller opens the filename.

FUNCTIONS

This section describes the recommended interface for generating temporary files and directories.

tempfile

This is the basic function to generate temporary files. The behaviour of the file can be changed using various options:

```
($fh, $filename) = tempfile();
```

Create a temporary file in the directory specified for temporary files, as specified by the tmpdir() function in *File::Spec*.

```
($fh, $filename) = tempfile($template);
```

Create a temporary file in the current directory using the supplied template. Trailing 'X' characters are replaced with random letters to generate the filename. At least four 'X' characters must be present in the template.

```
($fh, $filename) = tempfile($template, SUFFIX => $suffix)
```

Same as previously, except that a suffix is added to the template after the 'X' translation. Useful for ensuring that a temporary filename has a particular extension when needed by other applications. But see the WARNING at the end.

```
($fh, $filename) = tempfile($template, DIR => $dir);
```

Translates the template as before except that a directory name is specified.

```
($fh, $filename) = tempfile($template, UNLINK => 1);
```

Return the filename and filehandle as before except that the file is automatically removed when the program exits. Default is for the file to be removed if a file handle is requested and to be kept if the filename is requested.

If the template is not specified, a template is always automatically generated. This temporary file is placed in tmpdir() (*File::Spec*) unless a directory is specified explicitly with the DIR option.

```
$fh = tempfile( $template, DIR => $dir );
```

If called in scalar context, only the filehandle is returned and the file will automatically be deleted when closed (see the description of tmpfile() elsewhere in this document). This is the preferred

mode of operation, as if you only have a filehandle, you can never create a race condition by fumbling with the filename. On systems that can not unlink an open file (for example, Windows NT) the file is marked for deletion when the program ends (equivalent to setting UNLINK to 1).

```
(undef, $filename) = tempfile($template, OPEN => 0);
```

This will return the filename based on the template but will not open this file. Cannot be used in conjunction with UNLINK set to true. Default is to always open the file to protect from possible race conditions. A warning is issued if warnings are turned on. Consider using the `tmpnam()` and `mktemp()` functions described elsewhere in this document if opening the file is not required.

Options can be combined as required.

tempdir

This is the recommended interface for creation of temporary directories. The behaviour of the function depends on the arguments:

```
$tempdir = tempdir();
```

Create a directory in `tmpdir()` (see *File::Spec|File::Spec*).

```
$tempdir = tempdir( $template );
```

Create a directory from the supplied template. This template is similar to that described for `tempfile()`. 'X' characters at the end of the template are replaced with random letters to construct the directory name. At least four 'X' characters must be in the template.

```
$tempdir = tempdir ( DIR => $dir );
```

Specifies the directory to use for the temporary directory. The temporary directory name is derived from an internal template.

```
$tempdir = tempdir ( $template, DIR => $dir );
```

Prepend the supplied directory name to the template. The template should not include parent directory specifications itself. Any parent directory specifications are removed from the template before prepending the supplied directory.

```
$tempdir = tempdir ( $template, TMPDIR => 1 );
```

Using the supplied template, creat the temporary directory in a standard location for temporary files. Equivalent to doing

```
$tempdir = tempdir ( $template, DIR => File::Spec->tmpdir);
```

but shorter. Parent directory specifications are stripped from the template itself. The `TMPDIR` option is ignored if `DIR` is set explicitly. Additionally, `TMPDIR` is implied if neither a template nor a directory are supplied.

```
$tempdir = tempdir( $template, CLEANUP => 1);
```

Create a temporary directory using the supplied template, but attempt to remove it (and all files inside it) when the program exits. Note that an attempt will be made to remove all files from the directory even if they were not created by this module (otherwise why ask to clean it up?). The directory removal is made with the `rmtree()` function from the *File::Path|File::Path* module. Of course, if the template is not specified, the temporary directory will be created in `tmpdir()` and will also be removed at program exit.

MKTEMP FUNCTIONS

The following functions are Perl implementations of the `mktemp()` family of temp file generation system calls.

mkstemp

Given a template, returns a filehandle to the temporary file and the name of the file.

```
($fh, $name) = mkstemp( $template );
```

In scalar context, just the filehandle is returned.

The template may be any filename with some number of X's appended to it, for example ***/tmp/temp.XXXX***. The trailing X's are replaced with unique alphanumeric combinations.

mkstemps

Similar to `mkstemp()`, except that an extra argument can be supplied with a suffix to be appended to the template.

```
($fh, $name) = mkstemps( $template, $suffix );
```

For example a template of `testXXXXXX` and suffix of `.dat` would generate a file similar to ***testhGji_w.dat***.

Returns just the filehandle alone when called in scalar context.

mkdtemp

Create a directory from a template. The template must end in X's that are replaced by the routine.

```
$tmpdir_name = mkdtemp($template);
```

Returns the name of the temporary directory created. Returns undef on failure.

Directory must be removed by the caller.

mktemp

Returns a valid temporary filename but does not guarantee that the file will not be opened by someone else.

```
$unopened_file = mktemp($template);
```

Template is the same as that required by `mkstemp()`.

POSIX FUNCTIONS

This section describes the re–implementation of the `tmpnam()` and `tmpfile()` functions described in *POSIX* using the `mkstemp()` from this module.

Unlike the *POSIX\|POSIX* implementations, the directory used for the temporary file is not specified in a system include file (`P_tmpdir`) but simply depends on the choice of `tmpdir()` returned by *File::Spec\|File::Spec*. On some implementations this location can be set using the `TMPDIR` environment variable, which may not be secure. If this is a problem, simply use `mkstemp()` and specify a template.

tmpnam

When called in scalar context, returns the full name (including path) of a temporary file (uses `mktemp()`). The only check is that the file does not already exist, but there is no guarantee that that condition will continue to apply.

```
$file = tmpnam();
```

When called in list context, a filehandle to the open file and a filename are returned. This is achieved by calling `mkstemp()` after constructing a suitable template.

```
($fh, $file) = tmpnam();
```

If possible, this form should be used to prevent possible race conditions.

See *File::Spec/tmpdir* for information on the choice of temporary directory for a particular operating system.

tmpfile

In scalar context, returns the filehandle of a temporary file.

```
$fh = tmpfile();
```

The file is removed when the filehandle is closed or when the program exits. No access to the filename is provided.

ADDITIONAL FUNCTIONS

These functions are provided for backwards compatibility with common tempfile generation C library functions.

They are not exported and must be addressed using the full package name.

tempnam

Return the name of a temporary file in the specified directory using a prefix. The file is guaranteed not to exist at the time the function was called, but such guarantees are good for one clock tick only. Always use the proper form of `sysopen` with `O_CREAT | O_EXCL` if you must open such a filename.

```
$filename = File::Temp::tempnam( $dir, $prefix );
```

Equivalent to running `mktemp()` with `$dir/$prefixXXXXXXXX` (using unix file convention as an example)

Because this function uses `mktemp()`, it can suffer from race conditions.

UTILITY FUNCTIONS

Useful functions for dealing with the filehandle and filename.

unlink0

Given an open filehandle and the associated filename, make a safe unlink. This is achieved by first checking that the filename and filehandle initially point to the same file and that the number of links to the file is 1 (all fields returned by `stat()` are compared). Then the filename is unlinked and the filehandle checked once again to verify that the number of links on that file is now 0. This is the closest you can come to making sure that the filename unlinked was the same as the file whose descriptor you hold.

```
unlink0($fh, $path) or die "Error unlinking file $path safely";
```

Returns false on error. The filehandle is not closed since on some occasions this is not required.

On some platforms, for example Windows NT, it is not possible to unlink an open file (the file must be closed first). On those platforms, the actual unlinking is deferred until the program ends and good status is returned. A check is still performed to make sure that the filehandle and filename are pointing to the same thing (but not at the time the end block is executed since the deferred removal may not have access to the filehandle).

Additionally, on Windows NT not all the fields returned by `stat()` can be compared. For example, the `dev` and `rdev` fields seem to be different. Also, it seems that the size of the file returned by `stat()` does not always agree, with `stat(FH)` being more accurate than `stat(filename)`, presumably because of caching issues even when using autoflush (this is usually overcome by waiting a while after writing to the tempfile before attempting to `unlink0` it).

Finally, on NFS file systems the link count of the file handle does not always go to zero immediately after unlinking. Currently, this command is expected to fail on NFS disks.

PACKAGE VARIABLES

These functions control the global state of the package.

safe_level

Controls the lengths to which the module will go to check the safety of the temporary file or directory before proceeding. Options are:

STANDARD

Do the basic security measures to ensure the directory exists and is writable, that the `umask()` is fixed before opening of the file, that temporary files are opened only if they do not already exist, and that possible race conditions are avoided. Finally the *unlink0\"unlink0"* function is used to remove files safely.

MEDIUM In addition to the STANDARD security, the output directory is checked to make sure that it is owned either by root or the user running the program. If the directory is writable by group or by other, it is then checked to make sure that the sticky bit is set.

Will not work on platforms that do not support the `-k` test for sticky bit.

HIGH In addition to the MEDIUM security checks, also check for the possibility of ``chown()` giveaway'' using the *POSIX\|POSIX* `sysconf()` function. If this is a possibility, each directory in the path is checked in turn for safeness, recursively walking back to the root directory.

For platforms that do not support the *POSIX\|POSIX* `_PC_CHOWN_RESTRICTED` symbol (for example, Windows NT) it is assumed that ``chown()` giveaway'' is possible and the recursive test is performed.

The level can be changed as follows:

```
File::Temp->safe_level( File::Temp::HIGH );
```

The level constants are not exported by the module.

Currently, you must be running at least perl v5.6.0 in order to run with MEDIUM or HIGH security. This is simply because the safety tests use functions from *Fcntl\|Fcntl* that are not available in older versions of perl. The problem is that the version number for Fcntl is the same in perl 5.6.0 and in 5.005_03 even though they are different versions.

On systems that do not support the HIGH or MEDIUM safety levels (for example Win NT or OS/2) any attempt to change the level will be ignored. The decision to ignore rather than raise an exception allows portable programs to be written with high security in mind for the systems that can support this without those programs failing on systems where the extra tests are irrelevant.

If you really need to see whether the change has been accepted simply examine the return value of `safe_level`.

```
$newlevel = File::Temp->safe_level( File::Temp::HIGH );
die "Could not change to high security"
    if $newlevel != File::Temp::HIGH;
```

TopSystemUID

This is the highest UID on the current system that refers to a root UID. This is used to make sure that the temporary directory is owned by a system UID (`root`, `bin`, `sys` etc) rather than simply by root.

This is required since on many unix systems `/tmp` is not owned by root.

Default is to assume that any UID less than or equal to 10 is a root UID.

```
File::Temp->top_system_uid(10);
my $topid = File::Temp->top_system_uid;
```

This value can be adjusted to reduce security checking if required. The value is only relevant when `safe_level` is set to MEDIUM or higher.

WARNING

For maximum security, endeavour always to avoid ever looking at, touching, or even imputing the existence of the filename. You do not know that that filename is connected to the same file as the handle you have, and attempts to check this can only trigger more race conditions. It's far more secure to use the filehandle alone and dispense with the filename altogether.

If you need to pass the handle to something that expects a filename then, on a unix system, use `"/dev/fd/" . fileno($fh)` for arbitrary programs, or more generally `< "+<=&" . fileno($fh)` for Perl programs. You will have to clear the close-on-exec bit on that file descriptor before passing it to another process.

```
use Fcntl qw/F_SETFD F_GETFD/;
fcntl($tmpfh, F_SETFD, 0)
    or die "Can't clear close-on-exec flag on temp fh: $!\n";
```

HISTORY

Originally began life in May 1999 as an XS interface to the system `mkstemp()` function. In March 2000, the OpenBSD `mkstemp()` code was translated to Perl for total control of the code's security checking, to ensure the presence of the function regardless of operating system and to help with portability.

SEE ALSO

tmpnam, *tmpfile*, *File::Spec*, *File::Path*

See *File::MkTemp* for a different implementation of temporary file handling.

AUTHOR

Tim Jenness <t.jenness@jach.hawaii.edu>

Original Perl implementation loosely based on the OpenBSD C code for `mkstemp()`. Thanks to Tom Christiansen for suggesting that this module should be written and providing ideas for code improvements and security enhancements.

NAME

FileCache – keep more files open than the system permits

SYNOPSIS

```
cacheout $path;
print $path @data;
```

DESCRIPTION

The `cacheout` function will make sure that there's a filehandle open for writing available as the pathname you give it. It automatically closes and re–opens files if you exceed your system file descriptor maximum.

BUGS

sys/param.h lies with its `NOFILE` define on some systems, so you may have to set `$FileCache::cacheout_maxopen` yourself.

NAME

FileHandle – supply object methods for filehandles

SYNOPSIS

```
use FileHandle;

$fh = new FileHandle;
if ($fh->open("< file")) {
    print <$fh>;
    $fh->close;
}

$fh = new FileHandle "> FOO";
if (defined $fh) {
    print $fh "bar\n";
    $fh->close;
}

$fh = new FileHandle "file", "r";
if (defined $fh) {
    print <$fh>;
    undef $fh;       # automatically closes the file
}

$fh = new FileHandle "file", O_WRONLY|O_APPEND;
if (defined $fh) {
    print $fh "corge\n";
    undef $fh;       # automatically closes the file
}

$pos = $fh->getpos;
$fh->setpos($pos);

$fh->setvbuf($buffer_var, _IOLBF, 1024);

($readfh, $writefh) = FileHandle::pipe;

autoflush STDOUT 1;
```

DESCRIPTION

NOTE: This class is now a front–end to the IO::* classes.

`FileHandle::new` creates a `FileHandle`, which is a reference to a newly created symbol (see the `Symbol` package). If it receives any parameters, they are passed to `FileHandle::open`; if the open fails, the `FileHandle` object is destroyed. Otherwise, it is returned to the caller.

`FileHandle::new_from_fd` creates a `FileHandle` like `new` does. It requires two parameters, which are passed to `FileHandle::fdopen`; if the fdopen fails, the `FileHandle` object is destroyed. Otherwise, it is returned to the caller.

`FileHandle::open` accepts one parameter or two. With one parameter, it is just a front end for the built–in `open` function. With two parameters, the first parameter is a filename that may include whitespace or other special characters, and the second parameter is the open mode, optionally followed by a file permission value.

If `FileHandle::open` receives a Perl mode string ("", "+<", etc.) or a POSIX `fopen()` mode string ("w", "r+", etc.), it uses the basic Perl `open` operator.

If `FileHandle::open` is given a numeric mode, it passes that mode and the optional permissions value to the Perl `sysopen` operator. For convenience, `FileHandle::import` tries to import the O_XXX constants from the Fcntl module. If dynamic loading is not available, this may fail, but the rest of

FileHandle will still work.

`FileHandle::fdopen` is like `open` except that its first parameter is not a filename but rather a file handle name, a FileHandle object, or a file descriptor number.

If the C functions `fgetpos()` and `fsetpos()` are available, then `FileHandle::getpos` returns an opaque value that represents the current position of the FileHandle, and `FileHandle::setpos` uses that value to return to a previously visited position.

If the C function `setvbuf()` is available, then `FileHandle::setvbuf` sets the buffering policy for the FileHandle. The calling sequence for the Perl function is the same as its C counterpart, including the macros `_IOFBF`, `_IOLBF`, and `_IONBF`, except that the buffer parameter specifies a scalar variable to use as a buffer. WARNING: A variable used as a buffer by `FileHandle::setvbuf` must not be modified in any way until the FileHandle is closed or until `FileHandle::setvbuf` is called again, or memory corruption may result!

See *perlfunc* for complete descriptions of each of the following supported `FileHandle` methods, which are just front ends for the corresponding built–in functions:

```
close
fileno
getc
gets
eof
clearerr
seek
tell
```

See *perlvar* for complete descriptions of each of the following supported `FileHandle` methods:

```
autoflush
output_field_separator
output_record_separator
input_record_separator
input_line_number
format_page_number
format_lines_per_page
format_lines_left
format_name
format_top_name
format_line_break_characters
format_formfeed
```

Furthermore, for doing normal I/O you might need these:

`$fh`–print

See *print*.

`$fh`–printf

See *printf*.

`$fh`–getline

This works like `<$fh` described in *I/O Operators in perlop* except that it's more readable and can be safely called in a list context but still returns just one line.

`$fh`–getlines

This works like `<$fh` when called in a list context to read all the remaining lines in a file, except that it's more readable. It will also `croak()` if accidentally called in a scalar context.

There are many other functions available since FileHandle is descended from IO::File, IO::Seekable, and

IO::Handle. Please see those respective pages for documentation on more functions.

SEE ALSO

The **IO** extension, *perlfunc*, *I/O Operators in perlop*.

NAME

filetest – Perl pragma to control the filetest permission operators

SYNOPSIS

```
$can_perhaps_read = -r "file";       # use the mode bits
{
    use filetest 'access';           # intuit harder
    $can_really_read = -r "file";
}
$can_perhaps_read = -r "file";       # use the mode bits again
```

DESCRIPTION

This pragma tells the compiler to change the behaviour of the filetest permissions operators, the `-r -w -x -R -W -X` (see *perlfunc*).

The default behaviour to use the mode bits as returned by the `stat()` family of calls. This, however, may not be the right thing to do if for example various ACL (access control lists) schemes are in use. For such environments, `use filetest` may help the permission operators to return results more consistent with other tools.

Each "use filetest" or "no filetest" affects statements to the end of the enclosing block.

There may be a slight performance decrease in the filetests when `use filetest` is in effect, because in some systems the extended functionality needs to be emulated.

NOTE: using the file tests for security purposes is a lost cause from the start: there is a window open for race conditions (who is to say that the permissions will not change between the test and the real operation?). Therefore if you are serious about security, just try the real operation and test for its success. Think atomicity.

subpragma access

Currently only one subpragma, `access` is implemented. It enables (or disables) the use of `access()` or similar system calls. This extended filetest functionality is used only when the argument of the operators is a filename, not when it is a filehandle.

NAME

FindBin – Locate directory of original perl script

SYNOPSIS

```
use FindBin;
use lib "$FindBin::Bin/../lib";

or

use FindBin qw($Bin);
use lib "$Bin/../lib";
```

DESCRIPTION

Locates the full path to the script bin directory to allow the use of paths relative to the bin directory.

This allows a user to setup a directory tree for some software with directories <root>/bin and <root>/lib and then the above example will allow the use of modules in the lib directory without knowing where the software tree is installed.

If perl is invoked using the **–e** option or the perl script is read from `STDIN` then FindBin sets both `$Bin` and `$RealBin` to the current directory.

EXPORTABLE VARIABLES

```
$Bin         - path to bin directory from where script was invoked
$Script      - basename of script from which perl was invoked
$RealBin     - $Bin with all links resolved
$RealScript  - $Script with all links resolved
```

KNOWN BUGS

if perl is invoked as

```
perl filename
```

and *filename* does not have executable rights and a program called *filename* exists in the users `$ENV{PATH}` which satisfies both **–x** and **–T** then FindBin assumes that it was invoked via the `$ENV{PATH}`.

Workaround is to invoke perl as

```
perl ./filename
```

AUTHORS

FindBin is supported as part of the core perl distribution. Please send bug reports to ***<perlbug@perl.org>*** using the perlbug program included with perl.

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NAME

Getopt::Long – Extended processing of command line options

SYNOPSIS

```
use Getopt::Long;
$result = GetOptions (...option-descriptions...);
```

DESCRIPTION

The Getopt::Long module implements an extended getopt function called `GetOptions()`. This function adheres to the POSIX syntax for command line options, with GNU extensions. In general, this means that options have long names instead of single letters, and are introduced with a double dash "—". Support for bundling of command line options, as was the case with the more traditional single–letter approach, is provided but not enabled by default.

Command Line Options, an Introduction

Command line operated programs traditionally take their arguments from the command line, for example filenames or other information that the program needs to know. Besides arguments, these programs often take command line *options* as well. Options are not necessary for the program to work, hence the name 'option', but are used to modify its default behaviour. For example, a program could do its job quietly, but with a suitable option it could provide verbose information about what it did.

Command line options come in several flavours. Historically, they are preceded by a single dash –, and consist of a single letter.

```
-l -a -c
```

Usually, these single–character options can be bundled:

```
-lac
```

Options can have values, the value is placed after the option character. Sometimes with whitespace in between, sometimes not:

```
-s 24 -s24
```

Due to the very cryptic nature of these options, another style was developed that used long names. So instead of a cryptic `-l` one could use the more descriptive `–long`. To distinguish between a bundle of single–character options and a long one, two dashes are used to precede the option name. Early implementations of long options used a plus + instead. Also, option values could be specified either like

```
--size=24
```

or

```
--size 24
```

The + form is now obsolete and strongly deprecated.

Getting Started with Getopt::Long

Getopt::Long is the Perl5 successor of `newgetopt.pl`. This was the first Perl module that provided support for handling the new style of command line options, hence the name Getopt::Long. This module also supports single–character options and bundling. In this case, the options are restricted to alphabetic characters only, and the characters `?` and –.

To use Getopt::Long from a Perl program, you must include the following line in your Perl program:

```
use Getopt::Long;
```

This will load the core of the Getopt::Long module and prepare your program for using it. Most of the actual Getopt::Long code is not loaded until you really call one of its functions.

In the default configuration, options names may be abbreviated to uniqueness, case does not matter, and a single dash is sufficient, even for long option names. Also, options may be placed between non–option

arguments. See *Configuring Getopt::Long* for more details on how to configure Getopt::Long.

Simple options

The most simple options are the ones that take no values. Their mere presence on the command line enables the option. Popular examples are:

```
--all --verbose --quiet --debug
```

Handling simple options is straightforward:

```
my $verbose = '';   # option variable with default value (false)
my $all = '';       # option variable with default value (false)
GetOptions ('verbose' => \$verbose, 'all' => \$all);
```

The call to `GetOptions()` parses the command line arguments that are present in `@ARGV` and sets the option variable to the value `1` if the option did occur on the command line. Otherwise, the option variable is not touched. Setting the option value to true is often called *enabling* the option.

The option name as specified to the `GetOptions()` function is called the option *specification*. Later we'll see that this specification can contain more than just the option name. The reference to the variable is called the option *destination*.

`GetOptions()` will return a true value if the command line could be processed successfully. Otherwise, it will write error messages to STDERR, and return a false result.

A little bit less simple options

Getopt::Long supports two useful variants of simple options: *negatable* options and *incremental* options.

A negatable option is specified with a exclamation mark `!` after the option name:

```
my $verbose = '';   # option variable with default value (false)
GetOptions ('verbose!' => \$verbose);
```

Now, using `–verbose` on the command line will enable `$verbose`, as expected. But it is also allowed to use `–noverbose`, which will disable `$verbose` by setting its value to . Using a suitable default value, the program can find out whether `$verbose` is false by default, or disabled by using `–noverbose`.

An incremental option is specified with a plus + after the option name:

```
my $verbose = '';   # option variable with default value (false)
GetOptions ('verbose+' => \$verbose);
```

Using `–verbose` on the command line will increment the value of `$verbose`. This way the program can keep track of how many times the option occurred on the command line. For example, each occurrence of `–verbose` could increase the verbosity level of the program.

Mixing command line option with other arguments

Usually programs take command line options as well as other arguments, for example, file names. It is good practice to always specify the options first, and the other arguments last. Getopt::Long will, however, allow the options and arguments to be mixed and 'filter out' all the options before passing the rest of the arguments to the program. To stop Getopt::Long from processing further arguments, insert a double dash – on the command line:

```
--size 24 -- --all
```

In this example, `–all` will *not* be treated as an option, but passed to the program unharmed, in `@ARGV`.

Options with values

For options that take values it must be specified whether the option value is required or not, and what kind of value the option expects.

Three kinds of values are supported: integer numbers, floating point numbers, and strings.

If the option value is required, Getopt::Long will take the command line argument that follows the option and assign this to the option variable. If, however, the option value is specified as optional, this will only be done if that value does not look like a valid command line option itself.

```
my $tag = '';       # option variable with default value
GetOptions ('tag=s' => \$tag);
```

In the option specification, the option name is followed by an equals sign = and the letter s. The equals sign indicates that this option requires a value. The letter s indicates that this value is an arbitrary string. Other possible value types are i for integer values, and f for floating point values. Using a colon : instead of the equals sign indicates that the option value is optional. In this case, if no suitable value is supplied, string valued options get an empty string '' assigned, while numeric options are set to .

Options with multiple values

Options sometimes take several values. For example, a program could use multiple directories to search for library files:

```
--library lib/stdlib --library lib/extlib
```

To accomplish this behaviour, simply specify an array reference as the destination for the option:

```
my @libfiles = ();
GetOptions ("library=s" => \@libfiles);
```

Used with the example above, @libfiles would contain two strings upon completion: "lib/srdlib" and "lib/extlib", in that order. It is also possible to specify that only integer or floating point numbers are acceptible values.

Often it is useful to allow comma–separated lists of values as well as multiple occurrences of the options. This is easy using Perl's split() and join() operators:

```
my @libfiles = ();
GetOptions ("library=s" => \@libfiles);
@libfiles = split(/,/,join(',',@libfiles));
```

Of course, it is important to choose the right separator string for each purpose.

Options with hash values

If the option destination is a reference to a hash, the option will take, as value, strings of the form *key*=*value*. The value will be stored with the specified key in the hash.

```
my %defines = ();
GetOptions ("define=s" => \%defines);
```

When used with command line options:

```
--define os=linux --define vendor=redhat
```

the hash %defines will contain two keys, "os" with value "linux and "vendor" with value "redhat". It is also possible to specify that only integer or floating point numbers are acceptible values. The keys are always taken to be strings.

User–defined subroutines to handle options

Ultimate control over what should be done when (actually: each time) an option is encountered on the command line can be achieved by designating a reference to a subroutine (or an anonymous subroutine) as the option destination. When GetOptions() encounters the option, it will call the subroutine with two arguments: the name of the option, and the value to be assigned. It is up to the subroutine to store the value, or do whatever it thinks is appropriate.

A trivial application of this mechanism is to implement options that are related to each other. For example:

```
my $verbose = '';   # option variable with default value (false)
GetOptions ('verbose' => \$verbose,
```

```
                'quiet'   => sub { $verbose = 0 });
```

Here –verbose and –quiet control the same variable $verbose, but with opposite values.

If the subroutine needs to signal an error, it should call die() with the desired error message as its argument. GetOptions() will catch the die(), issue the error message, and record that an error result must be returned upon completion.

If the text of the error message starts with an exclamantion mark ! it is interpreted specially by GetOptions(). There is currently one special command implemented: die("!FINISH") will cause GetOptions() to stop processing options, as if it encountered a double dash –.

Options with multiple names

Often it is user friendly to supply alternate mnemonic names for options. For example –height could be an alternate name for –length. Alternate names can be included in the option specification, separated by vertical bar | characters. To implement the above example:

```
GetOptions ('length|height=f' => \$length);
```

The first name is called the *primary* name, the other names are called *aliases*.

Multiple alternate names are possible.

Case and abbreviations

Without additional configuration, GetOptions() will ignore the case of option names, and allow the options to be abbreviated to uniqueness.

```
GetOptions ('length|height=f' => \$length, "head" => \$head);
```

This call will allow –l and –L for the length option, but requires a least –hea and –hei for the head and height options.

Summary of Option Specifications

Each option specifier consists of two parts: the name specification and the argument specification.

The name specification contains the name of the option, optionally followed by a list of alternative names separated by vertical bar characters.

```
length            option name is "length"
length|size|l     name is "length", aliases are "size" and "l"
```

The argument specification is optional. If omitted, the option is considered boolean, a value of 1 will be assigned when the option is used on the command line.

The argument specification can be

! The option does not take an argument and may be negated, i.e. prefixed by "no". E.g. "foo!" will allow –foo (a value of 1 will be assigned) and –nofoo (a value of 0 will be assigned). If the option has aliases, this applies to the aliases as well.

Using negation on a single letter option when bundling is in effect is pointless and will result in a warning.

+ The option does not take an argument and will be incremented by 1 every time it appears on the command line. E.g. "more+", when used with –more –more –more, will increment the value three times, resulting in a value of 3 (provided it was 0 or undefined at first).

The + specifier is ignored if the option destination is not a scalar.

= *type* [*desttype*]

The option requires an argument of the given type. Supported types are:

s String. An arbitrary sequence of characters. It is valid for the argument to start with – or —.

i Integer. An optional leading plus or minus sign, followed by a sequence of digits.

f Real number. For example `3.14`, `-6.23E24` and so on.

The *desttype* can be `@` or `%` to specify that the option is list or a hash valued. This is only needed when the destination for the option value is not otherwise specified. It should be omitted when not needed.

: *type* [*desttype*]

Like =, but designates the argument as optional. If omitted, an empty string will be assigned to string values options, and the value zero to numeric options.

Note that if a string argument starts with – or —, it will be considered an option on itself.

Advanced Possibilities

Object oriented interface

Getopt::Long can be used in an object oriented way as well:

```
use Getopt::Long;
$p = new Getopt::Long::Parser;
$p->configure(...configuration options...);
if ($p->getoptions(...options descriptions...)) ...
```

Configuration options can be passed to the constructor:

```
$p = new Getopt::Long::Parser
         config => [...configuration options...];
```

For thread safety, each method call will acquire an exclusive lock to the Getopt::Long module. So don't call these methods from a callback routine!

Documentation and help texts

Getopt::Long encourages the use of Pod::Usage to produce help messages. For example:

```
use Getopt::Long;
use Pod::Usage;

my $man = 0;
my $help = 0;

GetOptions('help|?' => \$help, man => \$man) or pod2usage(2);
pod2usage(1) if $help;
pod2usage(-exitstatus => 0, -verbose => 2) if $man;

__END__

=head1 NAME

sample - Using GetOpt::Long and Pod::Usage

=head1 SYNOPSIS

sample [options] [file ...]

 Options:
   -help            brief help message
   -man             full documentation

=head1 OPTIONS

=over 8

=item B<-help>
```

```
Print a brief help message and exits.

=item B<-man>

Prints the manual page and exits.

=back

=head1 DESCRIPTION

B<This program> will read the given input file(s) and do someting
useful with the contents thereof.

=cut
```

See *Pod::Usage* for details.

Storing options in a hash

Sometimes, for example when there are a lot of options, having a separate variable for each of them can be cumbersome. `GetOptions()` supports, as an alternative mechanism, storing options in a hash.

To obtain this, a reference to a hash must be passed *as the first argument* to `GetOptions()`. For each option that is specified on the command line, the option value will be stored in the hash with the option name as key. Options that are not actually used on the command line will not be put in the hash, on other words, `exists($h{option})` (or `defined()`) can be used to test if an option was used. The drawback is that warnings will be issued if the program runs under `use strict` and uses `$h{option}` without testing with `exists()` or `defined()` first.

```
my %h = ();
GetOptions (\%h, 'length=i');       # will store in $h{length}
```

For options that take list or hash values, it is necessary to indicate this by appending an `@` or `%` sign after the type:

```
GetOptions (\%h, 'colours=s@');     # will push to @{$h{colours}}
```

To make things more complicated, the hash may contain references to the actual destinations, for example:

```
my $len = 0;
my %h = ('length' => \$len);
GetOptions (\%h, 'length=i');       # will store in $len
```

This example is fully equivalent with:

```
my $len = 0;
GetOptions ('length=i' => \$len);   # will store in $len
```

Any mixture is possible. For example, the most frequently used options could be stored in variables while all other options get stored in the hash:

```
my $verbose = 0;                    # frequently referred
my $debug = 0;                      # frequently referred
my %h = ('verbose' => \$verbose, 'debug' => \$debug);
GetOptions (\%h, 'verbose', 'debug', 'filter', 'size=i');
if ( $verbose ) { ... }
if ( exists $h{filter} ) { ... option 'filter' was specified ... }
```

Bundling

With bundling it is possible to set several single-character options at once. For example if `a`, `v` and `x` are all valid options,

```
-vax
```

would set all three.

Getopt::Long supports two levels of bundling. To enable bundling, a call to Getopt::Long::Configure is required.

The first level of bundling can be enabled with:

```
Getopt::Long::Configure ("bundling");
```

Configured this way, single–character options can be bundled but long options **must** always start with a double dash – to avoid abiguity. For example, when `vax`, `a`, `v` and `x` are all valid options,

```
-vax
```

would set `a`, `v` and `x`, but

```
--vax
```

would set `vax`.

The second level of bundling lifts this restriction. It can be enabled with:

```
Getopt::Long::Configure ("bundling_override");
```

Now, `-vax` would set the option `vax`.

When any level of bundling is enabled, option values may be inserted in the bundle. For example:

```
-h24w80
```

is equivalent to

```
-h 24 -w 80
```

When configured for bundling, single–character options are matched case sensitive while long options are matched case insensitive. To have the single–character options matched case insensitive as well, use:

```
Getopt::Long::Configure ("bundling", "ignorecase_always");
```

It goes without saying that bundling can be quite confusing.

The lonesome dash

Some applications require the option `-` (that's a lone dash). This can be achieved by adding an option specification with an empty name:

```
GetOptions ('' => \$stdio);
```

A lone dash on the command line will now be legal, and set options variable `$stdio`.

Argument call–back

A special option 'name' `<` can be used to designate a subroutine to handle non–option arguments. When `GetOptions()` encounters an argument that does not look like an option, it will immediately call this subroutine and passes it the argument as a parameter.

For example:

```
my $width = 80;
sub process { ... }
GetOptions ('width=i' => \$width, '<>' => \&process);
```

When applied to the following command line:

```
arg1 --width=72 arg2 --width=60 arg3
```

This will call `process("arg1")` while `$width` is `80`, `process("arg2")` while `$width` is `72`, and `process("arg3")` while `$width` is `60`.

This feature requires configuration option **permute**, see section *Configuring Getopt::Long*.

Configuring Getopt::Long

Getopt::Long can be configured by calling subroutine `Getopt::Long::Configure()`. This subroutine takes a list of quoted strings, each specifying a configuration option to be enabled, e.g. `ignore_case`, or disabled, e.g. `no_ignore_case`. Case does not matter. Multiple calls to `Configure()` are possible.

Alternatively, as of version 2.24, the configuration options may be passed together with the `use` statement:

```
use Getopt::Long qw(:config no_ignore_case bundling);
```

The following options are available:

default — This option causes all configuration options to be reset to their default values.

posix_default — This option causes all configuration options to be reset to their default values as if the environment variable POSIXLY_CORRECT had been set.

auto_abbrev — Allow option names to be abbreviated to uniqueness. Default is enabled unless environment variable POSIXLY_CORRECT has been set, in which case `auto_abbrev` is disabled.

getopt_compat — Allow + to start options. Default is enabled unless environment variable POSIXLY_CORRECT has been set, in which case `getopt_compat` is disabled.

gnu_compat — `gnu_compat` controls whether `–opt=` is allowed, and what it should do. Without `gnu_compat`, `–opt=` gives an error. With `gnu_compat`, `–opt=` will give option `opt` and empty value. This is the way GNU `getopt_long()` does it.

gnu_getopt — This is a short way of setting `gnu_compat bundling permute no_getopt_compat`. With `gnu_getopt`, command line handling should be fully compatible with GNU `getopt_long()`.

require_order — Whether command line arguments are allowed to be mixed with options. Default is disabled unless environment variable POSIXLY_CORRECT has been set, in which case `require_order` is enabled.

See also `permute`, which is the opposite of `require_order`.

permute — Whether command line arguments are allowed to be mixed with options. Default is enabled unless environment variable POSIXLY_CORRECT has been set, in which case `permute` is disabled. Note that `permute` is the opposite of `require_order`.

If `permute` is enabled, this means that

```
--foo arg1 --bar arg2 arg3
```

is equivalent to

```
--foo --bar arg1 arg2 arg3
```

If an argument call–back routine is specified, `@ARGV` will always be empty upon succesful return of `GetOptions()` since all options have been processed. The only exception is when – is used:

```
--foo arg1 --bar arg2 -- arg3
```

will call the call–back routine for arg1 and arg2, and terminate `GetOptions()` leaving `"arg2"` in `@ARGV`.

If `require_order` is enabled, options processing terminates when the first non–option is encountered.

```
--foo arg1 --bar arg2 arg3
```

is equivalent to

```
--foo -- arg1 --bar arg2 arg3
```

bundling (default: disabled)

Enabling this option will allow single−character options to be bundled. To distinguish bundles from long option names, long options *must* be introduced with − and single−character options (and bundles) with −.

Note: disabling `bundling` also disables `bundling_override`.

bundling_override (default: disabled)

If `bundling_override` is enabled, bundling is enabled as with `bundling` but now long option names override option bundles.

Note: disabling `bundling_override` also disables `bundling`.

Note: Using option bundling can easily lead to unexpected results, especially when mixing long options and bundles. Caveat emptor.

ignore_case (default: enabled)

If enabled, case is ignored when matching long option names. Single character options will be treated case−sensitive.

Note: disabling `ignore_case` also disables `ignore_case_always`.

ignore_case_always (default: disabled)

When bundling is in effect, case is ignored on single−character options also.

Note: disabling `ignore_case_always` also disables `ignore_case`.

pass_through (default: disabled)

Options that are unknown, ambiguous or supplied with an invalid option value are passed through in `@ARGV` instead of being flagged as errors. This makes it possible to write wrapper scripts that process only part of the user supplied command line arguments, and pass the remaining options to some other program.

This can be very confusing, especially when `permute` is also enabled.

prefix The string that starts options. If a constant string is not sufficient, see `prefix_pattern`.

prefix_pattern A Perl pattern that identifies the strings that introduce options. Default is `(−|-|\+)` unless environment variable POSIXLY_CORRECT has been set, in which case it is `(−|-)`.

debug (default: disabled)

Enable debugging output.

Return values and Errors

Configuration errors and errors in the option definitions are signalled using `die()` and will terminate the calling program unless the call to `Getopt::Long::GetOptions()` was embedded in `eval { ... }`, or `die()` was trapped using `$SIG{__DIE__}`.

GetOptions returns true to indicate success. It returns false when the function detected one or more errors during option parsing. These errors are signalled using `warn()` and can be trapped with `$SIG{__WARN__}`.

Errors that can't happen are signalled using `Carp::croak()`.

Legacy

The earliest development of `newgetopt.pl` started in 1990, with Perl version 4. As a result, its development, and the development of Getopt::Long, has gone through several stages. Since backward compatibility has always been extremely important, the current version of Getopt::Long still supports a lot of

constructs that nowadays are no longer necessary or otherwise unwanted. This section describes briefly some of these 'features'.

Default destinations

When no destination is specified for an option, GetOptions will store the resultant value in a global variable named `opt_XXX`, where *XXX* is the primary name of this option. When a progam executes under `use strict` (recommended), these variables must be pre−declared with `our()` or `use vars`.

```
our $opt_length = 0;
GetOptions ('length=i');    # will store in $opt_length
```

To yield a usable Perl variable, characters that are not part of the syntax for variables are translated to underscores. For example, `−fpp−struct−return` will set the variable `$opt_fpp_struct_return`. Note that this variable resides in the namespace of the calling program, not necessarily `main`. For example:

```
GetOptions ("size=i", "sizes=i@");
```

with command line "−size 10 −sizes 24 −sizes 48" will perform the equivalent of the assignments

```
$opt_size = 10;
@opt_sizes = (24, 48);
```

Alternative option starters

A string of alternative option starter characters may be passed as the first argument (or the first argument after a leading hash reference argument).

```
my $len = 0;
GetOptions ('/', 'length=i' => $len);
```

Now the command line may look like:

```
/length 24 -- arg
```

Note that to terminate options processing still requires a double dash −.

`GetOptions()` will not interpret a leading `< "<"` as option starters if the next argument is a reference. To force `< "<"` and `< ""` as option starters, use `< "<"` . Confusing? Well, **using a starter argument is strongly deprecated** anyway.

Configuration variables

Previous versions of Getopt::Long used variables for the purpose of configuring. Although manipulating these variables still work, it is strongly encouraged to use the `Configure` routine that was introduced in version 2.17. Besides, it is much easier.

Trouble Shooting

Warning: Ignoring '!' modifier for short option

This warning is issued when the '!' modifier is applied to a short (one−character) option and bundling is in effect. E.g.,

```
Getopt::Long::Configure("bundling");
GetOptions("foo|f!" => \$foo);
```

Note that older Getopt::Long versions did not issue a warning, because the '!' modifier was applied to the first name only. This bug was fixed in 2.22.

Solution: separate the long and short names and apply the '!' to the long names only, e.g.,

```
GetOptions("foo!" => \$foo, "f" => \$foo);
```

GetOptions does not return a false result when an option is not supplied

That's why they're called 'options'.

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NAME

getopt – Process single–character switches with switch clustering

getopts – Process single–character switches with switch clustering

SYNOPSIS

```
use Getopt::Std;

getopt('oDI');    # -o, -D & -I take arg.  Sets opt_* as a side effect.
getopt('oDI', \%opts);    # -o, -D & -I take arg.  Values in %opts
getopts('oif:');  # -o & -i are boolean flags, -f takes an argument
                  # Sets opt_* as a side effect.
getopts('oif:', \%opts);  # options as above. Values in %opts
```

DESCRIPTION

The `getopt()` functions processes single–character switches with switch clustering. Pass one argument which is a string containing all switches that take an argument. For each switch found, sets `$opt_x` (where x is the switch name) to the value of the argument, or 1 if no argument. Switches which take an argument don't care whether there is a space between the switch and the argument.

Note that, if your code is running under the recommended `use strict 'vars'` pragma, you will need to declare these package variables with "our":

```
our($opt_foo, $opt_bar);
```

For those of you who don't like additional global variables being created, `getopt()` and `getopts()` will also accept a hash reference as an optional second argument. Hash keys will be x (where x is the switch name) with key values the value of the argument or 1 if no argument is specified.

To allow programs to process arguments that look like switches, but aren't, both functions will stop processing switches when they see the argument –. The – will be removed from @ARGV.

NAME

I18N::Collate – compare 8–bit scalar data according to the current locale

```
***

WARNING: starting from the Perl version 5.003_06
the I18N::Collate interface for comparing 8-bit scalar data
according to the current locale

      HAS BEEN DEPRECATED

That is, please do not use it anymore for any new applications
and please migrate the old applications away from it because its
functionality was integrated into the Perl core language in the
release 5.003_06.

See the perllocale manual page for further information.

***
```

SYNOPSIS

```
use I18N::Collate;
setlocale(LC_COLLATE, 'locale-of-your-choice');
$s1 = new I18N::Collate "scalar_data_1";
$s2 = new I18N::Collate "scalar_data_2";
```

DESCRIPTION

This module provides you with objects that will collate according to your national character set, provided that the POSIX `setlocale()` function is supported on your system.

You can compare `$s1` and `$s2` above with

```
$s1 le $s2
```

to extract the data itself, you'll need a dereference: `$$s1`

This module uses `POSIX::setlocale()`. The basic collation conversion is done by `strxfrm()` which terminates at NUL characters being a decent C routine. `collate_xfrm()` handles embedded NUL characters gracefully.

The available locales depend on your operating system; try whether `locale -a` shows them or man pages for "locale" or "nlsinfo" or the direct approach `ls /usr/lib/nls/loc` or `ls /usr/lib/nls` or `ls /usr/lib/locale`. Not all the locales that your vendor supports are necessarily installed: please consult your operating system's documentation and possibly your local system administration. The locale names are probably something like `xx_XX.(ISO)?8859-N` or `xx_XX.(ISO)?8859N`, for example `fr_CH.ISO8859-1` is the Swiss (CH) variant of French (fr), ISO Latin (8859) 1 (–1) which is the Western European character set.

NAME

integer – Perl pragma to compute arithmetic in integer instead of double

SYNOPSIS

```
use integer;
$x = 10/3;
# $x is now 3, not 3.3333333333333333
```

DESCRIPTION

This tells the compiler to use integer operations from here to the end of the enclosing BLOCK. On many machines, this doesn't matter a great deal for most computations, but on those without floating point hardware, it can make a big difference.

Note that this affects the operations, not the numbers. If you run this code

```
use integer;
$x = 1.5;
$y = $x + 1;
$z = -1.5;
```

you'll be left with `$x == 1.5`, `$y == 2` and `$z == -1`. The `$z` case happens because unary – counts as an operation.

Native integer arithmetic (as provided by your C compiler) is used. This means that Perl's own semantics for arithmetic operations may not be preserved. One common source of trouble is the modulus of negative numbers, which Perl does one way, but your hardware may do another.

```
% perl -le 'print (4 % -3)'
-2
% perl -Minteger -le 'print (4 % -3)'
1
```

See *Pragmatic Modules*.

NAME

IPC::Open2, open2 – open a process for both reading and writing

SYNOPSIS

```
use IPC::Open2;

$pid = open2(\*RDRFH, \*WTRFH, 'some cmd and args');
  # or without using the shell
$pid = open2(\*RDRFH, \*WTRFH, 'some', 'cmd', 'and', 'args');

# or with handle autovivification
my($rdrfh, $wtrfh);
$pid = open2($rdrfh, $wtrfh, 'some cmd and args');
  # or without using the shell
$pid = open2($rdrfh, $wtrfh, 'some', 'cmd', 'and', 'args');
```

DESCRIPTION

The `open2()` function runs the given `$cmd` and connects `$rdrfh` for reading and `$wtrfh` for writing. It's what you think should work when you try

```
$pid = open(HANDLE, "|cmd args|");
```

The write filehandle will have autoflush turned on.

If `$rdrfh` is a string (that is, a bareword filehandle rather than a glob or a reference) and it begins with `<&`, then the child will send output directly to that file handle. If `$wtrfh` is a string that begins with `<&`, then `$wtrfh` will be closed in the parent, and the child will read from it directly. In both cases, there will be a dup(2) instead of a pipe(2) made.

If either reader or writer is the null string, this will be replaced by an autogenerated filehandle. If so, you must pass a valid lvalue in the parameter slot so it can be overwritten in the caller, or an exception will be raised.

`open2()` returns the process ID of the child process. It doesn't return on failure: it just raises an exception matching `/^open2:/`. However, `exec` failures in the child are not detected. You'll have to trap SIGPIPE yourself.

`open2()` does not wait for and reap the child process after it exits. Except for short programs where it's acceptable to let the operating system take care of this, you need to do this yourself. This is normally as simple as calling `waitpid $pid, 0` when you're done with the process. Failing to do this can result in an accumulation of defunct or "zombie" processes. See *waitpid* for more information.

This whole affair is quite dangerous, as you may block forever. It assumes it's going to talk to something like **bc**, both writing to it and reading from it. This is presumably safe because you "know" that commands like **bc** will read a line at a time and output a line at a time. Programs like **sort** that read their entire input stream first, however, are quite apt to cause deadlock.

The big problem with this approach is that if you don't have control over source code being run in the child process, you can't control what it does with pipe buffering. Thus you can't just open a pipe to `cat -v` and continually read and write a line from it.

The IO::Pty and Expect modules from CPAN can help with this, as they provide a real tty (well, a pseudo–tty, actually), which gets you back to line buffering in the invoked command again.

WARNING

The order of arguments differs from that of `open3()`.

SEE ALSO

See *IPC::Open3* for an alternative that handles STDERR as well. This function is really just a wrapper around `open3()`.

NAME

IPC::Open3, open3 – open a process for reading, writing, and error handling

SYNOPSIS

```
$pid = open3(\*WTRFH, \*RDRFH, \*ERRFH,
                 'some cmd and args', 'optarg', ...);

my($wtr, $rdr, $err);
$pid = open3($wtr, $rdr, $err,
                 'some cmd and args', 'optarg', ...);
```

DESCRIPTION

Extremely similar to `open2()`, `open3()` spawns the given `$cmd` and connects RDRFH for reading, WTRFH for writing, and ERRFH for errors. If ERRFH is false, or the same file descriptor as RDRFH, then STDOUT and STDERR of the child are on the same filehandle. The WTRFH will have autoflush turned on.

If WTRFH begins with `<` `<&` , then WTRFH will be closed in the parent, and the child will read from it directly. If RDRFH or ERRFH begins with `<` `&` , then the child will send output directly to that filehandle. In both cases, there will be a dup(2) instead of a pipe(2) made.

If either reader or writer is the null string, this will be replaced by an autogenerated filehandle. If so, you must pass a valid lvalue in the parameter slot so it can be overwritten in the caller, or an exception will be raised.

The filehandles may also be integers, in which case they are understood as file descriptors.

`open3()` returns the process ID of the child process. It doesn't return on failure: it just raises an exception matching `/^open3:/`. However, `exec` failures in the child are not detected. You'll have to trap SIGPIPE yourself.

`open3()` does not wait for and reap the child process after it exits. Except for short programs where it's acceptable to let the operating system take care of this, you need to do this yourself. This is normally as simple as calling `waitpid $pid, 0` when you're done with the process. Failing to do this can result in an accumulation of defunct or "zombie" processes. See *waitpid* for more information.

If you try to read from the child's stdout writer and their stderr writer, you'll have problems with blocking, which means you'll want to use `select()` or the IO::Select, which means you'd best use `sysread()` instead of `readline()` for normal stuff.

This is very dangerous, as you may block forever. It assumes it's going to talk to something like **bc**, both writing to it and reading from it. This is presumably safe because you "know" that commands like **bc** will read a line at a time and output a line at a time. Programs like **sort** that read their entire input stream first, however, are quite apt to cause deadlock.

The big problem with this approach is that if you don't have control over source code being run in the child process, you can't control what it does with pipe buffering. Thus you can't just open a pipe to `cat -v` and continually read and write a line from it.

WARNING

The order of arguments differs from that of `open2()`.

NAME

less – perl pragma to request less of something from the compiler

SYNOPSIS

```
use less;  # unimplemented
```

DESCRIPTION

Currently unimplemented, this may someday be a compiler directive to make certain trade–offs, such as perhaps

```
use less 'memory';
use less 'CPU';
use less 'fat';
```

NAME

locale – Perl pragma to use and avoid POSIX locales for built–in operations

SYNOPSIS

```
@x = sort @y;       # ASCII sorting order
{
    use locale;
    @x = sort @y;   # Locale-defined sorting order
}
@x = sort @y;       # ASCII sorting order again
```

DESCRIPTION

This pragma tells the compiler to enable (or disable) the use of POSIX locales for built–in operations (LC_CTYPE for regular expressions, and LC_COLLATE for string comparison). Each "use locale" or "no locale" affects statements to the end of the enclosing BLOCK.

See *perllocale* for more detailed information on how Perl supports locales.

NAME

Math::BigFloat – Arbitrary length float math package

SYNOPSIS

```
use Math::BigFloat;
$f = Math::BigFloat->new($string);

$f->fadd(NSTR) return NSTR            addition
$f->fsub(NSTR) return NSTR            subtraction
$f->fmul(NSTR) return NSTR            multiplication
$f->fdiv(NSTR[,SCALE]) returns NSTR   division to SCALE places
$f->fneg() return NSTR                negation
$f->fabs() return NSTR                absolute value
$f->fcmp(NSTR) return CODE            compare undef,<0,=0,>0
$f->fround(SCALE) return NSTR         round to SCALE digits
$f->ffround(SCALE) return NSTR        round at SCALEth place
$f->fnorm() return (NSTR)             normalize
$f->fsqrt([SCALE]) return NSTR        sqrt to SCALE places
```

DESCRIPTION

All basic math operations are overloaded if you declare your big floats as

```
$float = new Math::BigFloat "2.123123123123123123123123123123123";
```

number format

canonical strings have the form /[+-]\d+E[+-]\d+/ . Input values can have embedded whitespace.

Error returns 'NaN'

An input parameter was "Not a Number" or divide by zero or sqrt of negative number.

Division is computed to

`max($Math::BigFloat::div_scale,length(dividend)+length(divisor))` digits by default. Also used for default sqrt scale.

Rounding is performed

according to the value of `$Math::BigFloat::rnd_mode`:

```
trunc     truncate the value
zero      round towards 0
+inf      round towards +infinity (round up)
-inf      round towards -infinity (round down)
even      round to the nearest, .5 to the even digit
odd       round to the nearest, .5 to the odd digit
```

The default is `even` rounding.

BUGS

The current version of this module is a preliminary version of the real thing that is currently (as of perl5.002) under development.

The printf subroutine does not use the value of `$Math::BigFloat::rnd_mode` when rounding values for printing. Consequently, the way to print rounded values is to specify the number of digits both as an argument to `ffround` and in the `%f` printf string, as follows:

```
printf "%.3f\n", $bigfloat->ffround(-3);
```

AUTHOR

Mark Biggar

NAME

Math::BigInt – Arbitrary size integer math package

SYNOPSIS

```
use Math::BigInt;
$i = Math::BigInt->new($string);

$i->bneg return BINT               negation
$i->babs return BINT               absolute value
$i->bcmp(BINT) return CODE         compare numbers (undef,<0,=0,>0)
$i->badd(BINT) return BINT         addition
$i->bsub(BINT) return BINT         subtraction
$i->bmul(BINT) return BINT         multiplication
$i->bdiv(BINT) return (BINT,BINT)  division (quo,rem) just quo if scalar
$i->bmod(BINT) return BINT         modulus
$i->bgcd(BINT) return BINT         greatest common divisor
$i->bnorm return BINT              normalization
$i->blsft(BINT) return BINT        left shift
$i->brsft(BINT) return (BINT,BINT) right shift (quo,rem) just quo if scalar
$i->band(BINT) return BINT         bit-wise and
$i->bior(BINT) return BINT         bit-wise inclusive or
$i->bxor(BINT) return BINT         bit-wise exclusive or
$i->bnot return BINT               bit-wise not
```

DESCRIPTION

All basic math operations are overloaded if you declare your big integers as

```
$i = new Math::BigInt '123 456 789 123 456 789';
```

Canonical notation

Big integer value are strings of the form `/^[+-]\d+$/` with leading zeros suppressed.

Input

Input values to these routines may be strings of the form `/^\s*[+-]?[\d\s]+$/`.

Output

Output values always always in canonical form

Actual math is done in an internal format consisting of an array whose first element is the sign (/^[+–]$/) and whose remaining elements are base 100000 digits with the least significant digit first. The string 'NaN' is used to represent the result when input arguments are not numbers, as well as the result of dividing by zero.

EXAMPLES

```
'+0'                          canonical zero value
'   -123 123 123'             canonical value '-123123123'
'1 23 456 7890'               canonical value '+1234567890'
```

Autocreating constants

After `use Math::BigInt ':constant'` all the integer decimal constants in the given scope are converted to `Math::BigInt`. This conversion happens at compile time.

In particular

```
perl -MMath::BigInt=:constant -e 'print 2**100'
```

print the integer value of `2**100`. Note that without conversion of constants the expression 2**100 will be calculated as floating point number.

BUGS

The current version of this module is a preliminary version of the real thing that is currently (as of perl5.002) under development.

AUTHOR

Mark Biggar, overloaded interface by Ilya Zakharevich.

NAME

Math::Complex – complex numbers and associated mathematical functions

SYNOPSIS

```
use Math::Complex;

$z = Math::Complex->make(5, 6);
$t = 4 - 3*i + $z;
$j = cplxe(1, 2*pi/3);
```

DESCRIPTION

This package lets you create and manipulate complex numbers. By default, *Perl* limits itself to real numbers, but an extra `use` statement brings full complex support, along with a full set of mathematical functions typically associated with and/or extended to complex numbers.

If you wonder what complex numbers are, they were invented to be able to solve the following equation:

```
x*x = -1
```

and by definition, the solution is noted *i* (engineers use *j* instead since *i* usually denotes an intensity, but the name does not matter). The number *i* is a pure *imaginary* number.

The arithmetics with pure imaginary numbers works just like you would expect it with real numbers... you just have to remember that

```
i*i = -1
```

so you have:

```
5i + 7i = i * (5 + 7) = 12i
4i - 3i = i * (4 - 3) = i
4i * 2i = -8
6i / 2i = 3
1 / i = -i
```

Complex numbers are numbers that have both a real part and an imaginary part, and are usually noted:

```
a + bi
```

where `a` is the *real* part and `b` is the *imaginary* part. The arithmetic with complex numbers is straightforward. You have to keep track of the real and the imaginary parts, but otherwise the rules used for real numbers just apply:

```
(4 + 3i) + (5 - 2i) = (4 + 5) + i(3 - 2) = 9 + i
(2 + i) * (4 - i) = 2*4 + 4i -2i -i*i = 8 + 2i + 1 = 9 + 2i
```

A graphical representation of complex numbers is possible in a plane (also called the *complex plane*, but it's really a 2D plane). The number

```
z = a + bi
```

is the point whose coordinates are (a, b). Actually, it would be the vector originating from (0, 0) to (a, b). It follows that the addition of two complex numbers is a vectorial addition.

Since there is a bijection between a point in the 2D plane and a complex number (i.e. the mapping is unique and reciprocal), a complex number can also be uniquely identified with polar coordinates:

```
[rho, theta]
```

where `rho` is the distance to the origin, and `theta` the angle between the vector and the *x* axis. There is a notation for this using the exponential form, which is:

```
rho * exp(i * theta)
```

where *i* is the famous imaginary number introduced above. Conversion between this form and the cartesian form `a + bi` is immediate:

```
a = rho * cos(theta)
b = rho * sin(theta)
```

which is also expressed by this formula:

```
z = rho * exp(i * theta) = rho * (cos theta + i * sin theta)
```

In other words, it's the projection of the vector onto the *x* and *y* axes. Mathematicians call *rho* the *norm* or *modulus* and *theta* the *argument* of the complex number. The *norm* of `z` will be noted `abs(z)`.

The polar notation (also known as the trigonometric representation) is much more handy for performing multiplications and divisions of complex numbers, whilst the cartesian notation is better suited for additions and subtractions. Real numbers are on the *x* axis, and therefore *theta* is zero or *pi*.

All the common operations that can be performed on a real number have been defined to work on complex numbers as well, and are merely *extensions* of the operations defined on real numbers. This means they keep their natural meaning when there is no imaginary part, provided the number is within their definition set.

For instance, the `sqrt` routine which computes the square root of its argument is only defined for non−negative real numbers and yields a non−negative real number (it is an application from **R+** to **R+**). If we allow it to return a complex number, then it can be extended to negative real numbers to become an application from **R** to **C** (the set of complex numbers):

```
sqrt(x) = x >= 0 ? sqrt(x) : sqrt(-x)*i
```

It can also be extended to be an application from **C** to **C**, whilst its restriction to **R** behaves as defined above by using the following definition:

```
sqrt(z = [r,t]) = sqrt(r) * exp(i * t/2)
```

Indeed, a negative real number can be noted `[x,pi]` (the modulus *x* is always non−negative, so `[x,pi]` is really `-x`, a negative number) and the above definition states that

```
sqrt([x,pi]) = sqrt(x) * exp(i*pi/2) = [sqrt(x),pi/2] = sqrt(x)*i
```

which is exactly what we had defined for negative real numbers above. The `sqrt` returns only one of the solutions: if you want the both, use the `root` function.

All the common mathematical functions defined on real numbers that are extended to complex numbers share that same property of working *as usual* when the imaginary part is zero (otherwise, it would not be called an extension, would it?).

A *new* operation possible on a complex number that is the identity for real numbers is called the *conjugate*, and is noted with an horizontal bar above the number, or `~z` here.

```
 z = a + bi
~z = a - bi
```

Simple... Now look:

```
z * ~z = (a + bi) * (a - bi) = a*a + b*b
```

We saw that the norm of `z` was noted `abs(z)` and was defined as the distance to the origin, also known as:

```
rho = abs(z) = sqrt(a*a + b*b)
```

so

```
z * ~z = abs(z) ** 2
```

If z is a pure real number (i.e. `b == 0`), then the above yields:

```
a * a = abs(a) ** 2
```

which is true (`abs` has the regular meaning for real number, i.e. stands for the absolute value). This example explains why the norm of `z` is noted `abs(z)`: it extends the `abs` function to complex numbers, yet is the regular `abs` we know when the complex number actually has no imaginary part... This justifies *a posteriori* our use of the `abs` notation for the norm.

OPERATIONS

Given the following notations:

```
z1 = a + bi = r1 * exp(i * t1)
z2 = c + di = r2 * exp(i * t2)
z = <any complex or real number>
```

the following (overloaded) operations are supported on complex numbers:

```
z1 + z2 = (a + c) + i(b + d)
z1 - z2 = (a - c) + i(b - d)
z1 * z2 = (r1 * r2) * exp(i * (t1 + t2))
z1 / z2 = (r1 / r2) * exp(i * (t1 - t2))
z1 ** z2 = exp(z2 * log z1)
~z = a - bi
abs(z) = r1 = sqrt(a*a + b*b)
sqrt(z) = sqrt(r1) * exp(i * t/2)
exp(z) = exp(a) * exp(i * b)
log(z) = log(r1) + i*t
sin(z) = 1/2i (exp(i * z1) - exp(-i * z))
cos(z) = 1/2 (exp(i * z1) + exp(-i * z))
atan2(z1, z2) = atan(z1/z2)
```

The following extra operations are supported on both real and complex numbers:

```
Re(z) = a
Im(z) = b
arg(z) = t
abs(z) = r

cbrt(z) = z ** (1/3)
log10(z) = log(z) / log(10)
logn(z, n) = log(z) / log(n)

tan(z) = sin(z) / cos(z)

csc(z) = 1 / sin(z)
sec(z) = 1 / cos(z)
cot(z) = 1 / tan(z)

asin(z) = -i * log(i*z + sqrt(1-z*z))
acos(z) = -i * log(z + i*sqrt(1-z*z))
atan(z) = i/2 * log((i+z) / (i-z))

acsc(z) = asin(1 / z)
asec(z) = acos(1 / z)
acot(z) = atan(1 / z) = -i/2 * log((i+z) / (z-i))

sinh(z) = 1/2 (exp(z) - exp(-z))
cosh(z) = 1/2 (exp(z) + exp(-z))
tanh(z) = sinh(z) / cosh(z) = (exp(z) - exp(-z)) / (exp(z) + exp(-z))

csch(z) = 1 / sinh(z)
sech(z) = 1 / cosh(z)
coth(z) = 1 / tanh(z)
```

```
asinh(z) = log(z + sqrt(z*z+1))
acosh(z) = log(z + sqrt(z*z-1))
atanh(z) = 1/2 * log((1+z) / (1-z))

acsch(z) = asinh(1 / z)
asech(z) = acosh(1 / z)
acoth(z) = atanh(1 / z) = 1/2 * log((1+z) / (z-1))
```

arg, *abs*, *log*, *csc*, *cot*, *acsc*, *acot*, *csch*, *coth*, *acosech*, *acotanh*, have aliases *rho*, *theta*, *ln*, *cosec*, *cotan*, *acosec*, *acotan*, *cosech*, *cotanh*, *acosech*, *acotanh*, respectively. `Re`, `Im`, `arg`, `abs`, `rho`, and `theta` can be used also also mutators. The `cbrt` returns only one of the solutions: if you want all three, use the `root` function.

The *root* function is available to compute all the *n* roots of some complex, where *n* is a strictly positive integer. There are exactly *n* such roots, returned as a list. Getting the number mathematicians call `j` such that:

```
1 + j + j*j = 0;
```

is a simple matter of writing:

```
$j = ((root(1, 3))[1];
```

The *k*th root for `z = [r,t]` is given by:

```
(root(z, n))[k] = r**(1/n) * exp(i * (t + 2*k*pi)/n)
```

The *spaceship* comparison operator, <=>, is also defined. In order to ensure its restriction to real numbers is conform to what you would expect, the comparison is run on the real part of the complex number first, and imaginary parts are compared only when the real parts match.

CREATION

To create a complex number, use either:

```
$z = Math::Complex->make(3, 4);
$z = cplx(3, 4);
```

if you know the cartesian form of the number, or

```
$z = 3 + 4*i;
```

if you like. To create a number using the polar form, use either:

```
$z = Math::Complex->emake(5, pi/3);
$x = cplxe(5, pi/3);
```

instead. The first argument is the modulus, the second is the angle (in radians, the full circle is 2*pi). (Mnemonic: `e` is used as a notation for complex numbers in the polar form).

It is possible to write:

```
$x = cplxe(-3, pi/4);
```

but that will be silently converted into `[3,-3pi/4]`, since the modulus must be non-negative (it represents the distance to the origin in the complex plane).

It is also possible to have a complex number as either argument of either the `make` or `emake`: the appropriate component of the argument will be used.

```
$z1 = cplx(-2,  1);
$z2 = cplx($z1, 4);
```

STRINGIFICATION

When printed, a complex number is usually shown under its cartesian style *a+bi*, but there are legitimate cases where the polar style *[r,t]* is more appropriate.

By calling the class method `Math::Complex::display_format` and supplying either `"polar"` or `"cartesian"` as an argument, you override the default display style, which is `"cartesian"`. Not supplying any argument returns the current settings.

This default can be overridden on a per–number basis by calling the `display_format` method instead. As before, not supplying any argument returns the current display style for this number. Otherwise whatever you specify will be the new display style for *this* particular number.

For instance:

```
use Math::Complex;

Math::Complex::display_format('polar');
$j = (root(1, 3))[1];
print "j = $j\n";               # Prints "j = [1,2pi/3]"
$j->display_format('cartesian');
print "j = $j\n";               # Prints "j = -0.5+0.866025403784439i"
```

The polar style attempts to emphasize arguments like *k*pi/n* (where *n* is a positive integer and *k* an integer within [–9, +9]), this is called *polar pretty–printing*.

CHANGED IN PERL 5.6

The `display_format` class method and the corresponding `display_format` object method can now be called using a parameter hash instead of just a one parameter.

The old display format style, which can have values `"cartesian"` or `"polar"`, can be changed using the `"style"` parameter.

```
$j->display_format(style => "polar");
```

The one parameter calling convention also still works.

```
$j->display_format("polar");
```

There are two new display parameters.

The first one is `"format"`, which is a `sprintf()`–style format string to be used for both numeric parts of the complex number(s). The is somewhat system–dependent but most often it corresponds to `"%.15g"`. You can revert to the default by setting the `format` to `undef`.

```
# the $j from the above example

$j->display_format('format' => '%.5f');
print "j = $j\n";               # Prints "j = -0.50000+0.86603i"
$j->display_format('format' => undef);
print "j = $j\n";               # Prints "j = -0.5+0.86603i"
```

Notice that this affects also the return values of the `display_format` methods: in list context the whole parameter hash will be returned, as opposed to only the style parameter value. This is a potential incompatibility with earlier versions if you have been calling the `display_format` method in list context.

The second new display parameter is `"polar_pretty_print"`, which can be set to true or false, the default being true. See the previous section for what this means.

USAGE

Thanks to overloading, the handling of arithmetics with complex numbers is simple and almost transparent.

Here are some examples:

```
use Math::Complex;

$j = cplxe(1, 2*pi/3);  # $j ** 3 == 1
print "j = $j, j**3 = ", $j ** 3, "\n";
print "1 + j + j**2 = ", 1 + $j + $j**2, "\n";

$z = -16 + 0*i;                 # Force it to be a complex
print "sqrt($z) = ", sqrt($z), "\n";

$k = exp(i * 2*pi/3);
print "$j - $k = ", $j - $k, "\n";

$z->Re(3);                      # Re, Im, arg, abs,
$j->arg(2);                     # (the last two aka rho, theta)
                                # can be used also as mutators.
```

ERRORS DUE TO DIVISION BY ZERO OR LOGARITHM OF ZERO

The division (/) and the following functions

```
log     ln      log10   logn
tan     sec     csc     cot
atan    asec    acsc    acot
tanh    sech    csch    coth
atanh   asech   acsch   acoth
```

cannot be computed for all arguments because that would mean dividing by zero or taking logarithm of zero. These situations cause fatal runtime errors looking like this

```
cot(0): Division by zero.
(Because in the definition of cot(0), the divisor sin(0) is 0)
Died at ...
```

or

```
atanh(-1): Logarithm of zero.
Died at...
```

For the `csc`, `cot`, `asec`, `acsc`, `acot`, `csch`, `coth`, `asech`, `acsch`, the argument cannot be (zero). For the the logarithmic functions and the `atanh`, `acoth`, the argument cannot be `1` (one). For the `atanh`, `acoth`, the argument cannot be `-1` (minus one). For the `atan`, `acot`, the argument cannot be `i` (the imaginary unit). For the `atan`, `acoth`, the argument cannot be `-i` (the negative imaginary unit). For the `tan`, `sec`, `tanh`, the argument cannot be *pi/2 + k * pi*, where *k* is any integer.

Note that because we are operating on approximations of real numbers, these errors can happen when merely 'too close' to the singularities listed above.

ERRORS DUE TO INDIGESTIBLE ARGUMENTS

The `make` and `emake` accept both real and complex arguments. When they cannot recognize the arguments they will die with error messages like the following

```
Math::Complex::make: Cannot take real part of ...
Math::Complex::make: Cannot take real part of ...
Math::Complex::emake: Cannot take rho of ...
Math::Complex::emake: Cannot take theta of ...
```

BUGS

Saying `use Math::Complex;` exports many mathematical routines in the caller environment and even overrides some (`sqrt`, `log`). This is construed as a feature by the Authors, actually... ;–)

All routines expect to be given real or complex numbers. Don't attempt to use BigFloat, since Perl has

currently no rule to disambiguate a '+' operation (for instance) between two overloaded entities.

In Cray UNICOS there is some strange numerical instability that results in `root()`, `cos()`, `sin()`, `cosh()`, `sinh()`, losing accuracy fast. Beware. The bug may be in UNICOS math libs, in UNICOS C compiler, in Math::Complex. Whatever it is, it does not manifest itself anywhere else where Perl runs.

AUTHORS

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Extensive patches by Daniel S. Lewart *<d-lewart@uiuc.edu>*.

NAME

Math::Trig – trigonometric functions

SYNOPSIS

```
use Math::Trig;

$x = tan(0.9);
$y = acos(3.7);
$z = asin(2.4);

$halfpi = pi/2;

$rad = deg2rad(120);
```

DESCRIPTION

`Math::Trig` defines many trigonometric functions not defined by the core Perl which defines only the `sin()` and `cos()`. The constant **pi** is also defined as are a few convenience functions for angle conversions.

TRIGONOMETRIC FUNCTIONS

The tangent

tan

The cofunctions of the sine, cosine, and tangent (cosec/csc and cotan/cot are aliases)

csc, **cosec**, **sec**, **sec**, **cot**, **cotan**

The arcus (also known as the inverse) functions of the sine, cosine, and tangent

asin, **acos**, **atan**

The principal value of the arc tangent of y/x

atan2(y, x)

The arcus cofunctions of the sine, cosine, and tangent (acosec/acsc and acotan/acot are aliases)

acsc, **acosec**, **asec**, **acot**, **acotan**

The hyperbolic sine, cosine, and tangent

sinh, **cosh**, **tanh**

The cofunctions of the hyperbolic sine, cosine, and tangent (cosech/csch and cotanh/coth are aliases)

csch, **cosech**, **sech**, **coth**, **cotanh**

The arcus (also known as the inverse) functions of the hyperbolic sine, cosine, and tangent

asinh, **acosh**, **atanh**

The arcus cofunctions of the hyperbolic sine, cosine, and tangent (acsch/acosech and acoth/acotanh are aliases)

acsch, **acosech**, **asech**, **acoth**, **acotanh**

The trigonometric constant **pi** is also defined.

`$pi2` = 2 * **pi**;

ERRORS DUE TO DIVISION BY ZERO

The following functions

```
acoth
acsc
acsch
```

```
asec
asech
atanh
cot
coth
csc
csch
sec
sech
tan
tanh
```

cannot be computed for all arguments because that would mean dividing by zero or taking logarithm of zero. These situations cause fatal runtime errors looking like this

```
cot(0): Division by zero.
(Because in the definition of cot(0), the divisor sin(0) is 0)
Died at ...
```

or

```
atanh(-1): Logarithm of zero.
Died at...
```

For the `csc`, `cot`, `asec`, `acsc`, `acot`, `csch`, `coth`, `asech`, `acsch`, the argument cannot be (zero). For the `atanh`, `acoth`, the argument cannot be `1` (one). For the `atanh`, `acoth`, the argument cannot be `-1` (minus one). For the `tan`, `sec`, `tanh`, `sech`, the argument cannot be *pi/2 + k * pi*, where *k* is any integer.

SIMPLE (REAL) ARGUMENTS, COMPLEX RESULTS

Please note that some of the trigonometric functions can break out from the **real axis** into the **complex plane**. For example `asin(2)` has no definition for plain real numbers but it has definition for complex numbers.

In Perl terms this means that supplying the usual Perl numbers (also known as scalars, please see *perldata*) as input for the trigonometric functions might produce as output results that no more are simple real numbers: instead they are complex numbers.

The `Math::Trig` handles this by using the `Math::Complex` package which knows how to handle complex numbers, please see *Math::Complex* for more information. In practice you need not to worry about getting complex numbers as results because the `Math::Complex` takes care of details like for example how to display complex numbers. For example:

```
print asin(2), "\n";
```

should produce something like this (take or leave few last decimals):

```
1.5707963267949-1.31695789692482i
```

That is, a complex number with the real part of approximately `1.571` and the imaginary part of approximately `-1.317`.

PLANE ANGLE CONVERSIONS

(Plane, 2-dimensional) angles may be converted with the following functions.

```
$radians  = deg2rad($degrees);
$radians  = grad2rad($gradians);

$degrees  = rad2deg($radians);
$degrees  = grad2deg($gradians);

$gradians = deg2grad($degrees);
```

```
$gradians = rad2grad($radians);
```

The full circle is 2 *pi* radians or *360* degrees or *400* gradians. The result is by default wrapped to be inside the [0, {2pi,360,400}[circle. If you don't want this, supply a true second argument:

```
$zillions_of_radians  = deg2rad($zillions_of_degrees, 1);
$negative_degrees     = rad2deg($negative_radians, 1);
```

You can also do the wrapping explicitly by `rad2rad()`, `deg2deg()`, and `grad2grad()`.

RADIAL COORDINATE CONVERSIONS

Radial coordinate systems are the **spherical** and the **cylindrical** systems, explained shortly in more detail.

You can import radial coordinate conversion functions by using the `:radial` tag:

```
use Math::Trig ':radial';

($rho, $theta, $z)     = cartesian_to_cylindrical($x, $y, $z);
($rho, $theta, $phi)   = cartesian_to_spherical($x, $y, $z);
($x, $y, $z)           = cylindrical_to_cartesian($rho, $theta, $z);
($rho_s, $theta, $phi) = cylindrical_to_spherical($rho_c, $theta, $z);
($x, $y, $z)           = spherical_to_cartesian($rho, $theta, $phi);
($rho_c, $theta, $z)   = spherical_to_cylindrical($rho_s, $theta, $phi);
```

All angles are in radians.

COORDINATE SYSTEMS

Cartesian coordinates are the usual rectangular *(x, y, z)*−coordinates.

Spherical coordinates, *(rho, theta, pi)*, are three−dimensional coordinates which define a point in three−dimensional space. They are based on a sphere surface. The radius of the sphere is **rho**, also known as the *radial* coordinate. The angle in the *xy*−plane (around the *z*−axis) is **theta**, also known as the *azimuthal* coordinate. The angle from the *z*−axis is **phi**, also known as the *polar* coordinate. The 'North Pole' is therefore *0, 0, rho*, and the 'Bay of Guinea' (think of the missing big chunk of Africa) *0, pi/2, rho*. In geographical terms *phi* is latitude (northward positive, southward negative) and *theta* is longitude (eastward positive, westward negative).

BEWARE: some texts define *theta* and *phi* the other way round, some texts define the *phi* to start from the horizontal plane, some texts use *r* in place of *rho*.

Cylindrical coordinates, *(rho, theta, z)*, are three−dimensional coordinates which define a point in three−dimensional space. They are based on a cylinder surface. The radius of the cylinder is **rho**, also known as the *radial* coordinate. The angle in the *xy*−plane (around the *z*−axis) is **theta**, also known as the *azimuthal* coordinate. The third coordinate is the *z*, pointing up from the **theta**−plane.

3−D ANGLE CONVERSIONS

Conversions to and from spherical and cylindrical coordinates are available. Please notice that the conversions are not necessarily reversible because of the equalities like *pi* angles being equal to −*pi* angles.

cartesian_to_cylindrical

```
($rho, $theta, $z) = cartesian_to_cylindrical($x, $y, $z);
```

cartesian_to_spherical

```
($rho, $theta, $phi) = cartesian_to_spherical($x, $y, $z);
```

cylindrical_to_cartesian

```
($x, $y, $z) = cylindrical_to_cartesian($rho, $theta, $z);
```

cylindrical_to_spherical

```
($rho_s, $theta, $phi) = cylindrical_to_spherical($rho_c, $theta, $z);
```

Notice that when `$z` is not 0 `$rho_s` is not equal to `$rho_c`.

spherical_to_cartesian

```
($x, $y, $z) = spherical_to_cartesian($rho, $theta, $phi);
```

spherical_to_cylindrical

```
($rho_c, $theta, $z) = spherical_to_cylindrical($rho_s, $theta, $phi);
```

Notice that when `$z` is not 0 `$rho_c` is not equal to `$rho_s`.

GREAT CIRCLE DISTANCES

You can compute spherical distances, called **great circle distances**, by importing the `great_circle_distance` function:

```
use Math::Trig 'great_circle_distance'

$distance = great_circle_distance($theta0, $phi0, $theta1, $phi1, [, $rho]);
```

The *great circle distance* is the shortest distance between two points on a sphere. The distance is in `$rho` units. The `$rho` is optional, it defaults to 1 (the unit sphere), therefore the distance defaults to radians.

If you think geographically the *theta* are longitudes: zero at the Greenwhich meridian, eastward positive, westward negative—and the *phi* are latitudes: zero at the North Pole, northward positive, southward negative. **NOTE**: this formula thinks in mathematics, not geographically: the *phi* zero is at the North Pole, not at the Equator on the west coast of Africa (Bay of Guinea). You need to subtract your geographical coordinates from *pi/2* (also known as 90 degrees).

```
$distance = great_circle_distance($lon0, pi/2 - $lat0,
                                  $lon1, pi/2 - $lat1, $rho);
```

EXAMPLES

To calculate the distance between London (51.3N 0.5W) and Tokyo (35.7N 139.8E) in kilometers:

```
use Math::Trig qw(great_circle_distance deg2rad);

# Notice the 90 - latitude: phi zero is at the North Pole.
@L = (deg2rad(-0.5), deg2rad(90 - 51.3));
@T = (deg2rad(139.8),deg2rad(90 - 35.7));

$km = great_circle_distance(@L, @T, 6378);
```

The answer may be off by few percentages because of the irregular (slightly aspherical) form of the Earth. The used formula

```
lat0 = 90 degrees - phi0
lat1 = 90 degrees - phi1
d = R * arccos(cos(lat0) * cos(lat1) * cos(lon1 - lon01) +
               sin(lat0) * sin(lat1))
```

is also somewhat unreliable for small distances (for locations separated less than about five degrees) because it uses arc cosine which is rather ill−conditioned for values close to zero.

BUGS

Saying `use Math::Trig;` exports many mathematical routines in the caller environment and even overrides some (`sin`, `cos`). This is construed as a feature by the Authors, actually... ;−)

The code is not optimized for speed, especially because we use `Math::Complex` and thus go quite near complex numbers while doing the computations even when the arguments are not. This, however, cannot be completely avoided if we want things like `asin(2)` to give an answer instead of giving a fatal runtime error.

AUTHORS

Jarkko Hietaniemi *<jhi@iki.fi* and Raphael Manfredi *<Raphael_Manfredi@pobox.com*.

NAME

Net::hostent – by–name interface to Perl's built–in `gethost*()` functions

SYNOPSIS

```
use Net::hostnet;
```

DESCRIPTION

This module's default exports override the core `gethostbyname()` and `gethostbyaddr()` functions, replacing them with versions that return "Net::hostent" objects. This object has methods that return the similarly named structure field name from the C's hostent structure from ***netdb.h***; namely name, aliases, addrtype, length, and addr_list. The aliases and addr_list methods return array reference, the rest scalars. The addr method is equivalent to the zeroth element in the addr_list array reference.

You may also import all the structure fields directly into your namespace as regular variables using the :FIELDS import tag. (Note that this still overrides your core functions.) Access these fields as variables named with a preceding `h_`. Thus, `$host_obj->name()` corresponds to `$h_name` if you import the fields. Array references are available as regular array variables, so for example `@{ $host_obj->aliases() }` would be simply @h_aliases.

The `gethost()` function is a simple front–end that forwards a numeric argument to `gethostbyaddr()` by way of Socket::inet_aton, and the rest to `gethostbyname()`.

To access this functionality without the core overrides, pass the `use` an empty import list, and then access function functions with their full qualified names. On the other hand, the built–ins are still available via the `CORE::` pseudo–package.

EXAMPLES

```
use Net::hostent;
use Socket;

@ARGV = ('netscape.com') unless @ARGV;

for $host ( @ARGV ) {

   unless ($h = gethost($host)) {
       warn "$0: no such host: $host\n";
       next;
   }

   printf "\n%s is %s%s\n",
           $host,
           lc($h->name) eq lc($host) ? "" : "*really* ",
           $h->name;

   print "\taliases are ", join(", ", @{$h->aliases}), "\n"
                if @{$h->aliases};

   if ( @{$h->addr_list} > 1 ) {
       my $i;
       for $addr ( @{$h->addr_list} ) {
           printf "\taddr #%d is [%s]\n", $i++, inet_ntoa($addr);
       }
   } else {
       printf "\taddress is [%s]\n", inet_ntoa($h->addr);
   }

   if ($h = gethostbyaddr($h->addr)) {
       if (lc($h->name) ne lc($host)) {
           printf "\tThat addr reverses to host %s!\n", $h->name;
           $host = $h->name;
```

```
                redo;
            }
        }
    }
```

NOTE

While this class is currently implemented using the Class::Struct module to build a struct–like class, you shouldn't rely upon this.

AUTHOR

Tom Christiansen

NAME

Net::netent – by–name interface to Perl's built–in `getnet*()` functions

SYNOPSIS

```
use Net::netent qw(:FIELDS);
getnetbyname("loopback")               or die "bad net";
printf "%s is %08X\n", $n_name, $n_net;

use Net::netent;

$n = getnetbyname("loopback")          or die "bad net";
{ # there's gotta be a better way, eh?
    @bytes = unpack("C4", pack("N", $n->net));
    shift @bytes while @bytes && $bytes[0] == 0;
}
printf "%s is %08X [%d.%d.%d.%d]\n", $n->name, $n->net, @bytes;
```

DESCRIPTION

This module's default exports override the core `getnetbyname()` and `getnetbyaddr()` functions, replacing them with versions that return "Net::netent" objects. This object has methods that return the similarly named structure field name from the C's netent structure from ***netdb.h***; namely name, aliases, addrtype, and net. The aliases method returns an array reference, the rest scalars.

You may also import all the structure fields directly into your namespace as regular variables using the :FIELDS import tag. (Note that this still overrides your core functions.) Access these fields as variables named with a preceding `n_`. Thus, `$net_obj->name()` corresponds to `$n_name` if you import the fields. Array references are available as regular array variables, so for example `@{ $net_obj->aliases() }` would be simply @n_aliases.

The `getnet()` function is a simple front–end that forwards a numeric argument to `getnetbyaddr()`, and the rest to `getnetbyname()`.

To access this functionality without the core overrides, pass the `use` an empty import list, and then access function functions with their full qualified names. On the other hand, the built–ins are still available via the `CORE::` pseudo–package.

EXAMPLES

The `getnet()` functions do this in the Perl core:

```
sv_setiv(sv, (I32)nent->n_net);
```

The `gethost()` functions do this in the Perl core:

```
sv_setpvn(sv, hent->h_addr, len);
```

That means that the address comes back in binary for the host functions, and as a regular perl integer for the net ones. This seems a bug, but here's how to deal with it:

```
use strict;
use Socket;
use Net::netent;

@ARGV = ('loopback') unless @ARGV;

my($n, $net);

for $net ( @ARGV ) {

    unless ($n = getnetbyname($net)) {
       warn "$0: no such net: $net\n";
       next;
    }
```

```
        printf "\n%s is %s%s\n",
               $net,
               lc($n->name) eq lc($net) ? "" : "*really* ",
               $n->name;

        print "\taliases are ", join(", ", @{$n->aliases}), "\n"
                    if @{$n->aliases};

        # this is stupid; first, why is this not in binary?
        # second, why am i going through these convolutions
        # to make it looks right
        {
           my @a = unpack("C4", pack("N", $n->net));
           shift @a while @a && $a[0] == 0;
           printf "\taddr is %s [%d.%d.%d.%d]\n", $n->net, @a;
        }

        if ($n = getnetbyaddr($n->net)) {
           if (lc($n->name) ne lc($net)) {
               printf "\tThat addr reverses to net %s!\n", $n->name;
               $net = $n->name;
               redo;
           }
        }
    }
```

NOTE

While this class is currently implemented using the Class::Struct module to build a struct–like class, you shouldn't rely upon this.

AUTHOR

Tom Christiansen

NAME

Net::Ping – check a remote host for reachability

SYNOPSIS

```
use Net::Ping;

$p = Net::Ping->new();
print "$host is alive.\n" if $p->ping($host);
$p->close();

$p = Net::Ping->new("icmp");
foreach $host (@host_array)
{
    print "$host is ";
    print "NOT " unless $p->ping($host, 2);
    print "reachable.\n";
    sleep(1);
}
$p->close();

$p = Net::Ping->new("tcp", 2);
while ($stop_time > time())
{
    print "$host not reachable ", scalar(localtime()), "\n"
        unless $p->ping($host);
    sleep(300);
}
undef($p);

# For backward compatibility
print "$host is alive.\n" if pingecho($host);
```

DESCRIPTION

This module contains methods to test the reachability of remote hosts on a network. A ping object is first created with optional parameters, a variable number of hosts may be pinged multiple times and then the connection is closed.

You may choose one of three different protocols to use for the ping. The "udp" protocol is the default. Note that a live remote host may still fail to be pingable by one or more of these protocols. For example, www.microsoft.com is generally alive but not pingable.

With the "tcp" protocol the `ping()` method attempts to establish a connection to the remote host‘s echo port. If the connection is successfully established, the remote host is considered reachable. No data is actually echoed. This protocol does not require any special privileges but has higher overhead than the other two protocols.

Specifying the "udp" protocol causes the `ping()` method to send a udp packet to the remote host‘s echo port. If the echoed packet is received from the remote host and the received packet contains the same data as the packet that was sent, the remote host is considered reachable. This protocol does not require any special privileges.

If the "icmp" protocol is specified, the `ping()` method sends an icmp echo message to the remote host, which is what the UNIX ping program does. If the echoed message is received from the remote host and the echoed information is correct, the remote host is considered reachable. Specifying the "icmp" protocol requires that the program be run as root or that the program be setuid to root.

Functions

Net::Ping–new([$proto [, $def_timeout [, $bytes]]]);

Create a new ping object. All of the parameters are optional. $proto specifies the protocol to use when doing a ping. The current choices are "tcp", "udp" or "icmp". The default is "udp".

If a default timeout ($def_timeout) in seconds is provided, it is used when a timeout is not given to the ping() method (below). The timeout must be greater than 0 and the default, if not specified, is 5 seconds.

If the number of data bytes ($bytes) is given, that many data bytes are included in the ping packet sent to the remote host. The number of data bytes is ignored if the protocol is "tcp". The minimum (and default) number of data bytes is 1 if the protocol is "udp" and 0 otherwise. The maximum number of data bytes that can be specified is 1024.

$p–ping($host [, $timeout]);

Ping the remote host and wait for a response. $host can be either the hostname or the IP number of the remote host. The optional timeout must be greater than 0 seconds and defaults to whatever was specified when the ping object was created. If the hostname cannot be found or there is a problem with the IP number, undef is returned. Otherwise, 1 is returned if the host is reachable and 0 if it is not. For all practical purposes, undef and 0 and can be treated as the same case.

$p–close();

Close the network connection for this ping object. The network connection is also closed by "undef $p". The network connection is automatically closed if the ping object goes out of scope (e.g. $p is local to a subroutine and you leave the subroutine).

pingecho($host [, $timeout]);

To provide backward compatibility with the previous version of Net::Ping, a pingecho() subroutine is available with the same functionality as before. pingecho() uses the tcp protocol. The return values and parameters are the same as described for the ping() method. This subroutine is obsolete and may be removed in a future version of Net::Ping.

WARNING

pingecho() or a ping object with the tcp protocol use alarm() to implement the timeout. So, don't use alarm() in your program while you are using pingecho() or a ping object with the tcp protocol. The udp and icmp protocols do not use alarm() to implement the timeout.

NOTES

There will be less network overhead (and some efficiency in your program) if you specify either the udp or the icmp protocol. The tcp protocol will generate 2.5 times or more traffic for each ping than either udp or icmp. If many hosts are pinged frequently, you may wish to implement a small wait (e.g. 25ms or more) between each ping to avoid flooding your network with packets.

The icmp protocol requires that the program be run as root or that it be setuid to root. The tcp and udp protocols do not require special privileges, but not all network devices implement the echo protocol for tcp or udp.

Local hosts should normally respond to pings within milliseconds. However, on a very congested network it may take up to 3 seconds or longer to receive an echo packet from the remote host. If the timeout is set too low under these conditions, it will appear that the remote host is not reachable (which is almost the truth).

Reachability doesn't necessarily mean that the remote host is actually functioning beyond its ability to echo packets.

Because of a lack of anything better, this module uses its own routines to pack and unpack ICMP packets. It would be better for a separate module to be written which understands all of the different kinds of ICMP packets.

NAME

Net::protoent – by–name interface to Perl's built–in `getproto*()` functions

SYNOPSIS

```
use Net::protoent;
$p = getprotobyname(shift || 'tcp') || die "no proto";
printf "proto for %s is %d, aliases are %s\n",
   $p->name, $p->proto, "@{$p->aliases}";

use Net::protoent qw(:FIELDS);
getprotobyname(shift || 'tcp') || die "no proto";
print "proto for $p_name is $p_proto, aliases are @p_aliases\n";
```

DESCRIPTION

This module's default exports override the core `getprotoent()`, `getprotobyname()`, and `getnetbyport()` functions, replacing them with versions that return "Net::protoent" objects. They take default second arguments of "tcp". This object has methods that return the similarly named structure field name from the C's protoent structure from ***netdb.h***; namely name, aliases, and proto. The aliases method returns an array reference, the rest scalars.

You may also import all the structure fields directly into your namespace as regular variables using the :FIELDS import tag. (Note that this still overrides your core functions.) Access these fields as variables named with a preceding `p_`. Thus, `$proto_obj->name()` corresponds to `$p_name` if you import the fields. Array references are available as regular array variables, so for example `@{ $proto_obj->aliases() }` would be simply @p_aliases.

The `getproto()` function is a simple front–end that forwards a numeric argument to `getprotobyport()`, and the rest to `getprotobyname()`.

To access this functionality without the core overrides, pass the `use` an empty import list, and then access function functions with their full qualified names. On the other hand, the built–ins are still available via the `CORE::` pseudo–package.

NOTE

While this class is currently implemented using the Class::Struct module to build a struct–like class, you shouldn't rely upon this.

AUTHOR

Tom Christiansen

NAME

Net::servent – by–name interface to Perl's built–in `getserv*()` functions

SYNOPSIS

```
use Net::servent;
$s = getservbyname(shift || 'ftp') || die "no service";
printf "port for %s is %s, aliases are %s\n",
   $s->name, $s->port, "@{$s->aliases}";

use Net::servent qw(:FIELDS);
getservbyname(shift || 'ftp') || die "no service";
print "port for $s_name is $s_port, aliases are @s_aliases\n";
```

DESCRIPTION

This module's default exports override the core `getservent()`, `getservbyname()`, and `getnetbyport()` functions, replacing them with versions that return "Net::servent" objects. They take default second arguments of "tcp". This object has methods that return the similarly named structure field name from the C's servent structure from ***netdb.h***; namely name, aliases, port, and proto. The aliases method returns an array reference, the rest scalars.

You may also import all the structure fields directly into your namespace as regular variables using the :FIELDS import tag. (Note that this still overrides your core functions.) Access these fields as variables named with a preceding `n_`. Thus, `$serv_obj->name()` corresponds to `$s_name` if you import the fields. Array references are available as regular array variables, so for example `@{ $serv_obj->aliases() }` would be simply @s_aliases.

The `getserv()` function is a simple front–end that forwards a numeric argument to `getservbyport()`, and the rest to `getservbyname()`.

To access this functionality without the core overrides, pass the `use` an empty import list, and then access function functions with their full qualified names. On the other hand, the built–ins are still available via the `CORE::` pseudo–package.

EXAMPLES

```
use Net::servent qw(:FIELDS);

while (@ARGV) {
    my ($service, $proto) = ((split m!/!, shift), 'tcp');
    my $valet = getserv($service, $proto);
    unless ($valet) {
        warn "$0: No service: $service/$proto\n"
        next;
    }
    printf "service $service/$proto is port %d\n", $valet->port;
    print "alias are @s_aliases\n" if @s_aliases;
}
```

NOTE

While this class is currently implemented using the Class::Struct module to build a struct–like class, you shouldn't rely upon this.

AUTHOR

Tom Christiansen

NAME

open – perl pragma to set default disciplines for input and output

SYNOPSIS

```
use open IN => ":crlf", OUT => ":raw";
```

DESCRIPTION

The open pragma is used to declare one or more default disciplines for I/O operations. Any `open()` and `readpipe()` (aka qx//) operators found within the lexical scope of this pragma will use the declared defaults. Neither `open()` with an explicit set of disciplines, nor `sysopen()` are influenced by this pragma.

Only the two pseudo–disciplines ":raw" and ":crlf" are currently available.

The ":raw" discipline corresponds to "binary mode" and the ":crlf" discipline corresponds to "text mode" on platforms that distinguish between the two modes when opening files (which is many DOS–like platforms, including Windows). These two disciplines are currently no–ops on platforms where `binmode()` is a no–op, but will be supported everywhere in future.

UNIMPLEMENTED FUNCTIONALITY

Full–fledged support for I/O disciplines is currently unimplemented. When they are eventually supported, this pragma will serve as one of the interfaces to declare default disciplines for all I/O.

In future, any default disciplines declared by this pragma will be available by the special discipline name ":DEFAULT", and could be used within handle constructors that allow disciplines to be specified. This would make it possible to stack new disciplines over the default ones.

```
open FH, "<:para :DEFAULT", $file or die "can't open $file: $!";
```

Socket and directory handles will also support disciplines in future.

Full support for I/O disciplines will enable all of the supported disciplines to work on all platforms.

SEE ALSO

binmode in perlfunc, *open in perlfunc*, *perlunicode*

NAME

overload – Package for overloading perl operations

SYNOPSIS

```
package SomeThing;

use overload
    '+' => \&myadd,
    '-' => \&mysub;
    # etc
...

package main;
$a = new SomeThing 57;
$b=5+$a;
...
if (overload::Overloaded $b) {...}
...
$strval = overload::StrVal $b;
```

DESCRIPTION

Declaration of overloaded functions

The compilation directive

```
package Number;
use overload
    "+" => \&add,
    "*=" => "muas";
```

declares function `Number::add()` for addition, and method `muas()` in the "class" `Number` (or one of its base classes) for the assignment form `*=` of multiplication.

Arguments of this directive come in (key, value) pairs. Legal values are values legal inside a `&{ ... }` call, so the name of a subroutine, a reference to a subroutine, or an anonymous subroutine will all work. Note that values specified as strings are interpreted as methods, not subroutines. Legal keys are listed below.

The subroutine `add` will be called to execute `$a+$b` if `$a` is a reference to an object blessed into the package `Number`, or if `$a` is not an object from a package with defined mathemagic addition, but `$b` is a reference to a `Number`. It can also be called in other situations, like `$a+=7`, or `$a++`. See *MAGIC AUTOGENERATION*. (Mathemagical methods refer to methods triggered by an overloaded mathematical operator.)

Since overloading respects inheritance via the @ISA hierarchy, the above declaration would also trigger overloading of `+` and `*=` in all the packages which inherit from `Number`.

Calling Conventions for Binary Operations

The functions specified in the `use overload ...` directive are called with three (in one particular case with four, see *Last Resort*) arguments. If the corresponding operation is binary, then the first two arguments are the two arguments of the operation. However, due to general object calling conventions, the first argument should always be an object in the package, so in the situation of `7+$a`, the order of the arguments is interchanged. It probably does not matter when implementing the addition method, but whether the arguments are reversed is vital to the subtraction method. The method can query this information by examining the third argument, which can take three different values:

FALSE the order of arguments is as in the current operation.

TRUE the arguments are reversed.

undef the current operation is an assignment variant (as in $a+=7), but the usual function is called instead. This additional information can be used to generate some optimizations. Compare *Calling Conventions for Mutators*.

Calling Conventions for Unary Operations

Unary operation are considered binary operations with the second argument being undef. Thus the functions that overloads {"++"} is called with arguments ($a,undef,'') when $a++ is executed.

Calling Conventions for Mutators

Two types of mutators have different calling conventions:

++ and --

The routines which implement these operators are expected to actually *mutate* their arguments. So, assuming that $obj is a reference to a number,

```
sub incr { my $n = $ {$_[0]}; ++$n; $_[0] = bless \$n}
```

is an appropriate implementation of overloaded ++. Note that

```
sub incr { ++$ {$_[0]} ; shift }
```

is OK if used with preincrement and with postincrement. (In the case of postincrement a copying will be performed, see *Copy Constructor*.)

x= and other assignment versions

There is nothing special about these methods. They may change the value of their arguments, and may leave it as is. The result is going to be assigned to the value in the left-hand-side if different from this value.

This allows for the same method to be used as overloaded += and +. Note that this is *allowed*, but not recommended, since by the semantic of *"Fallback"* Perl will call the method for + anyway, if += is not overloaded.

Warning. Due to the presense of assignment versions of operations, routines which may be called in assignment context may create self-referential structures. Currently Perl will not free self-referential structures until cycles are explicitly broken. You may get problems when traversing your structures too.

Say,

```
use overload '+' => sub { bless [ \$_[0], \$_[1] ] };
```

is asking for trouble, since for code $obj += $foo the subroutine is called as $obj = add($obj, $foo, undef), or $obj = [\$obj, \$foo]. If using such a subroutine is an important optimization, one can overload += explicitly by a non-"optimized" version, or switch to non-optimized version if not defined $_[2] (see *Calling Conventions for Binary Operations*).

Even if no *explicit* assignment-variants of operators are present in the script, they may be generated by the optimizer. Say, ",$obj," or ',' . $obj . ',' may be both optimized to

```
my $tmp = ',' . $obj;     $tmp .= ',';
```

Overloadable Operations

The following symbols can be specified in use overload directive:

- *Arithmetic operations*

```
"+", "+=", "-", "-=", "*", "*=", "/", "/=", "%", "%=",
"**", "**=", "<<", "<<=", ">>", ">>=", "x", "x=", ".", ".=",
```

For these operations a substituted non-assignment variant can be called if the assignment variant is

not available. Methods for operations "+", "-", "+=", and "-=" can be called to automatically generate increment and decrement methods. The operation "-" can be used to autogenerate missing methods for unary minus or `abs`.

See *"MAGIC AUTOGENERATION"*, *"Calling Conventions for Mutators"* and *"Calling Conventions for Binary Operations"*) for details of these substitutions.

- *Comparison operations*

```
"<",  "<=", ">",  ">=", "==", "!=", "<=>",
"lt", "le", "gt", "ge", "eq", "ne", "cmp",
```

If the corresponding "spaceship" variant is available, it can be used to substitute for the missing operation. During `sort`ing arrays, `cmp` is used to compare values subject to `use overload`.

- *Bit operations*

```
"&", "^", "|", "neg", "!", "~",
```

"`neg`" stands for unary minus. If the method for `neg` is not specified, it can be autogenerated using the method for subtraction. If the method for "`!`" is not specified, it can be autogenerated using the methods for "`bool`", or "`"\"\""`", or "`0+`".

- *Increment and decrement*

```
"++", "--",
```

If undefined, addition and subtraction methods can be used instead. These operations are called both in prefix and postfix form.

- *Transcendental functions*

```
"atan2", "cos", "sin", "exp", "abs", "log", "sqrt",
```

If `abs` is unavailable, it can be autogenerated using methods for "<" or "<=>" combined with either unary minus or subtraction.

- *Boolean, string and numeric conversion*

```
"bool", "\"\"", "0+",
```

If one or two of these operations are not overloaded, the remaining ones can be used instead. `bool` is used in the flow control operators (like `while`) and for the ternary "`?:`" operation. These functions can return any arbitrary Perl value. If the corresponding operation for this value is overloaded too, that operation will be called again with this value.

As a special case if the overload returns the object itself then it will be used directly. An overloaded conversion returning the object is probably a bug, because you're likely to get something that looks like `YourPackage=HASH(0x8172b34)`.

- *Iteration*

```
"<>"
```

If not overloaded, the argument will be converted to a filehandle or glob (which may require a stringification). The same overloading happens both for the *read-filehandle* syntax `<$var>` and *globbing* syntax `<${var}>`.

- *Dereferencing*

```
'${}', '@{}', '%{}', '&{}', '*{}'.
```

If not overloaded, the argument will be dereferenced *as is*, thus should be of correct type. These functions should return a reference of correct type, or another object with overloaded dereferencing.

As a special case if the overload returns the object itself then it will be used directly (provided it is the correct type).

The dereference operators must be specified explicitly they will not be passed to "nomethod".

- *Special*

```
"nomethod", "fallback", "=",
```

see *SPECIAL SYMBOLS FOR `use overload`*.

See *"Fallback"* for an explanation of when a missing method can be autogenerated.

A computer–readable form of the above table is available in the hash %overload::ops, with values being space–separated lists of names:

```
with_assign      => '+ - * / % ** << >> x .',
assign           => '+= -= *= /= %= **= <<= >>= x= .=',
num_comparison   => '< <= > >= == !=',
'3way_comparison'=> '<=> cmp',
str_comparison   => 'lt le gt ge eq ne',
binary           => '& | ^',
unary            => 'neg ! ~',
mutators         => '++ --',
func             => 'atan2 cos sin exp abs log sqrt',
conversion       => 'bool "" 0+',
iterators        => '<>',
dereferencing    => '${} @{} %{} &{} *{}',
special          => 'nomethod fallback ='
```

Inheritance and overloading

Inheritance interacts with overloading in two ways.

Strings as values of `use overload` directive

If `value` in

```
use overload key => value;
```

is a string, it is interpreted as a method name.

Overloading of an operation is inherited by derived classes

Any class derived from an overloaded class is also overloaded. The set of overloaded methods is the union of overloaded methods of all the ancestors. If some method is overloaded in several ancestor, then which description will be used is decided by the usual inheritance rules:

If `A` inherits from `B` and `C` (in this order), `B` overloads `+` with `\&D::plus_sub`, and `C` overloads `+` by `"plus_meth"`, then the subroutine `D::plus_sub` will be called to implement operation `+` for an object in package `A`.

Note that since the value of the `fallback` key is not a subroutine, its inheritance is not governed by the above rules. In the current implementation, the value of `fallback` in the first overloaded ancestor is used, but this is accidental and subject to change.

SPECIAL SYMBOLS FOR `use overload`

Three keys are recognized by Perl that are not covered by the above description.

Last Resort

`"nomethod"` should be followed by a reference to a function of four parameters. If defined, it is called when the overloading mechanism cannot find a method for some operation. The first three arguments of this function coincide with the arguments for the corresponding method if it were found, the fourth argument is the symbol corresponding to the missing method. If several methods are tried, the last one is used. Say, `1-$a` can be equivalent to

```
&nomethodMethod($a,1,1,"-")
```

if the pair `"nomethod" => "nomethodMethod"` was specified in the `use overload` directive.

The "nomethod" mechanism is *not* used for the dereference operators (${} @{} %{} &{} *{}).

If some operation cannot be resolved, and there is no function assigned to "nomethod", then an exception will be raised via die() — unless "fallback" was specified as a key in use overload directive.

Fallback

The key "fallback" governs what to do if a method for a particular operation is not found. Three different cases are possible depending on the value of "fallback":

- undef — Perl tries to use a substituted method (see *MAGIC AUTOGENERATION*). If this fails, it then tries to calls "nomethod" value; if missing, an exception will be raised.
- TRUE — The same as for the undef value, but no exception is raised. Instead, it silently reverts to what it would have done were there no use overload present.
- defined, but FALSE — No autogeneration is tried. Perl tries to call "nomethod" value, and if this is missing, raises an exception.

Note. "fallback" inheritance via @ISA is not carved in stone yet, see *"Inheritance and overloading"*.

Copy Constructor

The value for "=" is a reference to a function with three arguments, i.e., it looks like the other values in use overload. However, it does not overload the Perl assignment operator. This would go against Camel hair.

This operation is called in the situations when a mutator is applied to a reference that shares its object with some other reference, such as

```
$a=$b;
++$a;
```

To make this change $a and not change $b, a copy of $$a is made, and $a is assigned a reference to this new object. This operation is done during execution of the ++$a, and not during the assignment, (so before the increment $$a coincides with $$b). This is only done if ++ is expressed via a method for '++' or '+=' (or nomethod). Note that if this operation is expressed via '+' a nonmutator, i.e., as in

```
$a=$b;
$a=$a+1;
```

then $a does not reference a new copy of $$a, since $$a does not appear as lvalue when the above code is executed.

If the copy constructor is required during the execution of some mutator, but a method for '=' was not specified, it can be autogenerated as a string copy if the object is a plain scalar.

Example

The actually executed code for

```
$a=$b;
Something else which does not modify $a or $b....
++$a;
```

may be

```
$a=$b;
Something else which does not modify $a or $b....
$a = $a->clone(undef,"");
$a->incr(undef,"");
```

if $b was mathemagical, and '++' was overloaded with \&incr, '=' was overloaded with \&clone.

Same behaviour is triggered by $b = $a++, which is consider a synonym for $b = $a; ++$a.

MAGIC AUTOGENERATION

If a method for an operation is not found, and the value for `"fallback"` is TRUE or undefined, Perl tries to autogenerate a substitute method for the missing operation based on the defined operations. Autogenerated method substitutions are possible for the following operations:

Assignment forms of arithmetic operations

`$a+=$b` can use the method for `"+"` if the method for `"+="` is not defined.

Conversion operations

String, numeric, and boolean conversion are calculated in terms of one another if not all of them are defined.

Increment and decrement

The `++$a` operation can be expressed in terms of `$a+=1` or `$a+1`, and `$a–` in terms of `$a-=1` and `$a-1`.

`abs($a)` can be expressed in terms of `$a<0` and `-$a` (or `0-$a`).

Unary minus can be expressed in terms of subtraction.

Negation `!` and `not` can be expressed in terms of boolean conversion, or string or numerical conversion.

Concatenation can be expressed in terms of string conversion.

Comparison operations

can be expressed in terms of its "spaceship" counterpart: either `<=>` or `cmp`:

```
<, >, <=, >=, ==, !=        in terms of <=>
lt, gt, le, ge, eq, ne      in terms of cmp
```

Iterator

```
<>                          in terms of builtin operations
```

Dereferencing

```
${} @{} %{} &{} *{}         in terms of builtin operations
```

Copy operator can be expressed in terms of an assignment to the dereferenced value, if this value is a scalar and not a reference.

Losing overloading

The restriction for the comparison operation is that even if, for example, '`cmp`' should return a blessed reference, the autogenerated '`lt`' function will produce only a standard logical value based on the numerical value of the result of '`cmp`'. In particular, a working numeric conversion is needed in this case (possibly expressed in terms of other conversions).

Similarly, `.=` and `x=` operators lose their mathemagical properties if the string conversion substitution is applied.

When you `chop()` a mathemagical object it is promoted to a string and its mathemagical properties are lost. The same can happen with other operations as well.

Run–time Overloading

Since all `use` directives are executed at compile–time, the only way to change overloading during run–time is to

```
eval 'use overload "+" => \&addmethod';
```

You can also use

```
eval 'no overload "+", "--", "<="';
```

though the use of these constructs during run–time is questionable.

Public functions

Package `overload.pm` provides the following public functions:

overload::StrVal(arg)

Gives string value of `arg` as in absence of stringify overloading.

overload::Overloaded(arg)

Returns true if `arg` is subject to overloading of some operations.

overload::Method(obj,op)

Returns `undef` or a reference to the method that implements `op`.

Overloading constants

For some application Perl parser mangles constants too much. It is possible to hook into this process via `overload::constant()` and `overload::remove_constant()` functions.

These functions take a hash as an argument. The recognized keys of this hash are

integer to overload integer constants,

float to overload floating point constants,

binary to overload octal and hexadecimal constants,

q to overload `q`–quoted strings, constant pieces of `qq`– and `qx`–quoted strings and here–documents,

qr to overload constant pieces of regular expressions.

The corresponding values are references to functions which take three arguments: the first one is the *initial* string form of the constant, the second one is how Perl interprets this constant, the third one is how the constant is used. Note that the initial string form does not contain string delimiters, and has backslashes in backslash–delimiter combinations stripped (thus the value of delimiter is not relevant for processing of this string). The return value of this function is how this constant is going to be interpreted by Perl. The third argument is undefined unless for overloaded `q`– and `qr`– constants, it is `q` in single–quote context (comes from strings, regular expressions, and single–quote HERE documents), it is `tr` for arguments of `tr`/`y` operators, it is `s` for right–hand side of `s`–operator, and it is `qq` otherwise.

Since an expression `"ab$cd,,"` is just a shortcut for `'ab' . $cd . ',,'`, it is expected that overloaded constant strings are equipped with reasonable overloaded catenation operator, otherwise absurd results will result. Similarly, negative numbers are considered as negations of positive constants.

Note that it is probably meaningless to call the functions `overload::constant()` and `overload::remove_constant()` from anywhere but `import()` and `unimport()` methods. From these methods they may be called as

```
sub import {
  shift;
  return unless @_;
  die "unknown import: @_" unless @_ == 1 and $_[0] eq ':constant';
  overload::constant integer => sub {Math::BigInt->new(shift)};
}
```

BUGS Currently overloaded–ness of constants does not propagate into `eval '...'`.

IMPLEMENTATION

What follows is subject to change RSN.

The table of methods for all operations is cached in magic for the symbol table hash for the package. The cache is invalidated during processing of `use overload`, `no overload`, new function definitions, and

changes in @ISA. However, this invalidation remains unprocessed until the next `blessing` into the package. Hence if you want to change overloading structure dynamically, you'll need an additional (fake) `blessing` to update the table.

(Every SVish thing has a magic queue, and magic is an entry in that queue. This is how a single variable may participate in multiple forms of magic simultaneously. For instance, environment variables regularly have two forms at once: their %ENV magic and their taint magic. However, the magic which implements overloading is applied to the stashes, which are rarely used directly, thus should not slow down Perl.)

If an object belongs to a package using overload, it carries a special flag. Thus the only speed penalty during arithmetic operations without overloading is the checking of this flag.

In fact, if `use overload` is not present, there is almost no overhead for overloadable operations, so most programs should not suffer measurable performance penalties. A considerable effort was made to minimize the overhead when overload is used in some package, but the arguments in question do not belong to packages using overload. When in doubt, test your speed with `use overload` and without it. So far there have been no reports of substantial speed degradation if Perl is compiled with optimization turned on.

There is no size penalty for data if overload is not used. The only size penalty if overload is used in some package is that *all* the packages acquire a magic during the next `blessing` into the package. This magic is three–words–long for packages without overloading, and carries the cache table if the package is overloaded.

Copying (`$a=$b`) is shallow; however, a one–level–deep copying is carried out before any operation that can imply an assignment to the object `$a` (or `$b`) refers to, like `$a++`. You can override this behavior by defining your own copy constructor (see *"Copy Constructor"*).

It is expected that arguments to methods that are not explicitly supposed to be changed are constant (but this is not enforced).

Metaphor clash

One may wonder why the semantic of overloaded `=` is so counter intuitive. If it *looks* counter intuitive to you, you are subject to a metaphor clash.

Here is a Perl object metaphor:

object is a reference to blessed data

and an arithmetic metaphor:

object is a thing by itself.

The *main* problem of overloading `=` is the fact that these metaphors imply different actions on the assignment `$a = $b` if `$a` and `$b` are objects. Perl–think implies that `$a` becomes a reference to whatever `$b` was referencing. Arithmetic–think implies that the value of "object" `$a` is changed to become the value of the object `$b`, preserving the fact that `$a` and `$b` are separate entities.

The difference is not relevant in the absence of mutators. After a Perl–way assignment an operation which mutates the data referenced by `$a` would change the data referenced by `$b` too. Effectively, after `$a = $b` values of `$a` and `$b` become *indistinguishable*.

On the other hand, anyone who has used algebraic notation knows the expressive power of the arithmetic metaphor. Overloading works hard to enable this metaphor while preserving the Perlian way as far as possible. Since it is not not possible to freely mix two contradicting metaphors, overloading allows the arithmetic way to write things *as far as all the mutators are called via overloaded access only*. The way it is done is described in *Copy Constructor*.

If some mutator methods are directly applied to the overloaded values, one may need to *explicitly unlink* other values which references the same value:

```
$a = new Data 23;
...
```

```
$b = $a;            # $b is "linked" to $a
...
$a = $a->clone;     # Unlink $b from $a
$a->increment_by(4);
```

Note that overloaded access makes this transparent:

```
$a = new Data 23;
$b = $a;            # $b is "linked" to $a
$a += 4;            # would unlink $b automagically
```

However, it would not make

```
$a = new Data 23;
$a = 4;             # Now $a is a plain 4, not 'Data'
```

preserve "objectness" of `$a`. But Perl *has* a way to make assignments to an object do whatever you want. It is just not the overload, but `tie()`ing interface (see *tie*). Adding a `FETCH()` method which returns the object itself, and `STORE()` method which changes the value of the object, one can reproduce the arithmetic metaphor in its completeness, at least for variables which were `tie()`d from the start.

(Note that a workaround for a bug may be needed, see *"BUGS"*.)

Cookbook

Please add examples to what follows!

Two–face scalars

Put this in ***two_face.pm*** in your Perl library directory:

```
package two_face;               # Scalars with separate string and
                                # numeric values.
sub new { my $p = shift; bless [@_], $p }
use overload '""' => \&str, '0+' => \&num, fallback => 1;
sub num {shift->[1]}
sub str {shift->[0]}
```

Use it as follows:

```
require two_face;
my $seven = new two_face ("vii", 7);
printf "seven=$seven, seven=%d, eight=%d\n", $seven, $seven+1;
print "seven contains `i'\n" if $seven =~ /i/;
```

(The second line creates a scalar which has both a string value, and a numeric value.) This prints:

```
seven=vii, seven=7, eight=8
seven contains `i'
```

Two–face references

Suppose you want to create an object which is accessible as both an array reference and a hash reference, similar to the *Pseudo–hashes: Using an array as a hash in pseudo–hash\|perlref* builtin Perl type. Let's make it better than a pseudo–hash by allowing index 0 to be treated as a normal element.

```
package two_refs;
use overload '%{}' => \&gethash, '@{}' => sub { $ {shift()} };
sub new {
  my $p = shift;
  bless \ [@_], $p;
}
sub gethash {
  my %h;
```

```
  my $self = shift;
  tie %h, ref $self, $self;
  \%h;
}

sub TIEHASH { my $p = shift; bless \ shift, $p }
my %fields;
my $i = 0;
$fields{$_} = $i++ foreach qw{zero one two three};
sub STORE {
  my $self = ${shift()};
  my $key = $fields{shift()};
  defined $key or die "Out of band access";
  $$self->[$key] = shift;
}
sub FETCH {
  my $self = ${shift()};
  my $key = $fields{shift()};
  defined $key or die "Out of band access";
  $$self->[$key];
}
```

Now one can access an object using both the array and hash syntax:

```
my $bar = new two_refs 3,4,5,6;
$bar->[2] = 11;
$bar->{two} == 11 or die 'bad hash fetch';
```

Note several important features of this example. First of all, the *actual* type of `$bar` is a scalar reference, and we do not overload the scalar dereference. Thus we can get the *actual* non–overloaded contents of `$bar` by just using `$$bar` (what we do in functions which overload dereference). Similarly, the object returned by the `TIEHASH()` method is a scalar reference.

Second, we create a new tied hash each time the hash syntax is used. This allows us not to worry about a possibility of a reference loop, would would lead to a memory leak.

Both these problems can be cured. Say, if we want to overload hash dereference on a reference to an object which is *implemented* as a hash itself, the only problem one has to circumvent is how to access this *actual* hash (as opposed to the *virtual* exhibited by overloaded dereference operator). Here is one possible fetching routine:

```
sub access_hash {
  my ($self, $key) = (shift, shift);
  my $class = ref $self;
  bless $self, 'overload::dummy'; # Disable overloading of %{}
  my $out = $self->{$key};
  bless $self, $class;        # Restore overloading
  $out;
}
```

To move creation of the tied hash on each access, one may an extra level of indirection which allows a non–circular structure of references:

```
package two_refs1;
use overload '%{}' => sub { ${shift()}->[1] },
             '@{}' => sub { ${shift()}->[0] };
sub new {
  my $p = shift;
  my $a = [@_];
```

```
  my %h;
  tie %h, $p, $a;
  bless \ [$a, \%h], $p;
}
sub gethash {
  my %h;
  my $self = shift;
  tie %h, ref $self, $self;
  \%h;
}

sub TIEHASH { my $p = shift; bless \ shift, $p }
my %fields;
my $i = 0;
$fields{$_} = $i++ foreach qw{zero one two three};
sub STORE {
  my $a = ${shift()};
  my $key = $fields{shift()};
  defined $key or die "Out of band access";
  $a->[$key] = shift;
}
sub FETCH {
  my $a = ${shift()};
  my $key = $fields{shift()};
  defined $key or die "Out of band access";
  $a->[$key];
}
```

Now if `$baz` is overloaded like this, then `$bar` is a reference to a reference to the intermediate array, which keeps a reference to an actual array, and the access hash. The `tie()`ing object for the access hash is also a reference to a reference to the actual array, so

- There are no loops of references.
- Both "objects" which are blessed into the class `two_refs1` are references to a reference to an array, thus references to a *scalar*. Thus the accessor expression `$$foo->[$ind]` involves no overloaded operations.

Symbolic calculator

Put this in ***symbolic.pm*** in your Perl library directory:

```
package symbolic;              # Primitive symbolic calculator
use overload nomethod => \&wrap;

sub new { shift; bless ['n', @_] }
sub wrap {
  my ($obj, $other, $inv, $meth) = @_;
  ($obj, $other) = ($other, $obj) if $inv;
  bless [$meth, $obj, $other];
}
```

This module is very unusual as overloaded modules go: it does not provide any usual overloaded operators, instead it provides the *Last Resort* operator `nomethod`. In this example the corresponding subroutine returns an object which encapsulates operations done over the objects: `new symbolic 3` contains `['n', 3]`, `2 + new symbolic 3` contains `['+', 2, ['n', 3]]`.

Here is an example of the script which "calculates" the side of circumscribed octagon using the above package:

```
require symbolic;
my $iter = 1;                   # 2**($iter+2) = 8
my $side = new symbolic 1;
my $cnt = $iter;

while ($cnt--) {
  $side = (sqrt(1 + $side**2) - 1)/$side;
}
print "OK\n";
```

The value of `$side` is

```
['/', ['-', ['sqrt', ['+', 1, ['**', ['n', 1], 2]],
                     undef], 1], ['n', 1]]
```

Note that while we obtained this value using a nice little script, there is no simple way to *use* this value. In fact this value may be inspected in debugger (see *perldebug*), but ony if `bareStringify` **O**ption is set, and not via `p` command.

If one attempts to print this value, then the overloaded operator `""` will be called, which will call `nomethod` operator. The result of this operator will be stringified again, but this result is again of type `symbolic`, which will lead to an infinite loop.

Add a pretty-printer method to the module ***symbolic.pm***:

```
sub pretty {
  my ($meth, $a, $b) = @{+shift};
  $a = 'u' unless defined $a;
  $b = 'u' unless defined $b;
  $a = $a->pretty if ref $a;
  $b = $b->pretty if ref $b;
  "[$meth $a $b]";
}
```

Now one can finish the script by

```
print "side = ", $side->pretty, "\n";
```

The method `pretty` is doing object-to-string conversion, so it is natural to overload the operator `""` using this method. However, inside such a method it is not necessary to pretty-print the *components* `$a` and `$b` of an object. In the above subroutine `"[$meth $a $b]"` is a catenation of some strings and components `$a` and `$b`. If these components use overloading, the catenation operator will look for an overloaded operator `.`, if not present, it will look for an overloaded operator `""`. Thus it is enough to use

```
use overload nomethod => \&wrap, '""' => \&str;
sub str {
  my ($meth, $a, $b) = @{+shift};
  $a = 'u' unless defined $a;
  $b = 'u' unless defined $b;
  "[$meth $a $b]";
}
```

Now one can change the last line of the script to

```
print "side = $side\n";
```

which outputs

```
side = [/ [- [sqrt [+ 1 [** [n 1 u] 2]] u] 1] [n 1 u]]
```

and one can inspect the value in debugger using all the possible methods.

Something is is still amiss: consider the loop variable `$cnt` of the script. It was a number, not an object. We cannot make this value of type `symbolic`, since then the loop will not terminate.

Indeed, to terminate the cycle, the `$cnt` should become false. However, the operator `bool` for checking falsity is overloaded (this time via overloaded `""`), and returns a long string, thus any object of type `symbolic` is true. To overcome this, we need a way to compare an object to 0. In fact, it is easier to write a numeric conversion routine.

Here is the text of ***symbolic.pm*** with such a routine added (and slightly modified `str()`):

```
package symbolic;              # Primitive symbolic calculator
use overload
  nomethod => \&wrap, '""' => \&str, '0+' => \&num;

sub new { shift; bless ['n', @_] }
sub wrap {
  my ($obj, $other, $inv, $meth) = @_;
  ($obj, $other) = ($other, $obj) if $inv;
  bless [$meth, $obj, $other];
}
sub str {
  my ($meth, $a, $b) = @{+shift};
  $a = 'u' unless defined $a;
  if (defined $b) {
    "[$meth $a $b]";
  } else {
    "[$meth $a]";
  }
}
my %subr = ( n => sub {$_[0]},
             sqrt => sub {sqrt $_[0]},
             '-' => sub {shift() - shift()},
             '+' => sub {shift() + shift()},
             '/' => sub {shift() / shift()},
             '*' => sub {shift() * shift()},
             '**' => sub {shift() ** shift()},
           );
sub num {
  my ($meth, $a, $b) = @{+shift};
  my $subr = $subr{$meth}
    or die "Do not know how to ($meth) in symbolic";
  $a = $a->num if ref $a eq __PACKAGE__;
  $b = $b->num if ref $b eq __PACKAGE__;
  $subr->($a,$b);
}
```

All the work of numeric conversion is done in %subr and `num()`. Of course, %subr is not complete, it contains only operators used in the example below. Here is the extra-credit question: why do we need an explicit recursion in `num()`? (Answer is at the end of this section.)

Use this module like this:

```
require symbolic;
my $iter = new symbolic 2;     # 16-gon
my $side = new symbolic 1;
my $cnt = $iter;

while ($cnt) {
```

```
    $cnt = $cnt - 1;    # Mutator `--' not implemented
    $side = (sqrt(1 + $side**2) - 1)/$side;
  }
  printf "%s=%f\n", $side, $side;
  printf "pi=%f\n", $side*(2**($iter+2));
```

It prints (without so many line breaks)

```
  [/ [- [sqrt [+ 1 [** [/ [- [sqrt [+ 1 [** [n 1] 2]]] 1]
                          [n 1]] 2]]] 1]
     [/ [- [sqrt [+ 1 [** [n 1] 2]]] 1] [n 1]]]=0.198912
  pi=3.182598
```

The above module is very primitive. It does not implement mutator methods (++, -= and so on), does not do deep copying (not required without mutators!), and implements only those arithmetic operations which are used in the example.

To implement most arithmetic operations is easy, one should just use the tables of operations, and change the code which fills %subr to

```
  my %subr = ( 'n' => sub {$_[0]} );
  foreach my $op (split " ", $overload::ops{with_assign}) {
    $subr{$op} = $subr{"$op="} = eval "sub {shift() $op shift()}";
  }
  my @bins = qw(binary 3way_comparison num_comparison str_comparison);
  foreach my $op (split " ", "@overload::ops{ @bins }") {
    $subr{$op} = eval "sub {shift() $op shift()}";
  }
  foreach my $op (split " ", "@overload::ops{qw(unary func)}") {
    print "defining `$op'\n";
    $subr{$op} = eval "sub {$op shift()}";
  }
```

Due to *Calling Conventions for Mutators*, we do not need anything special to make += and friends work, except filling += entry of %subr, and defining a copy constructor (needed since Perl has no way to know that the implementation of `'+='` does not mutate the argument, compare *Copy Constructor*).

To implement a copy constructor, add `'='` `=\&cpy` to `use overload` line, and code (this code assumes that mutators change things one level deep only, so recursive copying is not needed):

```
  sub cpy {
    my $self = shift;
    bless [@$self], ref $self;
  }
```

To make ++ and — work, we need to implement actual mutators, either directly, or in `nomethod`. We continue to do things inside `nomethod`, thus add

```
    if ($meth eq '++' or $meth eq '--') {
      @$obj = ($meth, (bless [@$obj]), 1); # Avoid circular reference
      return $obj;
    }
```

after the first line of `wrap()`. This is not a most effective implementation, one may consider

```
  sub inc { $_[0] = bless ['++', shift, 1]; }
```

instead.

As a final remark, note that one can fill %subr by

```
my %subr = ( 'n' => sub {$_[0]} );
foreach my $op (split " ", $overload::ops{with_assign}) {
  $subr{$op} = $subr{"$op="} = eval "sub {shift() $op shift()}";
}
my @bins = qw(binary 3way_comparison num_comparison str_comparison);
foreach my $op (split " ", "@overload::ops{ @bins }") {
  $subr{$op} = eval "sub {shift() $op shift()}";
}
foreach my $op (split " ", "@overload::ops{qw(unary func)}") {
  $subr{$op} = eval "sub {$op shift()}";
}
$subr{'++'} = $subr{'+'};
$subr{'--'} = $subr{'-'};
```

This finishes implementation of a primitive symbolic calculator in 50 lines of Perl code. Since the numeric values of subexpressions are not cached, the calculator is very slow.

Here is the answer for the exercise: In the case of `str()`, we need no explicit recursion since the overloaded `.`–operator will fall back to an existing overloaded operator `""`. Overloaded arithmetic operators *do not* fall back to numeric conversion if `fallback` is not explicitly requested. Thus without an explicit recursion `num()` would convert `['+', $a, $b]` to `$a + $b`, which would just rebuild the argument of `num()`.

If you wonder why defaults for conversion are different for `str()` and `num()`, note how easy it was to write the symbolic calculator. This simplicity is due to an appropriate choice of defaults. One extra note: due to the explicit recursion `num()` is more fragile than `sym()`: we need to explicitly check for the type of `$a` and `$b`. If components `$a` and `$b` happen to be of some related type, this may lead to problems.

Really symbolic calculator

One may wonder why we call the above calculator symbolic. The reason is that the actual calculation of the value of expression is postponed until the value is *used*.

To see it in action, add a method

```
sub STORE {
  my $obj = shift;
  $#$obj = 1;
  @$obj->[0,1] = ('=', shift);
}
```

to the package `symbolic`. After this change one can do

```
my $a = new symbolic 3;
my $b = new symbolic 4;
my $c = sqrt($a**2 + $b**2);
```

and the numeric value of `$c` becomes 5. However, after calling

```
$a->STORE(12);  $b->STORE(5);
```

the numeric value of `$c` becomes 13. There is no doubt now that the module symbolic provides a *symbolic* calculator indeed.

To hide the rough edges under the hood, provide a `tie()`d interface to the package `symbolic` (compare with *Metaphor clash*). Add methods

```
sub TIESCALAR { my $pack = shift; $pack->new(@_) }
sub FETCH { shift }
sub nop {  }           # Around a bug
```

(the bug is described in *"BUGS"*). One can use this new interface as

```
tie $a, 'symbolic', 3;
tie $b, 'symbolic', 4;
$a->nop;  $b->nop;    # Around a bug

my $c = sqrt($a**2 + $b**2);
```

Now numeric value of `$c` is 5. After `$a = 12; $b = 5` the numeric value of `$c` becomes 13. To insulate the user of the module add a method

```
sub vars { my $p = shift; tie($_, $p), $_->nop foreach @_; }
```

Now

```
my ($a, $b);
symbolic->vars($a, $b);
my $c = sqrt($a**2 + $b**2);

$a = 3; $b = 4;
printf "c5  %s=%f\n", $c, $c;

$a = 12; $b = 5;
printf "c13  %s=%f\n", $c, $c;
```

shows that the numeric value of `$c` follows changes to the values of `$a` and `$b`.

AUTHOR

Ilya Zakharevich *<ilya@math.mps.ohio−state.edu>*.

DIAGNOSTICS

When Perl is run with the **−Do** switch or its equivalent, overloading induces diagnostic messages.

Using the `m` command of Perl debugger (see *perldebug*) one can deduce which operations are overloaded (and which ancestor triggers this overloading). Say, if `eq` is overloaded, then the method `(eq` is shown by debugger. The method `()` corresponds to the `fallback` key (in fact a presence of this method shows that this package has overloading enabled, and it is what is used by the `Overloaded` function of module `overload`).

The module might issue the following warnings:

Odd number of arguments for overload::constant

(W) The call to overload::constant contained an odd number of arguments. The arguments should come in pairs.

'%s' is not an overloadable type

(W) You tried to overload a constant type the overload package is unaware of.

'%s' is not a code reference

(W) The second (fourth, sixth, ...) argument of overload::constant needs to be a code reference. Either an anonymous subroutine, or a reference to a subroutine.

BUGS

Because it is used for overloading, the per−package hash %OVERLOAD now has a special meaning in Perl. The symbol table is filled with names looking like line−noise.

For the purpose of inheritance every overloaded package behaves as if `fallback` is present (possibly undefined). This may create interesting effects if some package is not overloaded, but inherits from two overloaded packages.

Relation between overloading and `tie()`ing is broken. Overloading is triggered or not basing on the *previous* class of `tie()`d value.

This happens because the presence of overloading is checked too early, before any `tie()`d access is attempted. If the `FETCH()`ed class of the `tie()`d value does not change, a simple workaround is to access

the value immediately after `tie()`ing, so that after this call the *previous* class coincides with the current one.

Needed: a way to fix this without a speed penalty.

Barewords are not covered by overloaded string constants.

This document is confusing. There are grammos and misleading language used in places. It would seem a total rewrite is needed.

NAME

perlio – perl pragma to configure C level IO

SYNOPSIS

```
Shell:
  PERLIO=perlio perl ....

  print "Have ",join(',',keys %perlio::layers),"\n";
  print "Using ",join(',',@perlio::layers),"\n";
```

DESCRIPTION

Mainly a Place holder for now.

The `%perlio::layers` hash is a record of the available "layers" that may be pushed onto a `PerlIO` stream.

The `@perlio::layers` array is the current set of layers that are used when a new `PerlIO` stream is opened. The C code looks are the array each time a stream is opened so the "stack" can be manipulated by messing with the array :

```
pop(@perlio::layers);
push(@perlio::layers,$perlio::layers{'stdio'});
```

The values if both the hash and the array are perl objects, of class `perlio::Layer` which are created by the C code in `perlio.c`. As yet there is nothing useful you can do with the objects at the perl level.

There are three layers currently defined:

unix Low level layer which calls `read`, `write` and `lseek` etc.

stdio

Layer which calls `fread`, `fwrite` and `fseek`/`ftell` etc. Note that as this is "real" stdio it will ignore any layers beneath it and got straight to the operating system via the C library as usual.

perlio

This is a re–implementation of "stdio–like" buffering written as a PerlIO "layer". As such it will call whatever layer is below it for its operations.

Defaults and how to override them

If `Configure` found out how to do "fast" IO using system's stdio, then the default layers are :

```
unix stdio
```

Otherwise the default layers are

```
unix perlio
```

(STDERR will have just unix in this case as that is optimal way to make it "unbuffered" – do not add a buffering layer!)

The default may change once perlio has been better tested and tuned.

The default can be overridden by setting the environment variable PERLIO to a space separated list of layers (unix is always pushed first). This can be used to see the effect of/bugs in the various layers e.g.

```
cd .../perl/t
PERLIO=stdio  ./perl harness
PERLIO=perlio ./perl harness
```

AUTHOR

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NAME

Pod::Checker, `podchecker()` – check pod documents for syntax errors

SYNOPSIS

```
use Pod::Checker;

$syntax_okay = podchecker($filepath, $outputpath, %options);

my $checker = new Pod::Checker %options;
$checker->parse_from_file($filepath, \*STDERR);
```

OPTIONS/ARGUMENTS

`$filepath` is the input POD to read and `$outputpath` is where to write POD syntax error messages. Either argument may be a scalar indicating a file–path, or else a reference to an open filehandle. If unspecified, the input–file it defaults to `\*STDIN`, and the output–file defaults to `\*STDERR`.

`podchecker()`

This function can take a hash of options:

–warnings => *val*

Turn warnings on/off. *val* is usually 1 for on, but higher values trigger additional warnings. See *"Warnings"*.

DESCRIPTION

podchecker will perform syntax checking of Perl5 POD format documentation.

NOTE THAT THIS MODULE IS CURRENTLY IN THE BETA STAGE!

It is hoped that curious/ambitious user will help flesh out and add the additional features they wish to see in **Pod::Checker** and **podchecker** and verify that the checks are consistent with *perlpod*.

The following checks are currently preformed:

- Unknown '=xxxx' commands, unknown 'X<...>' interior–sequences, and unterminated interior sequences.
- Check for proper balancing of `=begin` and `=end`. The contents of such a block are generally ignored, i.e. no syntax checks are performed.
- Check for proper nesting and balancing of `=over`, `=item` and `=back`.
- Check for same nested interior–sequences (e.g. `L<...L<...>...>`).
- Check for malformed or nonexisting entities `E<...>`.
- Check for correct syntax of hyperlinks `L<...>`. See *perlpod* for details.
- Check for unresolved document–internal links. This check may also reveal misspelled links that seem to be internal links but should be links to something else.

DIAGNOSTICS

Errors

- empty =headn

  A heading (`=head1` or `=head2`) without any text? That ain't no heading!

- =over on line *N* without closing =back

  The `=over` command does not have a corresponding `=back` before the next heading (`=head1` or `=head2`) or the end of the file.

- =item without previous =over
- =back without previous =over

  An `=item` or `=back` command has been found outside a `=over`/`=back` block.

- No argument for =begin

  A `=begin` command was found that is not followed by the formatter specification.

- =end without =begin

  A standalone `=end` command was found.

- Nested =begin's

  There were at least two consecutive `=begin` commands without the corresponding `=end`. Only one `=begin` may be active at a time.

- =for without formatter specification

  There is no specification of the formatter after the `=for` command.

- unresolved internal link *NAME*

  The given link to *NAME* does not have a matching node in the current POD. This also happend when a single word node name is not enclosed in `""`.

- Unknown command "*CMD*"

  An invalid POD command has been found. Valid are `=head1`, `=head2`, `=over`, `=item`, `=back`, `=begin`, `=end`, `=for`, `=pod`, `=cut`

- Unknown interior–sequence "*SEQ*"

  An invalid markup command has been encountered. Valid are: `B<>`, `C<>`, `E<>`, `F<>`, `I<>`, `L<>`, `S<>`, `X<>`, `Z<>`

- nested commands *CMD*<...*CMD*<...>...>

  Two nested identical markup commands have been found. Generally this does not make sense.

- garbled entity *STRING*

  The *STRING* found cannot be interpreted as a character entity.

- Entity number out of range

  An entity specified by number (dec, hex, oct) is out of range (1–255).

- malformed link L<>

  The link found cannot be parsed because it does not conform to the syntax described in *perlpod*.

- nonempty Z<>

  The `Z<>` sequence is supposed to be empty.

- empty X<>

  The index entry specified contains nothing but whitespace.

- Spurious text after =pod / =cut

  The commands `=pod` and `=cut` do not take any arguments.

- Spurious character(s) after =back

  The `=back` command does not take any arguments.

Warnings

These may not necessarily cause trouble, but indicate mediocre style.

- multiple occurence of link target *name*

  The POD file has some `=item` and/or `=head` commands that have the same text. Potential hyperlinks to such a text cannot be unique then.

- line containing nothing but whitespace in paragraph

  There is some whitespace on a seemingly empty line. POD is very sensitive to such things, so this is flagged. **vi** users switch on the **list** option to avoid this problem.

  =begin _disabled_

- file does not start with =head

  The file starts with a different POD directive than head. This is most probably something you do not want.

  =end _disabled_

- No numeric argument for =over

  The `=over` command is supposed to have a numeric argument (the indentation).

- previous =item has no contents

  There is a list `=item` right above the flagged line that has no text contents. You probably want to delete empty items.

- preceding non–item paragraph(s)

  A list introduced by `=over` starts with a text or verbatim paragraph, but continues with `=items`. Move the non–item paragraph out of the `=over`/`=back` block.

- =item type mismatch (*one* vs. *two*)

  A list started with e.g. a bulletted `=item` and continued with a numbered one. This is obviously inconsistent. For most translators the type of the *first* `=item` determines the type of the list.

- *N* unescaped `<>` in paragraph

  Angle brackets not written as `<` and `>` can potentially cause errors as they could be misinterpreted as markup commands. This is only printed when the –warnings level is greater than 1.

- Unknown entity

  A character entity was found that does not belong to the standard ISO set or the POD specials `verbar` and `sol`.

- No items in =over

  The list opened with `=over` does not contain any items.

- No argument for =item

  `=item` without any parameters is deprecated. It should either be followed by `*` to indicate an unordered list, by a number (optionally followed by a dot) to indicate an ordered (numbered) list or simple text for a definition list.

- empty section in previous paragraph

  The previous section (introduced by a `=head` command) does not contain any text. This usually indicates that something is missing. Note: A `=head1` followed immediately by `=head2` does not trigger this warning.

- Verbatim paragraph in NAME section

  The NAME section (`=head1 NAME`) should consist of a single paragraph with the script/module name, followed by a dash '–' and a very short description of what the thing is good for.

Hyperlinks

There are some warnings wrt. malformed hyperlinks.

- collapsing newlines to blanks

  A hyperlink L<...> spans more than one line. This may indicate and error.

- ignoring leading/trailing whitespace in link

  There is whitespace at the beginning or the end of the contents of L<...>.

- (section) in '$page' deprecated

  There is a section detected in the page name of L<...>, e.g. L>passwd(2)>. POD hyperlinks may point to POD documents only. Please write C<passwd(2)> instead. Some formatters are able to expand this to appropriate code. For links to (builtin) functions, please say L<perlfunc/mkdir>, without ().

- alternative text/node '%s' contains non-escaped | or /

  The characters | and / are special in the L<...> context. Although the hyperlink parser does its best to determine which "/" is text and which is a delimiter in case of doubt, one ought to escape these literal characters like this:

```
/      E<sol>
|      E<verbar>
```

RETURN VALUE

podchecker returns the number of POD syntax errors found or -1 if there were no POD commands at all found in the file.

EXAMPLES

[T.B.D.]

INTERFACE

While checking, this module collects document properties, e.g. the nodes for hyperlinks (=headX, =item) and index entries (X<>). POD translators can use this feature to syntax-check and get the nodes in a first pass before actually starting to convert. This is expensive in terms of execution time, but allows for very robust conversions.

`Pod::Checker->new( %options )`

Return a reference to a new Pod::Checker object that inherits from Pod::Parser and is used for calling the required methods later. The following options are recognized:

`-warnings => num`
Print warnings if num is true. The higher the value of num,
the more warnings are printed. Currently there are only levels 1 and 2.

`-quiet => num`
If num is true, do not print any errors/warnings. This is useful
when Pod::Checker is used to munge POD code into plain text from within POD formatters.

```
$checker->poderror( @args )
$checker->poderror( {%opts}, @args )
```

Internal method for printing errors and warnings. If no options are given, simply prints "@_". The following options are recognized and used to form the output:

`-msg`

A message to print prior to @args.

`-line`

The line number the error occurred in.

`-file`

The file (name) the error occurred in.

`-severity`

The error level, should be 'WARNING' or 'ERROR'.

`$checker->num_errors()`

Set (if argument specified) and retrieve the number of errors found.

`$checker->name()`

Set (if argument specified) and retrieve the canonical name of POD as found in the `=head1 NAME` section.

`$checker->node()`

Add (if argument specified) and retrieve the nodes (as defined by `=headX` and `=item`) of the current POD. The nodes are returned in the order of their occurence. They consist of plain text, each piece of whitespace is collapsed to a single blank.

`$checker->idx()`

Add (if argument specified) and retrieve the index entries (as defined by `X<>`) of the current POD. They consist of plain text, each piece of whitespace is collapsed to a single blank.

`$checker->hyperlink()`

Add (if argument specified) and retrieve the hyperlinks (as defined by `L<>`) of the current POD. They consist of an 2−item array: line number and `Pod::Hyperlink` object.

AUTHOR

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Based on code for **`Pod::Text::pod2text()`** written by Tom Christiansen <tchrist@mox.perl.com>

NAME

Pod::Find – find POD documents in directory trees

SYNOPSIS

```
use Pod::Find qw(pod_find simplify_name);
my %pods = pod_find({ -verbose => 1, -inc => 1 });
foreach(keys %pods) {
   print "found library POD `$pods{$_}' in $_\n";
}

print "podname=",simplify_name('a/b/c/mymodule.pod'),"\n";

$location = pod_where( { -inc => 1 }, "Pod::Find" );
```

DESCRIPTION

Pod::Find provides a set of functions to locate POD files. Note that no function is exported by default to avoid pollution of your namespace, so be sure to specify them in the **use** statement if you need them:

```
use Pod::Find qw(pod_find);
```

pod_find({ %opts } , @directories)

The function **pod_find** searches for POD documents in a given set of files and/or directories. It returns a hash with the file names as keys and the POD name as value. The POD name is derived from the file name and its position in the directory tree.

E.g. when searching in ***$HOME/perl5lib***, the file ***$HOME/perl5lib/MyModule.pm*** would get the POD name *MyModule*, whereas ***$HOME/perl5lib/Myclass/Subclass.pm*** would be *Myclass::Subclass*. The name information can be used for POD translators.

Only text files containing at least one valid POD command are found.

A warning is printed if more than one POD file with the same POD name is found, e.g. ***CPAN.pm*** in different directories. This usually indicates duplicate occurrences of modules in the *@INC* search path.

OPTIONS The first argument for **pod_find** may be a hash reference with options. The rest are either directories that are searched recursively or files. The POD names of files are the plain basenames with any Perl–like extension (.pm, .pl, .pod) stripped.

`-verbose => 1`

Print progress information while scanning.

`-perl => 1`

Apply Perl–specific heuristics to find the correct PODs. This includes stripping Perl–like extensions, omitting subdirectories that are numeric but do *not* match the current Perl interpreter's version id, suppressing ***site_perl*** as a module hierarchy name etc.

`-script => 1`

Search for PODs in the current Perl interpreter's installation **scriptdir**. This is taken from the local *Config|Config* module.

`-inc => 1`

Search for PODs in the current Perl interpreter's *@INC* paths. This automatically considers paths specified in the `PERL5LIB` environment as this is prepended to *@INC* by the Perl interpreter itself.

simplify_name($str)

The function **simplify_name** is equivalent to **basename**, but also strips Perl–like extensions (.pm, .pl, .pod) and extensions like ***.bat***, ***.cmd*** on Win32 and OS/2, respectively.

pod_where({ %opts }, $pod)

Returns the location of a pod document given a search directory and a module (e.g. File::Find) or script (e.g. perldoc) name.

Options:

-inc => 1

Search @INC for the pod and also the scriptdir defined in the *Config|Config* module.

-dirs => [$dir1, $dir2, ...]

Reference to an array of search directories. These are searched in order before looking in @INC (if **–inc**). Current directory is used if none are specified.

-verbose => 1

List directories as they are searched

Returns the full path of the first occurence to the file. Package names (eg 'A::B') are automatically converted to directory names in the selected directory. (eg on unix 'A::B' is converted to 'A/B'). Additionally, '.pm', '.pl' and '.pod' are appended to the search automatically if required.

A subdirectory ***pod/*** is also checked if it exists in any of the given search directories. This ensures that e.g. *perlfunc|perlfunc* is found.

It is assumed that if a module name is supplied, that that name matches the file name. Pods are not opened to check for the 'NAME' entry.

A check is made to make sure that the file that is found does contain some pod documentation.

contains_pod($file , $verbose)

Returns true if the supplied filename (not POD module) contains some pod information.

AUTHOR

Marek Rouchal <marek@saftsack.fs.uni–bayreuth.de>, heavily borrowing code from Nick Ing–Simmons' PodToHtml.

Tim Jenness <t.jenness@jach.hawaii.edu> provided pod_where and contains_pod.

SEE ALSO

Pod::Parser, *Pod::Checker*, *perldoc*

NAME

Pod::Html – module to convert pod files to HTML

SYNOPSIS

```
use Pod::Html;
pod2html([options]);
```

DESCRIPTION

Converts files from pod format (see *perlpod*) to HTML format. It can automatically generate indexes and cross–references, and it keeps a cache of things it knows how to cross–reference.

ARGUMENTS

Pod::Html takes the following arguments:

backlink

```
--backlink="Back to Top"
```

Adds "Back to Top" links in front of every HEAD1 heading (except for the first). By default, no backlink are being generated.

css

```
--css=stylesheet
```

Specify the URL of a cascading style sheet.

flush

```
--flush
```

Flushes the item and directory caches.

header

```
--header
--noheader
```

Creates header and footer blocks containing the text of the NAME section. By default, no headers are being generated.

help

```
--help
```

Displays the usage message.

htmldir

```
--htmldir=name
```

Sets the directory in which the resulting HTML file is placed. This is used to generate relative links to other files. Not passing this causes all links to be absolute, since this is the value that tells Pod::Html the root of the documentation tree.

htmlroot

```
--htmlroot=name
```

Sets the base URL for the HTML files. When cross–references are made, the HTML root is prepended to the URL.

index

```
--index
--noindex
```

Generate an index at the top of the HTML file. This is the default behaviour.

infile

```
--infile=name
```

Specify the pod file to convert. Input is taken from STDIN if no infile is specified.

libpods

```
--libpods=name:...:name
```

List of page names (eg, "perlfunc") which contain linkable `=items`.

netscape

```
--netscape
--nonetscape
```

Use Netscape HTML directives when applicable. By default, they will **not** be used.

outfile

```
--outfile=name
```

Specify the HTML file to create. Output goes to STDOUT if no outfile is specified.

podpath

```
--podpath=name:...:name
```

Specify which subdirectories of the podroot contain pod files whose HTML converted forms can be linked–to in cross–references.

podroot

```
--podroot=name
```

Specify the base directory for finding library pods.

quiet

```
--quiet
--noquiet
```

Don't display *mostly harmless* warning messages. These messages will be displayed by default. But this is not the same as `verbose` mode.

recurse

```
--recurse
--norecurse
```

Recurse into subdirectories specified in podpath (default behaviour).

title

```
--title=title
```

Specify the title of the resulting HTML file.

verbose

```
--verbose
--noverbose
```

Display progress messages. By default, they won't be displayed.

EXAMPLE

```
pod2html("pod2html",
         "--podpath=lib:ext:pod:vms",
         "--podroot=/usr/src/perl",
         "--htmlroot=/perl/nmanual",
         "--libpods=perlfunc:perlguts:perlvar:perlrun:perlop",
```

```
                "--recurse",
                "--infile=foo.pod",
                "--outfile=/perl/nmanual/foo.html");
```

ENVIRONMENT

Uses `$Config{pod2html}` to setup default options.

AUTHOR

Tom Christiansen, <tchrist@perl.com>.

SEE ALSO

perlpod

COPYRIGHT

NAME

Pod::InputObjects – objects representing POD input paragraphs, commands, etc.

SYNOPSIS

```
use Pod::InputObjects;
```

REQUIRES

perl5.004, Carp

EXPORTS

Nothing.

DESCRIPTION

This module defines some basic input objects used by **Pod::Parser** when reading and parsing POD text from an input source. The following objects are defined:

=begin __PRIVATE__

package **Pod::InputSource**

An object corresponding to a source of POD input text. It is mostly a wrapper around a filehandle or `IO::Handle`–type object (or anything that implements the `getline()` method) which keeps track of some additional information relevant to the parsing of PODs.

=end __PRIVATE__

package **Pod::Paragraph**

An object corresponding to a paragraph of POD input text. It may be a plain paragraph, a verbatim paragraph, or a command paragraph (see *perlpod*).

package **Pod::InteriorSequence**

An object corresponding to an interior sequence command from the POD input text (see *perlpod*).

package **Pod::ParseTree**

An object corresponding to a tree of parsed POD text. Each "node" in a parse–tree (or *ptree*) is either a text–string or a reference to a **Pod::InteriorSequence** object. The nodes appear in the parse–tree in the order in which they were parsed from left–to–right.

Each of these input objects are described in further detail in the sections which follow.

Pod::InputSource

This object corresponds to an input source or stream of POD documentation. When parsing PODs, it is necessary to associate and store certain context information with each input source. All of this information is kept together with the stream itself in one of these `Pod::InputSource` objects. Each such object is merely a wrapper around an `IO::Handle` object of some kind (or at least something that implements the `getline()` method). They have the following methods/attributes:

=end __PRIVATE__

new()

```
my $pod_input1 = Pod::InputSource->new(-handle => $filehandle);
my $pod_input2 = new Pod::InputSource(-handle => $filehandle,
                                      -name   => $name);
my $pod_input3 = new Pod::InputSource(-handle => \*STDIN);
my $pod_input4 = Pod::InputSource->new(-handle => \*STDIN,
                                       -name => "(STDIN)");
```

This is a class method that constructs a `Pod::InputSource` object and returns a reference to the new input source object. It takes one or more keyword arguments in the form of a hash. The keyword `-handle` is required and designates the corresponding input handle. The keyword `-name` is optional and specifies the

name associated with the input handle (typically a file name).

=end __PRIVATE__

name()

```
my $filename = $pod_input->name();
$pod_input->name($new_filename_to_use);
```

This method gets/sets the name of the input source (usually a filename). If no argument is given, it returns a string containing the name of the input source; otherwise it sets the name of the input source to the contents of the given argument.

=end __PRIVATE__

handle()

```
my $handle = $pod_input->handle();
```

Returns a reference to the handle object from which input is read (the one used to contructed this input source object).

=end __PRIVATE__

was_cutting()

```
print "Yes.\n" if ($pod_input->was_cutting());
```

The value of the `cutting` state (that the **`cutting()`** method would have returned) immediately before any input was read from this input stream. After all input from this stream has been read, the `cutting` state is restored to this value.

=end __PRIVATE__

Pod::Paragraph

An object representing a paragraph of POD input text. It has the following methods/attributes:

Pod::Paragraph->new()

```
my $pod_para1 = Pod::Paragraph->new(-text => $text);
my $pod_para2 = Pod::Paragraph->new(-name => $cmd,
                                    -text => $text);
my $pod_para3 = new Pod::Paragraph(-text => $text);
my $pod_para4 = new Pod::Paragraph(-name => $cmd,
                                   -text => $text);
my $pod_para5 = Pod::Paragraph->new(-name => $cmd,
                                    -text => $text,
                                    -file => $filename,
                                    -line => $line_number);
```

This is a class method that constructs a `Pod::Paragraph` object and returns a reference to the new paragraph object. It may be given one or two keyword arguments. The `-text` keyword indicates the corresponding text of the POD paragraph. The `-name` keyword indicates the name of the corresponding POD command, such as `head1` or `item` (it should *not* contain the = prefix); this is needed only if the POD paragraph corresponds to a command paragraph. The `-file` and `-line` keywords indicate the filename and line number corresponding to the beginning of the paragraph

$pod_para->cmd_name()

```
my $para_cmd = $pod_para->cmd_name();
```

If this paragraph is a command paragraph, then this method will return the name of the command (*without* any leading = prefix).

$pod_para->text()

```
my $para_text = $pod_para->text();
```

This method will return the corresponding text of the paragraph.

$pod_para->raw_text()

```
my $raw_pod_para = $pod_para->raw_text();
```

This method will return the *raw* text of the POD paragraph, exactly as it appeared in the input.

$pod_para->cmd_prefix()

```
my $prefix = $pod_para->cmd_prefix();
```

If this paragraph is a command paragraph, then this method will return the prefix used to denote the command (which should be the string "=" or "==").

$pod_para->cmd_separator()

```
my $separator = $pod_para->cmd_separator();
```

If this paragraph is a command paragraph, then this method will return the text used to separate the command name from the rest of the paragraph (if any).

$pod_para->parse_tree()

```
my $ptree = $pod_parser->parse_text( $pod_para->text() );
$pod_para->parse_tree( $ptree );
$ptree = $pod_para->parse_tree();
```

This method will get/set the corresponding parse–tree of the paragraph's text.

$pod_para->file_line()

```
my ($filename, $line_number) = $pod_para->file_line();
my $position = $pod_para->file_line();
```

Returns the current filename and line number for the paragraph object. If called in a list context, it returns a list of two elements: first the filename, then the line number. If called in a scalar context, it returns a string containing the filename, followed by a colon (':'), followed by the line number.

Pod::InteriorSequence

An object representing a POD interior sequence command. It has the following methods/attributes:

Pod::InteriorSequence->new()

```
my $pod_seq1 = Pod::InteriorSequence->new(-name => $cmd
                                           -ldelim => $delimiter);
my $pod_seq2 = new Pod::InteriorSequence(-name => $cmd,
                                         -ldelim => $delimiter);
my $pod_seq3 = new Pod::InteriorSequence(-name => $cmd,
                                         -ldelim => $delimiter,
                                         -file => $filename,
                                         -line => $line_number);

my $pod_seq4 = new Pod::InteriorSequence(-name => $cmd, $ptree);
my $pod_seq5 = new Pod::InteriorSequence($cmd, $ptree);
```

This is a class method that constructs a `Pod::InteriorSequence` object and returns a reference to the new interior sequence object. It should be given two keyword arguments. The `-ldelim` keyword indicates the corresponding left–delimiter of the interior sequence (e.g. '<'). The `-name` keyword indicates the name of the corresponding interior sequence command, such as `I` or `B` or `C`. The `-file` and `-line` keywords indicate the filename and line number corresponding to the beginning of the interior sequence. If the `$ptree` argument is given, it must be the last argument, and it must be either string, or else an array–ref suitable for passing to **Pod::ParseTree::new** (or it may be a reference to an Pod::ParseTree object).

$pod_seq->cmd_name()

```
my $seq_cmd = $pod_seq->cmd_name();
```

The name of the interior sequence command.

$pod_seq->prepend()

```
$pod_seq->prepend($text);
$pod_seq1->prepend($pod_seq2);
```

Prepends the given string or parse−tree or sequence object to the parse−tree of this interior sequence.

$pod_seq->append()

```
$pod_seq->append($text);
$pod_seq1->append($pod_seq2);
```

Appends the given string or parse−tree or sequence object to the parse−tree of this interior sequence.

$pod_seq->nested()

```
$outer_seq = $pod_seq->nested || print "not nested";
```

If this interior sequence is nested inside of another interior sequence, then the outer/parent sequence that contains it is returned. Otherwise `undef` is returned.

$pod_seq->raw_text()

```
my $seq_raw_text = $pod_seq->raw_text();
```

This method will return the *raw* text of the POD interior sequence, exactly as it appeared in the input.

$pod_seq->left_delimiter()

```
my $ldelim = $pod_seq->left_delimiter();
```

The leftmost delimiter beginning the argument text to the interior sequence (should be "<").

$pod_seq->right_delimiter()

The rightmost delimiter beginning the argument text to the interior sequence (should be ">").

$pod_seq->parse_tree()

```
my $ptree = $pod_parser->parse_text($paragraph_text);
$pod_seq->parse_tree( $ptree );
$ptree = $pod_seq->parse_tree();
```

This method will get/set the corresponding parse−tree of the interior sequence's text.

$pod_seq->file_line()

```
my ($filename, $line_number) = $pod_seq->file_line();
my $position = $pod_seq->file_line();
```

Returns the current filename and line number for the interior sequence object. If called in a list context, it returns a list of two elements: first the filename, then the line number. If called in a scalar context, it returns a string containing the filename, followed by a colon (':'), followed by the line number.

Pod::InteriorSequence::DESTROY()

This method performs any necessary cleanup for the interior−sequence. If you override this method then it is **imperative** that you invoke the parent method from within your own method, otherwise *interior−sequence storage will not be reclaimed upon destruction!*

Pod::ParseTree

This object corresponds to a tree of parsed POD text. As POD text is scanned from left to right, it is parsed into an ordered list of text−strings and **Pod::InteriorSequence** objects (in order of appearance). A **Pod::ParseTree** object corresponds to this list of strings and sequences. Each interior sequence in the parse−tree may itself contain a parse−tree (since interior sequences may be nested).

Pod::ParseTree->new()

```
my $ptree1 = Pod::ParseTree->new;
my $ptree2 = new Pod::ParseTree;
my $ptree4 = Pod::ParseTree->new($array_ref);
my $ptree3 = new Pod::ParseTree($array_ref);
```

This is a class method that constructs a `Pod::Parse_tree` object and returns a reference to the new parse−tree. If a single−argument is given, it must be a reference to an array, and is used to initialize the root (top) of the parse tree.

$ptree->top()

```
my $top_node = $ptree->top();
$ptree->top( $top_node );
$ptree->top( @children );
```

This method gets/sets the top node of the parse−tree. If no arguments are given, it returns the topmost node in the tree (the root), which is also a **Pod::ParseTree**. If it is given a single argument that is a reference, then the reference is assumed to a parse−tree and becomes the new top node. Otherwise, if arguments are given, they are treated as the new list of children for the top node.

$ptree->children()

This method gets/sets the children of the top node in the parse−tree. If no arguments are given, it returns the list (array) of children (each of which should be either a string or a **Pod::InteriorSequence**. Otherwise, if arguments are given, they are treated as the new list of children for the top node.

$ptree->prepend()

This method prepends the given text or parse−tree to the current parse−tree. If the first item on the parse−tree is text and the argument is also text, then the text is prepended to the first item (not added as a separate string). Otherwise the argument is added as a new string or parse−tree *before* the current one.

$ptree->append()

This method appends the given text or parse−tree to the current parse−tree. If the last item on the parse−tree is text and the argument is also text, then the text is appended to the last item (not added as a separate string). Otherwise the argument is added as a new string or parse−tree *after* the current one.

$ptree->raw_text()

```
my $ptree_raw_text = $ptree->raw_text();
```

This method will return the *raw* text of the POD parse−tree exactly as it appeared in the input.

Pod::ParseTree::DESTROY()

This method performs any necessary cleanup for the parse−tree. If you override this method then it is **imperative** that you invoke the parent method from within your own method, otherwise *parse−tree storage will not be reclaimed upon destruction!*

SEE ALSO

See *Pod::Parser*, *Pod::Select*

AUTHOR

Brad Appleton <bradapp@enteract.com>

NAME

Pod::LaTeX – Convert Pod data to formatted Latex

SYNOPSIS

```
use Pod::LaTeX;
my $parser = Pod::LaTeX->new ( );

$parser->parse_from_filehandle;

$parser->parse_from_file ('file.pod', 'file.tex');
```

DESCRIPTION

`Pod::LaTeX` is a module to convert documentation in the Pod format into Latex. The **pod2latex**|*pod2latex* X<pod2latex command uses this module for translation.

`Pod::LaTeX` is a derived class from *Pod::Select*|*Pod::Select*.

OBJECT METHODS

The following methods are provided in this module. Methods inherited from `Pod::Select` are not described in the public interface.

=begin __PRIVATE__

`initialize`

Initialise the object. This method is subclassed from `Pod::Parser`. The base class method is invoked. This method defines the default behaviour of the object unless overridden by supplying arguments to the constructor.

Internal settings are defaulted as well as the public instance data. Internal hash values are accessed directly (rather than through a method) and start with an underscore.

This method should not be invoked by the user directly.

=end __PRIVATE__

Data Accessors

The following methods are provided for accessing instance data. These methods should be used for accessing configuration parameters rather than assuming the object is a hash.

Default values can be supplied by using these names as keys to a hash of arguments when using the `new()` constructor.

AddPreamble

Logical to control whether a `latex` preamble is to be written. If true, a valid `latex` preamble is written before the pod data is written. This is similar to:

```
\documentclass{article}
\begin{document}
```

but will be more complicated if table of contents and indexing are required. Can be used to set or retrieve the current value.

```
$add = $parser->AddPreamble();
$parser->AddPreamble(1);
```

If used in conjunction with `AddPostamble` a full latex document will be written that could be immediately processed by `latex`.

AddPostamble

Logical to control whether a standard `latex` ending is written to the output file after the document has been processed. In its simplest form this is simply:

```
\end{document}
```

but can be more complicated if a index is required. Can be used to set or retrieve the current value.

```
$add = $parser->AddPostamble();
$parser->AddPostamble(1);
```

If used in conjunction with `AddPreaamble` a full latex document will be written that could be immediately processed by `latex`.

Head1Level

The `latex` sectioning level that should be used to correspond to a pod `=head1` directive. This can be used, for example, to turn a `=head1` into a `latex subsection`. This should hold a number corresponding to the required position in an array containing the following elements:

```
[0] chapter
[1] section
[2] subsection
[3] subsubsection
[4] paragraph
[5] subparagraph
```

Can be used to set or retrieve the current value:

```
$parser->Head1Level(2);
$sect = $parser->Head1Level;
```

Setting this number too high can result in sections that may not be reproducible in the expected way. For example, setting this to 4 would imply that `=head3` do not have a corresponding `latex` section (`=head1` would correspond to a `paragraph`).

A check is made to ensure that the supplied value is an integer in the range 0 to 5.

Default is for a value of 1 (i.e. a `section`).

Label

This is the label that is prefixed to all `latex` label and index entries to make them unique. In general, pods have similarly titled sections (NAME, DESCRIPTION etc) and a `latex` label will be multiply defined if more than one pod document is to be included in a single `latex` file. To overcome this, this label is prefixed to a label whenever a label is required (joined with an underscore) or to an index entry (joined by an exclamation mark which is the normal index separator). For example, `\label{text}` becomes `\label{Label_text}`.

Can be used to set or retrieve the current value:

```
$label = $parser->Label;
$parser->Label($label);
```

This label is only used if `UniqueLabels` is true. Its value is set automatically from the `NAME` field if `ReplaceNAMEwithSection` is true. If this is not the case it must be set manually before starting the parse.

Default value is `undef`.

LevelNoNum

Control the point at which `latex` section numbering is turned off. For example, this can be used to make sure that `latex` sections are numbered but subsections are not.

Can be used to set or retrieve the current value:

```
$lev = $parser->LevelNoNum;
$parser->LevelNoNum(2);
```

The argument must be an integer between 0 and 5 and is the same as the number described in `Head1Level` method description. The number has nothing to do with the pod heading number, only the `latex` sectioning.

Default is 2. (i.e. `latex` subsections are written as `subsection*` but sections are numbered).

MakeIndex

Controls whether `latex` commands for creating an index are to be inserted into the preamble and postamble

```
$makeindex = $parser->MakeIndex;
$parser->MakeIndex(0);
```

Irrelevant if both `AddPreamble` and `AddPostamble` are false (or equivalently, `UserPreamble` and `UserPostamble` are set).

Default is for an index to be created.

ReplaceNAMEwithSection

This controls whether the `NAME` section in the pod is to be translated literally or converted to a slightly modified output where the section name is the pod name rather than "NAME".

If true, the pod segment

```
=head1 NAME

pod::name - purpose

=head1 SYNOPSIS
```

is converted to the `latex`

```
\section{pod::name\label{pod_name}\index{pod::name}}

Purpose

\subsection*{SYNOPSIS\label{pod_name_SYNOPSIS}%
             \index{pod::name!SYNOPSIS}}
```

(dependent on the value of `Head1Level` and `LevelNoNum`). Note that subsequent `head1` directives translate to subsections rather than sections and that the labels and index now include the pod name (dependent on the value of `UniqueLabels`).

The `Label` is set from the pod name regardless of any current value of `Label`.

```
$mod = $parser->ReplaceNAMEwithSection;
$parser->ReplaceNAMEwithSection(0);
```

Default is to translate the pod literally.

StartWithNewPage

If true, each pod translation will begin with a `latex \clearpage`.

```
$parser->StartWithNewPage(1);
$newpage = $parser->StartWithNewPage;
```

Default is false.

TableOfContents

If true, a table of contents will be created. Irrelevant if `AddPreamble` is false or `UserPreamble` is set.

```
$toc = $parser->TableOfContents;
$parser->TableOfContents(1);
```

Default is false.

UniqueLabels

If true, the translator will attempt to make sure that each `latex` label or index entry will be uniquely identified by prefixing the contents of `Label`. This allows multiple documents to be combined without clashing common labels such as `DESCRIPTION` and `SYNOPSIS`

```
$parser->UniqueLabels(1);
$unq = $parser->UniqueLabels;
```

Default is true.

UserPreamble

User supplied `latex` preamble. Added before the pod translation data.

If set, the contents will be prepended to the output file before the translated data regardless of the value of `AddPreamble`. `MakeIndex` and `TableOfContents` will also be ignored.

UserPostamble

User supplied `latex` postamble. Added after the pod translation data.

If set, the contents will be prepended to the output file after the translated data regardless of the value of `AddPostamble`. `MakeIndex` will also be ignored.

Lists

Contains details of the currently active lists.
The array contains `Pod::List` objects. A new `Pod::List`
object is created each time a list is encountered and it is pushed onto this stack. When the list context ends, it is popped from the stack. The array will be empty if no lists are active.

Returns array of list information in list context Returns array ref in scalar context

=begin __PRIVATE__

Subclassed methods

The following methods override methods provided in the `Pod::Select` base class. See `Pod::Parser` and `Pod::Select` for more information on what these methods require.

begin_pod

Writes the `latex` preamble if requested.

end_pod

Write the closing `latex` code.

command

Process basic pod commands.

verbatim

Verbatim text

textblock

Plain text paragraph.

interior_sequence

Interior sequence expansion

List Methods

Methods used to handle lists.

begin_list

Called when a new list is found (via the `over` directive). Creates a new `Pod::List` object and stores it on the list stack.

```
$parser->begin_list($indent, $line_num);
```

end_list

Called when the end of a list is found (the `back` directive). Pops the `Pod::List` object off the stack of lists and writes the `latex` code required to close a list.

```
$parser->end_list($line_num);
```

add_item

Add items to the list. The first time an item is encountered (determined from the state of the current `Pod::List` object) the type of list is determined (ordered, unnumbered or description) and the relevant latex code issued.

```
$parser->add_item($paragraph, $line_num);
```

Methods for headings

head

Print a heading of the required level.

```
$parser->head($level, $paragraph, $parobj);
```

The first argument is the pod heading level. The second argument is the contents of the heading. The 3rd argument is a Pod::Paragraph object so that the line number can be extracted.

=end __PRIVATE__

=begin __PRIVATE__

Internal methods

Internal routines are described in this section. They do not form part of the public interface. All private methods start with an underscore.

_output

Output text to the output filehandle. This method must be always be called to output parsed text.

```
$parser->_output($text);
```

Does not write anything if a =begin or =for is active that should be ignored.

_replace_special_chars

Subroutine to replace characters that are special in `latex` with the escaped forms

```
$escaped = $parser->_replace_special_chars($paragraph);
```

Need to call this routine before interior_sequences are munged but not if verbatim.

Special characters and the `latex` equivalents are:

```
}       \}
{       \{
_       \_
$       \$
%       \%
&       \&
\       $\backslash$
^       \^{}
~       \~{}
|       $|$
```

_create_label

Return a string that can be used as an internal reference in a `latex` document (i.e. accepted by the `\label` command)

```
$label = $parser->_create_label($string)
```

If UniqueLabels is true returns a label prefixed by `Label()` This can be suppressed with an optional second argument.

```
$label = $parser->_create_label($string, $suppress);
```

If a second argument is supplied (of any value including undef) the `Label()` is never prefixed. This means that this routine can be called to create a `Label()` without prefixing a previous setting.

_create_index

Similar to `_create_label` except an index entry is created. If `UniqueLabels` is true, the index entry is prefixed by the current `Label` and an exclamation mark.

```
$ind = $parser->_create_index($paragraph);
```

An exclamation mark is used by `makeindex` to generate sub–entries in an index.

_clean_latex_commands

Removes latex commands from text. The latex command is assumed to be of the form `\command{ text }`. "`text`" is retained

```
$clean = $parser->_clean_latex_commands($text);
```

=end __PRIVATE__

NOTES

Compatible with `latex2e` only. Can not be used with `latex` v2.09 or earlier.

A subclass of `Pod::Select` so that specific pod sections can be converted to `latex` by using the `select` method.

Some HTML escapes are missing and many have not been tested.

SEE ALSO

Pod::Parser, *Pod::Select*, *pod2latex*

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=begin __PRIVATE__

REVISION

`$Id:` LaTeX.pm,v 1.6 2000/08/21 09:05:03 timj Exp `$`

=end __PRIVATE__

NAME

Pod::Man – Convert POD data to formatted *roff input

SYNOPSIS

```
use Pod::Man;
my $parser = Pod::Man->new (release => $VERSION, section => 8);

# Read POD from STDIN and write to STDOUT.
$parser->parse_from_filehandle;

# Read POD from file.pod and write to file.1.
$parser->parse_from_file ('file.pod', 'file.1');
```

DESCRIPTION

Pod::Man is a module to convert documentation in the POD format (the preferred language for documenting Perl) into *roff input using the man macro set. The resulting *roff code is suitable for display on a terminal using nroff(1), normally via man(1), or printing using troff(1). It is conventionally invoked using the driver script **pod2man**, but it can also be used directly.

As a derived class from Pod::Parser, Pod::Man supports the same methods and interfaces. See *Pod::Parser* for all the details; briefly, one creates a new parser with `Pod::Man->new()` and then calls either `parse_from_filehandle()` or `parse_from_file()`.

`new()` can take options, in the form of key/value pairs that control the behavior of the parser. See below for details.

If no options are given, Pod::Man uses the name of the input file with any trailing `.pod`, `.pm`, or `.pl` stripped as the man page title, to section 1 unless the file ended in `.pm` in which case it defaults to section 3, to a centered title of "User Contributed Perl Documentation", to a centered footer of the Perl version it is run with, and to a left-hand footer of the modification date of its input (or the current date if given STDIN for input).

Pod::Man assumes that your *roff formatters have a fixed-width font named CW. If yours is called something else (like CR), use the `fixed` option to specify it. This generally only matters for troff output for printing. Similarly, you can set the fonts used for bold, italic, and bold italic fixed-width output.

Besides the obvious pod conversions, Pod::Man also takes care of formatting `func()`, func(n), and simple variable references like `$foo` or @bar so you don't have to use code escapes for them; complex expressions like `$fred{'stuff'}` will still need to be escaped, though. It also translates dashes that aren't used as hyphens into en dashes, makes long dashes—like this—into proper em dashes, fixes "paired quotes," makes C++ and PI look right, puts a little space between double underbars, makes ALLCAPS a teeny bit smaller in troff(1), and escapes stuff that *roff treats as special so that you don't have to.

The recognized options to `new()` are as follows. All options take a single argument.

center

Sets the centered page header to use instead of "User Contributed Perl Documentation".

date

Sets the left-hand footer. By default, the modification date of the input file will be used, or the current date if `stat()` can't find that file (the case if the input is from STDIN), and the date will be formatted as YYYY-MM-DD.

fixed

The fixed-width font to use for vertabim text and code. Defaults to CW. Some systems may want CR instead. Only matters for troff(1) output.

fixedbold

Bold version of the fixed-width font. Defaults to CB. Only matters for troff(1) output.

fixeditalic

Italic version of the fixed−width font (actually, something of a misnomer, since most fixed−width fonts only have an oblique version, not an italic version). Defaults to CI. Only matters for troff(1) output.

fixedbolditalic

Bold italic (probably actually oblique) version of the fixed−width font. Pod::Man doesn't assume you have this, and defaults to CB. Some systems (such as Solaris) have this font available as CX. Only matters for troff(1) output.

quotes

Sets the quote marks used to surround C< text. If the value is a single character, it is used as both the left and right quote; if it is two characters, the first character is used as the left quote and the second as the right quoted; and if it is four characters, the first two are used as the left quote and the second two as the right quote.

This may also be set to the special value `none`, in which case no quote marks are added around C< text (but the font is still changed for troff output).

release

Set the centered footer. By default, this is the version of Perl you run Pod::Man under. Note that some system an macro sets assume that the centered footer will be a modification date and will prepend something like "Last modified: "; if this is the case, you may want to set `release` to the last modified date and `date` to the version number.

section

Set the section for the `.TH` macro. The standard section numbering convention is to use 1 for user commands, 2 for system calls, 3 for functions, 4 for devices, 5 for file formats, 6 for games, 7 for miscellaneous information, and 8 for administrator commands. There is a lot of variation here, however; some systems (like Solaris) use 4 for file formats, 5 for miscellaneous information, and 7 for devices. Still others use 1m instead of 8, or some mix of both. About the only section numbers that are reliably consistent are 1, 2, and 3.

By default, section 1 will be used unless the file ends in .pm in which case section 3 will be selected.

The standard Pod::Parser method `parse_from_filehandle()` takes up to two arguments, the first being the file handle to read POD from and the second being the file handle to write the formatted output to. The first defaults to STDIN if not given, and the second defaults to STDOUT. The method `parse_from_file()` is almost identical, except that its two arguments are the input and output disk files instead. See *Pod::Parser* for the specific details.

DIAGNOSTICS

roff font should be 1 or 2 chars, not "%s"

(F) You specified a *roff font (using `fixed`, `fixedbold`, etc.) that wasn't either one or two characters. Pod::Man doesn't support *roff fonts longer than two characters, although some *roff extensions do (the canonical versions of nroff(1) and troff(1) don't either).

Invalid link %s

(W) The POD source contained a `L<>` sequence that Pod::Man was unable to parse. You should never see this error message; it probably indicates a bug in Pod::Man.

Invalid quote specification "%s"

(F) The quote specification given (the quotes option to the constructor) was invalid. A quote specification must be one, two, or four characters long.

%s:%d: Unknown command paragraph "%s".

(W) The POD source contained a non−standard command paragraph (something of the form `=command args`) that Pod::Man didn't know about. It was ignored.

Unknown escape E<%s>

(W) The POD source contained an `E<>` escape that Pod::Man didn't know about. `E<%s>` was printed verbatim in the output.

Unknown sequence %s

(W) The POD source contained a non−standard interior sequence (something of the form `X<>`) that Pod::Man didn't know about. It was ignored.

%s: Unknown command paragraph "%s" on line %d.

(W) The POD source contained a non−standard command paragraph (something of the form `=command args`) that Pod::Man didn't know about. It was ignored.

Unmatched =back

(W) Pod::Man encountered a `=back` command that didn't correspond to an `=over` command.

BUGS

The lint−like features and strict POD format checking done by **pod2man** are not yet implemented and should be, along with the corresponding `lax` option.

The NAME section should be recognized specially and index entries emitted for everything in that section. This would have to be deferred until the next section, since extraneous things in NAME tends to confuse various man page processors.

The handling of hyphens, en dashes, and em dashes is somewhat fragile, and one may get the wrong one under some circumstances. This should only matter for troff(1) output.

When and whether to use small caps is somewhat tricky, and Pod::Man doesn't necessarily get it right.

Pod::Man doesn't handle font names longer than two characters. Neither do most troff(1) implementations, but GNU troff does as an extension. It would be nice to support as an option for those who want to use it.

The preamble added to each output file is rather verbose, and most of it is only necessary in the presence of E<> escapes for non−ASCII characters. It would ideally be nice if all of those definitions were only output if needed, perhaps on the fly as the characters are used.

Some of the automagic applied to file names assumes Unix directory separators.

Pod::Man is excessively slow.

SEE ALSO

Pod::Parser|Pod::Parser, perlpod(1), pod2man(1), nroff(1), troff(1), man(1), man(7)

Ossanna, Joseph F., and Brian W. Kernighan. "Troff User's Manual," Computing Science Technical Report No. 54, AT&T Bell Laboratories. This is the best documentation of standard nroff(1) and troff(1). At the time of this writing, it's available at http://www.cs.bell−labs.com/cm/cs/cstr.html.

The man page documenting the man macro set may be man(5) instead of man(7) on your system. Also, please see pod2man(1) for extensive documentation on writing manual pages if you've not done it before and aren't familiar with the conventions.

AUTHOR

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NAME

Pod::Parser – base class for creating POD filters and translators

SYNOPSIS

```
use Pod::Parser;

package MyParser;
@ISA = qw(Pod::Parser);

sub command {
    my ($parser, $command, $paragraph, $line_num) = @_;
    ## Interpret the command and its text; sample actions might be:
    if ($command eq 'head1') { ... }
    elsif ($command eq 'head2') { ... }
    ## ... other commands and their actions
    my $out_fh = $parser->output_handle();
    my $expansion = $parser->interpolate($paragraph, $line_num);
    print $out_fh $expansion;
}

sub verbatim {
    my ($parser, $paragraph, $line_num) = @_;
    ## Format verbatim paragraph; sample actions might be:
    my $out_fh = $parser->output_handle();
    print $out_fh $paragraph;
}

sub textblock {
    my ($parser, $paragraph, $line_num) = @_;
    ## Translate/Format this block of text; sample actions might be:
    my $out_fh = $parser->output_handle();
    my $expansion = $parser->interpolate($paragraph, $line_num);
    print $out_fh $expansion;
}

sub interior_sequence {
    my ($parser, $seq_command, $seq_argument) = @_;
    ## Expand an interior sequence; sample actions might be:
    return "*$seq_argument*"     if ($seq_command eq 'B');
    return "`$seq_argument'"     if ($seq_command eq 'C');
    return "_${seq_argument}_'"  if ($seq_command eq 'I');
    ## ... other sequence commands and their resulting text
}

package main;

## Create a parser object and have it parse file whose name was
## given on the command-line (use STDIN if no files were given).
$parser = new MyParser();
$parser->parse_from_filehandle(\*STDIN)  if (@ARGV == 0);
for (@ARGV) { $parser->parse_from_file($_); }
```

REQUIRES

perl5.005, Pod::InputObjects, Exporter, Symbol, Carp

EXPORTS

Nothing.

DESCRIPTION

Pod::Parser is a base class for creating POD filters and translators. It handles most of the effort involved with parsing the POD sections from an input stream, leaving subclasses free to be concerned only with performing the actual translation of text.

Pod::Parser parses PODs, and makes method calls to handle the various components of the POD. Subclasses of **Pod::Parser** override these methods to translate the POD into whatever output format they desire.

QUICK OVERVIEW

To create a POD filter for translating POD documentation into some other format, you create a subclass of **Pod::Parser** which typically overrides just the base class implementation for the following methods:

- `command()`
- `verbatim()`
- `textblock()`
- `interior_sequence()`

You may also want to override the `begin_input()` and `end_input()` methods for your subclass (to perform any needed per−file and/or per−document initialization or cleanup).

If you need to perform any preprocesssing of input before it is parsed you may want to override one or more of `preprocess_line()` and/or `preprocess_paragraph()`.

Sometimes it may be necessary to make more than one pass over the input files. If this is the case you have several options. You can make the first pass using **Pod::Parser** and override your methods to store the intermediate results in memory somewhere for the `end_pod()` method to process. You could use **Pod::Parser** for several passes with an appropriate state variable to control the operation for each pass. If your input source can't be reset to start at the beginning, you can store it in some other structure as a string or an array and have that structure implement a `getline()` method (which is all that `parse_from_filehandle()` uses to read input).

Feel free to add any member data fields you need to keep track of things like current font, indentation, horizontal or vertical position, or whatever else you like. Be sure to read *"PRIVATE METHODS AND DATA"* to avoid name collisions.

For the most part, the **Pod::Parser** base class should be able to do most of the input parsing for you and leave you free to worry about how to intepret the commands and translate the result.

Note that all we have described here in this quick overview is the simplest most straightforward use of **Pod::Parser** to do stream−based parsing. It is also possible to use the **Pod::Parser::parse_text** function to do more sophisticated tree−based parsing. See *"TREE−BASED PARSING"*.

PARSING OPTIONS

A *parse−option* is simply a named option of **Pod::Parser** with a value that corresponds to a certain specified behavior. These various behaviors of **Pod::Parser** may be enabled/disabled by setting or or unsetting one or more *parse−options* using the `parseopts()` method. The set of currently accepted parse−options is as follows:

−want_nonPODs (default: unset)

Normally (by default) **Pod::Parser** will only provide access to the POD sections of the input. Input paragraphs that are not part of the POD−format documentation are not made available to the caller (not even using `preprocess_paragraph()`). Setting this option to a non−empty, non−zero value will allow `preprocess_paragraph()` to see non−POD sections of the input as well as POD sections. The `cutting()` method can be used to determine if the corresponding paragraph is a POD paragraph,

or some other input paragraph.

–process_cut_cmd (default: unset)

Normally (by default) **Pod::Parser** handles the `=cut` POD directive by itself and does not pass it on to the caller for processing. Setting this option to a non–empty, non–zero value will cause **Pod::Parser** to pass the `=cut` directive to the caller just like any other POD command (and hence it may be processed by the **`command()`** method).

Pod::Parser will still interpret the `=cut` directive to mean that "cutting mode" has been (re)entered, but the caller will get a chance to capture the actual `=cut` paragraph itself for whatever purpose it desires.

–warnings (default: unset)

Normally (by default) **Pod::Parser** recognizes a bare minimum of pod syntax errors and warnings and issues diagnostic messages for errors, but not for warnings. (Use **Pod::Checker** to do more thorough checking of POD syntax.) Setting this option to a non–empty, non–zero value will cause **Pod::Parser** to issue diagnostics for the few warnings it recognizes as well as the errors.

Please see *`"parseopts()"`* for a complete description of the interface for the setting and unsetting of parse–options.

RECOMMENDED SUBROUTINE/METHOD OVERRIDES

Pod::Parser provides several methods which most subclasses will probably want to override. These methods are as follows:

`command()`

```
$parser->command($cmd,$text,$line_num,$pod_para);
```

This method should be overridden by subclasses to take the appropriate action when a POD command paragraph (denoted by a line beginning with "=") is encountered. When such a POD directive is seen in the input, this method is called and is passed:

`$cmd`

the name of the command for this POD paragraph

`$text`

the paragraph text for the given POD paragraph command.

`$line_num`

the line–number of the beginning of the paragraph

`$pod_para`

a reference to a `Pod::Paragraph` object which contains further information about the paragraph command (see *Pod::InputObjects* for details).

Note that this method *is* called for `=pod` paragraphs.

The base class implementation of this method simply treats the raw POD command as normal block of paragraph text (invoking the **`textblock()`** method with the command paragraph).

`verbatim()`

```
$parser->verbatim($text,$line_num,$pod_para);
```

This method may be overridden by subclasses to take the appropriate action when a block of verbatim text is encountered. It is passed the following parameters:

`$text`

the block of text for the verbatim paragraph

`$line_num`

the line–number of the beginning of the paragraph

$pod_para

a reference to a `Pod::Paragraph` object which contains further information about the paragraph (see *Pod::InputObjects* for details).

The base class implementation of this method simply prints the textblock (unmodified) to the output filehandle.

textblock()

```
$parser->textblock($text,$line_num,$pod_para);
```

This method may be overridden by subclasses to take the appropriate action when a normal block of POD text is encountered (although the base class method will usually do what you want). It is passed the following parameters:

`$text`

the block of text for the a POD paragraph

`$line_num`

the line–number of the beginning of the paragraph

`$pod_para`

a reference to a `Pod::Paragraph` object which contains further information about the paragraph (see *Pod::InputObjects* for details).

In order to process interior sequences, subclasses implementations of this method will probably want to invoke either **interpolate()** or **parse_text()**, passing it the text block `$text`, and the corresponding line number in `$line_num`, and then perform any desired processing upon the returned result.

The base class implementation of this method simply prints the text block as it occurred in the input stream).

interior_sequence()

```
$parser->interior_sequence($seq_cmd,$seq_arg,$pod_seq);
```

This method should be overridden by subclasses to take the appropriate action when an interior sequence is encountered. An interior sequence is an embedded command within a block of text which appears as a command name (usually a single uppercase character) followed immediately by a string of text which is enclosed in angle brackets. This method is passed the sequence command `$seq_cmd` and the corresponding text `$seq_arg`. It is invoked by the **interpolate()** method for each interior sequence that occurs in the string that it is passed. It should return the desired text string to be used in place of the interior sequence. The `$pod_seq` argument is a reference to a `Pod::InteriorSequence` object which contains further information about the interior sequence. Please see *Pod::InputObjects* for details if you need to access this additional information.

Subclass implementations of this method may wish to invoke the **nested()** method of `$pod_seq` to see if it is nested inside some other interior–sequence (and if so, which kind).

The base class implementation of the **interior_sequence()** method simply returns the raw text of the interior sequence (as it occurred in the input) to the caller.

OPTIONAL SUBROUTINE/METHOD OVERRIDES

Pod::Parser provides several methods which subclasses may want to override to perform any special pre/post–processing. These methods do *not* have to be overridden, but it may be useful for subclasses to take advantage of them.

new()

```
my $parser = Pod::Parser->new();
```

This is the constructor for **Pod::Parser** and its subclasses. You *do not* need to override this method! It is capable of constructing subclass objects as well as base class objects, provided you use any of the following

constructor invocation styles:

```
my $parser1 = MyParser->new();
my $parser2 = new MyParser();
my $parser3 = $parser2->new();
```

where `MyParser` is some subclass of **Pod::Parser**.

Using the syntax `MyParser::new()` to invoke the constructor is *not* recommended, but if you insist on being able to do this, then the subclass *will* need to override the **`new()`** constructor method. If you do override the constructor, you *must* be sure to invoke the **`initialize()`** method of the newly blessed object.

Using any of the above invocations, the first argument to the constructor is always the corresponding package name (or object reference). No other arguments are required, but if desired, an associative array (or hash−table) my be passed to the **`new()`** constructor, as in:

```
my $parser1 = MyParser->new( MYDATA => $value1, MOREDATA => $value2 );
my $parser2 = new MyParser( -myflag => 1 );
```

All arguments passed to the **`new()`** constructor will be treated as key/value pairs in a hash−table. The newly constructed object will be initialized by copying the contents of the given hash−table (which may have been empty). The **`new()`** constructor for this class and all of its subclasses returns a blessed reference to the initialized object (hash−table).

`initialize()`

```
$parser->initialize();
```

This method performs any necessary object initialization. It takes no arguments (other than the object instance of course, which is typically copied to a local variable named `$self`). If subclasses override this method then they *must* be sure to invoke `$self->SUPER::initialize()`.

`begin_pod()`

```
$parser->begin_pod();
```

This method is invoked at the beginning of processing for each POD document that is encountered in the input. Subclasses should override this method to perform any per−document initialization.

`begin_input()`

```
$parser->begin_input();
```

This method is invoked by **`parse_from_filehandle()`** immediately *before* processing input from a filehandle. The base class implementation does nothing, however, subclasses may override it to perform any per−file initializations.

Note that if multiple files are parsed for a single POD document (perhaps the result of some future `=include` directive) this method is invoked for every file that is parsed. If you wish to perform certain initializations once per document, then you should use **`begin_pod()`**.

`end_input()`

```
$parser->end_input();
```

This method is invoked by **`parse_from_filehandle()`** immediately *after* processing input from a filehandle. The base class implementation does nothing, however, subclasses may override it to perform any per−file cleanup actions.

Please note that if multiple files are parsed for a single POD document (perhaps the result of some kind of `=include` directive) this method is invoked for every file that is parsed. If you wish to perform certain cleanup actions once per document, then you should use **`end_pod()`**.

end_pod()

```
$parser->end_pod();
```

This method is invoked at the end of processing for each POD document that is encountered in the input. Subclasses should override this method to perform any per−document finalization.

preprocess_line()

```
$textline = $parser->preprocess_line($text, $line_num);
```

This method should be overridden by subclasses that wish to perform any kind of preprocessing for each *line* of input (*before* it has been determined whether or not it is part of a POD paragraph). The parameter `$text` is the input line; and the parameter `$line_num` is the line number of the corresponding text line.

The value returned should correspond to the new text to use in its place. If the empty string or an undefined value is returned then no further processing will be performed for this line.

Please note that the **preprocess_line()** method is invoked *before* the **preprocess_paragraph()** method. After all (possibly preprocessed) lines in a paragraph have been assembled together and it has been determined that the paragraph is part of the POD documentation from one of the selected sections, then **preprocess_paragraph()** is invoked.

The base class implementation of this method returns the given text.

preprocess_paragraph()

```
$textblock = $parser->preprocess_paragraph($text, $line_num);
```

This method should be overridden by subclasses that wish to perform any kind of preprocessing for each block (paragraph) of POD documentation that appears in the input stream. The parameter `$text` is the POD paragraph from the input file; and the parameter `$line_num` is the line number for the beginning of the corresponding paragraph.

The value returned should correspond to the new text to use in its place If the empty string is returned or an undefined value is returned, then the given `$text` is ignored (not processed).

This method is invoked after gathering up all the lines in a paragraph and after determining the cutting state of the paragraph, but before trying to further parse or interpret them. After **preprocess_paragraph()** returns, the current cutting state (which is returned by `$self->cutting()`) is examined. If it evaluates to true then input text (including the given `$text`) is cut (not processed) until the next POD directive is encountered.

Please note that the **preprocess_line()** method is invoked *before* the **preprocess_paragraph()** method. After all (possibly preprocessed) lines in a paragraph have been assembled together and either it has been determined that the paragraph is part of the POD documentation from one of the selected sections or the `-want_nonPODs` option is true, then **preprocess_paragraph()** is invoked.

The base class implementation of this method returns the given text.

METHODS FOR PARSING AND PROCESSING

Pod::Parser provides several methods to process input text. These methods typically won't need to be overridden (and in some cases they can't be overridden), but subclasses may want to invoke them to exploit their functionality.

parse_text()

```
$ptree1 = $parser->parse_text($text, $line_num);
$ptree2 = $parser->parse_text({%opts}, $text, $line_num);
$ptree3 = $parser->parse_text(\%opts, $text, $line_num);
```

This method is useful if you need to perform your own interpolation of interior sequences and can't rely upon **interpolate** to expand them in simple bottom−up order order.

The parameter `$text` is a string or block of text to be parsed for interior sequences; and the parameter

`$line_num` is the line number corresponding to the beginning of `$text`.

`parse_text()` will parse the given text into a parse−tree of "nodes." and interior−sequences. Each "node" in the parse tree is either a text−string, or a **Pod::InteriorSequence**. The result returned is a parse−tree of type **Pod::ParseTree**. Please see *Pod::InputObjects* for more information about **Pod::InteriorSequence** and **Pod::ParseTree**.

If desired, an optional hash−ref may be specified as the first argument to customize certain aspects of the parse−tree that is created and returned. The set of recognized option keywords are:

−expand_seq => *code−ref|method−name*

Normally, the parse−tree returned by **`parse_text()`** will contain an unexpanded `Pod::InteriorSequence` object for each interior−sequence encountered. Specifying **−expand_seq** tells **`parse_text()`** to "expand" every interior−sequence it sees by invoking the referenced function (or named method of the parser object) and using the return value as the expanded result.

If a subroutine reference was given, it is invoked as:

```
&$code_ref( $parser, $sequence )
```

and if a method−name was given, it is invoked as:

```
$parser->method_name( $sequence )
```

where `$parser` is a reference to the parser object, and `$sequence` is a reference to the interior−sequence object. [*NOTE*: If the **`interior_sequence()`** method is specified, then it is invoked according to the interface specified in *`"interior_sequence()"`*].

−expand_text => *code−ref|method−name*

Normally, the parse−tree returned by **`parse_text()`** will contain a text−string for each contiguous sequence of characters outside of an interior−sequence. Specifying **−expand_text** tells **`parse_text()`** to "preprocess" every such text−string it sees by invoking the referenced function (or named method of the parser object) and using the return value as the preprocessed (or "expanded") result. [Note that if the result is an interior−sequence, then it will *not* be expanded as specified by the **−expand_seq** option; Any such recursive expansion needs to be handled by the specified callback routine.]

If a subroutine reference was given, it is invoked as:

```
&$code_ref( $parser, $text, $ptree_node )
```

and if a method−name was given, it is invoked as:

```
$parser->method_name( $text, $ptree_node )
```

where `$parser` is a reference to the parser object, `$text` is the text−string encountered, and `$ptree_node` is a reference to the current node in the parse−tree (usually an interior−sequence object or else the top−level node of the parse−tree).

−expand_ptree => *code−ref|method−name*

Rather than returning a `Pod::ParseTree`, pass the parse−tree as an argument to the referenced subroutine (or named method of the parser object) and return the result instead of the parse−tree object.

If a subroutine reference was given, it is invoked as:

```
&$code_ref( $parser, $ptree )
```

and if a method−name was given, it is invoked as:

```
$parser->method_name( $ptree )
```

where `$parser` is a reference to the parser object, and `$ptree` is a reference to the parse−tree object.

interpolate()

```
$textblock = $parser->interpolate($text, $line_num);
```

This method translates all text (including any embedded interior sequences) in the given text string `$text` and returns the interpolated result. The parameter `$line_num` is the line number corresponding to the beginning of `$text`.

interpolate() merely invokes a private method to recursively expand nested interior sequences in bottom-up order (innermost sequences are expanded first). If there is a need to expand nested sequences in some alternate order, use **parse_text** instead.

parse_paragraph()

```
$parser->parse_paragraph($text, $line_num);
```

This method takes the text of a POD paragraph to be processed, along with its corresponding line number, and invokes the appropriate method (one of **command()**, **verbatim()**, or **textblock()**).

For performance reasons, this method is invoked directly without any dynamic lookup; Hence subclasses may *not* override it!

=end __PRIVATE__

parse_from_filehandle()

```
$parser->parse_from_filehandle($in_fh,$out_fh);
```

This method takes an input filehandle (which is assumed to already be opened for reading) and reads the entire input stream looking for blocks (paragraphs) of POD documentation to be processed. If no first argument is given the default input filehandle `STDIN` is used.

The `$in_fh` parameter may be any object that provides a **getline()** method to retrieve a single line of input text (hence, an appropriate wrapper object could be used to parse PODs from a single string or an array of strings).

Using `$in_fh->getline()`, input is read line-by-line and assembled into paragraphs or "blocks" (which are separated by lines containing nothing but whitespace). For each block of POD documentation encountered it will invoke a method to parse the given paragraph.

If a second argument is given then it should correspond to a filehandle where output should be sent (otherwise the default output filehandle is `STDOUT` if no output filehandle is currently in use).

NOTE: For performance reasons, this method caches the input stream at the top of the stack in a local variable. Any attempts by clients to change the stack contents during processing when in the midst executing of this method *will not affect* the input stream used by the current invocation of this method.

This method does *not* usually need to be overridden by subclasses.

parse_from_file()

```
$parser->parse_from_file($filename,$outfile);
```

This method takes a filename and does the following:

- opens the input and output files for reading (creating the appropriate filehandles)
- invokes the **parse_from_filehandle()** method passing it the corresponding input and output filehandles.
- closes the input and output files.

If the special input filename "-" or "<&STDIN" is given then the STDIN filehandle is used for input (and no open or close is performed). If no input filename is specified then "-" is implied.

If a second argument is given then it should be the name of the desired output file. If the special output filename "-" or "&STDOUT" is given then the STDOUT filehandle is used for output (and no open or close

is performed). If the special output filename "&STDERR" is given then the STDERR filehandle is used for output (and no open or close is performed). If no output filehandle is currently in use and no output filename is specified, then "−" is implied.

This method does *not* usually need to be overridden by subclasses.

ACCESSOR METHODS

Clients of **Pod::Parser** should use the following methods to access instance data fields:

errorsub()

```
$parser->errorsub("method_name");
$parser->errorsub(\&warn_user);
$parser->errorsub(sub { print STDERR, @_ });
```

Specifies the method or subroutine to use when printing error messages about POD syntax. The supplied method/subroutine *must* return TRUE upon successful printing of the message. If undef is given, then the **warn** builtin is used to issue error messages (this is the default behavior).

```
my $errorsub = $parser->errorsub()
my $errmsg = "This is an error message!\n"
(ref $errorsub) and &{$errorsub}($errmsg)
    or (defined $errorsub) and $parser->$errorsub($errmsg)
        or  warn($errmsg);
```

Returns a method name, or else a reference to the user−supplied subroutine used to print error messages. Returns undef if the **warn** builtin is used to issue error messages (this is the default behavior).

cutting()

```
$boolean = $parser->cutting();
```

Returns the current cutting state: a boolean−valued scalar which evaluates to true if text from the input file is currently being "cut" (meaning it is *not* considered part of the POD document).

```
$parser->cutting($boolean);
```

Sets the current cutting state to the given value and returns the result.

parseopts()

When invoked with no additional arguments, **parseopts** returns a hashtable of all the current parsing options.

```
## See if we are parsing non-POD sections as well as POD ones
my %opts = $parser->parseopts();
$opts{'-want_nonPODs}' and print "-want_nonPODs\n";
```

When invoked using a single string, **parseopts** treats the string as the name of a parse−option and returns its corresponding value if it exists (returns undef if it doesn't).

```
## Did we ask to see '=cut' paragraphs?
my $want_cut = $parser->parseopts('-process_cut_cmd');
$want_cut and print "-process_cut_cmd\n";
```

When invoked with multiple arguments, **parseopts** treats them as key/value pairs and the specified parse−option names are set to the given values. Any unspecified parse−options are unaffected.

```
## Set them back to the default
$parser->parseopts(-warnings => 0);
```

When passed a single hash−ref, **parseopts** uses that hash to completely reset the existing parse−options, all previous parse−option values are lost.

```
## Reset all options to default
$parser->parseopts( { } );
```

See *"PARSING OPTIONS"* for more information on the name and meaning of each parse–option currently recognized.

output_file()

```
$fname = $parser->output_file();
```

Returns the name of the output file being written.

output_handle()

```
$fhandle = $parser->output_handle();
```

Returns the output filehandle object.

input_file()

```
$fname = $parser->input_file();
```

Returns the name of the input file being read.

input_handle()

```
$fhandle = $parser->input_handle();
```

Returns the current input filehandle object.

input_streams()

```
$listref = $parser->input_streams();
```

Returns a reference to an array which corresponds to the stack of all the input streams that are currently in the middle of being parsed.

While parsing an input stream, it is possible to invoke **parse_from_file()** or **parse_from_filehandle()** to parse a new input stream and then return to parsing the previous input stream. Each input stream to be parsed is pushed onto the end of this input stack before any of its input is read. The input stream that is currently being parsed is always at the end (or top) of the input stack. When an input stream has been exhausted, it is popped off the end of the input stack.

Each element on this input stack is a reference to `Pod::InputSource` object. Please see *Pod::InputObjects* for more details.

This method might be invoked when printing diagnostic messages, for example, to obtain the name and line number of the all input files that are currently being processed.

=end __PRIVATE__

top_stream()

```
$hashref = $parser->top_stream();
```

Returns a reference to the hash–table that represents the element that is currently at the top (end) of the input stream stack (see *"`input_streams()`"*). The return value will be the `undef` if the input stack is empty.

This method might be used when printing diagnostic messages, for example, to obtain the name and line number of the current input file.

=end __PRIVATE__

PRIVATE METHODS AND DATA

Pod::Parser makes use of several internal methods and data fields which clients should not need to see or use. For the sake of avoiding name collisions for client data and methods, these methods and fields are briefly discussed here. Determined hackers may obtain further information about them by reading the **Pod::Parser** source code.

Private data fields are stored in the hash–object whose reference is returned by the **new()** constructor for this class. The names of all private methods and data–fields used by **Pod::Parser** begin with a prefix of "_" and match the regular expression `/^_\w+$/`.

_push_input_stream()

```
$hashref = $parser->_push_input_stream($in_fh,$out_fh);
```

This method will push the given input stream on the input stack and perform any necessary beginning–of–document or beginning–of–file processing. The argument `$in_fh` is the input stream filehandle to push, and `$out_fh` is the corresponding output filehandle to use (if it is not given or is undefined, then the current output stream is used, which defaults to standard output if it doesnt exist yet).

The value returned will be reference to the hash–table that represents the new top of the input stream stack. *Please Note* that it is possible for this method to use default values for the input and output file handles. If this happens, you will need to look at the `INPUT` and `OUTPUT` instance data members to determine their new values.

=end _PRIVATE_

_pop_input_stream()

```
$hashref = $parser->_pop_input_stream();
```

This takes no arguments. It will perform any necessary end–of–file or end–of–document processing and then pop the current input stream from the top of the input stack.

The value returned will be reference to the hash–table that represents the new top of the input stream stack.

=end _PRIVATE_

TREE–BASED PARSING

If straightforward stream–based parsing wont meet your needs (as is likely the case for tasks such as translating PODs into structured markup languages like HTML and XML) then you may need to take the tree–based approach. Rather than doing everything in one pass and calling the **interpolate()** method to expand sequences into text, it may be desirable to instead create a parse–tree using the **parse_text()** method to return a tree–like structure which may contain an ordered list list of children (each of which may be a text–string, or a similar tree–like structure).

Pay special attention to *"METHODS FOR PARSING AND PROCESSING"* and to the objects described in *Pod::InputObjects*. The former describes the gory details and parameters for how to customize and extend the parsing behavior of **Pod::Parser**. **Pod::InputObjects** provides several objects that may all be used interchangeably as parse–trees. The most obvious one is the **Pod::ParseTree** object. It defines the basic interface and functionality that all things trying to be a POD parse–tree should do. A **Pod::ParseTree** is defined such that each "node" may be a text–string, or a reference to another parse–tree. Each **Pod::Paragraph** object and each **Pod::InteriorSequence** object also supports the basic parse–tree interface.

The **parse_text()** method takes a given paragraph of text, and returns a parse–tree that contains one or more children, each of which may be a text–string, or an InteriorSequence object. There are also callback–options that may be passed to **parse_text()** to customize the way it expands or transforms interior–sequences, as well as the returned result. These callbacks can be used to create a parse–tree with custom–made objects (which may or may not support the parse–tree interface, depending on how you choose to do it).

If you wish to turn an entire POD document into a parse–tree, that process is fairly straightforward. The **parse_text()** method is the key to doing this successfully. Every paragraph–callback (i.e. the polymorphic methods for **command()**, **verbatim()**, and **textblock()** paragraphs) takes a **Pod::Paragraph** object as an argument. Each paragraph object has a **parse_tree()** method that can be used to get or set a corresponding parse–tree. So for each of those paragraph–callback methods, simply call **parse_text()** with the options you desire, and then use the returned parse–tree to assign to the given paragraph object.

That gives you a parse–tree for each paragraph – so now all you need is an ordered list of paragraphs. You can maintain that yourself as a data element in the object/hash. The most straightforward way would be

simply to use an array−ref, with the desired set of custom "options" for each invocation of **parse_text**. Let's assume the desired option−set is given by the hash `%options`. Then we might do something like the following:

```
package MyPodParserTree;

@ISA = qw( Pod::Parser );

...

sub begin_pod {
    my $self = shift;
    $self->{'-paragraphs'} = [];  ## initialize paragraph list
}

sub command {
    my ($parser, $command, $paragraph, $line_num, $pod_para) = @_;
    my $ptree = $parser->parse_text({%options}, $paragraph, ...);
    $pod_para->parse_tree( $ptree );
    push @{ $self->{'-paragraphs'} }, $pod_para;
}

sub verbatim {
    my ($parser, $paragraph, $line_num, $pod_para) = @_;
    push @{ $self->{'-paragraphs'} }, $pod_para;
}

sub textblock {
    my ($parser, $paragraph, $line_num, $pod_para) = @_;
    my $ptree = $parser->parse_text({%options}, $paragraph, ...);
    $pod_para->parse_tree( $ptree );
    push @{ $self->{'-paragraphs'} }, $pod_para;
}

...

package main;
...
my $parser = new MyPodParserTree(...);
$parser->parse_from_file(...);
my $paragraphs_ref = $parser->{'-paragraphs'};
```

Of course, in this module−author's humble opinion, I'd be more inclined to use the existing **Pod::ParseTree** object than a simple array. That way everything in it, paragraphs and sequences, all respond to the same core interface for all parse−tree nodes. The result would look something like:

```
package MyPodParserTree2;

...

sub begin_pod {
    my $self = shift;
    $self->{'-ptree'} = new Pod::ParseTree;  ## initialize parse-tree
}

sub parse_tree {
    ## convenience method to get/set the parse-tree for the entire POD
    (@_ > 1)  and  $_[0]->{'-ptree'} = $_[1];
    return $_[0]->{'-ptree'};
}
```

```
sub command {
    my ($parser, $command, $paragraph, $line_num, $pod_para) = @_;
    my $ptree = $parser->parse_text({<<options>>}, $paragraph, ...);
    $pod_para->parse_tree( $ptree );
    $parser->parse_tree()->append( $pod_para );
}

sub verbatim {
    my ($parser, $paragraph, $line_num, $pod_para) = @_;
    $parser->parse_tree()->append( $pod_para );
}

sub textblock {
    my ($parser, $paragraph, $line_num, $pod_para) = @_;
    my $ptree = $parser->parse_text({<<options>>}, $paragraph, ...);
    $pod_para->parse_tree( $ptree );
    $parser->parse_tree()->append( $pod_para );
}

...

package main;
...
my $parser = new MyPodParserTree2(...);
$parser->parse_from_file(...);
my $ptree = $parser->parse_tree;
...
```

Now you have the entire POD document as one great big parse–tree. You can even use the **–expand_seq** option to **parse_text** to insert whole different kinds of objects. Just don't expect **Pod::Parser** to know what to do with them after that. That will need to be in your code. Or, alternatively, you can insert any object you like so long as it conforms to the **Pod::ParseTree** interface.

One could use this to create subclasses of **Pod::Paragraphs** and **Pod::InteriorSequences** for specific commands (or to create your own custom node–types in the parse–tree) and add some kind of **`emit()`** method to each custom node/subclass object in the tree. Then all you'd need to do is recursively walk the tree in the desired order, processing the children (most likely from left to right) by formatting them if they are text–strings, or by calling their **`emit()`** method if they are objects/references.

SEE ALSO

Pod::InputObjects, *Pod::Select*

Pod::InputObjects defines POD input objects corresponding to command paragraphs, parse–trees, and interior–sequences.

Pod::Select is a subclass of **Pod::Parser** which provides the ability to selectively include and/or exclude sections of a POD document from being translated based upon the current heading, subheading, subsubheading, etc.

=for __PRIVATE__ **Pod::Callbacks** is a subclass of **Pod::Parser** which gives its users the ability the employ *callback functions* instead of, or in addition to, overriding methods of the base class.

=for __PRIVATE__ **Pod::Select** and **Pod::Callbacks** do not override any methods nor do they define any new methods with the same name. Because of this, they may *both* be used (in combination) as a base class of the same subclass in order to combine their functionality without causing any namespace clashes due to multiple inheritance.

AUTHOR

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Based on code for **Pod::Text** written by Tom Christiansen <tchrist@mox.perl.com>

NAME

Pod::ParseUtils – helpers for POD parsing and conversion

SYNOPSIS

```
use Pod::ParseUtils;

my $list = new Pod::List;
my $link = Pod::Hyperlink->new('Pod::Parser');
```

DESCRIPTION

Pod::ParseUtils contains a few object–oriented helper packages for POD parsing and processing (i.e. in POD formatters and translators).

Pod::List

Pod::List can be used to hold information about POD lists (written as =over ... =item ... =back) for further processing. The following methods are available:

`Pod::List->new()`

Create a new list object. Properties may be specified through a hash reference like this:

```
my $list = Pod::List->new({ -start => $., -indent => 4 });
```

See the individual methods/properties for details.

`$list->file()`

Without argument, retrieves the file name the list is in. This must have been set before by either specifying **–file** in the **`new()`** method or by calling the **`file()`** method with a scalar argument.

`$list->start()`

Without argument, retrieves the line number where the list started. This must have been set before by either specifying **–start** in the **`new()`** method or by calling the **`start()`** method with a scalar argument.

`$list->indent()`

Without argument, retrieves the indent level of the list as specified in `=over n`. This must have been set before by either specifying **–indent** in the **`new()`** method or by calling the **`indent()`** method with a scalar argument.

`$list->type()`

Without argument, retrieves the list type, which can be an arbitrary value, e.g. `OL`, `UL`, ... when thinking the HTML way. This must have been set before by either specifying **–type** in the **`new()`** method or by calling the **`type()`** method with a scalar argument.

`$list->rx()`

Without argument, retrieves a regular expression for simplifying the individual item strings once the list type has been determined. Usage: E.g. when converting to HTML, one might strip the leading number in an ordered list as `<OL>` already prints numbers itself. This must have been set before by either specifying **–rx** in the **`new()`** method or by calling the **`rx()`** method with a scalar argument.

`$list->item()`

Without argument, retrieves the array of the items in this list. The items may be represented by any scalar. If an argument has been given, it is pushed on the list of items.

`$list->parent()`

Without argument, retrieves information about the parent holding this list, which is represented as an arbitrary scalar. This must have been set before by either specifying **–parent** in the **`new()`** method or by calling the **`parent()`** method with a scalar argument.

$list->tag()

Without argument, retrieves information about the list tag, which can be any scalar. This must have been set before by either specifying **–tag** in the **new()** method or by calling the **tag()** method with a scalar argument.

Pod::Hyperlink

Pod::Hyperlink is a class for manipulation of POD hyperlinks. Usage:

```
my $link = Pod::Hyperlink->new('alternative text|page/"section in page"');
```

The **Pod::Hyperlink** class is mainly designed to parse the contents of the L<...> sequence, providing a simple interface for accessing the different parts of a POD hyperlink for further processing. It can also be used to construct hyperlinks.

`Pod::Hyperlink->new()`

The **new()** method can either be passed a set of key/value pairs or a single scalar value, namely the contents of a L<...> sequence. An object of the class `Pod::Hyperlink` is returned. The value `undef` indicates a failure, the error message is stored in `$@`.

`$link->parse($string)`

This method can be used to (re)parse a (new) hyperlink, i.e. the contents of a L<...> sequence. The result is stored in the current object. Warnings are stored in the **warnings** property. E.g. sections like L<open(2)> are deprected, as they do not point to Perl documents. L<DBI::foo(3p)> is wrong as well, the manpage section can simply be dropped.

`$link->markup($string)`

Set/retrieve the textual value of the link. This string contains special markers P<> and Q<> that should be expanded by the translator's interior sequence expansion engine to the formatter–specific code to highlight/activate the hyperlink. The details have to be implemented in the translator.

`$link->text()`

This method returns the textual representation of the hyperlink as above, but without markers (read only). Depending on the link type this is one of the following alternatives (the + and * denote the portions of the text that are marked up):

```
the +perl+ manpage
the *$|* entry in the +perlvar+ manpage
the section on *OPTIONS* in the +perldoc+ manpage
the section on *DESCRIPTION* elsewhere in this document
```

`$link->warning()`

After parsing, this method returns any warnings encountered during the parsing process.

`$link->file()`
`$link->line()`

Just simple slots for storing information about the line and the file the link was encountered in. Has to be filled in manually.

`$link->page()`

This method sets or returns the POD page this link points to.

`$link->node()`

As above, but the destination node text of the link.

`$link->alttext()`

Sets or returns an alternative text specified in the link.

$link->type()

The node type, either `section` or `item`. As an unofficial type, there is also `hyperlink`, derived from e.g. `L<http://perl.com>`

`$link->link()`

Returns the link as contents of `L<>`. Reciprocal to **parse()**.

Pod::Cache

Pod::Cache holds information about a set of POD documents, especially the nodes for hyperlinks. The following methods are available:

`Pod::Cache->new()`

Create a new cache object. This object can hold an arbitrary number of POD documents of class Pod::Cache::Item.

`$cache->item()`

Add a new item to the cache. Without arguments, this method returns a list of all cache elements.

`$cache->find_page($name)`

Look for a POD document named `$name` in the cache. Returns the reference to the corresponding Pod::Cache::Item object or undef if not found.

Pod::Cache::Item

Pod::Cache::Item holds information about individual POD documents, that can be grouped in a Pod::Cache object. It is intended to hold information about the hyperlink nodes of POD documents. The following methods are available:

`Pod::Cache::Item->new()`

Create a new object.

`$cacheitem->page()`

Set/retrieve the POD document name (e.g. "Pod::Parser").

`$cacheitem->description()`

Set/retrieve the POD short description as found in the `=head1 NAME` section.

`$cacheitem->path()`

Set/retrieve the POD file storage path.

`$cacheitem->file()`

Set/retrieve the POD file name.

`$cacheitem->nodes()`

Add a node (or a list of nodes) to the document's node list. Note that the order is kept, i.e. start with the first node and end with the last. If no argument is given, the current list of nodes is returned in the same order the nodes have been added. A node can be any scalar, but usually is a pair of node string and unique id for the `find_node` method to work correctly.

`$cacheitem->find_node($name)`

Look for a node or index entry named `$name` in the object. Returns the unique id of the node (i.e. the second element of the array stored in the node arry) or undef if not found.

`$cacheitem->idx()`

Add an index entry (or a list of them) to the document's index list. Note that the order is kept, i.e. start with the first node and end with the last. If no argument is given, the current list of index entries is returned in the same order the entries have been added. An index entry can be any scalar, but usually is a pair of string and unique id.

AUTHOR

Marek Rouchal <marek@saftsack.fs.uni−bayreuth.de>, borrowing a lot of things from *pod2man* and *pod2roff* as well as other POD processing tools by Tom Christiansen, Brad Appleton and Russ Allbery.

SEE ALSO

pod2man, *pod2roff*, *Pod::Parser*, *Pod::Checker*, *pod2html*

NAME

Pod::Plainer – Perl extension for converting Pod to old style Pod.

SYNOPSIS

```
use Pod::Plainer;

my $parser = Pod::Plainer -> new ();
$parser -> parse_from_filehandle(\*STDIN);
```

DESCRIPTION

Pod::Plainer uses Pod::Parser which takes Pod with the (new) ‘C<< .. >>’ constructs and returns the old(er) style with just ‘C<>‘; ‘<’ and ’’ are replaced by ‘E<lt>’ and ‘E<gt>’.

This can be used to pre–process Pod before using tools which do not recognise the new style Pods.

EXPORT

None by default.

AUTHOR

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SEE ALSO

See *Pod::Parser*.

NAME

Pod::Select, `podselect()` – extract selected sections of POD from input

SYNOPSIS

```
use Pod::Select;

## Select all the POD sections for each file in @filelist
## and print the result on standard output.
podselect(@filelist);

## Same as above, but write to tmp.out
podselect({-output => "tmp.out"}, @filelist):

## Select from the given filelist, only those POD sections that are
## within a 1st level section named any of: NAME, SYNOPSIS, OPTIONS.
podselect({-sections => ["NAME|SYNOPSIS", "OPTIONS"]}, @filelist):

## Select the "DESCRIPTION" section of the PODs from STDIN and write
## the result to STDERR.
podselect({-output => ">&STDERR", -sections => ["DESCRIPTION"]}, \*STDIN);
```

or

```
use Pod::Select;

## Create a parser object for selecting POD sections from the input
$parser = new Pod::Select();

## Select all the POD sections for each file in @filelist
## and print the result to tmp.out.
$parser->parse_from_file("<&STDIN", "tmp.out");

## Select from the given filelist, only those POD sections that are
## within a 1st level section named any of: NAME, SYNOPSIS, OPTIONS.
$parser->select("NAME|SYNOPSIS", "OPTIONS");
for (@filelist) { $parser->parse_from_file($_); }

## Select the "DESCRIPTION" and "SEE ALSO" sections of the PODs from
## STDIN and write the result to STDERR.
$parser->select("DESCRIPTION");
$parser->add_selection("SEE ALSO");
$parser->parse_from_filehandle(\*STDIN, \*STDERR);
```

REQUIRES

perl5.005, Pod::Parser, Exporter, Carp

EXPORTS

`podselect()`

DESCRIPTION

`podselect()` is a function which will extract specified sections of pod documentation from an input stream. This ability is provided by the **Pod::Select** module which is a subclass of **Pod::Parser**. **Pod::Select** provides a method named **`select()`** to specify the set of POD sections to select for processing/printing. **`podselect()`** merely creates a **Pod::Select** object and then invokes the **`podselect()`** followed by **`parse_from_file()`**.

SECTION SPECIFICATIONS

`podselect()` and **`Pod::Select::select()`** may be given one or more "section specifications" to restrict the text processed to only the desired set of sections and their corresponding subsections. A section specification is a string containing one or more Perl–style regular expressions separated by forward slashes

("/"). If you need to use a forward slash literally within a section title you can escape it with a backslash ("\/").

The formal syntax of a section specification is:

- *head1-title-regex/head2-title-regex/...*

Any omitted or empty regular expressions will default to ".*". Please note that each regular expression given is implicitly anchored by adding "^" and "$" to the beginning and end. Also, if a given regular expression starts with a "!" character, then the expression is *negated* (so `!foo` would match anything *except* `foo`).

Some example section specifications follow.

Match the `NAME` and `SYNOPSIS` sections and all of their subsections:

```
NAME|SYNOPSIS
```

Match only the `Question` and `Answer` subsections of the `DESCRIPTION` section:

```
DESCRIPTION/Question|Answer
```

Match the `Comments` subsection of *all* sections:

```
/Comments
```

Match all subsections of `DESCRIPTION` *except* for `Comments`:

```
DESCRIPTION/!Comments
```

Match the `DESCRIPTION` section but do *not* match any of its subsections:

```
DESCRIPTION/!.+
```

Match all top level sections but none of their subsections:

```
/!.+
```

=begin _NOT_IMPLEMENTED_

RANGE SPECIFICATIONS

`podselect()` and **`Pod::Select::select()`** may be given one or more "range specifications" to restrict the text processed to only the desired ranges of paragraphs in the desired set of sections. A range specification is a string containing a single Perl-style regular expression (a regex), or else two Perl-style regular expressions (regexs) separated by a ".." (Perl's "range" operator is ".."). The regexs in a range specification are delimited by forward slashes ("/"). If you need to use a forward slash literally within a regex you can escape it with a backslash ("\/").

The formal syntax of a range specification is:

- */start-range-regex/*[*../end-range-regex/*]

Where each the item inside square brackets (the ".." followed by the end-range-regex) is optional. Each "range-regex" is of the form:

```
=cmd-expr text-expr
```

Where *cmd-expr* is intended to match the name of one or more POD commands, and *text-expr* is intended to match the paragraph text for the command. If a range-regex is supposed to match a POD command, then the first character of the regex (the one after the initial '/') absolutely *must* be an single '=' character; it may not be anything else (not even a regex meta-character) if it is supposed to match against the name of a POD command.

If no =*cmd-expr* is given then the text-expr will be matched against plain textblocks unless it is preceded by a space, in which case it is matched against verbatim text-blocks. If no *text-expr* is given then only the command-portion of the paragraph is matched against.

Note that these two expressions are each implicitly anchored. This means that when matching against the command−name, there will be an implicit '^' and '$' around the given *=cmd−expr*; and when matching against the paragraph text there will be an implicit '\A' and '\Z' around the given *text−expr*.

Unlike with section−specs, the '!' character does *not* have any special meaning (negation or otherwise) at the beginning of a range−spec!

Some example range specifications follow.

Match all `=for html` paragraphs:

```
/=for html/
```

Match all paragraphs between `=begin html` and `=end html` (note that this will *not* work correctly if such sections are nested):

```
/=begin html/../=end html/
```

Match all paragraphs between the given `=item` name until the end of the current section:

```
/=item mine/../=head\d/
```

Match all paragraphs between the given `=item` until the next item, or until the end of the itemized list (note that this will *not* work as desired if the item contains an itemized list nested within it):

```
/=item mine/../=(item|back)/
```

=end _NOT_IMPLEMENTED_

OBJECT METHODS

The following methods are provided in this module. Each one takes a reference to the object itself as an implicit first parameter.

curr_headings()

```
($head1, $head2, $head3, ...) = $parser->curr_headings();
$head1 = $parser->curr_headings(1);
```

This method returns a list of the currently active section headings and subheadings in the document being parsed. The list of headings returned corresponds to the most recently parsed paragraph of the input.

If an argument is given, it must correspond to the desired section heading number, in which case only the specified section heading is returned. If there is no current section heading at the specified level, then `undef` is returned.

select()

```
$parser->select($section_spec1,$section_spec2,...);
```

This method is used to select the particular sections and subsections of POD documentation that are to be printed and/or processed. The existing set of selected sections is *replaced* with the given set of sections. See **add_selection()** for adding to the current set of selected sections.

Each of the `$section_spec` arguments should be a section specification as described in *"SECTION SPECIFICATIONS"*. The section specifications are parsed by this method and the resulting regular expressions are stored in the invoking object.

If no `$section_spec` arguments are given, then the existing set of selected sections is cleared out (which means `all` sections will be processed).

This method should *not* normally be overridden by subclasses.

add_selection()

```
$parser->add_selection($section_spec1,$section_spec2,...);
```

This method is used to add to the currently selected sections and subsections of POD documentation that are to be printed and/or processed. See `<select()` for replacing the currently selected sections.

Each of the `$section_spec` arguments should be a section specification as described in *"SECTION SPECIFICATIONS"*. The section specifications are parsed by this method and the resulting regular expressions are stored in the invoking object.

This method should *not* normally be overridden by subclasses.

`clear_selections()`

```
$parser->clear_selections();
```

This method takes no arguments, it has the exact same effect as invoking `<select()` with no arguments.

`match_section()`

```
$boolean = $parser->match_section($heading1,$heading2,...);
```

Returns a value of true if the given section and subsection heading titles match any of the currently selected section specifications in effect from prior calls to **`select()`** and **`add_selection()`** (or if there are no explictly selected/deselected sections).

The arguments `$heading1, $heading2,` etc. are the heading titles of the corresponding sections, subsections, etc. to try and match. If `$headingN` is omitted then it defaults to the current corresponding section heading title in the input.

This method should *not* normally be overridden by subclasses.

`is_selected()`

```
$boolean = $parser->is_selected($paragraph);
```

This method is used to determine if the block of text given in `$paragraph` falls within the currently selected set of POD sections and subsections to be printed or processed. This method is also responsible for keeping track of the current input section and subsections. It is assumed that `$paragraph` is the most recently read (but not yet processed) input paragraph.

The value returned will be true if the `$paragraph` and the rest of the text in the same section as `$paragraph` should be selected (included) for processing; otherwise a false value is returned.

EXPORTED FUNCTIONS

The following functions are exported by this module. Please note that these are functions (not methods) and therefore `do not` take an implicit first argument.

`podselect()`

```
podselect(\%options,@filelist);
```

podselect will print the raw (untranslated) POD paragraphs of all POD sections in the given input files specified by `@filelist` according to the given options.

If any argument to **podselect** is a reference to a hash (associative array) then the values with the following keys are processed as follows:

–output

A string corresponding to the desired output file (or `"&STDOUT"` or `"&STDERR"`). The default is to use standard output.

–sections

A reference to an array of sections specifications (as described in *"SECTION SPECIFICATIONS"*) which indicate the desired set of POD sections and subsections to be selected from input. If no section specifications are given, then all sections of the PODs are used.

=begin _NOT_IMPLEMENTED_

–ranges

A reference to an array of range specifications (as described in *"RANGE SPECIFICATIONS"*) which indicate the desired range of POD paragraphs to be selected from the desired input sections. If no range

specifications are given, then all paragraphs of the desired sections are used.

=end _NOT_IMPLEMENTED_

All other arguments should correspond to the names of input files containing POD sections. A file name of "-" or "<&STDIN" will be interpeted to mean standard input (which is the default if no filenames are given).

PRIVATE METHODS AND DATA

Pod::Select makes uses a number of internal methods and data fields which clients should not need to see or use. For the sake of avoiding name collisions with client data and methods, these methods and fields are briefly discussed here. Determined hackers may obtain further information about them by reading the **Pod::Select** source code.

Private data fields are stored in the hash-object whose reference is returned by the **new()** constructor for this class. The names of all private methods and data-fields used by **Pod::Select** begin with a prefix of "_" and match the regular expression `/^_\w+$/`.

_compile_section_spec()

```
$listref = $parser->_compile_section_spec($section_spec);
```

This function (note it is a function and *not* a method) takes a section specification (as described in *"SECTION SPECIFICATIONS"*) given in `$section_sepc`, and compiles it into a list of regular expressions. If `$section_spec` has no syntax errors, then a reference to the list (array) of corresponding regular expressions is returned; otherwise `undef` is returned and an error message is printed (using **carp**) for each invalid regex.

=end _PRIVATE_

$self->{_SECTION_HEADINGS}

A reference to an array of the current section heading titles for each heading level (note that the first heading level title is at index 0).

=end _PRIVATE_

$self->{_SELECTED_SECTIONS}

A reference to an array of references to arrays. Each subarray is a list of anchored regular expressions (preceded by a "!" if the expression is to be negated). The index of the expression in the subarray should correspond to the index of the heading title in `$self->{_SECTION_HEADINGS}` that it is to be matched against.

=end _PRIVATE_

SEE ALSO

Pod::Parser

AUTHOR

Brad Appleton <bradapp@enteract.com>

Based on code for **pod2text** written by Tom Christiansen <tchrist@mox.perl.com>

NAME

Pod::Text::Color – Convert POD data to formatted color ASCII text

SYNOPSIS

```
use Pod::Text::Color;
my $parser = Pod::Text::Color->new (sentence => 0, width => 78);

# Read POD from STDIN and write to STDOUT.
$parser->parse_from_filehandle;

# Read POD from file.pod and write to file.txt.
$parser->parse_from_file ('file.pod', 'file.txt');
```

DESCRIPTION

Pod::Text::Color is a simple subclass of Pod::Text that highlights output text using ANSI color escape sequences. Apart from the color, it in all ways functions like Pod::Text. See *Pod::Text* for details and available options.

Term::ANSIColor is used to get colors and therefore must be installed to use this module.

BUGS

This is just a basic proof of concept. It should be seriously expanded to support configurable coloration via options passed to the constructor, and **pod2text** should be taught about those.

SEE ALSO

Pod::Text|*Pod::Text*, *Pod::Parser*|*Pod::Parser*

AUTHOR

Russ Allbery <rra@stanford.edu>.

NAME

Pod::Text::Color – Convert POD data to ASCII text with format escapes

SYNOPSIS

```
use Pod::Text::Termcap;
my $parser = Pod::Text::Termcap->new (sentence => 0, width => 78);

# Read POD from STDIN and write to STDOUT.
$parser->parse_from_filehandle;

# Read POD from file.pod and write to file.txt.
$parser->parse_from_file ('file.pod', 'file.txt');
```

DESCRIPTION

Pod::Text::Termcap is a simple subclass of Pod::Text that highlights output text using the correct termcap escape sequences for the current terminal. Apart from the format codes, it in all ways functions like Pod::Text. See *Pod::Text* for details and available options.

SEE ALSO

Pod::Text|Pod::Text, *Pod::Parser|Pod::Parser*

AUTHOR

Russ Allbery <rra@stanford.edu>.

NAME

Pod::Text – Convert POD data to formatted ASCII text

SYNOPSIS

```
use Pod::Text;
my $parser = Pod::Text->new (sentence => 0, width => 78);

# Read POD from STDIN and write to STDOUT.
$parser->parse_from_filehandle;

# Read POD from file.pod and write to file.txt.
$parser->parse_from_file ('file.pod', 'file.txt');
```

DESCRIPTION

Pod::Text is a module that can convert documentation in the POD format (the preferred language for documenting Perl) into formatted ASCII. It uses no special formatting controls or codes whatsoever, and its output is therefore suitable for nearly any device.

As a derived class from Pod::Parser, Pod::Text supports the same methods and interfaces. See *Pod::Parser* for all the details; briefly, one creates a new parser with `Pod::Text->new()` and then calls either `parse_from_filehandle()` or `parse_from_file()`.

`new()` can take options, in the form of key/value pairs, that control the behavior of the parser. The currently recognized options are:

alt
: If set to a true value, selects an alternate output format that, among other things, uses a different heading style and marks `=item` entries with a colon in the left margin. Defaults to false.

indent
: The number of spaces to indent regular text, and the default indentation for `=over` blocks. Defaults to 4.

loose
: If set to a true value, a blank line is printed after a `=head1` heading. If set to false (the default), no blank line is printed after `=head1`, although one is still printed after `=head2`. This is the default because it's the expected formatting for manual pages; if you're formatting arbitrary text documents, setting this to true may result in more pleasing output.

quotes
: Sets the quote marks used to surround C< text. If the value is a single character, it is used as both the left and right quote; if it is two characters, the first character is used as the left quote and the second as the right quoted; and if it is four characters, the first two are used as the left quote and the second two as the right quote.

  This may also be set to the special value `none`, in which case no quote marks are added around C< text.

sentence
: If set to a true value, Pod::Text will assume that each sentence ends in two spaces, and will try to preserve that spacing. If set to false, all consecutive whitespace in non–verbatim paragraphs is compressed into a single space. Defaults to true.

width
: The column at which to wrap text on the right–hand side. Defaults to 76.

The standard Pod::Parser method `parse_from_filehandle()` takes up to two arguments, the first being the file handle to read POD from and the second being the file handle to write the formatted output to. The first defaults to STDIN if not given, and the second defaults to STDOUT. The method `parse_from_file()` is almost identical, except that its two arguments are the input and output disk files

instead. See *Pod::Parser* for the specific details.

DIAGNOSTICS

Bizarre space in item

(W) Something has gone wrong in internal `=item` processing. This message indicates a bug in Pod::Text; you should never see it.

Can't open %s for reading: %s

(F) Pod::Text was invoked via the compatibility mode `pod2text()` interface and the input file it was given could not be opened.

Invalid quote specification "%s"

(F) The quote specification given (the quotes option to the constructor) was invalid. A quote specification must be one, two, or four characters long.

%s:%d: Unknown command paragraph "%s".

(W) The POD source contained a non-standard command paragraph (something of the form `=command args`) that Pod::Man didn't know about. It was ignored.

Unknown escape: %s

(W) The POD source contained an `E<>` escape that Pod::Text didn't know about.

Unknown sequence: %s

(W) The POD source contained a non-standard internal sequence (something of the form `X<>`) that Pod::Text didn't know about.

Unmatched =back

(W) Pod::Text encountered a `=back` command that didn't correspond to an `=over` command.

RESTRICTIONS

Embedded Ctrl-As (octal 001) in the input will be mapped to spaces on output, due to an internal implementation detail.

NOTES

This is a replacement for an earlier Pod::Text module written by Tom Christiansen. It has a revamped interface, since it now uses Pod::Parser, but an interface roughly compatible with the old `Pod::Text::pod2text()` function is still available. Please change to the new calling convention, though.

The original Pod::Text contained code to do formatting via termcap sequences, although it wasn't turned on by default and it was problematic to get it to work at all. This rewrite doesn't even try to do that, but a subclass of it does. Look for *Pod::Text::Termcap|Pod::Text::Termcap*.

SEE ALSO

Pod::Parser|Pod::Parser, *Pod::Text::Termcap|Pod::Text::Termcap*, pod2text(1)

AUTHOR

Russ Allbery <rra@stanford.edu>, based *very* heavily on the original Pod::Text by Tom Christiansen <tchrist@mox.perl.com> and its conversion to Pod::Parser by Brad Appleton <bradapp@enteract.com>.

NAME

Pod::Usage, `pod2usage()` – print a usage message from embedded pod documentation

SYNOPSIS

```
use Pod::Usage

my $message_text  = "This text precedes the usage message.";
my $exit_status   = 2;          ## The exit status to use
my $verbose_level = 0;          ## The verbose level to use
my $filehandle    = \*STDERR;   ## The filehandle to write to

pod2usage($message_text);

pod2usage($exit_status);

pod2usage( { -message => $message_text ,
             -exitval => $exit_status  ,
             -verbose => $verbose_level,
             -output  => $filehandle } );

pod2usage(   -msg     => $message_text ,
             -exitval => $exit_status  ,
             -verbose => $verbose_level,
             -output  => $filehandle   );
```

ARGUMENTS

pod2usage should be given either a single argument, or a list of arguments corresponding to an associative array (a "hash"). When a single argument is given, it should correspond to exactly one of the following:

- A string containing the text of a message to print *before* printing the usage message
- A numeric value corresponding to the desired exit status
- A reference to a hash

If more than one argument is given then the entire argument list is assumed to be a hash. If a hash is supplied (either as a reference or as a list) it should contain one or more elements with the following keys:

`-message`
`-msg`

The text of a message to print immediately prior to printing the program‘s usage message.

`-exitval`

The desired exit status to pass to the **`exit()`** function. This should be an integer, or else the string "NOEXIT" to indicate that control should simply be returned without terminating the invoking process.

`-verbose`

The desired level of "verboseness" to use when printing the usage message. If the corresponding value is 0, then only the "SYNOPSIS" section of the pod documentation is printed. If the corresponding value is 1, then the "SYNOPSIS" section, along with any section entitled "OPTIONS", "ARGUMENTS", or "OPTIONS AND ARGUMENTS" is printed. If the corresponding value is 2 or more then the entire manpage is printed.

`-output`

A reference to a filehandle, or the pathname of a file to which the usage message should be written. The default is `\*STDERR` unless the exit value is less than 2 (in which case the default is `\*STDOUT`).

-input

A reference to a filehandle, or the pathname of a file from which the invoking script's pod documentation should be read. It defaults to the file indicated by `$0` (`$PROGRAM_NAME` for users of ***English.pm***).

`-pathlist`

A list of directory paths. If the input file does not exist, then it will be searched for in the given directory list (in the order the directories appear in the list). It defaults to the list of directories implied by `$ENV{PATH}`. The list may be specified either by a reference to an array, or by a string of directory paths which use the same path separator as `$ENV{PATH}` on your system (e.g., `:` for Unix, `;` for MSWin32 and DOS).

DESCRIPTION

pod2usage will print a usage message for the invoking script (using its embedded pod documentation) and then exit the script with the desired exit status. The usage message printed may have any one of three levels of "verboseness": If the verbose level is 0, then only a synopsis is printed. If the verbose level is 1, then the synopsis is printed along with a description (if present) of the command line options and arguments. If the verbose level is 2, then the entire manual page is printed.

Unless they are explicitly specified, the default values for the exit status, verbose level, and output stream to use are determined as follows:

- If neither the exit status nor the verbose level is specified, then the default is to use an exit status of 2 with a verbose level of 0.
- If an exit status *is* specified but the verbose level is *not*, then the verbose level will default to 1 if the exit status is less than 2 and will default to 0 otherwise.
- If an exit status is *not* specified but verbose level *is* given, then the exit status will default to 2 if the verbose level is 0 and will default to 1 otherwise.
- If the exit status used is less than 2, then output is printed on `STDOUT`. Otherwise output is printed on `STDERR`.

Although the above may seem a bit confusing at first, it generally does "the right thing" in most situations. This determination of the default values to use is based upon the following typical Unix conventions:

- An exit status of 0 implies "success". For example, **diff(1)** exits with a status of 0 if the two files have the same contents.
- An exit status of 1 implies possibly abnormal, but non–defective, program termination. For example, **grep(1)** exits with a status of 1 if it did *not* find a matching line for the given regular expression.
- An exit status of 2 or more implies a fatal error. For example, **ls(1)** exits with a status of 2 if you specify an illegal (unknown) option on the command line.
- Usage messages issued as a result of bad command–line syntax should go to `STDERR`. However, usage messages issued due to an explicit request to print usage (like specifying **–help** on the command line) should go to `STDOUT`, just in case the user wants to pipe the output to a pager (such as **more(1)**).
- If program usage has been explicitly requested by the user, it is often desireable to exit with a status of 1 (as opposed to 0) after issuing the user–requested usage message. It is also desireable to give a more verbose description of program usage in this case.

pod2usage doesn't force the above conventions upon you, but it will use them by default if you don't expressly tell it to do otherwise. The ability of **`pod2usage()`** to accept a single number or a string makes it convenient to use as an innocent looking error message handling function:

```
use Pod::Usage;
use Getopt::Long;
```

```
## Parse options
GetOptions("help", "man", "flag1")  ||  pod2usage(2);
pod2usage(1)  if ($opt_help);
pod2usage(-verbose => 2)  if ($opt_man);

## Check for too many filenames
pod2usage("$0: Too many files given.\n")  if (@ARGV > 1);
```

Some user's however may feel that the above "economy of expression" is not particularly readable nor consistent and may instead choose to do something more like the following:

```
use Pod::Usage;
use Getopt::Long;

## Parse options
GetOptions("help", "man", "flag1")  ||  pod2usage(-verbose => 0);
pod2usage(-verbose => 1)  if ($opt_help);
pod2usage(-verbose => 2)  if ($opt_man);

## Check for too many filenames
pod2usage(-verbose => 2, -message => "$0: Too many files given.\n")
    if (@ARGV > 1);
```

As with all things in Perl, *there's more than one way to do it*, and **`pod2usage()`** adheres to this philosophy. If you are interested in seeing a number of different ways to invoke **pod2usage** (although by no means exhaustive), please refer to *"EXAMPLES"*.

EXAMPLES

Each of the following invocations of `pod2usage()` will print just the "SYNOPSIS" section to `STDERR` and will exit with a status of 2:

```
pod2usage();

pod2usage(2);

pod2usage(-verbose => 0);

pod2usage(-exitval => 2);

pod2usage({-exitval => 2, -output => \*STDERR});

pod2usage({-verbose => 0, -output  => \*STDERR});

pod2usage(-exitval => 2, -verbose => 0);

pod2usage(-exitval => 2, -verbose => 0, -output => \*STDERR);
```

Each of the following invocations of `pod2usage()` will print a message of "Syntax error." (followed by a newline) to `STDERR`, immediately followed by just the "SYNOPSIS" section (also printed to `STDERR`) and will exit with a status of 2:

```
pod2usage("Syntax error.");

pod2usage(-message => "Syntax error.", -verbose => 0);

pod2usage(-msg  => "Syntax error.", -exitval => 2);

pod2usage({-msg => "Syntax error.", -exitval => 2, -output => \*STDERR});

pod2usage({-msg => "Syntax error.", -verbose => 0, -output => \*STDERR});

pod2usage(-msg  => "Syntax error.", -exitval => 2, -verbose => 0);

pod2usage(-message => "Syntax error.",
          -exitval => 2,
          -verbose => 0,
```

```
            -output  => \*STDERR);
```

Each of the following invocations of `pod2usage()` will print the "SYNOPSIS" section and any "OPTIONS" and/or "ARGUMENTS" sections to `STDOUT` and will exit with a status of 1:

```
pod2usage(1);

pod2usage(-verbose => 1);

pod2usage(-exitval => 1);

pod2usage({-exitval => 1, -output => \*STDOUT});

pod2usage({-verbose => 1, -output => \*STDOUT});

pod2usage(-exitval => 1, -verbose => 1);

pod2usage(-exitval => 1, -verbose => 1, -output => \*STDOUT});
```

Each of the following invocations of `pod2usage()` will print the entire manual page to `STDOUT` and will exit with a status of 1:

```
pod2usage(-verbose  => 2);

pod2usage({-verbose => 2, -output => \*STDOUT});

pod2usage(-exitval  => 1, -verbose => 2);

pod2usage({-exitval => 1, -verbose => 2, -output => \*STDOUT});
```

Recommended Use

Most scripts should print some type of usage message to `STDERR` when a command line syntax error is detected. They should also provide an option (usually `-H` or `-help`) to print a (possibly more verbose) usage message to `STDOUT`. Some scripts may even wish to go so far as to provide a means of printing their complete documentation to `STDOUT` (perhaps by allowing a `-man` option). The following complete example uses **Pod::Usage** in combination with **Getopt::Long** to do all of these things:

```
use Getopt::Long;
use Pod::Usage;

my $man = 0;
my $help = 0;
## Parse options and print usage if there is a syntax error,
## or if usage was explicitly requested.
GetOptions('help|?' => \$help, man => \$man) or pod2usage(2);
pod2usage(1) if $help;
pod2usage(-verbose => 2) if $man;

## If no arguments were given, then allow STDIN to be used only
## if it's not connected to a terminal (otherwise print usage)
pod2usage("$0: No files given.")  if ((@ARGV == 0) && (-t STDIN));
__END__

=head1 NAME

sample - Using GetOpt::Long and Pod::Usage

=head1 SYNOPSIS

sample [options] [file ...]

 Options:
   -help            brief help message
   -man             full documentation
```

```
=head1 OPTIONS

=over 8

=item B<-help>

Print a brief help message and exits.

=item B<-man>

Prints the manual page and exits.

=back

=head1 DESCRIPTION

B<This program> will read the given input file(s) and do something
useful with the contents thereof.

=cut
```

CAVEATS

By default, **pod2usage()** will use $0 as the path to the pod input file. Unfortunately, not all systems on which Perl runs will set $0 properly (although if $0 isn't found, **pod2usage()** will search $ENV{PATH} or else the list specified by the -pathlist option). If this is the case for your system, you may need to explicitly specify the path to the pod docs for the invoking script using something similar to the following:

```
pod2usage(-exitval => 2, -input => "/path/to/your/pod/docs");
```

AUTHOR

Brad Appleton <bradapp@enteract.com>

Based on code for **Pod::Text::pod2text()** written by Tom Christiansen <tchrist@mox.perl.com>

ACKNOWLEDGEMENTS

Steven McDougall <swmcd@world.std.com> for his help and patience with re-writing this manpage.

NAME

Search::Dict, look – search for key in dictionary file

SYNOPSIS

```
use Search::Dict;
look *FILEHANDLE, $key, $dict, $fold;
```

DESCRIPTION

Sets file position in FILEHANDLE to be first line greater than or equal (stringwise) to *$key*. Returns the new file position, or –1 if an error occurs.

The flags specify dictionary order and case folding:

If *$dict* is true, search by dictionary order (ignore anything but word characters and whitespace).

If *$fold* is true, ignore case.

NAME

SelectSaver – save and restore selected file handle

SYNOPSIS

```
use SelectSaver;

{
   my $saver = new SelectSaver(FILEHANDLE);
   # FILEHANDLE is selected
}
# previous handle is selected

{
   my $saver = new SelectSaver;
   # new handle may be selected, or not
}
# previous handle is selected
```

DESCRIPTION

A `SelectSaver` object contains a reference to the file handle that was selected when it was created. If its `new` method gets an extra parameter, then that parameter is selected; otherwise, the selected file handle remains unchanged.

When a `SelectSaver` is destroyed, it re–selects the file handle that was selected when it was created.

NAME

SelfLoader – load functions only on demand

SYNOPSIS

```
package FOOBAR;
use SelfLoader;

... (initializing code)

__DATA__
sub {....
```

DESCRIPTION

This module tells its users that functions in the FOOBAR package are to be autoloaded from after the __DATA__ token. See also *Autoloading in perlsub*.

The __DATA__ token

The __DATA__ token tells the perl compiler that the perl code for compilation is finished. Everything after the __DATA__ token is available for reading via the filehandle FOOBAR::DATA, where FOOBAR is the name of the current package when the __DATA__ token is reached. This works just the same as __END__ does in package 'main', but for other modules data after __END__ is not automatically retrievable, whereas data after __DATA__ is. The __DATA__ token is not recognized in versions of perl prior to 5.001m.

Note that it is possible to have __DATA__ tokens in the same package in multiple files, and that the last __DATA__ token in a given package that is encountered by the compiler is the one accessible by the filehandle. This also applies to __END__ and main, i.e. if the 'main' program has an __END__, but a module 'require'd (_not_ 'use'd) by that program has a 'package main;' declaration followed by an '__DATA__', then the DATA filehandle is set to access the data after the __DATA__ in the module, _not_ the data after the __END__ token in the 'main' program, since the compiler encounters the 'require'd file later.

SelfLoader autoloading

The **SelfLoader** works by the user placing the __DATA__ token *after* perl code which needs to be compiled and run at 'require' time, but *before* subroutine declarations that can be loaded in later – usually because they may never be called.

The **SelfLoader** will read from the FOOBAR::DATA filehandle to load in the data after __DATA__, and load in any subroutine when it is called. The costs are the one–time parsing of the data after __DATA__, and a load delay for the _first_ call of any autoloaded function. The benefits (hopefully) are a speeded up compilation phase, with no need to load functions which are never used.

The **SelfLoader** will stop reading from __DATA__ if it encounters the __END__ token – just as you would expect. If the __END__ token is present, and is followed by the token DATA, then the **SelfLoader** leaves the FOOBAR::DATA filehandle open on the line after that token.

The **SelfLoader** exports the AUTOLOAD subroutine to the package using the **SelfLoader**, and this loads the called subroutine when it is first called.

There is no advantage to putting subroutines which will _always_ be called after the __DATA__ token.

Autoloading and package lexicals

A 'my $pack_lexical' statement makes the variable $pack_lexical local _only_ to the file up to the __DATA__ token. Subroutines declared elsewhere _cannot_ see these types of variables, just as if you declared subroutines in the package but in another file, they cannot see these variables.

So specifically, autoloaded functions cannot see package lexicals (this applies to both the **SelfLoader** and the Autoloader). The vars pragma provides an alternative to defining package–level globals that will be visible to autoloaded routines. See the documentation on **vars** in the pragma section of *perlmod*.

SelfLoader and AutoLoader

The **SelfLoader** can replace the AutoLoader – just change 'use AutoLoader' to 'use SelfLoader' (though note that the **SelfLoader** exports the AUTOLOAD function – but if you have your own AUTOLOAD and are using the AutoLoader too, you probably know what you're doing), and the `__END__` token to `__DATA__`. You will need perl version 5.001m or later to use this (version 5.001 with all patches up to patch m).

There is no need to inherit from the **SelfLoader**.

The **SelfLoader** works similarly to the AutoLoader, but picks up the subs from after the `__DATA__` instead of in the 'lib/auto' directory. There is a maintenance gain in not needing to run AutoSplit on the module at installation, and a runtime gain in not needing to keep opening and closing files to load subs. There is a runtime loss in needing to parse the code after the `__DATA__`. Details of the **AutoLoader** and another view of these distinctions can be found in that module's documentation.

__DATA__, __END__, and the FOOBAR::DATA filehandle.

This section is only relevant if you want to use the `FOOBAR::DATA` together with the **SelfLoader**.

Data after the `__DATA__` token in a module is read using the FOOBAR::DATA filehandle. `__END__` can still be used to denote the end of the `__DATA__` section if followed by the token DATA – this is supported by the **SelfLoader**. The `FOOBAR::DATA` filehandle is left open if an `__END__` followed by a DATA is found, with the filehandle positioned at the start of the line after the `__END__` token. If no `__END__` token is present, or an `__END__` token with no DATA token on the same line, then the filehandle is closed.

The **SelfLoader** reads from wherever the current position of the `FOOBAR::DATA` filehandle is, until the EOF or `__END__`. This means that if you want to use that filehandle (and ONLY if you want to), you should either

1. Put all your subroutine declarations immediately after the `__DATA__` token and put your own data after those declarations, using the `__END__` token to mark the end of subroutine declarations. You must also ensure that the **SelfLoader** reads first by calling `'SelfLoader->load_stubs();'`, or by using a function which is selfloaded;

or

2. You should read the `FOOBAR::DATA` filehandle first, leaving the handle open and positioned at the first line of subroutine declarations.

You could conceivably do both.

Classes and inherited methods.

For modules which are not classes, this section is not relevant. This section is only relevant if you have methods which could be inherited.

A subroutine stub (or forward declaration) looks like

```
sub stub;
```

i.e. it is a subroutine declaration without the body of the subroutine. For modules which are not classes, there is no real need for stubs as far as autoloading is concerned.

For modules which ARE classes, and need to handle inherited methods, stubs are needed to ensure that the method inheritance mechanism works properly. You can load the stubs into the module at 'require' time, by adding the statement `'SelfLoader->load_stubs();'` to the module to do this.

The alternative is to put the stubs in before the `__DATA__` token BEFORE releasing the module, and for this purpose the `Devel::SelfStubber` module is available. However this does require the extra step of ensuring that the stubs are in the module. If this is done I strongly recommend that this is done BEFORE releasing the module – it should NOT be done at install time in general.

Multiple packages and fully qualified subroutine names

Subroutines in multiple packages within the same file are supported – but you should note that this requires exporting the `SelfLoader::AUTOLOAD` to every package which requires it. This is done automatically by the **SelfLoader** when it first loads the subs into the cache, but you should really specify it in the initialization before the `__DATA__` by putting a 'use SelfLoader' statement in each package.

Fully qualified subroutine names are also supported. For example,

```
__DATA__
sub foo::bar {23}
package baz;
sub dob {32}
```

will all be loaded correctly by the **SelfLoader**, and the **SelfLoader** will ensure that the packages 'foo' and 'baz' correctly have the **SelfLoader** `AUTOLOAD` method when the data after `__DATA__` is first parsed.

NAME

Shell – run shell commands transparently within perl

SYNOPSIS

See below.

DESCRIPTION

```
Date: Thu, 22 Sep 94 16:18:16 -0700
Message-Id: <9409222318.AA17072@scalpel.netlabs.com>
To: perl5-porters@isu.edu
From: Larry Wall <lwall@scalpel.netlabs.com>
Subject: a new module I just wrote
```

Here's one that'll whack your mind a little out.

```
#!/usr/bin/perl

use Shell;

$foo = echo("howdy", "<funny>", "world");
print $foo;

$passwd = cat("</etc/passwd");
print $passwd;

sub ps;
print ps -ww;

cp("/etc/passwd", "/tmp/passwd");
```

That's maybe too gonzo. It actually exports an AUTOLOAD to the current package (and uncovered a bug in Beta 3, by the way). Maybe the usual usage should be

```
use Shell qw(echo cat ps cp);
```

Larry

If you set `$Shell::capture_stderr` to 1, the module will attempt to capture the STDERR of the process as well.

The module now should work on Win32.

```
Jenda
```

There seemed to be a problem where all arguments to a shell command were quoted before being executed. As in the following example:

```
cat('</etc/passwd');
ls('*.pl');
```

really turned into:

```
cat '</etc/passwd'
ls '*.pl'
```

instead of:

```
cat </etc/passwd
ls *.pl
```

and of course, this is wrong.

I have fixed this bug, it was brought up by Wolfgang Laun [ID 20000326.008]

Casey

OBJECT ORIENTED SYNTAX

Shell now has an OO interface. Good for namespace conservation and shell representation.

```
use Shell;
my $sh = Shell->new;
print $sh->ls;
```

Casey

AUTHOR

Larry Wall

Changes by Jenda@Krynicky.cz and Dave Cottle <d.cottle@csc.canterbury.ac.nz

Changes and bug fixes by Casey Tweten <crt@kiski.net

NAME

sigtrap – Perl pragma to enable simple signal handling

SYNOPSIS

```
use sigtrap;
use sigtrap qw(stack-trace old-interface-signals);  # equivalent
use sigtrap qw(BUS SEGV PIPE ABRT);
use sigtrap qw(die INT QUIT);
use sigtrap qw(die normal-signals);
use sigtrap qw(die untrapped normal-signals);
use sigtrap qw(die untrapped normal-signals
               stack-trace any error-signals);
use sigtrap 'handler' => \&my_handler, 'normal-signals';
use sigtrap qw(handler my_handler normal-signals
               stack-trace error-signals);
```

DESCRIPTION

The **sigtrap** pragma is a simple interface to installing signal handlers. You can have it install one of two handlers supplied by **sigtrap** itself (one which provides a Perl stack trace and one which simply `die()`s), or alternately you can supply your own handler for it to install. It can be told only to install a handler for signals which are either untrapped or ignored. It has a couple of lists of signals to trap, plus you can supply your own list of signals.

The arguments passed to the `use` statement which invokes **sigtrap** are processed in order. When a signal name or the name of one of **sigtrap**'s signal lists is encountered a handler is immediately installed, when an option is encountered it affects subsequently installed handlers.

OPTIONS

SIGNAL HANDLERS

These options affect which handler will be used for subsequently installed signals.

stack–trace

The handler used for subsequently installed signals outputs a Perl stack trace to STDERR and then tries to dump core. This is the default signal handler.

die The handler used for subsequently installed signals calls `die` (actually `croak`) with a message indicating which signal was caught.

handler *your–handler*

your–handler will be used as the handler for subsequently installed signals. *your–handler* can be any value which is valid as an assignment to an element of `%SIG`.

SIGNAL LISTS

sigtrap has a few built–in lists of signals to trap. They are:

normal–signals

These are the signals which a program might normally expect to encounter and which by default cause it to terminate. They are HUP, INT, PIPE and TERM.

error–signals

These signals usually indicate a serious problem with the Perl interpreter or with your script. They are ABRT, BUS, EMT, FPE, ILL, QUIT, SEGV, SYS and TRAP.

old–interface–signals

These are the signals which were trapped by default by the old **sigtrap** interface, they are ABRT, BUS, EMT, FPE, ILL, PIPE, QUIT, SEGV, SYS, TERM, and TRAP. If no signals or signals lists are passed to **sigtrap**, this list is used.

For each of these three lists, the collection of signals set to be trapped is checked before trapping; if your architecture does not implement a particular signal, it will not be trapped but rather silently ignored.

OTHER

untrapped

This token tells **sigtrap** to install handlers only for subsequently listed signals which aren't already trapped or ignored.

any This token tells **sigtrap** to install handlers for all subsequently listed signals. This is the default behavior.

signal

Any argument which looks like a signal name (that is, `/^[A-Z][A-Z0-9]*$/`) indicates that **sigtrap** should install a handler for that name.

number

Require that at least version *number* of **sigtrap** is being used.

EXAMPLES

Provide a stack trace for the old-interface-signals:

```
use sigtrap;
```

Ditto:

```
use sigtrap qw(stack-trace old-interface-signals);
```

Provide a stack trace on the 4 listed signals only:

```
use sigtrap qw(BUS SEGV PIPE ABRT);
```

Die on INT or QUIT:

```
use sigtrap qw(die INT QUIT);
```

Die on HUP, INT, PIPE or TERM:

```
use sigtrap qw(die normal-signals);
```

Die on HUP, INT, PIPE or TERM, except don't change the behavior for signals which are already trapped or ignored:

```
use sigtrap qw(die untrapped normal-signals);
```

Die on receipt one of an of the **normal-signals** which is currently **untrapped**, provide a stack trace on receipt of **any** of the **error-signals**:

```
use sigtrap qw(die untrapped normal-signals
               stack-trace any error-signals);
```

Install `my_handler()` as the handler for the **normal-signals**:

```
use sigtrap 'handler', \&my_handler, 'normal-signals';
```

Install `my_handler()` as the handler for the normal-signals, provide a Perl stack trace on receipt of one of the error-signals:

```
use sigtrap qw(handler my_handler normal-signals
               stack-trace error-signals);
```

NAME

strict – Perl pragma to restrict unsafe constructs

SYNOPSIS

```
use strict;

use strict "vars";
use strict "refs";
use strict "subs";

use strict;
no strict "vars";
```

DESCRIPTION

If no import list is supplied, all possible restrictions are assumed. (This is the safest mode to operate in, but is sometimes too strict for casual programming.) Currently, there are three possible things to be strict about: "subs", "vars", and "refs".

`strict refs`

This generates a runtime error if you use symbolic references (see *perlref*).

```
use strict 'refs';
$ref = \$foo;
print $$ref;        # ok
$ref = "foo";
print $$ref;        # runtime error; normally ok
$file = "STDOUT";
print $file "Hi!";  # error; note: no comma after $file
```

There is one exception to this rule:

```
$bar = \&{'foo'};
&$bar;
```

is allowed so that `goto &$AUTOLOAD` would not break under stricture.

`strict vars`

This generates a compile–time error if you access a variable that wasn't declared via "our" or `use vars`, localized via `my()`, or wasn't fully qualified. Because this is to avoid variable suicide problems and subtle dynamic scoping issues, a merely `local()` variable isn't good enough. See *my* and *local*.

```
use strict 'vars';
$X::foo = 1;         # ok, fully qualified
my $foo = 10;        # ok, my() var
local $foo = 9;      # blows up

package Cinna;
our $bar;                    # Declares $bar in current package
$bar = 'HgS';                # ok, global declared via pragma
```

The `local()` generated a compile–time error because you just touched a global name without fully qualifying it.

Because of their special use by `sort()`, the variables `$a` and `$b` are exempted from this check.

`strict subs`

This disables the poetry optimization, generating a compile–time error if you try to use a bareword identifier that's not a subroutine, unless it appears in curly braces or on the left hand side of the "=>" symbol.

```
use strict 'subs';
$SIG{PIPE} = Plumber# blows up
$SIG{PIPE} = "Plumber";# just fine: bareword in curlies always ok
$SIG{PIPE} = \&Plumber;# preferred form
```

See *Pragmatic Modules*.

NAME

subs – Perl pragma to predeclare sub names

SYNOPSIS

```
use subs qw(frob);
frob 3..10;
```

DESCRIPTION

This will predeclare all the subroutine whose names are in the list, allowing you to use them without parentheses even before they're declared.

Unlike pragmas that affect the `$^H` hints variable, the `use vars` and `use subs` declarations are not BLOCK–scoped. They are thus effective for the entire file in which they appear. You may not rescind such declarations with `no vars` or `no subs`.

See *Pragmatic Modules* and *strict subs*.

NAME

Symbol – manipulate Perl symbols and their names

SYNOPSIS

```
use Symbol;

$sym = gensym;
open($sym, "filename");
$_ = <$sym>;
# etc.

ungensym $sym;      # no effect

print qualify("x"), "\n";              # "Test::x"
print qualify("x", "FOO"), "\n"        # "FOO::x"
print qualify("BAR::x"), "\n";         # "BAR::x"
print qualify("BAR::x", "FOO"), "\n";  # "BAR::x"
print qualify("STDOUT", "FOO"), "\n";  # "main::STDOUT" (global)
print qualify(\*x), "\n";              # returns \*x
print qualify(\*x, "FOO"), "\n";       # returns \*x

use strict refs;
print { qualify_to_ref $fh } "foo!\n";
$ref = qualify_to_ref $name, $pkg;

use Symbol qw(delete_package);
delete_package('Foo::Bar');
print "deleted\n" unless exists $Foo::{'Bar::'};
```

DESCRIPTION

`Symbol::gensym` creates an anonymous glob and returns a reference to it. Such a glob reference can be used as a file or directory handle.

For backward compatibility with older implementations that didn't support anonymous globs, `Symbol::ungensym` is also provided. But it doesn't do anything.

`Symbol::qualify` turns unqualified symbol names into qualified variable names (e.g. "myvar" –> "MyPackage::myvar"). If it is given a second parameter, `qualify` uses it as the default package; otherwise, it uses the package of its caller. Regardless, global variable names (e.g. "STDOUT", "ENV", "SIG") are always qualified with "main::".

Qualification applies only to symbol names (strings). References are left unchanged under the assumption that they are glob references, which are qualified by their nature.

`Symbol::qualify_to_ref` is just like `Symbol::qualify` except that it returns a glob ref rather than a symbol name, so you can use the result even if `use strict 'refs'` is in effect.

`Symbol::delete_package` wipes out a whole package namespace. Note this routine is not exported by default—you may want to import it explicitly.

NAME

Term::ANSIColor – Color screen output using ANSI escape sequences

SYNOPSIS

```
use Term::ANSIColor;
print color 'bold blue';
print "This text is bold blue.\n";
print color 'reset';
print "This text is normal.\n";
print colored ("Yellow on magenta.\n", 'yellow on_magenta');
print "This text is normal.\n";
print colored ['yellow on_magenta'], "Yellow on magenta.\n";

use Term::ANSIColor qw(:constants);
print BOLD, BLUE, "This text is in bold blue.\n", RESET;

use Term::ANSIColor qw(:constants);
$Term::ANSIColor::AUTORESET = 1;
print BOLD BLUE "This text is in bold blue.\n";
print "This text is normal.\n";
```

DESCRIPTION

This module has two interfaces, one through `color()` and `colored()` and the other through constants.

`color()` takes any number of strings as arguments and considers them to be space–separated lists of attributes. It then forms and returns the escape sequence to set those attributes. It doesn't print it out, just returns it, so you'll have to print it yourself if you want to (this is so that you can save it as a string, pass it to something else, send it to a file handle, or do anything else with it that you might care to).

The recognized attributes (all of which should be fairly intuitive) are clear, reset, dark, bold, underline, underscore, blink, reverse, concealed, black, red, green, yellow, blue, magenta, on_black, on_red, on_green, on_yellow, on_blue, on_magenta, on_cyan, and on_white. Case is not significant. Underline and underscore are equivalent, as are clear and reset, so use whichever is the most intuitive to you. The color alone sets the foreground color, and on_color sets the background color.

Note that not all attributes are supported by all terminal types, and some terminals may not support any of these sequences. Dark, blink, and concealed in particular are frequently not implemented.

Attributes, once set, last until they are unset (by sending the attribute "reset"). Be careful to do this, or otherwise your attribute will last after your script is done running, and people get very annoyed at having their prompt and typing changed to weird colors.

As an aid to help with this, `colored()` takes a scalar as the first argument and any number of attribute strings as the second argument and returns the scalar wrapped in escape codes so that the attributes will be set as requested before the string and reset to normal after the string. Alternately, you can pass a reference to an array as the first argument, and then the contents of that array will be taken as attributes and color codes and the remainder of the arguments as text to colorize.

Normally, `colored()` just puts attribute codes at the beginning and end of the string, but if you set `$Term::ANSIColor::EACHLINE` to some string, that string will be considered the line delimiter and the attribute will be set at the beginning of each line of the passed string and reset at the end of each line. This is often desirable if the output is being sent to a program like a pager that can be confused by attributes that span lines. Normally you'll want to set `$Term::ANSIColor::EACHLINE` to `"\n"` to use this feature.

Alternately, if you import `:constants`, you can use the constants CLEAR, RESET, BOLD, DARK, UNDERLINE, UNDERSCORE, BLINK, REVERSE, CONCEALED, BLACK, RED, GREEN, YELLOW, BLUE, MAGENTA, ON_BLACK, ON_RED, ON_GREEN, ON_YELLOW, ON_BLUE, ON_MAGENTA, ON_CYAN, and ON_WHITE directly. These are the same as color('attribute') and can be used if you prefer

typing:

```
print BOLD BLUE ON_WHITE "Text\n", RESET;
```

to

```
print colored ("Text\n", 'bold blue on_white');
```

When using the constants, if you don't want to have to remember to add the `, RESET` at the end of each print line, you can set `$Term::ANSIColor::AUTORESET` to a true value. Then, the display mode will automatically be reset if there is no comma after the constant. In other words, with that variable set:

```
print BOLD BLUE "Text\n";
```

will reset the display mode afterwards, whereas:

```
print BOLD, BLUE, "Text\n";
```

will not.

The subroutine interface has the advantage over the constants interface in that only two subroutines are exported into your namespace, versus twenty–two in the constants interface. On the flip side, the constants interface has the advantage of better compile time error checking, since misspelled names of colors or attributes in calls to `color()` and `colored()` won't be caught until runtime whereas misspelled names of constants will be caught at compile time. So, polute your namespace with almost two dozen subroutines that you may not even use that often, or risk a silly bug by mistyping an attribute. Your choice, TMTOWTDI after all.

DIAGNOSTICS

Invalid attribute name %s

(F) You passed an invalid attribute name to either `color()` or `colored()`.

Name "%s" used only once: possible typo

(W) You probably mistyped a constant color name such as:

```
print FOOBAR "This text is color FOOBAR\n";
```

It's probably better to always use commas after constant names in order to force the next error.

No comma allowed after filehandle

(F) You probably mistyped a constant color name such as:

```
print FOOBAR, "This text is color FOOBAR\n";
```

Generating this fatal compile error is one of the main advantages of using the constants interface, since you'll immediately know if you mistype a color name.

Bareword "%s" not allowed while "strict subs" in use

(F) You probably mistyped a constant color name such as:

```
$Foobar = FOOBAR . "This line should be blue\n";
```

or:

```
@Foobar = FOOBAR, "This line should be blue\n";
```

This will only show up under use strict (another good reason to run under use strict).

RESTRICTIONS

It would be nice if one could leave off the commas around the constants entirely and just say:

```
print BOLD BLUE ON_WHITE "Text\n" RESET;
```

but the syntax of Perl doesn't allow this. You need a comma after the string. (Of course, you may consider it a bug that commas between all the constants aren't required, in which case you may feel free to insert

commas unless you're using `$Term::ANSIColor::AUTORESET`.)

For easier debuging, you may prefer to always use the commas when not setting `$Term::ANSIColor::AUTORESET` so that you'll get a fatal compile error rather than a warning.

NOTES

Jean Delvare provided the following table of different common terminal emulators and their support for the various attributes:

	clear	bold	dark	under	blink	reverse	conceal
xterm	yes	yes	no	yes	bold	yes	yes
linux	yes	yes	yes	bold	yes	yes	no
rxvt	yes	yes	no	yes	bold/black	yes	no
dtterm	yes	yes	yes	yes	reverse	yes	yes
teraterm	yes	reverse	no	yes	rev/red	yes	no
aixterm	kinda	normal	no	yes	no	yes	yes

Where the entry is other than yes or no, that emulator interpret the given attribute as something else instead. Note that on an aixterm, clear doesn't reset colors; you have to explicitly set the colors back to what you want. More entries in this table are welcome.

AUTHORS

Original idea (using constants) by Zenin (zenin@best.com), reimplemented using subs by Russ Allbery (rra@stanford.edu), and then combined with the original idea by Russ with input from Zenin.

NAME

Term::Cap – Perl termcap interface

SYNOPSIS

```
require Term::Cap;
$terminal = Tgetent Term::Cap { TERM => undef, OSPEED => $ospeed };
$terminal->Trequire(qw/ce ku kd/);
$terminal->Tgoto('cm', $col, $row, $FH);
$terminal->Tputs('dl', $count, $FH);
$terminal->Tpad($string, $count, $FH);
```

DESCRIPTION

These are low−level functions to extract and use capabilities from a terminal capability (termcap) database.

The **Tgetent** function extracts the entry of the specified terminal type *TERM* (defaults to the environment variable *TERM*) from the database.

It will look in the environment for a *TERMCAP* variable. If found, and the value does not begin with a slash, and the terminal type name is the same as the environment string *TERM*, the *TERMCAP* string is used instead of reading a termcap file. If it does begin with a slash, the string is used as a path name of the termcap file to search. If *TERMCAP* does not begin with a slash and name is different from *TERM*, **Tgetent** searches the files ***$HOME/.termcap***, ***/etc/termcap***, and ***/usr/share/misc/termcap***, in that order, unless the environment variable *TERMPATH* exists, in which case it specifies a list of file pathnames (separated by spaces or colons) to be searched **instead**. Whenever multiple files are searched and a tc field occurs in the requested entry, the entry it names must be found in the same file or one of the succeeding files. If there is a `:tc=...:` in the *TERMCAP* environment variable string it will continue the search in the files as above.

OSPEED is the terminal output bit rate (often mistakenly called the baud rate). *OSPEED* can be specified as either a POSIX termios/SYSV termio speeds (where 9600 equals 9600) or an old BSD−style speeds (where 13 equals 9600).

Tgetent returns a blessed object reference which the user can then use to send the control strings to the terminal using **Tputs** and **Tgoto**. It calls `croak` on failure.

Tgoto decodes a cursor addressing string with the given parameters.

The output strings for **Tputs** are cached for counts of 1 for performance. **Tgoto** and **Tpad** do not cache. `$self->{_xx}` is the raw termcap data and `$self->{xx}` is the cached version.

```
print $terminal->Tpad($self->{_xx}, 1);
```

Tgoto, **Tputs**, and **Tpad** return the string and will also output the string to `$FH` if specified.

The extracted termcap entry is available in the object as `$self->{TERMCAP}`.

EXAMPLES

```
# Get terminal output speed
require POSIX;
my $termios = new POSIX::Termios;
$termios->getattr;
my $ospeed = $termios->getospeed;

# Old-style ioctl code to get ospeed:
#     require 'ioctl.pl';
#     ioctl(TTY,$TIOCGETP,$sgtty);
#     ($ispeed,$ospeed) = unpack('cc',$sgtty);

# allocate and initialize a terminal structure
$terminal = Tgetent Term::Cap { TERM => undef, OSPEED => $ospeed };
```

```
# require certain capabilities to be available
$terminal->Trequire(qw/ce ku kd/);

# Output Routines, if $FH is undefined these just return the string

# Tgoto does the % expansion stuff with the given args
$terminal->Tgoto('cm', $col, $row, $FH);

# Tputs doesn't do any % expansion.
$terminal->Tputs('dl', $count = 1, $FH);
```

NAME

Term::Complete – Perl word completion module

SYNOPSIS

```
$input = Complete('prompt_string', \@completion_list);
$input = Complete('prompt_string', @completion_list);
```

DESCRIPTION

This routine provides word completion on the list of words in the array (or array ref).

The tty driver is put into raw mode using the system command `stty raw -echo` and restored using `stty -raw echo`.

The following command characters are defined:

<tab>

Attempts word completion. Cannot be changed.

^D Prints completion list. Defined by *$Term::Complete::complete*.

^U Erases the current input. Defined by *$Term::Complete::kill*.

<del>, <bs>

Erases one character. Defined by *$Term::Complete::erase1* and *$Term::Complete::erase2*.

DIAGNOSTICS

Bell sounds when word completion fails.

BUGS

The completion character <tab> cannot be changed.

AUTHOR

Wayne Thompson

NAME

Term::ReadLine – Perl interface to various `readline` packages. If no real package is found, substitutes stubs instead of basic functions.

SYNOPSIS

```
use Term::ReadLine;
$term = new Term::ReadLine 'Simple Perl calc';
$prompt = "Enter your arithmetic expression: ";
$OUT = $term->OUT || STDOUT;
while ( defined ($_ = $term->readline($prompt)) ) {
  $res = eval($_), "\n";
  warn $@ if $@;
  print $OUT $res, "\n" unless $@;
  $term->addhistory($_) if /\S/;
}
```

DESCRIPTION

This package is just a front end to some other packages. At the moment this description is written, the only such package is Term–ReadLine, available on CPAN near you. The real target of this stub package is to set up a common interface to whatever Readline emerges with time.

Minimal set of supported functions

All the supported functions should be called as methods, i.e., either as

```
$term = new Term::ReadLine 'name';
```

or as

```
$term->addhistory('row');
```

where `$term` is a return value of Term::ReadLine–>Init.

`ReadLine` returns the actual package that executes the commands. Among possible values are `Term::ReadLine::Gnu`, `Term::ReadLine::Perl`, `Term::ReadLine::Stub` `Exporter`.

`new` returns the handle for subsequent calls to following functions. Argument is the name of the application. Optionally can be followed by two arguments for `IN` and `OUT` filehandles. These arguments should be globs.

`readline` gets an input line, *possibly* with actual `readline` support. Trailing newline is removed. Returns `undef` on `EOF`.

`addhistory` adds the line to the history of input, from where it can be used if the actual `readline` is present.

`IN`, `$OUT` return the filehandles for input and output or `undef` if `readline` input and output cannot be used for Perl.

`MinLine` If argument is specified, it is an advice on minimal size of line to be included into history. `undef` means do not include anything into history. Returns the old value.

`findConsole` returns an array with two strings that give most appropriate names for files for input and output using conventions `"<$in", ">out"`.

Attribs returns a reference to a hash which describes internal configuration of the package. Names of keys in this hash conform to standard conventions with the leading `rl_` stripped.

`Features` Returns a reference to a hash with keys being features present in current implementation. Several optional features are used in the minimal interface: `appname` should be present if the first argument to `new` is recognized, and `minline` should be present if `MinLine`

method is not dummy. `autohistory` should be present if lines are put into history automatically (maybe subject to `MinLine`), and `addhistory` if `addhistory` method is not dummy.

If `Features` method reports a feature `attribs` as present, the method `Attribs` is not dummy.

Additional supported functions

Actually `Term::ReadLine` can use some other package, that will support reacher set of commands.

All these commands are callable via method interface and have names which conform to standard conventions with the leading `rl_` stripped.

The stub package included with the perl distribution allows some additional methods:

`tkRunning` makes Tk event loop run when waiting for user input (i.e., during `readline` method).

`ornaments` makes the command line stand out by using termcap data. The argument to `ornaments` should be 0, 1, or a string of a form `"aa,bb,cc,dd"`. Four components of this string should be names of *terminal capacities*, first two will be issued to make the prompt standout, last two to make the input line standout.

`newTTY` takes two arguments which are input filehandle and output filehandle. Switches to use these filehandles.

One can check whether the currently loaded ReadLine package supports these methods by checking for corresponding `Features`.

EXPORTS

None

ENVIRONMENT

The environment variable `PERL_RL` governs which ReadLine clone is loaded. If the value is false, a dummy interface is used. If the value is true, it should be tail of the name of the package to use, such as `Perl` or `Gnu`.

As a special case, if the value of this variable is space–separated, the tail might be used to disable the ornaments by setting the tail to be `o=0` or `ornaments=0`. The head should be as described above, say

If the variable is not set, or if the head of space–separated list is empty, the best available package is loaded.

```
export "PERL_RL=Perl o=0"     # Use Perl ReadLine without ornaments
export "PERL_RL= o=0"         # Use best available ReadLine without ornaments
```

(Note that processing of `PERL_RL` for ornaments is in the discretion of the particular used `Term::ReadLine::*` package).

NAME

Test::Harness – run perl standard test scripts with statistics

SYNOPSIS

use Test::Harness;

runtests(@tests);

DESCRIPTION

(By using the *Test* module, you can write test scripts without knowing the exact output this module expects. However, if you need to know the specifics, read on!)

Perl test scripts print to standard output `"ok N"` for each single test, where `N` is an increasing sequence of integers. The first line output by a standard test script is `"1..M"` with `M` being the number of tests that should be run within the test script. Test::Harness::runtests(@tests) runs all the testscripts named as arguments and checks standard output for the expected `"ok N"` strings.

After all tests have been performed, `runtests()` prints some performance statistics that are computed by the Benchmark module.

The test script output

Any output from the testscript to standard error is ignored and bypassed, thus will be seen by the user. Lines written to standard output containing `/^(not\s+)?ok\b/` are interpreted as feedback for `runtests()`. All other lines are discarded.

It is tolerated if the test numbers after `ok` are omitted. In this case Test::Harness maintains temporarily its own counter until the script supplies test numbers again. So the following test script

```
print <<END;
1..6
not ok
ok
not ok
ok
ok
END
```

will generate

```
FAILED tests 1, 3, 6
Failed 3/6 tests, 50.00% okay
```

The global variable `$Test::Harness::verbose` is exportable and can be used to let `runtests()` display the standard output of the script without altering the behavior otherwise.

The global variable `$Test::Harness::switches` is exportable and can be used to set perl command line options used for running the test script(s). The default value is `-w`.

If the standard output line contains substring `# Skip` (with variations in spacing and case) after `ok` or `ok NUMBER`, it is counted as a skipped test. If the whole testscript succeeds, the count of skipped tests is included in the generated output.

`Test::Harness` reports the text after `# Skip(whatever)` as a reason for skipping. Similarly, one can include a similar explanation in a `1..0` line emitted if the test is skipped completely:

```
1..0 # Skipped: no leverage found
```

EXPORT

`&runtests` is exported by Test::Harness per default.

DIAGNOSTICS

`All tests successful.\nFiles=%d,  Tests=%d, %s`

If all tests are successful some statistics about the performance are printed.

`FAILED tests %s\n\tFailed %d/%d tests, %.2f%% okay.`

For any single script that has failing subtests statistics like the above are printed.

`Test returned status %d (wstat %d)`

Scripts that return a non–zero exit status, both `$? >> 8` and `$?` are printed in a message similar to the above.

`Failed 1 test, %.2f%% okay. %s`
`Failed %d/%d tests, %.2f%% okay. %s`

If not all tests were successful, the script dies with one of the above messages.

ENVIRONMENT

Setting `HARNESS_IGNORE_EXITCODE` makes harness ignore the exit status of child processes.

Setting `HARNESS_NOTTY` to a true value forces it to behave as though STDOUT were not a console. You may need to set this if you don't want harness to output more frequent progress messages using carriage returns. Some consoles may not handle carriage returns properly (which results in a somewhat messy output).

Setting `HARNESS_COMPILE_TEST` to a true value will make harness attempt to compile the test using `perlcc` before running it.

If `HARNESS_FILELEAK_IN_DIR` is set to the name of a directory, harness will check after each test whether new files appeared in that directory, and report them as

```
  LEAKED FILES: scr.tmp 0 my.db
```

If relative, directory name is with respect to the current directory at the moment `runtests()` was called. Putting absolute path into `HARNESS_FILELEAK_IN_DIR` may give more predicatable results.

The value of `HARNESS_PERL_SWITCHES` will be prepended to the switches used to invoke perl on each test. For example, setting `HARNESS_PERL_SWITCHES` to "–W" will run all tests with all warnings enabled.

If `HARNESS_COLUMNS` is set, then this value will be used for the width of the terminal. If it is not set then it will default to `COLUMNS`. If this is not set, it will default to 80. Note that users of Bourne–sh based shells will need to `export COLUMNS` for this module to use that variable.

Harness sets `HARNESS_ACTIVE` before executing the individual tests. This allows the tests to determine if they are being executed through the harness or by any other means.

SEE ALSO

Test for writing test scripts and also *Benchmark* for the underlying timing routines.

AUTHORS

Either Tim Bunce or Andreas Koenig, we don't know. What we know for sure is, that it was inspired by Larry Wall's TEST script that came with perl distributions for ages. Numerous anonymous contributors exist. Current maintainer is Andreas Koenig.

BUGS

Test::Harness uses `$^X` to determine the perl binary to run the tests with. Test scripts running via the shebang (`#!`) line may not be portable because `$^X` is not consistent for shebang scripts across platforms. This is no problem when Test::Harness is run with an absolute path to the perl binary or when `$^X` can be found in the path.

NAME

Test - provides a simple framework for writing test scripts

SYNOPSIS

```
use strict;
use Test;

# use a BEGIN block so we print our plan before MyModule is loaded
BEGIN { plan tests => 14, todo => [3,4] }

# load your module...
use MyModule;

ok(0); # failure
ok(1); # success

ok(0); # ok, expected failure (see todo list, above)
ok(1); # surprise success!

ok(0,1);             # failure: '0' ne '1'
ok('broke','fixed'); # failure: 'broke' ne 'fixed'
ok('fixed','fixed'); # success: 'fixed' eq 'fixed'
ok('fixed',qr/x/);   # success: 'fixed' =~ qr/x/

ok(sub { 1+1 }, 2);  # success: '2' eq '2'
ok(sub { 1+1 }, 3);  # failure: '2' ne '3'
ok(0, int(rand(2));  # (just kidding :-)

my @list = (0,0);
ok @list, 3, "\@list=".join(',',@list);      #extra diagnostics
ok 'segmentation fault', '/(?i)success/';    #regex match

skip($feature_is_missing, ...);    #do platform specific test
```

DESCRIPTION

Test::Harness expects to see particular output when it executes tests. This module aims to make writing proper test scripts just a little bit easier (and less error prone :–).

TEST TYPES

- NORMAL TESTS

  These tests are expected to succeed. If they don't something's screwed up!

- SKIPPED TESTS

  Skip is for tests that might or might not be possible to run depending on the availability of platform specific features. The first argument should evaluate to true (think "yes, please skip") if the required feature is not available. After the first argument, skip works exactly the same way as do normal tests.

- TODO TESTS

  TODO tests are designed for maintaining an **executable TODO list**. These tests are expected NOT to succeed. If a TODO test does succeed, the feature in question should not be on the TODO list, now should it?

  Packages should NOT be released with succeeding TODO tests. As soon as a TODO test starts working, it should be promoted to a normal test and the newly working feature should be documented in the release notes or change log.

RETURN VALUE

Both `ok` and `skip` return true if their test succeeds and false otherwise in a scalar context.

ONFAIL

```
BEGIN { plan test => 4, onfail => sub { warn "CALL 911!" } }
```

While test failures should be enough, extra diagnostics can be triggered at the end of a test run. `onfail` is passed an array ref of hash refs that describe each test failure. Each hash will contain at least the following fields: `package`, `repetition`, and `result`. (The file, line, and test number are not included because their correspondence to a particular test is tenuous.) If the test had an expected value or a diagnostic string, these will also be included.

The **optional** `onfail` hook might be used simply to print out the version of your package and/or how to report problems. It might also be used to generate extremely sophisticated diagnostics for a particularly bizarre test failure. However it's not a panacea. Core dumps or other unrecoverable errors prevent the `onfail` hook from running. (It is run inside an `END` block.) Besides, `onfail` is probably over-kill in most cases. (Your test code should be simpler than the code it is testing, yes?)

SEE ALSO

Test::Harness and, perhaps, test coverage analysis tools.

AUTHOR

NAME

abbrev – create an abbreviation table from a list

SYNOPSIS

```
use Text::Abbrev;
abbrev $hashref, LIST
```

DESCRIPTION

Stores all unambiguous truncations of each element of LIST as keys in the associative array referenced by `$hashref`. The values are the original list elements.

EXAMPLE

```
$hashref = abbrev qw(list edit send abort gripe);

%hash = abbrev qw(list edit send abort gripe);

abbrev $hashref, qw(list edit send abort gripe);

abbrev(*hash, qw(list edit send abort gripe));
```

NAME

Text::ParseWords – parse text into an array of tokens or array of arrays

SYNOPSIS

```
use Text::ParseWords;
@lists = &nested_quotewords($delim, $keep, @lines);
@words = &quotewords($delim, $keep, @lines);
@words = &shellwords(@lines);
@words = &parse_line($delim, $keep, $line);
@words = &old_shellwords(@lines); # DEPRECATED!
```

DESCRIPTION

The `&nested_quotewords()` and `&quotewords()` functions accept a delimiter (which can be a regular expression) and a list of lines and then breaks those lines up into a list of words ignoring delimiters that appear inside quotes. `&quotewords()` returns all of the tokens in a single long list, while `&nested_quotewords()` returns a list of token lists corresponding to the elements of @lines. `&parse_line()` does tokenizing on a single string. The `&*quotewords()` functions simply call `&parse_lines()`, so if you're only splitting one line you can call `&parse_lines()` directly and save a function call.

The `$keep` argument is a boolean flag. If true, then the tokens are split on the specified delimiter, but all other characters (quotes, backslashes, etc.) are kept in the tokens. If `$keep` is false then the `&*quotewords()` functions remove all quotes and backslashes that are not themselves backslash–escaped or inside of single quotes (i.e., `&quotewords()` tries to interpret these characters just like the Bourne shell). NB: these semantics are significantly different from the original version of this module shipped with Perl 5.000 through 5.004. As an additional feature, `$keep` may be the keyword "delimiters" which causes the functions to preserve the delimiters in each string as tokens in the token lists, in addition to preserving quote and backslash characters.

`&shellwords()` is written as a special case of `&quotewords()`, and it does token parsing with whitespace as a delimiter— similar to most Unix shells.

EXAMPLES

The sample program:

```
use Text::ParseWords;
@words = &quotewords('\s+', 0, q{this   is "a test" of\ quotewords \"for you});
$i = 0;
foreach (@words) {
    print "$i: <$_>\n";
    $i++;
}
```

produces:

```
0: <this>
1: <is>
2: <a test>
3: <of quotewords>
4: <"for>
5: <you>
```

demonstrating:

0 a simple word

1 multiple spaces are skipped because of our `$delim`

2 use of quotes to include a space in a word

3 use of a backslash to include a space in a word

4 use of a backslash to remove the special meaning of a double−quote

5 another simple word (note the lack of effect of the backslashed double−quote)

Replacing `&quotewords('\s+', 0, q{this is...})` with `&shellwords(q{this is...})` is a simpler way to accomplish the same thing.

AUTHORS

Maintainer is Hal Pomeranz <pomeranz@netcom.com, 1994−1997 (Original author unknown). Much of the code for `&parse_line()` (including the primary regexp) from Joerk Behrends <jbehrends@multimediaproduzenten.de.

Examples section another documentation provided by John Heidemann <johnh@ISI.EDU

Bug reports, patches, and nagging provided by lots of folks— thanks everybody! Special thanks to Michael Schwern <schwern@envirolink.org for assuring me that a `&nested_quotewords()` would be useful, and to Jeff Friedl <jfriedl@yahoo−inc.com for telling me not to worry about error−checking (sort of— you had to be there).

NAME

Text::Soundex – Implementation of the Soundex Algorithm as Described by Knuth

SYNOPSIS

```
use Text::Soundex;

$code = soundex $string;            # get soundex code for a string
@codes = soundex @list;             # get list of codes for list of strings

# set value to be returned for strings without soundex code

$soundex_nocode = 'Z000';
```

DESCRIPTION

This module implements the soundex algorithm as described by Donald Knuth in Volume 3 of **The Art of Computer Programming**. The algorithm is intended to hash words (in particular surnames) into a small space using a simple model which approximates the sound of the word when spoken by an English speaker. Each word is reduced to a four character string, the first character being an upper case letter and the remaining three being digits.

If there is no soundex code representation for a string then the value of `$soundex_nocode` is returned. This is initially set to `undef`, but many people seem to prefer an *unlikely* value like `Z000` (how unlikely this is depends on the data set being dealt with.) Any value can be assigned to `$soundex_nocode`.

In scalar context `soundex` returns the soundex code of its first argument, and in list context a list is returned in which each element is the soundex code for the corresponding argument passed to `soundex` e.g.

```
@codes = soundex qw(Mike Stok);
```

leaves `@codes` containing `('M200', 'S320')`.

EXAMPLES

Knuth's examples of various names and the soundex codes they map to are listed below:

```
Euler, Ellery -> E460
Gauss, Ghosh -> G200
Hilbert, Heilbronn -> H416
Knuth, Kant -> K530
Lloyd, Ladd -> L300
Lukasiewicz, Lissajous -> L222
```

so:

```
$code = soundex 'Knuth';              # $code contains 'K530'
@list = soundex qw(Lloyd Gauss);      # @list contains 'L300', 'G200'
```

LIMITATIONS

As the soundex algorithm was originally used a **long** time ago in the US it considers only the English alphabet and pronunciation.

As it is mapping a large space (arbitrary length strings) onto a small space (single letter plus 3 digits) no inference can be made about the similarity of two strings which end up with the same soundex code. For example, both `Hilbert` and `Heilbronn` end up with a soundex code of `H416`.

AUTHOR

This code was implemented by Mike Stok (`stok@cybercom.net`) from the description given by Knuth. Ian Phillips (`ian@pipex.net`) and Rich Pinder (`rpinder@hsc.usc.edu`) supplied ideas and spotted mistakes.

NAME

Text::Tabs — expand and unexpand tabs per the unix expand(1) and unexpand(1)

SYNOPSIS

```
use Text::Tabs;

$tabstop = 4;
@lines_without_tabs = expand(@lines_with_tabs);
@lines_with_tabs = unexpand(@lines_without_tabs);
```

DESCRIPTION

Text::Tabs does about what the unix utilities expand(1) and unexpand(1) do. Given a line with tabs in it, expand will replace the tabs with the appropriate number of spaces. Given a line with or without tabs in it, unexpand will add tabs when it can save bytes by doing so. Invisible compression with plain ascii!

BUGS

expand doesn't handle newlines very quickly — do not feed it an entire document in one string. Instead feed it an array of lines.

AUTHOR

David Muir Sharnoff <muir@idiom.com

NAME

Text::Wrap – line wrapping to form simple paragraphs

SYNOPSIS

```
use Text::Wrap

print wrap($initial_tab, $subsequent_tab, @text);
print fill($initial_tab, $subsequent_tab, @text);

use Text::Wrap qw(wrap $columns $huge);

$columns = 132;
$huge = 'die';
$huge = 'wrap';
```

DESCRIPTION

`Text::Wrap::wrap()` is a very simple paragraph formatter. It formats a single paragraph at a time by breaking lines at word boundaries. Indentation is controlled for the first line (`$initial_tab`) and all subsequent lines (`$subsequent_tab`) independently.

Lines are wrapped at `$Text::Wrap::columns` columns. `$Text::Wrap::columns` should be set to the full width of your output device.

When words that are longer than `$columns` are encountered, they are broken up. Previous versions of `wrap()` `die()`ed instead. To restore the old (dying) behavior, set `$Text::Wrap::huge` to 'die'.

`Text::Wrap::fill()` is a simple multi–paragraph formatter. It formats each paragraph separately and then joins them together when it's done. It will destroy any whitespace in the original text. It breaks text into paragraphs by looking for whitespace after a newline. In other respects it acts like `wrap()`.

EXAMPLE

```
print wrap("\t","","This is a bit of text that forms
        a normal book-style paragraph");
```

AUTHOR

David Muir Sharnoff <muir@idiom.com with help from Tim Pierce and many many others.

NAME

Tie::Array – base class for tied arrays

SYNOPSIS

```
package NewArray;
use Tie::Array;
@ISA = ('Tie::Array');

# mandatory methods
sub TIEARRAY { ... }
sub FETCH { ... }
sub FETCHSIZE { ... }

sub STORE { ... }         # mandatory if elements writeable
sub STORESIZE { ... }     # mandatory if elements can be added/deleted
sub EXISTS { ... }        # mandatory if exists() expected to work
sub DELETE { ... }        # mandatory if delete() expected to work

# optional methods - for efficiency
sub CLEAR { ... }
sub PUSH { ... }
sub POP { ... }
sub SHIFT { ... }
sub UNSHIFT { ... }
sub SPLICE { ... }
sub EXTEND { ... }
sub DESTROY { ... }

package NewStdArray;
use Tie::Array;

@ISA = ('Tie::StdArray');

# all methods provided by default

package main;

$object = tie @somearray,Tie::NewArray;
$object = tie @somearray,Tie::StdArray;
$object = tie @somearray,Tie::NewStdArray;
```

DESCRIPTION

This module provides methods for array–tying classes. See *perltie* for a list of the functions required in order to tie an array to a package. The basic **Tie::Array** package provides stub `DESTROY`, and `EXTEND` methods that do nothing, stub `DELETE` and `EXISTS` methods that `croak()` if the `delete()` or `exists()` builtins are ever called on the tied array, and implementations of `PUSH`, `POP`, `SHIFT`, `UNSHIFT`, `SPLICE` and `CLEAR` in terms of basic `FETCH`, `STORE`, `FETCHSIZE`, `STORESIZE`.

The **Tie::StdArray** package provides efficient methods required for tied arrays which are implemented as blessed references to an "inner" perl array. It inherits from **Tie::Array**, and should cause tied arrays to behave exactly like standard arrays, allowing for selective overloading of methods.

For developers wishing to write their own tied arrays, the required methods are briefly defined below. See the *perltie* section for more detailed descriptive, as well as example code:

TIEARRAY classname, LIST

The class method is invoked by the command `tie @array, classname`. Associates an array instance with the specified class. `LIST` would represent additional arguments (along the lines of *AnyDBM_File* and compatriots) needed to complete the association. The method should return an object of a class which provides the methods below.

STORE this, index, value

Store datum *value* into *index* for the tied array associated with object *this*. If this makes the array larger then class's mapping of `undef` should be returned for new positions.

FETCH this, index

Retrieve the datum in *index* for the tied array associated with object *this*.

FETCHSIZE this

Returns the total number of items in the tied array associated with object *this*. (Equivalent to `scalar(@array)`).

STORESIZE this, count

Sets the total number of items in the tied array associated with object *this* to be *count*. If this makes the array larger then class's mapping of `undef` should be returned for new positions. If the array becomes smaller then entries beyond count should be deleted.

EXTEND this, count

Informative call that array is likely to grow to have *count* entries. Can be used to optimize allocation. This method need do nothing.

EXISTS this, key

Verify that the element at index *key* exists in the tied array *this*.

The **Tie::Array** implementation is a stub that simply croaks.

DELETE this, key

Delete the element at index *key* from the tied array *this*.

The **Tie::Array** implementation is a stub that simply croaks.

CLEAR this

Clear (remove, delete, ...) all values from the tied array associated with object *this*.

DESTROY this

Normal object destructor method.

PUSH this, LIST

Append elements of LIST to the array.

POP this

Remove last element of the array and return it.

SHIFT this

Remove the first element of the array (shifting other elements down) and return it.

UNSHIFT this, LIST

Insert LIST elements at the beginning of the array, moving existing elements up to make room.

SPLICE this, offset, length, LIST

Perform the equivalent of `splice` on the array.

offset is optional and defaults to zero, negative values count back from the end of the array.

length is optional and defaults to rest of the array.

LIST may be empty.

Returns a list of the original *length* elements at *offset*.

CAVEATS

There is no support at present for tied @ISA. There is a potential conflict between magic entries needed to notice setting of @ISA, and those needed to implement 'tie'.

Very little consideration has been given to the behaviour of tied arrays when `$[` is not default value of zero.

AUTHOR

Nick Ing–Simmons <nik@tiuk.ti.com>

NAME

Tie::Handle, Tie::StdHandle – base class definitions for tied handles

SYNOPSIS

```
package NewHandle;
require Tie::Handle;

@ISA = (Tie::Handle);

sub READ { ... }            # Provide a needed method
sub TIEHANDLE { ... }       # Overrides inherited method

package main;

tie *FH, 'NewHandle';
```

DESCRIPTION

This module provides some skeletal methods for handle–tying classes. See *perltie* for a list of the functions required in tying a handle to a package. The basic **Tie::Handle** package provides a `new` method, as well as methods `TIEHANDLE`, `PRINT`, `PRINTF` and `GETC`.

For developers wishing to write their own tied–handle classes, the methods are summarized below. The *perltie* section not only documents these, but has sample code as well:

TIEHANDLE classname, LIST

The method invoked by the command `tie *glob, classname`. Associates a new glob instance with the specified class. `LIST` would represent additional arguments (along the lines of *AnyDBM_File* and compatriots) needed to complete the association.

WRITE this, scalar, length, offset

Write *length* bytes of data from *scalar* starting at *offset*.

PRINT this, LIST

Print the values in *LIST*

PRINTF this, format, LIST

Print the values in *LIST* using *format*

READ this, scalar, length, offset

Read *length* bytes of data into *scalar* starting at *offset*.

READLINE this

Read a single line

GETC this

Get a single character

CLOSE this

Close the handle

OPEN this, filename

(Re–)open the handle

BINMODE this

Specify content is binary

EOF this

Test for end of file.

TELL this

Return position in the file.

SEEK this, offset, whence

Position the file.

Test for end of file.

DESTROY this

Free the storage associated with the tied handle referenced by *this*. This is rarely needed, as Perl manages its memory quite well. But the option exists, should a class wish to perform specific actions upon the destruction of an instance.

MORE INFORMATION

The *perltie* section contains an example of tying handles.

COMPATIBILITY

This version of Tie::Handle is neither related to nor compatible with the Tie::Handle (3.0) module available on CPAN. It was due to an accident that two modules with the same name appeared. The namespace clash has been cleared in favor of this module that comes with the perl core in September 2000 and accordingly the version number has been bumped up to 4.0.

NAME

Tie::Hash, Tie::StdHash – base class definitions for tied hashes

SYNOPSIS

```
package NewHash;
require Tie::Hash;

@ISA = (Tie::Hash);

sub DELETE { ... }          # Provides needed method
sub CLEAR { ... }           # Overrides inherited method

package NewStdHash;
require Tie::Hash;

@ISA = (Tie::StdHash);

# All methods provided by default, define only those needing overrides
sub DELETE { ... }

package main;

tie %new_hash, 'NewHash';
tie %new_std_hash, 'NewStdHash';
```

DESCRIPTION

This module provides some skeletal methods for hash–tying classes. See *perltie* for a list of the functions required in order to tie a hash to a package. The basic **Tie::Hash** package provides a `new` method, as well as methods `TIEHASH`, `EXISTS` and `CLEAR`. The **Tie::StdHash** package provides most methods required for hashes in *perltie*. It inherits from **Tie::Hash**, and causes tied hashes to behave exactly like standard hashes, allowing for selective overloading of methods. The `new` method is provided as grandfathering in the case a class forgets to include a `TIEHASH` method.

For developers wishing to write their own tied hashes, the required methods are briefly defined below. See the *perltie* section for more detailed descriptive, as well as example code:

TIEHASH classname, LIST

The method invoked by the command `tie %hash, classname`. Associates a new hash instance with the specified class. `LIST` would represent additional arguments (along the lines of *AnyDBM_File* and compatriots) needed to complete the association.

STORE this, key, value

Store datum *value* into *key* for the tied hash *this*.

FETCH this, key

Retrieve the datum in *key* for the tied hash *this*.

FIRSTKEY this

Return the (key, value) pair for the first key in the hash.

NEXTKEY this, lastkey

Return the next key for the hash.

EXISTS this, key

Verify that *key* exists with the tied hash *this*.

The **Tie::Hash** implementation is a stub that simply croaks.

DELETE this, key

Delete the key *key* from the tied hash *this*.

CLEAR this

Clear all values from the tied hash *this*.

CAVEATS

The *perltie* documentation includes a method called `DESTROY` as a necessary method for tied hashes. Neither **Tie::Hash** nor **Tie::StdHash** define a default for this method. This is a standard for class packages, but may be omitted in favor of a simple default.

MORE INFORMATION

The packages relating to various DBM−related implementations (***DB_File***, ***NDBM_File***, etc.) show examples of general tied hashes, as does the *Config* module. While these do not utilize **Tie::Hash**, they serve as good working examples.

NAME

Tie::RefHash – use references as hash keys

SYNOPSIS

```
require 5.004;
use Tie::RefHash;
tie HASHVARIABLE, 'Tie::RefHash', LIST;
tie HASHVARIABLE, 'Tie::RefHash::Nestable', LIST;

untie HASHVARIABLE;
```

DESCRIPTION

This module provides the ability to use references as hash keys if you first `tie` the hash variable to this module. Normally, only the keys of the tied hash itself are preserved as references; to use references as keys in hashes–of–hashes, use Tie::RefHash::Nestable, included as part of Tie::Hash.

It is implemented using the standard perl TIEHASH interface. Please see the `tie` entry in perlfunc(1) and perltie(1) for more information.

The Nestable version works by looking for hash references being stored and converting them to tied hashes so that they too can have references as keys. This will happen without warning whenever you store a reference to one of your own hashes in the tied hash.

EXAMPLE

```
use Tie::RefHash;
tie %h, 'Tie::RefHash';
$a = [];
$b = {};
$c = \*main;
$d = \"gunk";
$e = sub { 'foo' };
%h = ($a => 1, $b => 2, $c => 3, $d => 4, $e => 5);
$a->[0] = 'foo';
$b->{foo} = 'bar';
for (keys %h) {
   print ref($_), "\n";
}

tie %h, 'Tie::RefHash::Nestable';
$h{$a}->{$b} = 1;
for (keys %h, keys %{$h{$a}}) {
   print ref($_), "\n";
}
```

AUTHOR

Gurusamy Sarathy gsar@activestate.com

VERSION

Version 1.21 22 Jun 1999

SEE ALSO

perl(1), perlfunc(1), perltie(1)

NAME

Tie::Scalar, Tie::StdScalar – base class definitions for tied scalars

SYNOPSIS

```
package NewScalar;
require Tie::Scalar;

@ISA = (Tie::Scalar);

sub FETCH { ... }           # Provide a needed method
sub TIESCALAR { ... }       # Overrides inherited method

package NewStdScalar;
require Tie::Scalar;

@ISA = (Tie::StdScalar);

# All methods provided by default, so define only what needs be overridden
sub FETCH { ... }

package main;

tie $new_scalar, 'NewScalar';
tie $new_std_scalar, 'NewStdScalar';
```

DESCRIPTION

This module provides some skeletal methods for scalar–tying classes. See *perltie* for a list of the functions required in tying a scalar to a package. The basic **Tie::Scalar** package provides a `new` method, as well as methods `TIESCALAR`, `FETCH` and `STORE`. The **Tie::StdScalar** package provides all the methods specified in *perltie*. It inherits from **Tie::Scalar** and causes scalars tied to it to behave exactly like the built–in scalars, allowing for selective overloading of methods. The `new` method is provided as a means of grandfathering, for classes that forget to provide their own `TIESCALAR` method.

For developers wishing to write their own tied–scalar classes, the methods are summarized below. The *perltie* section not only documents these, but has sample code as well:

TIESCALAR classname, LIST

The method invoked by the command `tie $scalar, classname`. Associates a new scalar instance with the specified class. `LIST` would represent additional arguments (along the lines of *AnyDBM_File* and compatriots) needed to complete the association.

FETCH this

Retrieve the value of the tied scalar referenced by *this*.

STORE this, value

Store data *value* in the tied scalar referenced by *this*.

DESTROY this

Free the storage associated with the tied scalar referenced by *this*. This is rarely needed, as Perl manages its memory quite well. But the option exists, should a class wish to perform specific actions upon the destruction of an instance.

MORE INFORMATION

The *perltie* section uses a good example of tying scalars by associating process IDs with priority.

NAME

Tie::SubstrHash – Fixed–table–size, fixed–key–length hashing

SYNOPSIS

```
require Tie::SubstrHash;

tie %myhash, 'Tie::SubstrHash', $key_len, $value_len, $table_size;
```

DESCRIPTION

The **Tie::SubstrHash** package provides a hash–table–like interface to an array of determinate size, with constant key size and record size.

Upon tying a new hash to this package, the developer must specify the size of the keys that will be used, the size of the value fields that the keys will index, and the size of the overall table (in terms of key–value pairs, not size in hard memory). *These values will not change for the duration of the tied hash*. The newly–allocated hash table may now have data stored and retrieved. Efforts to store more than `$table_size` elements will result in a fatal error, as will efforts to store a value not exactly `$value_len` characters in length, or reference through a key not exactly `$key_len` characters in length. While these constraints may seem excessive, the result is a hash table using much less internal memory than an equivalent freely–allocated hash table.

CAVEATS

Because the current implementation uses the table and key sizes for the hashing algorithm, there is no means by which to dynamically change the value of any of the initialization parameters.

The hash does not support `exists()`.

NAME

Time::gmtime – by–name interface to Perl's built–in `gmtime()` function

SYNOPSIS

```
use Time::gmtime;
$gm = gmtime();
printf "The day in Greenwich is %s\n",
   (qw(Sun Mon Tue Wed Thu Fri Sat Sun))[ gm->wday() ];

use Time::gmtime w(:FIELDS;
printf "The day in Greenwich is %s\n",
   (qw(Sun Mon Tue Wed Thu Fri Sat Sun))[ gm_wday() ];

$now = gmctime();

use Time::gmtime;
use File::stat;
$date_string = gmctime(stat($file)->mtime);
```

DESCRIPTION

This module's default exports override the core `gmtime()` function, replacing it with a version that returns "Time::tm" objects. This object has methods that return the similarly named structure field name from the C's tm structure from ***time.h***; namely sec, min, hour, mday, mon, year, wday, yday, and isdst.

You may also import all the structure fields directly into your namespace as regular variables using the :FIELDS import tag. (Note that this still overrides your core functions.) Access these fields as variables named with a preceding `tm_` in front their method names. Thus, `$tm_obj->mday()` corresponds to `$tm_mday` if you import the fields.

The `gmctime()` function provides a way of getting at the scalar sense of the original `CORE::gmtime()` function.

To access this functionality without the core overrides, pass the `use` an empty import list, and then access function functions with their full qualified names. On the other hand, the built–ins are still available via the `CORE::` pseudo–package.

NOTE

While this class is currently implemented using the Class::Struct module to build a struct–like class, you shouldn't rely upon this.

AUTHOR

Tom Christiansen

NAME

Time::Local – efficiently compute time from local and GMT time

SYNOPSIS

```
$time = timelocal($sec,$min,$hours,$mday,$mon,$year);
$time = timegm($sec,$min,$hours,$mday,$mon,$year);
```

DESCRIPTION

These routines are the inverse of built–in perl fuctions `localtime()` and `gmtime()`. They accept a date as a six–element array, and return the corresponding time(2) value in seconds since the Epoch (Midnight, January 1, 1970). This value can be positive or negative.

It is worth drawing particular attention to the expected ranges for the values provided. While the day of the month is expected to be in the range 1..31, the month should be in the range 0..11. This is consistent with the values returned from `localtime()` and `gmtime()`.

The `timelocal()` and `timegm()` functions perform range checking on the input `$sec`, `$min`, `$hours`, `$mday`, and `$mon` values by default. If you'd rather they didn't, you can explicitly import the `timelocal_nocheck()` and `timegm_nocheck()` functions.

```
use Time::Local 'timelocal_nocheck';

{
    # The 365th day of 1999
    print scalar localtime timelocal_nocheck 0,0,0,365,0,99;

    # The twenty thousandth day since 1970
    print scalar localtime timelocal_nocheck 0,0,0,20000,0,70;

    # And even the 10,000,000th second since 1999!
    print scalar localtime timelocal_nocheck 10000000,0,0,1,0,99;
}
```

Your mileage may vary when trying these with minutes and hours, and it doesn't work at all for months.

Strictly speaking, the year should also be specified in a form consistent with `localtime()`, i.e. the offset from 1900. In order to make the interpretation of the year easier for humans, however, who are more accustomed to seeing years as two–digit or four–digit values, the following conventions are followed:

- Years greater than 999 are interpreted as being the actual year, rather than the offset from 1900. Thus, 1963 would indicate the year Martin Luther King won the Nobel prize, not the year 2863.
- Years in the range 100..999 are interpreted as offset from 1900, so that 112 indicates 2012. This rule also applies to years less than zero (but see note below regarding date range).
- Years in the range 0..99 are interpreted as shorthand for years in the rolling "current century," defined as 50 years on either side of the current year. Thus, today, in 1999, 0 would refer to 2000, and 45 to 2045, but 55 would refer to 1955. Twenty years from now, 55 would instead refer to 2055. This is messy, but matches the way people currently think about two digit dates. Whenever possible, use an absolute four digit year instead.

The scheme above allows interpretation of a wide range of dates, particularly if 4–digit years are used.

Please note, however, that the range of dates that can be actually be handled depends on the size of an integer (time_t) on a given platform. Currently, this is 32 bits for most systems, yielding an approximate range from Dec 1901 to Jan 2038.

Both `timelocal()` and `timegm()` croak if given dates outside the supported range.

IMPLEMENTATION

These routines are quite efficient and yet are always guaranteed to agree with `localtime()` and `gmtime()`. We manage this by caching the start times of any months we've seen before. If we know the start time of the month, we can always calculate any time within the month. The start times themselves are guessed by successive approximation starting at the current time, since most dates seen in practice are close to the current date. Unlike algorithms that do a binary search (calling gmtime once for each bit of the time value, resulting in 32 calls), this algorithm calls it at most 6 times, and usually only once or twice. If you hit the month cache, of course, it doesn't call it at all.

`timelocal()` is implemented using the same cache. We just assume that we're translating a GMT time, and then fudge it when we're done for the timezone and daylight savings arguments. Note that the timezone is evaluated for each date because countries occasionally change their official timezones. Assuming that `localtime()` corrects for these changes, this routine will also be correct. The daylight savings offset is currently assumed to be one hour.

BUGS

The whole scheme for interpreting two−digit years can be considered a bug.

Note that the cache currently handles only years from 1900 through 2155.

The proclivity to `croak()` is probably a bug.

NAME

Time::localtime – by–name interface to Perl's built–in `localtime()` function

SYNOPSIS

```
use Time::localtime;
printf "Year is %d\n", localtime->year() + 1900;

$now = ctime();

use Time::localtime;
use File::stat;
$date_string = ctime(stat($file)->mtime);
```

DESCRIPTION

This module's default exports override the core `localtime()` function, replacing it with a version that returns "Time::tm" objects. This object has methods that return the similarly named structure field name from the C's tm structure from ***time.h***; namely sec, min, hour, mday, mon, year, wday, yday, and isdst.

You may also import all the structure fields directly into your namespace as regular variables using the :FIELDS import tag. (Note that this still overrides your core functions.) Access these fields as variables named with a preceding `tm_` in front their method names. Thus, `$tm_obj->mday()` corresponds to `$tm_mday` if you import the fields.

The `ctime()` function provides a way of getting at the scalar sense of the original `CORE::localtime()` function.

To access this functionality without the core overrides, pass the `use` an empty import list, and then access function functions with their full qualified names. On the other hand, the built–ins are still available via the `CORE::` pseudo–package.

NOTE

While this class is currently implemented using the Class::Struct module to build a struct–like class, you shouldn't rely upon this.

AUTHOR

Tom Christiansen

NAME

Time::tm – internal object used by Time::gmtime and Time::localtime

SYNOPSIS

Don't use this module directly.

DESCRIPTION

This module is used internally as a base class by Time::localtime And Time::gmtime functions. It creates a Time::tm struct object which is addressable just like's C's tm structure from ***time.h***; namely with sec, min, hour, mday, mon, year, wday, yday, and isdst.

This class is an internal interface only.

AUTHOR

Tom Christiansen

NAME

UNIVERSAL – base class for ALL classes (blessed references)

SYNOPSIS

```
$io = $fd->isa("IO::Handle");
$sub = $obj->can('print');

$yes = UNIVERSAL::isa($ref, "HASH");
```

DESCRIPTION

`UNIVERSAL` is the base class which all bless references will inherit from, see *perlobj*

`UNIVERSAL` provides the following methods

isa (TYPE)

`isa` returns *true* if `REF` is blessed into package `TYPE` or inherits from package `TYPE`.

`isa` can be called as either a static or object method call.

can (METHOD)

`can` checks if the object has a method called `METHOD`. If it does then a reference to the sub is returned. If it does not then *undef* is returned.

`can` can be called as either a static or object method call.

VERSION ([REQUIRE])

`VERSION` will return the value of the variable `$VERSION` in the package the object is blessed into. If `REQUIRE` is given then it will do a comparison and die if the package version is not greater than or equal to `REQUIRE`.

`VERSION` can be called as either a static or object method call.

The `isa` and `can` methods can also be called as subroutines

UNIVERSAL::isa (VAL, TYPE)

`isa` returns *true* if one of the following statements is true.

- `VAL` is a reference blessed into either package `TYPE` or a package which inherits from package `TYPE`.
- `VAL` is a reference to a `TYPE` of Perl variable (e.g. 'HASH').
- `VAL` is the name of a package that inherits from (or is itself) package `TYPE`.

UNIVERSAL::can (VAL, METHOD)

If `VAL` is a blessed reference which has a method called `METHOD`, `can` returns a reference to the subroutine. If `VAL` is not a blessed reference, or if it does not have a method `METHOD`, *undef* is returned.

These subroutines should *not* be imported via `use UNIVERSAL qw(...)`. If you want simple local access to them you can do

```
*isa = \&UNIVERSAL::isa;
```

to import isa into your package.

NAME

User::grent – by–name interface to Perl's built–in `getgr*()` functions

SYNOPSIS

```
use User::grent;
$gr = getgrgid(0) or die "No group zero";
if ( $gr->name eq 'wheel' && @{$gr->members} > 1 ) {
    print "gid zero name wheel, with other members";
}

use User::grent qw(:FIELDS;
getgrgid(0) or die "No group zero";
if ( $gr_name eq 'wheel' && @gr_members > 1 ) {
    print "gid zero name wheel, with other members";
}

$gr = getgr($whoever);
```

DESCRIPTION

This module's default exports override the core `getgrent()`, `getgruid()`, and `getgrnam()` functions, replacing them with versions that return "User::grent" objects. This object has methods that return the similarly named structure field name from the C's passwd structure from ***grp.h***; namely name, passwd, gid, and members (not mem). The first three return scalars, the last an array reference.

You may also import all the structure fields directly into your namespace as regular variables using the :FIELDS import tag. (Note that this still overrides your core functions.) Access these fields as variables named with a preceding `gr_`. Thus, `$group_obj->gid()` corresponds to `$gr_gid` if you import the fields. Array references are available as regular array variables, so `@{ $group_obj->members() }` would be simply @gr_members.

The `getpw()` function is a simple front–end that forwards a numeric argument to `getpwuid()` and the rest to `getpwnam()`.

To access this functionality without the core overrides, pass the `use` an empty import list, and then access function functions with their full qualified names. On the other hand, the built–ins are still available via the `CORE::` pseudo–package.

NOTE

While this class is currently implemented using the Class::Struct module to build a struct–like class, you shouldn't rely upon this.

AUTHOR

Tom Christiansen

NAME

User::pwent – by–name interface to Perl's built–in `getpw*()` functions

SYNOPSIS

```
use User::pwent;
$pw = getpwnam('daemon')       || die "No daemon user";
if ( $pw->uid == 1 && $pw->dir =~ m#^/(bin|tmp)?\z#s ) {
    print "gid 1 on root dir";
}

$real_shell = $pw->shell || '/bin/sh';

for (($fullname, $office, $workphone, $homephone) =
       split /\s*,\s*/, $pw->gecos)
{
   s/&/ucfirst(lc($pw->name))/ge;
}

use User::pwent qw(:FIELDS);
getpwnam('daemon')             || die "No daemon user";
if ( $pw_uid == 1 && $pw_dir =~ m#^/(bin|tmp)?\z#s ) {
    print "gid 1 on root dir";
}

$pw = getpw($whoever);

use User::pwent qw/:DEFAULT pw_has/;
if (pw_has(qw[gecos expire quota])) { .... }
if (pw_has("name uid gid passwd"))  { .... }
print "Your struct pwd has: ", scalar pw_has(), "\n";
```

DESCRIPTION

This module's default exports override the core `getpwent()`, `getpwuid()`, and `getpwnam()` functions, replacing them with versions that return `User::pwent` objects. This object has methods that return the similarly named structure field name from the C's passwd structure from ***pwd.h***, stripped of their leading "pw_" parts, namely `name`, `passwd`, `uid`, `gid`, `change`, `age`, `quota`, `comment`, `class`, `gecos`, `dir`, `shell`, and `expire`. The `passwd`, `gecos`, and `shell` fields are tainted when running in taint mode.

You may also import all the structure fields directly into your namespace as regular variables using the :FIELDS import tag. (Note that this still overrides your core functions.) Access these fields as variables named with a preceding `pw_` in front their method names. Thus, `< $passwd_obj-shell` corresponds to `$pw_shell` if you import the fields.

The `getpw()` function is a simple front–end that forwards a numeric argument to `getpwuid()` and the rest to `getpwnam()`.

To access this functionality without the core overrides, pass the `use` an empty import list, and then access function functions with their full qualified names. The built–ins are always still available via the `CORE::` pseudo–package.

System Specifics

Perl believes that no machine ever has more than one of `change`, `age`, or `quota` implemented, nor more than one of either `comment` or `class`. Some machines do not support `expire`, `gecos`, or allegedly, `passwd`. You may call these methods no matter what machine you're on, but they return `undef` if unimplemented.

You may ask whether one of these was implemented on the system Perl was built on by asking the importable `pw_has` function about them. This function returns true if all parameters are supported fields on

the build platform, false if one or more were not, and raises an exception if you asked about a field that Perl never knows how to provide. Parameters may be in a space−separated string, or as separate arguments. If you pass no parameters, the function returns the list of `struct pwd` fields supported by your build platform's C library, as a list in list context, or a space−separated string in scalar context. Note that just because your C library had a field doesn't necessarily mean that it's fully implemented on that system.

Interpretation of the `gecos` field varies between systems, but traditionally holds 4 comma−separated fields containing the user's full name, office location, work phone number, and home phone number. An `&` in the gecos field should be replaced by the user's properly capitalized login `name`. The `shell` field, if blank, must be assumed to be ***/bin/sh***. Perl does not do this for you. The `passwd` is one−way hashed garble, not clear text, and may not be unhashed save by brute−force guessing. Secure systems use more a more secure hashing than DES. On systems supporting shadow password systems, Perl automatically returns the shadow password entry when called by a suitably empowered user, even if your underlying vendor−provided C library was too short−sighted to realize it should do this.

See passwd(5) and getpwent(3) for details.

NOTE

While this class is currently implemented using the Class::Struct module to build a struct−like class, you shouldn't rely upon this.

AUTHOR

Tom Christiansen

HISTORY

March 18th, 2000

Reworked internals to support better interface to dodgey fields than normal Perl function provides. Added `pw_has()` field. Improved documentation.

NAME

utf8 – Perl pragma to enable/disable UTF–8 in source code

SYNOPSIS

```
use utf8;
no utf8;
```

DESCRIPTION

WARNING: The implementation of Unicode support in Perl is incomplete. See *perlunicode* for the exact details.

The `use utf8` pragma tells the Perl parser to allow UTF–8 in the program text in the current lexical scope. The `no utf8` pragma tells Perl to switch back to treating the source text as literal bytes in the current lexical scope.

This pragma is primarily a compatibility device. Perl versions earlier than 5.6 allowed arbitrary bytes in source code, whereas in future we would like to standardize on the UTF–8 encoding for source text. Until UTF–8 becomes the default format for source text, this pragma should be used to recognize UTF–8 in the source. When UTF–8 becomes the standard source format, this pragma will effectively become a no–op. This pragma already is a no–op on EBCDIC platforms (where it is alright to code perl in EBCDIC rather than UTF–8).

Enabling the `utf8` pragma has the following effects:

- Bytes in the source text that have their high–bit set will be treated as being part of a literal UTF–8 character. This includes most literals such as identifiers, string constants, constant regular expression patterns and package names.
- In the absence of inputs marked as UTF–8, regular expressions within the scope of this pragma will default to using character semantics instead of byte semantics.

```
@bytes_or_chars = split //, $data;  # may split to bytes if data
                                    # $data isn't UTF-8
{
    use utf8;                       # force char semantics
    @chars = split //, $data;       # splits characters
}
```

SEE ALSO

perlunicode, *bytes*

NAME

vars – Perl pragma to predeclare global variable names (obsolete)

SYNOPSIS

```
use vars qw($frob @mung %seen);
```

DESCRIPTION

NOTE: The functionality provided by this pragma has been superseded by `our` declarations, available in Perl v5.6.0 or later. See *our*.

This will predeclare all the variables whose names are in the list, allowing you to use them under "use strict", and disabling any typo warnings.

Unlike pragmas that affect the `$^H` hints variable, the `use vars` and `use subs` declarations are not BLOCK–scoped. They are thus effective for the entire file in which they appear. You may not rescind such declarations with `no vars` or `no subs`.

Packages such as the **AutoLoader** and **SelfLoader** that delay loading of subroutines within packages can create problems with package lexicals defined using `my()`. While the **vars** pragma cannot duplicate the effect of package lexicals (total transparency outside of the package), it can act as an acceptable substitute by pre–declaring global symbols, ensuring their availability to the later–loaded routines.

See *Pragmatic Modules*.

NAME

warnings::register – warnings import function

NAME

warnings – Perl pragma to control optional warnings

SYNOPSIS

```
use warnings;
no warnings;

use warnings "all";
no warnings "all";

use warnings::register;
if (warnings::enabled()) {
    warnings::warn("some warning");
}

if (warnings::enabled("void")) {
    warnings::warn("void", "some warning");
}

if (warnings::enabled($object)) {
    warnings::warn($object, "some warning");
}

warnif("some warning");
warnif("void", "some warning");
warnif($object, "some warning");
```

DESCRIPTION

If no import list is supplied, all possible warnings are either enabled or disabled.

A number of functions are provided to assist module authors.

use warnings::register

Creates a new warnings category with the same name as the package where the call to the pragma is used.

`warnings::enabled()`

Use the warnings category with the same name as the current package.

Return TRUE if that warnings category is enabled in the calling module. Otherwise returns FALSE.

warnings::enabled(`$category`)

Return TRUE if the warnings category, `$category`, is enabled in the calling module. Otherwise returns FALSE.

warnings::enabled(`$object`)

Use the name of the class for the object reference, `$object`, as the warnings category.

Return TRUE if that warnings category is enabled in the first scope where the object is used. Otherwise returns FALSE.

warnings::warn(`$message`)

Print `$message` to STDERR.

Use the warnings category with the same name as the current package.

If that warnings category has been set to "FATAL" in the calling module then die. Otherwise return.

warnings::warn(`$category, $message`)

Print `$message` to STDERR.

If the warnings category, `$category`, has been set to "FATAL" in the calling module then die. Otherwise return.

warnings::warn(`$object, $message`)

Print `$message` to STDERR.

Use the name of the class for the object reference, `$object`, as the warnings category.

If that warnings category has been set to "FATAL" in the scope where `$object` is first used then die. Otherwise return.

warnings::warnif(`$message`)

Equivalent to:

```
if (warnings::enabled())
  { warnings::warn($message) }
```

warnings::warnif(`$category, $message`)

Equivalent to:

```
if (warnings::enabled($category))
  { warnings::warn($category, $message) }
```

warnings::warnif(`$object, $message`)

Equivalent to:

```
if (warnings::enabled($object))
  { warnings::warn($object, $message) }
```

See *Pragmatic Modules* and *perllexwarn*.

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