

gawk.info

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Chapter 1

gawk.info

1.1 gawk.info

General Introduction

This file documents `awk`, a program that you can use to select particular records in a file and perform operations upon them.

This is Edition 0.15 of 'The GAWK Manual', for the 2.15 version of the GNU implementation of AWK.

Preface

What you can do with `awk`; brief history and acknowledgements.

Copying

Your right to copy and distribute `gawk`.

This Manual

Using this manual.
Includes sample input files that you can use.

Getting Started

A basic introduction to using `awk`.
How to run an `awk` program.
Command line syntax.

Reading Files

How to read files and manipulate fields.

Printing

How to print using `awk`. Describes the `print` and `printf` statements.
Also describes redirection of output.

One-liners

Short, sample `awk` programs.

Patterns

The various types of patterns explained in detail.

Actions

The various types of actions are introduced here. Describes expressions and the various operators in detail. Also describes comparison expressions.

Expressions

Expressions are the basic building blocks of statements.

Statements

The various control statements are described in detail.

Arrays

The description and use of arrays. Also includes array-oriented control statements.

Built-in

The built-in functions are summarized here.

User-defined

User-defined functions are described in detail.

Built-in Variables

Built-in Variables

Command Line

How to run gawk.

Language History

The evolution of the awk language.

Installation

Installing gawk under various operating systems.

Gawk Summary

gawk Options and Language Summary.

Sample Program

A sample awk program with a complete explanation.

Bugs

Reporting Problems and Bugs.

Notes

Something about the implementation of gawk.

Glossary

An explanation of some unfamiliar terms.

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1.2 gawk.info/Preface

Preface

If you are like many computer users, you would frequently like to make changes in various text files wherever certain patterns appear, or extract data from parts of certain lines while discarding the rest. To write a program to do this in a language such as C or Pascal is a time-consuming inconvenience that may take many lines of code. The job may be easier with awk.

The awk utility interprets a special-purpose programming language that makes it possible to handle simple data-reformatting jobs easily with just a few lines of code.

The GNU implementation of awk is called gawk; it is fully upward compatible with the System V Release 4 version of awk. gawk is also upward compatible with the POSIX (draft) specification of the awk language. This means that all properly written awk programs should work with gawk. Thus, we usually don't distinguish between gawk and other awk implementations in this manual.

This manual teaches you what awk does and how you can use awk effectively. You should already be familiar with basic system commands such as ls. Using awk you can:

- * manage small, personal databases
- * generate reports
- * validate data
- * produce indexes, and perform other document preparation tasks
- * even experiment with algorithms that can be adapted later to other computer languages

History

The history of gawk and
awk. Acknowledgements.

1.3 gawk.info/History

History of awk and gawk
=====

The name awk comes from the initials of its designers: Alfred V. Aho, Peter J. Weinberger, and Brian W. Kernighan. The original version of awk was written in 1977. In 1985 a new version made the programming language more powerful, introducing user-defined functions, multiple input streams, and computed regular expressions. This new version became generally available with System V Release 3.1. The version in System V Release 4 added some new features and also cleaned up the behavior in some of the "dark corners" of the language. The specification for awk in the POSIX Command Language and Utilities standard further clarified the language based on feedback from both the gawk designers, and the original awk designers.

The GNU implementation, gawk, was written in 1986 by Paul Rubin and Jay Fenlason, with advice from Richard Stallman. John Woods contributed parts of the code as well. In 1988 and 1989, David Trueman, with help from Arnold Robbins, thoroughly reworked gawk for compatibility with the newer awk. Current development (1992) focuses on bug fixes, performance improvements, and standards compliance.

We need to thank many people for their assistance in producing this manual. Jay Fenlason contributed many ideas and sample programs. Richard Mlynarik and Robert J. Chassell gave helpful comments on early drafts of this manual. The paper 'A Supplemental Document for awk' by John W. Pierce of the Chemistry Department at UC San Diego, pinpointed several issues relevant both to awk implementation and to this manual, that would otherwise have escaped us. David Trueman, Pat Rankin, and Michal Jaegermann also contributed sections of the manual.

The following people provided many helpful comments on this edition of the manual: Rick Adams, Michael Brennan, Rich Burrridge, Diane Close, Christopher ("Topher") Eliot, Michael Lijewski, Pat Rankin, Miriam Robbins, and Michal Jaegermann. Robert J. Chassell provided much valuable advice on the use of Texinfo.

Finally, we would like to thank Brian Kernighan of Bell Labs for invaluable assistance during the testing and debugging of gawk, and for help in clarifying numerous points about the language.

1.4 gawk.info/Copying

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1.5 gawk.info/This Manual

Using this Manual

The term `awk` refers to a particular program, and to the language you use to tell this program what to do. When we need to be careful, we call the program "the `awk` utility" and the language "the `awk` language." The term `gawk` refers to a version of `awk` developed as part the GNU project. The purpose of this manual is to explain both the `awk` language and how to run the `awk` utility.

While concentrating on the features of `gawk`, the manual will also attempt to describe important differences between `gawk` and other `awk` implementations. In particular, any features that are not in the POSIX standard for `awk` will be noted.

The term `awk` program refers to a program written by you in the `awk` programming language.

See

Getting Started with `awk`
, for the bare essentials you need to

know to start using `awk`.

Some useful "one-liners" are included to give you a feel for the `awk` language (see Useful).

A sample `awk` program has been provided for you (see
Sample Program
).

If you find terms that you aren't familiar with, try looking them up in the glossary (see
Glossary
).

The entire `awk` language is summarized for quick reference in

`gawk` Summary

. Look there if you just need to refresh your memory about a particular feature.

Most of the time complete `awk` programs are used as examples, but in some of the more advanced sections, only the part of the `awk` program

that illustrates the concept being described is shown.

Sample Data Files

Sample data files for use in the awk programs illustrated in this manual.

1.6 gawk.info/Sample Data Files

Data Files for the Examples

=====

Many of the examples in this manual take their input from two sample data files. The first, called BBS-list, represents a list of computer bulletin board systems together with information about those systems. The second data file, called inventory-shipped, contains information about shipments on a monthly basis. Each line of these files is one record.

In the file BBS-list, each record contains the name of a computer bulletin board, its phone number, the board's baud rate, and a code for the number of hours it is operational. An A in the last column means the board operates 24 hours a day. A B in the last column means the board operates evening and weekend hours, only. A C means the board operates only on weekends.

aardvark	555-5553	1200/300	B
alpo-net	555-3412	2400/1200/300	A
barfly	555-7685	1200/300	A
bites	555-1675	2400/1200/300	A
camelot	555-0542	300	C
core	555-2912	1200/300	C
fooeY	555-1234	2400/1200/300	B
foot	555-6699	1200/300	B
macfoo	555-6480	1200/300	A
sdace	555-3430	2400/1200/300	A
sabafoo	555-2127	1200/300	C

The second data file, called inventory-shipped, represents information about shipments during the year. Each record contains the month of the year, the number of green crates shipped, the number of red boxes shipped, the number of orange bags shipped, and the number of blue packages shipped, respectively. There are 16 entries, covering the 12 months of one year and 4 months of the next year.

Jan	13	25	15	115
Feb	15	32	24	226
Mar	15	24	34	228
Apr	31	52	63	420
May	16	34	29	208
Jun	31	42	75	492
Jul	24	34	67	436

```

Aug 15 34 47 316
Sep 13 55 37 277
Oct 29 54 68 525
Nov 20 87 82 577
Dec 17 35 61 401

Jan 21 36 64 620
Feb 26 58 80 652
Mar 24 75 70 495
Apr 21 70 74 514

```

If you are reading this in GNU Emacs using Info, you can copy the regions of text showing these sample files into your own test files. This way you can try out the examples shown in the remainder of this document. You do this by using the command M-x write-region to copy text from the Info file into a file for use with awk (See Misc File Ops, for more information). Using this information, create your own BBS-list and inventory-shipped files, and practice what you learn in this manual.

1.7 gawk.info/Getting Started

Getting Started with awk

The basic function of awk is to search files for lines (or other units of text) that contain certain patterns. When a line matches one of the patterns, awk performs specified actions on that line. awk keeps processing input lines in this way until the end of the input file is reached.

When you run awk, you specify an awk program which tells awk what to do. The program consists of a series of rules. (It may also contain function definitions, but that is an advanced feature, so we will ignore it for now. See

User-defined Functions

.) Each rule specifies

one pattern to search for, and one action to perform when that pattern is found.

Syntactically, a rule consists of a pattern followed by an action. The action is enclosed in curly braces to separate it from the pattern. Rules are usually separated by newlines. Therefore, an awk program looks like this:

```

pattern { action }
pattern { action }
...

```

Very Simple

A very simple example.

Two Rules	A less simple one-line example with two rules.
More Complex	A more complex example.
Running gawk	How to run gawk programs; includes command line syntax.
Comments	Adding documentation to gawk programs.
Statements-Lines	Subdividing or combining statements into lines.
When	When to use gawk and when to use other things.

1.8 gawk.info/Very Simple

A Very Simple Example

=====

The following command runs a simple awk program that searches the input file BBS-list for the string of characters: foo. (A string of characters is usually called, a string. The term string is perhaps based on similar usage in English, such as "a string of pearls," or, "a string of cars in a train.")

```
awk '/foo/ { print $0 }' BBS-list
```

When lines containing foo are found, they are printed, because print \$0 means print the current line. (Just print by itself means the same thing, so we could have written that instead.)

You will notice that slashes, /, surround the string foo in the actual awk program. The slashes indicate that foo is a pattern to search for. This type of pattern is called a regular expression, and is covered in more detail later (see

Regular Expressions as Patterns
)

There are single-quotes around the awk program so that the shell won't interpret any of it as special shell characters.

Here is what this program prints:

foeey	555-1234	2400/1200/300	B
foot	555-6699	1200/300	B
macfoo	555-6480	1200/300	A
sabafoo	555-2127	1200/300	C

In an awk rule, either the pattern or the action can be omitted, but not both. If the pattern is omitted, then the action is performed for every input line. If the action is omitted, the default action is to print all lines that match the pattern.

Thus, we could leave out the action (the print statement and the curly braces) in the above example, and the result would be the same: all lines matching the pattern `foo` would be printed. By comparison, omitting the print statement but retaining the curly braces makes an empty action that does nothing; then no lines would be printed.

1.9 gawk.info/Two Rules

An Example with Two Rules

=====

The awk utility reads the input files one line at a time. For each line, awk tries the patterns of each of the rules. If several patterns match then several actions are run, in the order in which they appear in the awk program. If no patterns match, then no actions are run.

After processing all the rules (perhaps none) that match the line, awk reads the next line (however, see

The next Statement

). This

continues until the end of the file is reached.

For example, the awk program:

```
/12/ { print $0 }
/21/ { print $0 }
```

contains two rules. The first rule has the string `12` as the pattern and `print $0` as the action. The second rule has the string `21` as the pattern and also has `print $0` as the action. Each rule's action is enclosed in its own pair of braces.

This awk program prints every line that contains the string `12` or the string `21`. If a line contains both strings, it is printed twice, once by each rule.

If we run this program on our two sample data files, `BBS-list` and `inventory-shipped`, as shown here:

```
awk '/12/ { print $0 }
     /21/ { print $0 }' BBS-list inventory-shipped
```

we get the following output:

```
aardvark      555-5553      1200/300      B
alpo-net      555-3412      2400/1200/300 A
barfly        555-7685      1200/300      A
bites         555-1675      2400/1200/300 A
```

```

core          555-2912      1200/300      C
fooe          555-1234      2400/1200/300 B
foot         555-6699      1200/300      B
macfoo       555-6480      1200/300      A
sdace        555-3430      2400/1200/300 A
sabafoo      555-2127      1200/300      C
sabafoo      555-2127      1200/300      C
Jan  21  36  64  620
Apr  21  70  74  514

```

Note how the line in BBS-list beginning with sabafoo was printed twice, once for each rule.

1.10 gawk.info/More Complex

A More Complex Example

```
=====
```

Here is an example to give you an idea of what typical awk programs do. This example shows how awk can be used to summarize, select, and rearrange the output of another utility. It uses features that haven't been covered yet, so don't worry if you don't understand all the details.

```
ls -l | awk '$5 == "Nov" { sum += $4 }
           END { print sum }'
```

This command prints the total number of bytes in all the files in the current directory that were last modified in November (of any year). (In the C shell you would need to type a semicolon and then a backslash at the end of the first line; in a POSIX-compliant shell, such as the Bourne shell or the Bourne-Again shell, you can type the example as shown.)

The `ls -l` part of this example is a command that gives you a listing of the files in a directory, including file size and date. Its output looks like this:

```

-rw-r--r--  1 close          1933 Nov  7 13:05 Makefile
-rw-r--r--  1 close        10809 Nov  7 13:03 gawk.h
-rw-r--r--  1 close           983 Apr 13 12:14 gawk.tab.h
-rw-r--r--  1 close       31869 Jun 15 12:20 gawk.y
-rw-r--r--  1 close      22414 Nov  7 13:03 gawk1.c
-rw-r--r--  1 close      37455 Nov  7 13:03 gawk2.c
-rw-r--r--  1 close      27511 Dec  9 13:07 gawk3.c
-rw-r--r--  1 close       7989 Nov  7 13:03 gawk4.c

```

The first field contains read-write permissions, the second field contains the number of links to the file, and the third field identifies the owner of the file. The fourth field contains the size of the file in bytes. The fifth, sixth, and seventh fields contain the month, day, and time, respectively, that the file was last modified. Finally, the eighth field contains the name of the file.

The `$5 == "Nov"` in our awk program is an expression that tests whether the fifth field of the output from `ls -l` matches the string `Nov`. Each time a line has the string `Nov` in its fifth field, the action `{ sum += $4 }` is performed. This adds the fourth field (the file size) to the variable `sum`. As a result, when awk has finished reading all the input lines, `sum` is the sum of the sizes of files whose lines matched the pattern. (This works because awk variables are automatically initialized to zero.)

After the last line of output from `ls` has been processed, the `END` rule is executed, and the value of `sum` is printed. In this example, the value of `sum` would be `80600`.

These more advanced awk techniques are covered in later sections (see

Overview of Actions

). Before you can move on to more advanced awk programming, you have to know how awk interprets your input and displays your output. By manipulating fields and using `print` statements, you can produce some very useful and spectacular looking reports.

1.11 gawk.info/Running gawk

How to Run awk Programs

=====

There are several ways to run an awk program. If the program is short, it is easiest to include it in the command that runs awk, like this:

```
awk 'program' input-file1 input-file2 ...
```

where `program` consists of a series of patterns and actions, as described earlier.

When the program is long, it is usually more convenient to put it in a file and run it with a command like this:

```
awk -f program-file input-file1 input-file2 ...
```

One-shot

Running a short throw-away awk program.

Read Terminal

Using no input files (input from terminal instead).

Long

Putting permanent awk programs in files.

Executable Scripts
Making self-contained awk programs.

1.12 gawk.info/One-shot

One-shot Throw-away awk Programs

Once you are familiar with `awk`, you will often type simple programs at the moment you want to use them. Then you can write the program as the first argument of the `awk` command, like this:

```
awk 'program' input-file1 input-file2 ...
```

where `program` consists of a series of patterns and actions, as described earlier.

This command format instructs the shell to start `awk` and use the `program` to process records in the input file(s). There are single quotes around `program` so that the shell doesn't interpret any `awk` characters as special shell characters. They also cause the shell to treat all of `program` as a single argument for `awk` and allow `program` to be more than one line long.

This format is also useful for running short or medium-sized `awk` programs from shell scripts, because it avoids the need for a separate file for the `awk` program. A self-contained shell script is more reliable since there are no other files to misplace.

1.13 gawk.info/Read Terminal

Running `awk` without Input Files

You can also run `awk` without any input files. If you type the command line:

```
awk 'program'
```

then `awk` applies the `program` to the standard input, which usually means whatever you type on the terminal. This continues until you indicate end-of-file by typing Control-d.

For example, if you execute this command:

```
awk '/th/'
```

whatever you type next is taken as data for that `awk` program. If you go on to type the following data:

```

Kathy
Ben
Tom
Beth
Seth
Karen
Thomas
Control-d

```

then awk prints this output:

```

Kathy
Beth
Seth

```

as matching the pattern `th`. Notice that it did not recognize Thomas as matching the pattern. The awk language is case sensitive, and matches patterns exactly. (However, you can override this with the variable `IGNORECASE`. See

Case-sensitivity in Matching
.)

1.14 gawk.info/Long

Running Long Programs

Sometimes your awk programs can be very long. In this case it is more convenient to put the program into a separate file. To tell awk to use that file for its program, you type:

```
awk -f source-file input-file1 input-file2 ...
```

The `-f` instructs the awk utility to get the awk program from the file `source-file`. Any file name can be used for `source-file`. For example, you could put the program:

```
/th/
```

into the file `th-prog`. Then this command:

```
awk -f th-prog
```

does the same thing as this one:

```
awk '/th/'
```

which was explained earlier (see [Running awk without Input Files](#)).

Note that you don't usually need single quotes around the file name that you specify with `-f`, because most file names don't contain any of

the shell's special characters. Notice that in `th-prog`, the `awk` program did not have single quotes around it. The quotes are only needed for programs that are provided on the `awk` command line.

If you want to identify your `awk` program files clearly as such, you can add the extension `.awk` to the file name. This doesn't affect the execution of the `awk` program, but it does make "housekeeping" easier.

1.15 gawk.info/Executable Scripts

Executable awk Programs

Once you have learned `awk`, you may want to write self-contained `awk` scripts, using the `#!` script mechanism. You can do this on many Unix systems (1) (and someday on GNU).

For example, you could create a text file named `hello`, containing the following (where `BEGIN` is a feature we have not yet discussed):

```
#!/bin/awk -f

# a sample awk program
BEGIN { print "hello, world" }
```

After making this file executable (with the `chmod` command), you can simply type:

```
hello
```

at the shell, and the system will arrange to run `awk` (2) as if you had typed:

```
awk -f hello
```

Self-contained `awk` scripts are useful when you want to write a program which users can invoke without knowing that the program is written in `awk`.

If your system does not support the `#!` mechanism, you can get a similar effect using a regular shell script. It would look something like this:

```
: The colon makes sure this script is executed by the Bourne shell.
awk 'program' "$@"
```

Using this technique, it is vital to enclose the program in single quotes to protect it from interpretation by the shell. If you omit the quotes, only a shell wizard can predict the results.

The `"$@"` causes the shell to forward all the command line arguments to the `awk` program, without interpretation. The first line, which starts with a colon, is used so that this shell script will work even

if invoked by a user who uses the C shell.

----- Footnotes -----

(1) The #! mechanism works on Unix systems derived from Berkeley Unix, System V Release 4, and some System V Release 3 systems.

(2) The line beginning with #! lists the full pathname of an interpreter to be run, and an optional initial command line argument to pass to that interpreter. The operating system then runs the interpreter with the given argument and the full argument list of the executed program. The first argument in the list is the full pathname of the awk program. The rest of the argument list will either be options to awk, or data files, or both.

1.16 gawk.info/Comments

Comments in awk Programs
=====

A comment is some text that is included in a program for the sake of human readers, and that is not really part of the program. Comments can explain what the program does, and how it works. Nearly all programming languages have provisions for comments, because programs are typically hard to understand without their extra help.

In the awk language, a comment starts with the sharp sign character, #, and continues to the end of the line. The awk language ignores the rest of a line following a sharp sign. For example, we could have put the following into th-prog:

```
# This program finds records containing the pattern th. This is how
# you continue comments on additional lines.
/th/
```

You can put comment lines into keyboard-composed throw-away awk programs also, but this usually isn't very useful; the purpose of a comment is to help you or another person understand the program at a later time.

1.17 gawk.info/Statements-Lines

awk Statements versus Lines
=====

Most often, each line in an awk program is a separate statement or separate rule, like this:

```
awk '/12/ { print $0 }
     /21/ { print $0 }' BBS-list inventory-shipped
```

But sometimes statements can be more than one line, and lines can contain several statements. You can split a statement into multiple lines by inserting a newline after any of the following:

```
, { ? : || && do else
```

A newline at any other point is considered the end of the statement. (Splitting lines after `?` and `:` is a minor gawk extension. The `?` and `:` referred to here is the three operand conditional expression described in

Conditional Expressions
)

If you would like to split a single statement into two lines at a point where a newline would terminate it, you can continue it by ending the first line with a backslash character, `\`. This is allowed absolutely anywhere in the statement, even in the middle of a string or regular expression. For example:

```
awk '/This program is too long, so continue it\  
on the next line/ { print $1 }'
```

We have generally not used backslash continuation in the sample programs in this manual. Since in gawk there is no limit on the length of a line, it is never strictly necessary; it just makes programs prettier. We have preferred to make them even more pretty by keeping the statements short. Backslash continuation is most useful when your awk program is in a separate source file, instead of typed in on the command line. You should also note that many awk implementations are more picky about where you may use backslash continuation. For maximal portability of your awk programs, it is best not to split your lines in the middle of a regular expression or a string.

Warning: backslash continuation does not work as described above with the C shell. Continuation with backslash works for awk programs in files, and also for one-shot programs provided you are using a POSIX-compliant shell, such as the Bourne shell or the Bourne-again shell. But the C shell used on Berkeley Unix behaves differently! There, you must use two backslashes in a row, followed by a newline.

When awk statements within one rule are short, you might want to put more than one of them on a line. You do this by separating the statements with a semicolon, `;`. This also applies to the rules themselves. Thus, the previous program could have been written:

```
/12/ { print $0 } ; /21/ { print $0 }
```

Note: the requirement that rules on the same line must be separated with a semicolon is a recent change in the awk language; it was done for consistency with the treatment of statements within an action.

1.18 gawk.info/When

When to Use awk

=====

You might wonder how awk might be useful for you. Using additional utility programs, more advanced patterns, field separators, arithmetic statements, and other selection criteria, you can produce much more complex output. The awk language is very useful for producing reports from large amounts of raw data, such as summarizing information from the output of other utility programs like ls. (See

A More Complex Example
.)

Programs written with awk are usually much smaller than they would be in other languages. This makes awk programs easy to compose and use. Often awk programs can be quickly composed at your terminal, used once, and thrown away. Since awk programs are interpreted, you can avoid the usually lengthy edit-compile-test-debug cycle of software development.

Complex programs have been written in awk, including a complete retargetable assembler for 8-bit microprocessors (see
Glossary
, for
more information) and a microcode assembler for a special purpose Prolog computer. However, awk's capabilities are strained by tasks of such complexity.

If you find yourself writing awk scripts of more than, say, a few hundred lines, you might consider using a different programming language. Emacs Lisp is a good choice if you need sophisticated string or pattern matching capabilities. The shell is also good at string and pattern matching; in addition, it allows powerful use of the system utilities. More conventional languages, such as C, C++, and Lisp, offer better facilities for system programming and for managing the complexity of large programs. Programs in these languages may require more lines of source code than the equivalent awk programs, but they are easier to maintain and usually run more efficiently.

1.19 gawk.info/Reading Files

Reading Input Files

In the typical awk program, all input is read either from the standard input (by default the keyboard, but often a pipe from another command) or from files whose names you specify on the awk command line. If you specify input files, awk reads them in order, reading all the data from one before going on to the next. The name of the current input file can be found in the built-in variable FILENAME (see

Built-in Variables
).

The input is read in units called records, and processed by the rules one record at a time. By default, each record is one line. Each record is split automatically into fields, to make it more convenient for a rule to work on its parts.

On rare occasions you will need to use the `getline` command, which can do explicit input from any number of files (see

Explicit Input with `getline`
).

Records
Controlling how data is split into records.

Fields
An introduction to fields.

Non-Constant Fields
Non-constant Field Numbers.

Changing Fields
Changing the Contents of a Field.

Field Separators
The field separator and how to change it.

Constant Size
Reading constant width data.

Multiple Line
Reading multi-line records.

Getline
Reading files under explicit program control using the `getline` function.

Close Input
Closing an input file (so you can read from the beginning once more).

1.20 gawk.info/Records

How Input is Split into Records
=====

The `awk` language divides its input into records and fields. Records are separated by a character called the record separator. By default,

the record separator is the newline character, defining a record to be a single line of text.

Sometimes you may want to use a different character to separate your records. You can use a different character by changing the built-in variable `RS`. The value of `RS` is a string that says how to separate records; the default value is `"\n"`, the string containing just a newline character. This is why records are, by default, single lines.

`RS` can have any string as its value, but only the first character of the string is used as the record separator. The other characters are ignored. `RS` is exceptional in this regard; `awk` uses the full value of all its other built-in variables.

You can change the value of `RS` in the `awk` program with the assignment operator, `=` (see

`Assignment Expressions`

). The new

record-separator character should be enclosed in quotation marks to make a string constant. Often the right time to do this is at the beginning of execution, before any input has been processed, so that the very first record will be read with the proper separator. To do this, use the special `BEGIN` pattern (see

`BEGIN and END Special Patterns`

). For

example:

```
awk 'BEGIN { RS = "/" } ; { print $0 }' BBS-list
```

changes the value of `RS` to `"/"`, before reading any input. This is a string whose first character is a slash; as a result, records are separated by slashes. Then the input file is read, and the second rule in the `awk` program (the action with no pattern) prints each record. Since each `print` statement adds a newline at the end of its output, the effect of this `awk` program is to copy the input with each slash changed to a newline.

Another way to change the record separator is on the command line, using the variable-assignment feature (see

`Invoking awk`

).

```
awk '{ print $0 }' RS="/" BBS-list
```

This sets `RS` to `/` before processing `BBS-list`.

Reaching the end of an input file terminates the current input record, even if the last character in the file is not the character in `RS`.

The empty string, `""` (a string of no characters), has a special meaning as the value of `RS`: it means that records are separated only by blank lines. See

`Multiple-Line Records`

, for more details.

The `awk` utility keeps track of the number of records that have been

read so far from the current input file. This value is stored in a built-in variable called FNR. It is reset to zero when a new file is started. Another built-in variable, NR, is the total number of input records read so far from all files. It starts at zero but is never automatically reset to zero.

If you change the value of RS in the middle of an awk run, the new value is used to delimit subsequent records, but the record currently being processed (and records already processed) are not affected.

1.21 gawk.info/Fields

Examining Fields

=====

When awk reads an input record, the record is automatically separated or parsed by the interpreter into chunks called fields. By default, fields are separated by whitespace, like words in a line. Whitespace in awk means any string of one or more spaces and/or tabs; other characters such as newline, formfeed, and so on, that are considered whitespace by other languages are not considered whitespace by awk.

The purpose of fields is to make it more convenient for you to refer to these pieces of the record. You don't have to use them--you can operate on the whole record if you wish--but fields are what make simple awk programs so powerful.

To refer to a field in an awk program, you use a dollar-sign, \$, followed by the number of the field you want. Thus, \$1 refers to the first field, \$2 to the second, and so on. For example, suppose the following is a line of input:

This seems like a pretty nice example.

Here the first field, or \$1, is This; the second field, or \$2, is seems; and so on. Note that the last field, \$7, is example.. Because there is no space between the e and the ., the period is considered part of the seventh field.

No matter how many fields there are, the last field in a record can be represented by \$NF. So, in the example above, \$NF would be the same as \$7, which is example.. Why this works is explained below (see

Non-constant Field Numbers

). If you try to refer to a field beyond the last one, such as \$8 when the record has only 7 fields, you get the empty string.

Plain NF, with no \$, is a built-in variable whose value is the number of fields in the current record.

\$0, which looks like an attempt to refer to the zeroth field, is a

special case: it represents the whole input record. This is what you would use if you weren't interested in fields.

Here are some more examples:

```
awk '$1 ~ /foo/ { print $0 }' BBS-list
```

This example prints each record in the file BBS-list whose first field contains the string foo. The operator ~ is called a matching operator (see

Comparison Expressions

); it tests whether a string (here, the field \$1) matches a given regular expression.

By contrast, the following example:

```
awk '/foo/ { print $1, $NF }' BBS-list
```

looks for foo in the entire record and prints the first field and the last field for each input record containing a match.

1.22 gawk.info/Non-Constant Fields

Non-constant Field Numbers

=====

The number of a field does not need to be a constant. Any expression in the awk language can be used after a \$ to refer to a field. The value of the expression specifies the field number. If the value is a string, rather than a number, it is converted to a number. Consider this example:

```
awk '{ print $NR }'
```

Recall that NR is the number of records read so far: 1 in the first record, 2 in the second, etc. So this example prints the first field of the first record, the second field of the second record, and so on. For the twentieth record, field number 20 is printed; most likely, the record has fewer than 20 fields, so this prints a blank line.

Here is another example of using expressions as field numbers:

```
awk '{ print $(2*2) }' BBS-list
```

The awk language must evaluate the expression (2*2) and use its value as the number of the field to print. The * sign represents multiplication, so the expression 2*2 evaluates to 4. The parentheses are used so that the multiplication is done before the \$ operation; they are necessary whenever there is a binary operator in the field-number expression. This example, then, prints the hours of operation (the fourth field) for every line of the file BBS-list.

If the field number you compute is zero, you get the entire record.

Thus, `$(2-2)` has the same value as `$0`. Negative field numbers are not allowed.

The number of fields in the current record is stored in the built-in variable `NF` (see

[Built-in Variables](#)

). The expression `$NF` is not a special feature: it is the direct consequence of evaluating `NF` and using its value as a field number.

1.23 gawk.info/Changing Fields

Changing the Contents of a Field

=====
You can change the contents of a field as seen by `awk` within an `awk` program; this changes what `awk` perceives as the current input record. (The actual input is untouched: `awk` never modifies the input file.)

Consider this example:

```
awk '{ $3 = $2 - 10; print $2, $3 }' inventory-shipped
```

The `-` sign represents subtraction, so this program reassigns field three, `$3`, to be the value of field two minus ten, `$2 - 10`. (See

[Arithmetic Operators](#)

.) Then field two, and the new value for field three, are printed.

In order for this to work, the text in field `$2` must make sense as a number; the string of characters must be converted to a number in order for the computer to do arithmetic on it. The number resulting from the subtraction is converted back to a string of characters which then becomes field three. See

[Conversion of Strings and Numbers](#)

.

When you change the value of a field (as perceived by `awk`), the text of the input record is recalculated to contain the new field where the old one was. Therefore, `$0` changes to reflect the altered field. Thus,

```
awk '{ $2 = $2 - 10; print $0 }' inventory-shipped
```

prints a copy of the input file, with 10 subtracted from the second field of each line.

You can also assign contents to fields that are out of range. For example:

```
awk '{ $6 = ($5 + $4 + $3 + $2) ; print $6 }' inventory-shipped
```

We've just created `$6`, whose value is the sum of fields `$2`, `$3`, `$4`, and

\$5. The + sign represents addition. For the file inventory-shipped, \$6 represents the total number of parcels shipped for a particular month.

Creating a new field changes the internal awk copy of the current input record--the value of \$0. Thus, if you do print \$0 after adding a field, the record printed includes the new field, with the appropriate number of field separators between it and the previously existing fields.

This recomputation affects and is affected by several features not yet discussed, in particular, the output field separator, OFS, which is used to separate the fields (see

Output Separators
) , and NF (the number

of fields; see

Examining Fields
) . For example, the value of NF is set

to the number of the highest field you create.

Note, however, that merely referencing an out-of-range field does not change the value of either \$0 or NF. Referencing an out-of-range field merely produces a null string. For example:

```
if ($(NF+1) != "")
    print "can't happen"
else
    print "everything is normal"
```

should print everything is normal, because NF+1 is certain to be out of range. (See

The if Statement
, for more information about awk's if-else

statements.)

It is important to note that assigning to a field will change the value of \$0, but will not change the value of NF, even when you assign the null string to a field. For example:

```
echo a b c d | awk '{ OFS = ":"; $2 = "" ; print ; print NF }'
```

prints

```
a::c:d
4
```

The field is still there, it just has an empty value. You can tell because there are two colons in a row.

1.24 gawk.info/Field Separators

Specifying how Fields are Separated

=====

(This section is rather long; it describes one of the most fundamental operations in awk. If you are a novice with awk, we recommend that you re-read this section after you have studied the section on regular expressions,

Regular Expressions as Patterns
.)

The way awk splits an input record into fields is controlled by the field separator, which is a single character or a regular expression. awk scans the input record for matches for the separator; the fields themselves are the text between the matches. For example, if the field separator is oo, then the following line:

```
moo goo gai pan
```

would be split into three fields: m, g and gai pan.

The field separator is represented by the built-in variable FS. Shell programmers take note! awk does not use the name IFS which is used by the shell.

You can change the value of FS in the awk program with the assignment operator, = (see

Assignment Expressions
).

Often the right time to do this is at the beginning of execution, before any input has been processed, so that the very first record will be read with the proper separator. To do this, use the special BEGIN pattern (see

BEGIN and END Special Patterns

). For example, here we set the value of FS to the string ",":

```
awk 'BEGIN { FS = "," } ; { print $2 }'
```

Given the input line,

```
John Q. Smith, 29 Oak St., Walamazoo, MI 42139
```

this awk program extracts the string 29 Oak St..

Sometimes your input data will contain separator characters that don't separate fields the way you thought they would. For instance, the person's name in the example we've been using might have a title or suffix attached, such as John Q. Smith, LXIX. From input containing such a name:

```
John Q. Smith, LXIX, 29 Oak St., Walamazoo, MI 42139
```

the previous sample program would extract LXIX, instead of 29 Oak St.. If you were expecting the program to print the address, you would be surprised. So choose your data layout and separator characters carefully to prevent such problems.

As you know, by default, fields are separated by whitespace sequences (spaces and tabs), not by single spaces: two spaces in a row do not delimit an empty field. The default value of the field separator is a

string " " containing a single space. If this value were interpreted in the usual way, each space character would separate fields, so two spaces in a row would make an empty field between them. The reason this does not happen is that a single space as the value of FS is a special case: it is taken to specify the default manner of delimiting fields.

If FS is any other single character, such as ",", then each occurrence of that character separates two fields. Two consecutive occurrences delimit an empty field. If the character occurs at the beginning or the end of the line, that too delimits an empty field. The space character is the only single character which does not follow these rules.

More generally, the value of FS may be a string containing any regular expression. Then each match in the record for the regular expression separates fields. For example, the assignment:

```
FS = ", \t"
```

makes every area of an input line that consists of a comma followed by a space and a tab, into a field separator. (\t stands for a tab.)

For a less trivial example of a regular expression, suppose you want single spaces to separate fields the way single commas were used above. You can set FS to "[]". This regular expression matches a single space and nothing else.

FS can be set on the command line. You use the -F argument to do so. For example:

```
awk -F, 'program' input-files
```

sets FS to be the , character. Notice that the argument uses a capital F. Contrast this with -f, which specifies a file containing an awk program. Case is significant in command options: the -F and -f options have nothing to do with each other. You can use both options at the same time to set the FS argument and get an awk program from a file.

The value used for the argument to -F is processed in exactly the same way as assignments to the built-in variable FS. This means that if the field separator contains special characters, they must be escaped appropriately. For example, to use a \ as the field separator, you would have to type:

```
# same as FS = "\"
awk -F\\ '...' files ...
```

Since \ is used for quoting in the shell, awk will see -F\ . Then awk processes the \ for escape characters (see

Constant Expressions
) , finally yielding a single \ to be used for the field separator.

As a special case, in compatibility mode (see
Invoking awk

), if the argument to `-F` is `t`, then `FS` is set to the tab character. (This is because if you type `-F\t`, without the quotes, at the shell, the `\` gets deleted, so `awk` figures that you really want your fields to be separated with tabs, and not `ts`. Use `-v FS="t"` on the command line if you really do want to separate your fields with `ts`.)

For example, let's use an `awk` program file called `baud.awk` that contains the pattern `/300/`, and the action `print $1`. Here is the program:

```
/300/ { print $1 }
```

Let's also set `FS` to be the `-` character, and run the program on the file `BBS-list`. The following command prints a list of the names of the bulletin boards that operate at 300 baud and the first three digits of their phone numbers:

```
awk -F- -f baud.awk BBS-list
```

It produces this output:

```
aardvark      555
alpo
barfly        555
bites         555
camelot       555
core          555
foeey         555
foot          555
macfoo        555
sdace         555
sabafoo       555
```

Note the second line of output. If you check the original file, you will see that the second line looked like this:

```
alpo-net      555-3412      2400/1200/300      A
```

The `-` as part of the system's name was used as the field separator, instead of the `-` in the phone number that was originally intended. This demonstrates why you have to be careful in choosing your field and record separators.

The following program searches the system password file, and prints the entries for users who have no password:

```
awk -F: '$2 == ""' /etc/passwd
```

Here we use the `-F` option on the command line to set the field separator. Note that fields in `/etc/passwd` are separated by colons. The second field represents a user's encrypted password, but if the field is empty, that user has no password.

According to the POSIX standard, `awk` is supposed to behave as if each record is split into fields at the time that it is read. In particular, this means that you can change the value of `FS` after a

record is read, but before any of the fields are referenced. The value of the fields (i.e. how they were split) should reflect the old value of FS, not the new one.

However, many implementations of awk do not do this. Instead, they defer splitting the fields until a field reference actually happens, using the current value of FS! This behavior can be difficult to diagnose. The following example illustrates the results of the two methods. (The sed command prints just the first line of /etc/passwd.)

```
sed lq /etc/passwd | awk '{ FS = ":" ; print $1 }'
```

will usually print

```
root
```

on an incorrect implementation of awk, while gawk will print something like

```
root:nSijPlPhZZwgE:0:0:Root:/:
```

There is an important difference between the two cases of FS = " " (a single blank) and FS = "[\t]+" (which is a regular expression matching one or more blanks or tabs). For both values of FS, fields are separated by runs of blanks and/or tabs. However, when the value of FS is " ", awk will strip leading and trailing whitespace from the record, and then decide where the fields are.

For example, the following expression prints b:

```
echo ' a b c d ' | awk '{ print $2 }'
```

However, the following prints a:

```
echo ' a b c d ' | awk 'BEGIN { FS = "[ \t]+" } ; { print $2 }'
```

In this case, the first field is null.

The stripping of leading and trailing whitespace also comes into play whenever \$0 is recomputed. For instance, this pipeline

```
echo ' a b c d' | awk '{ print; $2 = $2; print }'
```

produces this output:

```
 a b c d
a b c d
```

The first print statement prints the record as it was read, with leading whitespace intact. The assignment to \$2 rebuilds \$0 by concatenating \$1 through \$NF together, separated by the value of OFS. Since the leading whitespace was ignored when finding \$1, it is not part of the new \$0. Finally, the last print statement prints the new \$0.

The following table summarizes how fields are split, based on the value of FS.

FS == " "

Fields are separated by runs of whitespace. Leading and trailing whitespace are ignored. This is the default.

FS == any single character

Fields are separated by each occurrence of the character. Multiple successive occurrences delimit empty fields, as do leading and trailing occurrences.

FS == regexp

Fields are separated by occurrences of characters that match regexp. Leading and trailing matches of regexp delimit empty fields.

1.25 gawk.info/Constant Size

Reading Fixed-width Data

=====

(This section discusses an advanced, experimental feature. If you are a novice awk user, you may wish to skip it on the first reading.)

gawk 2.13 introduced a new facility for dealing with fixed-width fields with no distinctive field separator. Data of this nature arises typically in one of at least two ways: the input for old FORTRAN programs where numbers are run together, and the output of programs that did not anticipate the use of their output as input for other programs.

An example of the latter is a table where all the columns are lined up by the use of a variable number of spaces and empty fields are just spaces. Clearly, awk's normal field splitting based on FS will not work well in this case. (Although a portable awk program can use a series of substr calls on \$0, this is awkward and inefficient for a large number of fields.)

The splitting of an input record into fixed-width fields is specified by assigning a string containing space-separated numbers to the built-in variable FIELDWIDTHS. Each number specifies the width of the field including columns between fields. If you want to ignore the columns between fields, you can specify the width as a separate field that is subsequently ignored.

The following data is the output of the w utility. It is useful to illustrate the use of FIELDWIDTHS.

```

10:06pm up 21 days, 14:04, 23 users
User      tty      login idle   JCPU  PCPU  what
hzuo     ttyV0    8:58pm   9      5    vi p24.tex
hzang    ttyV3    6:37pm   50     -    -csh
eklye    ttyV5    9:53pm   7      1    em thes.tex
dportein ttyV6    8:17pm  1:47   -    -csh

```

```

gierd   ttyD3   10:00pm   1           elm
dave    ttyD4    9:47pm    4           4   w
brent   ttyp0    26Jun91   4:46   26:46   4:41   bash
dave    ttyq4    26Jun9115days   46       46   wnewmail

```

The following program takes the above input, converts the idle time to number of seconds and prints out the first two fields and the calculated idle time. (This program uses a number of awk features that haven't been introduced yet.)

```

BEGIN { FIELDWIDTHS = "9 6 10 6 7 7 35" }
NR > 2 {
  idle = $4
  sub(/^ */, "", idle) # strip leading spaces
  if (idle == "") idle = 0
  if (idle ~ /:/) { split(idle, t, ":"); idle = t[1] * 60 + t[2] }
  if (idle ~ /days/) { idle *= 24 * 60 * 60 }

  print $1, $2, idle
}

```

Here is the result of running the program on the data:

```

hzuo    ttyV0   0
hzang   ttyV3   50
eklye   ttyV5   0
dportein ttyV6  107
gierd   ttyD3   1
dave    ttyD4   0
brent   ttyp0   286
dave    ttyq4  1296000

```

Another (possibly more practical) example of fixed-width input data would be the input from a deck of balloting cards. In some parts of the United States, voters make their choices by punching holes in computer cards. These cards are then processed to count the votes for any particular candidate or on any particular issue. Since a voter may choose not to vote on some issue, any column on the card may be empty. An awk program for processing such data could use the FIELDWIDTHS feature to simplify reading the data.

This feature is still experimental, and will likely evolve over time.

1.26 gawk.info/Multiple Line

Multiple-Line Records

=====

In some data bases, a single line cannot conveniently hold all the information in one entry. In such cases, you can use multi-line records.

The first step in doing this is to choose your data format: when records are not defined as single lines, how do you want to define them?

What should separate records?

One technique is to use an unusual character or string to separate records. For example, you could use the formfeed character (written `\f` in `awk`, as in C) to separate them, making each record a page of the file. To do this, just set the variable `RS` to `"\f"` (a string containing the formfeed character). Any other character could equally well be used, as long as it won't be part of the data in a record.

Another technique is to have blank lines separate records. By a special dispensation, a null string as the value of `RS` indicates that records are separated by one or more blank lines. If you set `RS` to the null string, a record always ends at the first blank line encountered. And the next record doesn't start until the first nonblank line that follows--no matter how many blank lines appear in a row, they are considered one record-separator. (End of file is also considered a record separator.)

The second step is to separate the fields in the record. One way to do this is to put each field on a separate line: to do this, just set the variable `FS` to the string `"\n"`. (This simple regular expression matches a single newline.)

Another way to separate fields is to divide each of the lines into fields in the normal manner. This happens by default as a result of a special feature: when `RS` is set to the null string, the newline character always acts as a field separator. This is in addition to whatever field separations result from `FS`.

The original motivation for this special exception was probably so that you get useful behavior in the default case (i.e., `FS == ""`). This feature can be a problem if you really don't want the newline character to separate fields, since there is no way to prevent it. However, you can work around this by using the `split` function to break up the record manually (see

Built-in Functions for String Manipulation
).

1.27 gawk.info/Getline

Explicit Input with getline

=====

So far we have been getting our input files from `awk`'s main input stream--either the standard input (usually your terminal) or the files specified on the command line. The `awk` language has a special built-in command called `getline` that can be used to read input under your explicit control.

This command is quite complex and should not be used by beginners. It is covered here because this is the chapter on input. The examples that follow the explanation of the `getline` command include material that has not been covered yet. Therefore, come back and study the

getline command after you have reviewed the rest of this manual and have a good knowledge of how awk works.

getline returns 1 if it finds a record, and 0 if the end of the file is encountered. If there is some error in getting a record, such as a file that cannot be opened, then getline returns -1. In this case, gawk sets the variable ERRNO to a string describing the error that occurred.

In the following examples, command stands for a string value that represents a shell command.

getline

The getline command can be used without arguments to read input from the current input file. All it does in this case is read the next input record and split it up into fields. This is useful if you've finished processing the current record, but you want to do some special processing right now on the next record. Here's an example:

```
awk '{
    if (t = index($0, "/*")) {
        if (t > 1)
            tmp = substr($0, 1, t - 1)
        else
            tmp = ""
        u = index(substr($0, t + 2), "*/")
        while (u == 0) {
            getline
            t = -1
            u = index($0, "*/")
        }
        if (u <= length($0) - 2)
            $0 = tmp substr($0, t + u + 3)
        else
            $0 = tmp
    }
    print $0
}'
```

This awk program deletes all C-style comments, /* ... */, from the input. By replacing the print \$0 with other statements, you could perform more complicated processing on the uncommented input, like searching for matches of a regular expression. (This program has a subtle problem--can you spot it?)

This form of the getline command sets NF (the number of fields; see

Examining Fields

), NR (the number of records read so far; see

How Input is Split into Records

), FNR (the number of records read

from this input file), and the value of \$0.

Note: the new value of \$0 is used in testing the patterns of any subsequent rules. The original value of \$0 that triggered the

rule which executed `getline` is lost. By contrast, the next statement reads a new record but immediately begins processing it normally, starting with the first rule in the program. See

The next Statement

.

`getline var`

This form of `getline` reads a record into the variable `var`. This is useful when you want your program to read the next record from the current input file, but you don't want to subject the record to the normal input processing.

For example, suppose the next line is a comment, or a special string, and you want to read it, but you must make certain that it won't trigger any rules. This version of `getline` allows you to read that line and store it in a variable so that the main read-a-line-and-check-each-rule loop of `awk` never sees it.

The following example swaps every two lines of input. For example, given:

```
wan
tew
free
phore
```

it outputs:

```
tew
wan
phore
free
```

Here's the program:

```
awk '{
    if ((getline tmp) > 0) {
        print tmp
        print $0
    } else
        print $0
}'
```

The `getline` function used in this way sets only the variables `NR` and `FNR` (and of course, `var`). The record is not split into fields, so the values of the fields (including `$0`) and the value of `NF` do not change.

`getline < file`

This form of the `getline` function takes its input from the file `file`. Here `file` is a string-valued expression that specifies the file name. `< file` is called a redirection since it directs input to come from a different place.

This form is useful if you want to read your input from a particular file, instead of from the main input stream. For

example, the following program reads its input record from the file `foo.input` when it encounters a first field with a value equal to 10 in the current input file.

```
awk '{
  if ($1 == 10) {
    getline < "foo.input"
    print
  } else
    print
}'
```

Since the main input stream is not used, the values of `NR` and `FNR` are not changed. But the record read is split into fields in the normal manner, so the values of `$0` and other fields are changed. So is the value of `NF`.

This does not cause the record to be tested against all the patterns in the `awk` program, in the way that would happen if the record were read normally by the main processing loop of `awk`. However the new record is tested against any subsequent rules, just as when `getline` is used without a redirection.

`getline var < file`

This form of the `getline` function takes its input from the file `file` and puts it in the variable `var`. As above, `file` is a string-valued expression that specifies the file from which to read.

In this version of `getline`, none of the built-in variables are changed, and the record is not split into fields. The only variable changed is `var`.

For example, the following program copies all the input files to the output, except for records that say `@include filename`. Such a record is replaced by the contents of the file `filename`.

```
awk '{
  if (NF == 2 && $1 == "@include") {
    while ((getline line < $2) > 0)
      print line
    close($2)
  } else
    print
}'
```

Note here how the name of the extra input file is not built into the program; it is taken from the data, from the second field on the `@include` line.

The `close` function is called to ensure that if two identical `@include` lines appear in the input, the entire specified file is included twice. See

Closing Input Files and Pipes

One deficiency of this program is that it does not process nested

@include statements the way a true macro preprocessor would.

command | getline

You can pipe the output of a command into getline. A pipe is simply a way to link the output of one program to the input of another. In this case, the string command is run as a shell command and its output is piped into awk to be used as input. This form of getline reads one record from the pipe.

For example, the following program copies input to output, except for lines that begin with @execute, which are replaced by the output produced by running the rest of the line as a shell command:

```
awk '{
    if ($1 == "@execute") {
        tmp = substr($0, 10)
        while ((tmp | getline) > 0)
            print
        close(tmp)
    } else
        print
}'
```

The close function is called to ensure that if two identical @execute lines appear in the input, the command is run for each one. See

Closing Input Files and Pipes

.

Given the input:

```
foo
bar
baz
@execute who
bletch
```

the program might produce:

```
foo
bar
baz
hack      ttyv0   Jul 13 14:22
hack      ttyv0   Jul 13 14:23      (gnu:0)
hack      ttyv1   Jul 13 14:23      (gnu:0)
hack      ttyv2   Jul 13 14:23      (gnu:0)
hack      ttyv3   Jul 13 14:23      (gnu:0)
bletch
```

Notice that this program ran the command who and printed the result. (If you try this program yourself, you will get different results, showing you who is logged in on your system.)

This variation of getline splits the record into fields, sets the value of NF and recomputes the value of \$0. The values of NR and FNR are not changed.

command | getline var

The output of the command command is sent through a pipe to getline and into the variable var. For example, the following program reads the current date and time into the variable current_time, using the date utility, and then prints it.

```
awk 'BEGIN {
    "date" | getline current_time
    close("date")
    print "Report printed on " current_time
}'
```

In this version of getline, none of the built-in variables are changed, and the record is not split into fields.

1.28 gawk.info/Close Input

Closing Input Files and Pipes

=====

If the same file name or the same shell command is used with getline more than once during the execution of an awk program, the file is opened (or the command is executed) only the first time. At that time, the first record of input is read from that file or command. The next time the same file or command is used in getline, another record is read from it, and so on.

This implies that if you want to start reading the same file again from the beginning, or if you want to rerun a shell command (rather than reading more output from the command), you must take special steps. What you must do is use the close function, as follows:

```
close(filename)
```

or

```
close(command)
```

The argument filename or command can be any expression. Its value must exactly equal the string that was used to open the file or start the command--for example, if you open a pipe with this:

```
"sort -r names" | getline foo
```

then you must close it with this:

```
close("sort -r names")
```

Once this function call is executed, the next getline from that file or command will reopen the file or rerun the command.

close returns a value of zero if the close succeeded. Otherwise, the value will be non-zero. In this case, gawk sets the variable ERRNO

to a string describing the error that occurred.

1.29 gawk.info/Printing

Printing Output

One of the most common things that actions do is to output or print some or all of the input. For simple output, use the print statement. For fancier formatting use the printf statement. Both are described in this chapter.

Print

The print statement.

Print Examples

Simple examples of print statements.

Output Separators

The output separators and how to change them.

OFMT

Controlling Numeric Output With print.

Printf

The printf statement.

Redirection

How to redirect output to multiple files and pipes.

Special Files

File name interpretation in gawk.
gawk allows access to
inherited file descriptors.

1.30 gawk.info/Print

The print Statement

=====

The print statement does output with simple, standardized formatting. You specify only the strings or numbers to be printed, in a list separated by commas. They are output, separated by single spaces, followed by a newline. The statement looks like this:

```
print item1, item2, ...
```

The entire list of items may optionally be enclosed in parentheses. The parentheses are necessary if any of the item expressions uses a relational operator; otherwise it could be confused with a redirection (see

Redirecting Output of print and printf

). The relational operators

are ==, !=, <, >, >=, <=, ~ and !~ (see

Comparison Expressions

).

The items printed can be constant strings or numbers, fields of the current record (such as \$1), variables, or any awk expressions. The print statement is completely general for computing what values to print. With two exceptions, you cannot specify how to print them--how many columns, whether to use exponential notation or not, and so on. (See

Output Separators

, and

Controlling Numeric Output with print

.) For

that, you need the printf statement (see

Using printf Statements for Fancier Printing

).

The simple statement print with no items is equivalent to print \$0: it prints the entire current record. To print a blank line, use print "", where "" is the null, or empty, string.

To print a fixed piece of text, use a string constant such as "Hello there" as one item. If you forget to use the double-quote characters, your text will be taken as an awk expression, and you will probably get an error. Keep in mind that a space is printed between any two items.

Most often, each print statement makes one line of output. But it isn't limited to one line. If an item value is a string that contains a newline, the newline is output along with the rest of the string. A single print can make any number of lines this way.

1.31 gawk.info/Print Examples

Examples of print Statements

=====

Here is an example of printing a string that contains embedded newlines:

```
awk 'BEGIN { print "line one\nline two\nline three" }'
```

produces output like this:

```
line one
line two
line three
```

Here is an example that prints the first two fields of each input record, with a space between them:

```
awk '{ print $1, $2 }' inventory-shipped
```

Its output looks like this:

```
Jan 13
Feb 15
Mar 15
...
```

A common mistake in using the print statement is to omit the comma between two items. This often has the effect of making the items run together in the output, with no space. The reason for this is that juxtaposing two string expressions in awk means to concatenate them. For example, without the comma:

```
awk '{ print $1 $2 }' inventory-shipped
```

prints:

```
Jan13
Feb15
Mar15
...
```

Neither example's output makes much sense to someone unfamiliar with the file `inventory-shipped`. A heading line at the beginning would make it clearer. Let's add some headings to our table of months (\$1) and green crates shipped (\$2). We do this using the BEGIN pattern (see

```
BEGIN and END Special Patterns
) to force the headings to be printed
```

only once:

```
awk 'BEGIN { print "Month Crates"
           print "-----" }
     { print $1, $2 }' inventory-shipped
```

Did you already guess what happens? This program prints the following:

```
Month Crates
-----
Jan 13
Feb 15
Mar 15
...
```

The headings and the table data don't line up! We can fix this by printing some spaces between the two fields:

```
awk 'BEGIN { print "Month Crates"
```

```

    print "-----" }
  { print $1, "    ", $2 }' inventory-shipped

```

You can imagine that this way of lining up columns can get pretty complicated when you have many columns to fix. Counting spaces for two or three columns can be simple, but more than this and you can get "lost" quite easily. This is why the `printf` statement was created (see

```

    Using printf Statements for Fancier Printing
  ); one of its specialties

```

is lining up columns of data.

1.32 gawk.info/Output Separators

```

    Output Separators
=====

```

As mentioned previously, a `print` statement contains a list of items, separated by commas. In the output, the items are normally separated by single spaces. But they do not have to be spaces; a single space is only the default. You can specify any string of characters to use as the output field separator by setting the built-in variable `OFS`. The initial value of this variable is the string " ", that is, just a single space.

The output from an entire `print` statement is called an output record. Each `print` statement outputs one output record and then outputs a string called the output record separator. The built-in variable `ORS` specifies this string. The initial value of the variable is the string "\n" containing a newline character; thus, normally each `print` statement makes a separate line.

You can change how output fields and records are separated by assigning new values to the variables `OFS` and/or `ORS`. The usual place to do this is in the `BEGIN` rule (see

```

    BEGIN and END Special Patterns
  ), so

```

that it happens before any input is processed. You may also do this with assignments on the command line, before the names of your input files.

The following example prints the first and second fields of each input record separated by a semicolon, with a blank line added after each line:

```

awk 'BEGIN { OFS = ";"; ORS = "\n\n" }
     { print $1, $2 }' BBS-list

```

If the value of `ORS` does not contain a newline, all your output will be run together on a single line, unless you output newlines some other way.

1.33 gawk.info/OFMT

Controlling Numeric Output with print

=====

When you use the `print` statement to print numeric values, `awk` internally converts the number to a string of characters, and prints that string. `awk` uses the `sprintf` function to do this conversion. For now, it suffices to say that the `sprintf` function accepts a format specification that tells it how to format numbers (or strings), and that there are a number of different ways that numbers can be formatted. The different format specifications are discussed more fully in

Using printf Statements for Fancier Printing

.

The built-in variable `OFMT` contains the default format specification that `print` uses with `sprintf` when it wants to convert a number to a string for printing. By supplying different format specifications as the value of `OFMT`, you can change how `print` will print your numbers. As a brief example:

```
awk 'BEGIN { OFMT = "%d" # print numbers as integers
          print 17.23 }'
```

will print 17.

1.34 gawk.info/Printf

Using printf Statements for Fancier Printing

=====

If you want more precise control over the output format than `print` gives you, use `printf`. With `printf` you can specify the width to use for each item, and you can specify various stylistic choices for numbers (such as what radix to use, whether to print an exponent, whether to print a sign, and how many digits to print after the decimal point). You do this by specifying a string, called the format string, which controls how and where to print the other arguments.

Basic Printf

Syntax of the `printf` statement.

Control Letters

Format-control letters.

Format Modifiers

Format-specification modifiers.

Printf Examples

Several examples.

1.35 gawk.info/Basic Printf

Introduction to the printf Statement

The printf statement looks like this:

```
printf format, item1, item2, ...
```

The entire list of arguments may optionally be enclosed in parentheses. The parentheses are necessary if any of the item expressions uses a relational operator; otherwise it could be confused with a redirection (see

Redirecting Output of print and printf

). The relational operators

are ==, !=, <, >, >=, <=, ~ and !~ (see

Comparison Expressions

).

The difference between printf and print is the argument format. This is an expression whose value is taken as a string; it specifies how to output each of the other arguments. It is called the format string.

The format string is the same as in the ANSI C library function printf. Most of format is text to be output verbatim. Scattered among this text are format specifiers, one per item. Each format specifier says to output the next item at that place in the format.

The printf statement does not automatically append a newline to its output. It outputs only what the format specifies. So if you want a newline, you must include one in the format. The output separator variables OFS and ORS have no effect on printf statements.

1.36 gawk.info/Control Letters

Format-Control Letters

A format specifier starts with the character % and ends with a format-control letter; it tells the printf statement how to output one item. (If you actually want to output a %, write %%.) The

format-control letter specifies what kind of value to print. The rest of the format specifier is made up of optional modifiers which are parameters such as the field width to use.

Here is a list of the format-control letters:

c

This prints a number as an ASCII character. Thus, `printf "%c", 65` outputs the letter A. The output for a string value is the first character of the string.

d

This prints a decimal integer.

i

This also prints a decimal integer.

e

This prints a number in scientific (exponential) notation. For example,

```
printf "%4.3e", 1950
```

prints `1.950e+03`, with a total of four significant figures of which three follow the decimal point. The 4.3 are modifiers, discussed below.

f

This prints a number in floating point notation.

g

This prints a number in either scientific notation or floating point notation, whichever uses fewer characters.

o

This prints an unsigned octal integer.

s

This prints a string.

x

This prints an unsigned hexadecimal integer.

X

This prints an unsigned hexadecimal integer. However, for the values 10 through 15, it uses the letters A through F instead of a through f.

%

This isn't really a format-control letter, but it does have a meaning when used after a %: the sequence %% outputs one %. It does not consume an argument.

1.37 gawk.info/Format Modifiers

Modifiers for printf Formats

A format specification can also include modifiers that can control how much of the item's value is printed and how much space it gets. The modifiers come between the % and the format-control letter. Here are the possible modifiers, in the order in which they may appear:

-

The minus sign, used before the width modifier, says to left-justify the argument within its specified width. Normally the argument is printed right-justified in the specified width. Thus,

```
printf "%-4s", "foo"

prints foo .
```

width

This is a number representing the desired width of a field. Inserting any number between the % sign and the format control character forces the field to be expanded to this width. The default way to do this is to pad with spaces on the left. For example,

```
printf "%4s", "foo"

prints  foo.
```

The value of width is a minimum width, not a maximum. If the item value requires more than width characters, it can be as wide as necessary. Thus,

```
printf "%4s", "foobar"

prints foobar.
```

Preceding the width with a minus sign causes the output to be padded with spaces on the right, instead of on the left.

.prec

This is a number that specifies the precision to use when printing. This specifies the number of digits you want printed to the right of the decimal point. For a string, it specifies the maximum number of characters from the string that should be printed.

The C library printf's dynamic width and prec capability (for example, "%*.s") is supported. Instead of supplying explicit width and/or prec values in the format string, you pass them in the argument list. For example:

```
w = 5
p = 3
s = "abcdefg"
```



```
printf "<%*. *s>\n", w, p, s
```

is exactly equivalent to

```
s = "abcdefg"
printf "<%5.3s>\n", s
```

Both programs output < **abc >. (We have used the bullet symbol "*" to represent a space, to clearly show you that there are two spaces in the output.)

Earlier versions of awk did not support this capability. You may simulate it by using concatenation to build up the format string, like so:

```
w = 5
p = 3
s = "abcdefg"
printf "<% " w "." p "s>\n", s
```

This is not particularly easy to read, however.

1.38 gawk.info/Printf Examples

Examples of Using printf

Here is how to use printf to make an aligned table:

```
awk '{ printf "%-10s %s\n", $1, $2 }' BBS-list
```

prints the names of bulletin boards (\$1) of the file BBS-list as a string of 10 characters, left justified. It also prints the phone numbers (\$2) afterward on the line. This produces an aligned two-column table of names and phone numbers:

```
aardvark 555-5553
alpo-net 555-3412
barfly   555-7685
bites    555-1675
camelot  555-0542
core     555-2912
fooeey   555-1234
foot     555-6699
macfoo   555-6480
sdace    555-3430
sabafoo  555-2127
```

Did you notice that we did not specify that the phone numbers be printed as numbers? They had to be printed as strings because the numbers are separated by a dash. This dash would be interpreted as a minus sign if we had tried to print the phone numbers as numbers. This would have led to some pretty confusing results.

We did not specify a width for the phone numbers because they are the last things on their lines. We don't need to put spaces after them.

We could make our table look even nicer by adding headings to the tops of the columns. To do this, use the BEGIN pattern (see

BEGIN and END Special Patterns

) to force the header to be printed only

once, at the beginning of the awk program:

```
awk 'BEGIN { print "Name      Number"
           print "----      -" }
     { printf "%-10s %s\n", $1, $2 }' BBS-list
```

Did you notice that we mixed print and printf statements in the above example? We could have used just printf statements to get the same results:

```
awk 'BEGIN { printf "%-10s %s\n", "Name", "Number"
           printf "%-10s %s\n", "----", "-" }
     { printf "%-10s %s\n", $1, $2 }' BBS-list
```

By outputting each column heading with the same format specification used for the elements of the column, we have made sure that the headings are aligned just like the columns.

The fact that the same format specification is used three times can be emphasized by storing it in a variable, like this:

```
awk 'BEGIN { format = "%-10s %s\n"
           printf format, "Name", "Number"
           printf format, "----", "-" }
     { printf format, $1, $2 }' BBS-list
```

See if you can use the printf statement to line up the headings and table data for our inventory-shipped example covered earlier in the section on the print statement (see The print Statement).

1.39 gawk.info/Redirection

Redirecting Output of print and printf

=====

So far we have been dealing only with output that prints to the standard output, usually your terminal. Both print and printf can also send their output to other places. This is called redirection.

A redirection appears after the print or printf statement. Redirections in awk are written just like redirections in shell commands, except that they are written inside the awk program.

File-Pipe Redirection

Redirecting Output to Files and Pipes.

Close Output

How to close output files and pipes.

1.40 gawk.info/File-Pipe Redirection

Redirecting Output to Files and Pipes

Here are the three forms of output redirection. They are all shown for the print statement, but they work identically for printf also.

print items > output-file

This type of redirection prints the items onto the output file output-file. The file name output-file can be any expression. Its value is changed to a string and then used as a file name (see

Expressions as Action Statements

).

When this type of redirection is used, the output-file is erased before the first output is written to it. Subsequent writes do not erase output-file, but append to it. If output-file does not exist, then it is created.

For example, here is how one awk program can write a list of BBS names to a file name-list and a list of phone numbers to a file phone-list. Each output file contains one name or number per line.

```
awk '{ print $2 > "phone-list"
      print $1 > "name-list" }' BBS-list
```

print items >> output-file

This type of redirection prints the items onto the output file output-file. The difference between this and the single-> redirection is that the old contents (if any) of output-file are not erased. Instead, the awk output is appended to the file.

print items | command

It is also possible to send output through a pipe instead of into a file. This type of redirection opens a pipe to command and writes the values of items through this pipe, to another process created to execute command.

The redirection argument command is actually an awk expression. Its value is converted to a string, whose contents give the shell command to be run.

For example, this produces two files, one unsorted list of BBS

names and one list sorted in reverse alphabetical order:

```
awk '{ print $1 > "names.unsorted"
      print $1 | "sort -r > names.sorted" }' BBS-list
```

Here the unsorted list is written with an ordinary redirection while the sorted list is written by piping through the sort utility.

Here is an example that uses redirection to mail a message to a mailing list bug-system. This might be useful when trouble is encountered in an awk script run periodically for system maintenance.

```
report = "mail bug-system"
print "Awk script failed:", $0 | report
print "at record number", FNR, "of", FILENAME | report
close(report)
```

We call the close function here because it's a good idea to close the pipe as soon as all the intended output has been sent to it. See

Closing Output Files and Pipes
, for more information on this.

This example also illustrates the use of a variable to represent a file or command: it is not necessary to always use a string constant. Using a variable is generally a good idea, since awk requires you to spell the string value identically every time.

Redirecting output using >, >>, or | asks the system to open a file or pipe only if the particular file or command you've specified has not already been written to by your program, or if it has been closed since it was last written to.

1.41 gawk.info/Close Output

Closing Output Files and Pipes

When a file or pipe is opened, the file name or command associated with it is remembered by awk and subsequent writes to the same file or command are appended to the previous writes. The file or pipe stays open until awk exits. This is usually convenient.

Sometimes there is a reason to close an output file or pipe earlier than that. To do this, use the close function, as follows:

```
close(filename)
```

or

```
close(command)
```

The argument `filename` or `command` can be any expression. Its value must exactly equal the string used to open the file or pipe to begin with--for example, if you open a pipe with this:

```
print $1 | "sort -r > names.sorted"
```

then you must close it with this:

```
close("sort -r > names.sorted")
```

Here are some reasons why you might need to close an output file:

- * To write a file and read it back later on in the same awk program. Close the file when you are finished writing it; then you can start reading it with `getline` (see `Explicit Input with getline`).
- * To write numerous files, successively, in the same awk program. If you don't close the files, eventually you may exceed a system limit on the number of open files in one process. So close each one when you are finished writing it.
- * To make a command finish. When you redirect output through a pipe, the command reading the pipe normally continues to try to read input as long as the pipe is open. Often this means the command cannot really do its work until the pipe is closed. For example, if you redirect output to the mail program, the message is not actually sent until the pipe is closed.
- * To run the same program a second time, with the same arguments. This is not the same thing as giving more input to the first run!

For example, suppose you pipe output to the mail program. If you output several lines redirected to this pipe without closing it, they make a single message of several lines. By contrast, if you close the pipe after each line of output, then each line makes a separate message.

`close` returns a value of zero if the close succeeded. Otherwise, the value will be non-zero. In this case, gawk sets the variable `ERRNO` to a string describing the error that occurred.

1.42 gawk.info/Special Files

Standard I/O Streams

=====

Running programs conventionally have three input and output streams already available to them for reading and writing. These are known as the standard input, standard output, and standard error output. These streams are, by default, terminal input and output, but they are often redirected with the shell, via the `<`, `<<`, `>`, `>>`, `>&` and `|` operators.

Standard error is used only for writing error messages; the reason we have two separate streams, standard output and standard error, is so that they can be redirected separately.

In other implementations of `awk`, the only way to write an error message to standard error in an `awk` program is as follows:

```
print "Serious error detected!\n" | "cat 1>&2"
```

This works by opening a pipeline to a shell command which can access the standard error stream which it inherits from the `awk` process. This is far from elegant, and is also inefficient, since it requires a separate process. So people writing `awk` programs have often neglected to do this. Instead, they have sent the error messages to the terminal, like this:

```
NF != 4 {  
    printf("line %d skipped: doesn't have 4 fields\n", FNR) > "/dev/tty"  
}
```

This has the same effect most of the time, but not always: although the standard error stream is usually the terminal, it can be redirected, and when that happens, writing to the terminal is not correct. In fact, if `awk` is run from a background job, it may not have a terminal at all. Then opening `/dev/tty` will fail.

`gawk` provides special file names for accessing the three standard streams. When you redirect input or output in `gawk`, if the file name matches one of these special names, then `gawk` directly uses the stream it stands for.

`/dev/stdin`
The standard input (file descriptor 0).

`/dev/stdout`
The standard output (file descriptor 1).

`/dev/stderr`
The standard error output (file descriptor 2).

`/dev/fd/N`
The file associated with file descriptor `N`. Such a file must have been opened by the program initiating the `awk` execution (typically the shell). Unless you take special pains, only descriptors 0, 1 and 2 are available.

The file names `/dev/stdin`, `/dev/stdout`, and `/dev/stderr` are aliases for `/dev/fd/0`, `/dev/fd/1`, and `/dev/fd/2`, respectively, but they are more self-explanatory.

The proper way to write an error message in a `gawk` program is to use `/dev/stderr`, like this:

```
NF != 4 {  
    printf("line %d skipped: doesn't have 4 fields\n", FNR) > "/dev/stderr"  
}
```

gawk also provides special file names that give access to information about the running gawk process. Each of these "files" provides a single record of information. To read them more than once, you must first close them with the close function (see

Closing Input Files and Pipes
). The filenames are:

/dev/pid

Reading this file returns the process ID of the current process, in decimal, terminated with a newline.

/dev/ppid

Reading this file returns the parent process ID of the current process, in decimal, terminated with a newline.

/dev/pgrpid

Reading this file returns the process group ID of the current process, in decimal, terminated with a newline.

/dev/user

Reading this file returns a single record terminated with a newline. The fields are separated with blanks. The fields represent the following information:

\$1

The value of the getuid system call.

\$2

The value of the geteuid system call.

\$3

The value of the getgid system call.

\$4

The value of the getegid system call.

If there are any additional fields, they are the group IDs returned by getgroups system call. (Multiple groups may not be supported on all systems.)

These special file names may be used on the command line as data files, as well as for I/O redirections within an awk program. They may not be used as source files with the -f option.

Recognition of these special file names is disabled if gawk is in compatibility mode (see

Invoking awk
).

Caution: Unless your system actually has a /dev/fd directory (or any of the other above listed special files), the interpretation of these file names is done by gawk itself. For example, using /dev/fd/4 for output will actually write on file descriptor 4, and not on a new file descriptor that was dup'ed from file descriptor 4. Most of the time this does not matter; however, it is important to not close any of the files related to file descriptors

0, 1, and 2. If you do close one of these files, unpredictable behavior will result.

1.43 gawk.info/One-liners

Useful "One-liners"

Useful awk programs are often short, just a line or two. Here is a collection of useful, short programs to get you started. Some of these programs contain constructs that haven't been covered yet. The description of the program will give you a good idea of what is going on, but please read the rest of the manual to become an awk expert!

Since you are reading this in Info, each line of the example code is enclosed in quotes, to represent text that you would type literally. The examples themselves represent shell commands that use single quotes to keep the shell from interpreting the contents of the program. When reading the examples, focus on the text between the open and close quotes.

```
awk '{ if (NF > max) max = NF }
      END { print max }'
```

This program prints the maximum number of fields on any input line.

```
awk 'length($0) > 80'
```

This program prints every line longer than 80 characters. The sole rule has a relational expression as its pattern, and has no action (so the default action, printing the record, is used).

```
awk 'NF > 0'
```

This program prints every line that has at least one field. This is an easy way to delete blank lines from a file (or rather, to create a new file similar to the old file but from which the blank lines have been deleted).

```
awk '{ if (NF > 0) print }'
```

This program also prints every line that has at least one field. Here we allow the rule to match every line, then decide in the action whether to print.

```
awk 'BEGIN { for (i = 1; i <= 7; i++)
           print int(101 * rand()) }'
```

This program prints 7 random numbers from 0 to 100, inclusive.

```
ls -l files | awk '{ x += $4 } ; END { print "total bytes: " x }'
```

This program prints the total number of bytes used by files.

```
expand file | awk '{ if (x < length()) x = length() }
                  END { print "maximum line length is " x }'
```

This program prints the maximum line length of file. The input is piped through the expand program to change tabs into spaces, so the widths compared are actually the right-margin columns.


```
awk 'BEGIN { FS = ":" }
     { print $1 | "sort" }' /etc/passwd
     This program prints a sorted list of the login names of all users.
```

```
awk '{ nlines++ }
     END { print nlines }'
     This programs counts lines in a file.
```

```
awk 'END { print NR }'
     This program also counts lines in a file, but lets awk do the work.
```

```
awk '{ print NR, $0 }'
     This program adds line numbers to all its input files, similar to
     cat -n.
```

1.44 gawk.info/Patterns

Patterns

Patterns in awk control the execution of rules: a rule is executed when its pattern matches the current input record. This chapter tells all about how to write patterns.

Kinds of Patterns

A list of all kinds of patterns.
The following subsections describe them in detail.

Regexp

Regular expressions such as /foo/.

Comparison Patterns

Comparison expressions such as \$1 > 10.

Boolean Patterns

Combining comparison expressions.

Expression Patterns

Any expression can be used as a pattern.

Ranges

Pairs of patterns specify record ranges.

BEGIN-END

Specifying initialization and cleanup rules.

Empty

The empty pattern, which matches every record. ↵

1.45 gawk.info/Kinds of Patterns

Kinds of Patterns

=====

Here is a summary of the types of patterns supported in awk.

/regular expression/

A regular expression as a pattern. It matches when the text of the input record fits the regular expression. (See

Regular Expressions as Patterns
.)

expression

A single expression. It matches when its value, converted to a number, is nonzero (if a number) or nonnull (if a string). (See

Expressions as Patterns
.)

pat1, pat2

A pair of patterns separated by a comma, specifying a range of records. (See

Specifying Record Ranges with Patterns
.)

BEGIN

END

Special patterns to supply start-up or clean-up information to awk. (See

BEGIN and END Special Patterns
.)

null

The empty pattern matches every input record. (See

The Empty Pattern
.)

1.46 gawk.info/Regexp

Regular Expressions as Patterns

=====

A regular expression, or regexp, is a way of describing a class of strings. A regular expression enclosed in slashes (/) is an awk pattern that matches every input record whose text belongs to that

class.

The simplest regular expression is a sequence of letters, numbers, or both. Such a regexp matches any string that contains that sequence. Thus, the regexp `foo` matches any string containing `foo`. Therefore, the pattern `/foo/` matches any input record containing `foo`. Other kinds of regexps let you specify more complicated classes of strings.

Regexp Usage

How to Use Regular Expressions

Regexp Operators

Regular Expression Operators

Case-sensitivity

How to do case-insensitive matching.

1.47 gawk.info/Regexp Usage

How to Use Regular Expressions

A regular expression can be used as a pattern by enclosing it in slashes. Then the regular expression is matched against the entire text of each record. (Normally, it only needs to match some part of the text in order to succeed.) For example, this prints the second field of each record that contains `foo` anywhere:

```
awk '/foo/ { print $2 }' BBS-list
```

Regular expressions can also be used in comparison expressions. Then you can specify the string to match against; it need not be the entire current input record. These comparison expressions can be used as patterns or in `if`, `while`, `for`, and `do` statements.

`exp ~ /regexp/`

This is true if the expression `exp` (taken as a character string) is matched by `regexp`. The following example matches, or selects, all input records with the upper-case letter `J` somewhere in the first field:

```
awk '$1 ~ /J/' inventory-shipped
```

So does this:

```
awk '{ if ($1 ~ /J/) print }' inventory-shipped
```

`exp !~ /regexp/`

This is true if the expression `exp` (taken as a character string) is not matched by `regexp`. The following example matches, or selects, all input records whose first field does not contain the

upper-case letter J:

```
awk '$1 !~ /J/' inventory-shipped
```

The right hand side of a `~` or `!~` operator need not be a constant regexp (i.e., a string of characters between slashes). It may be any expression. The expression is evaluated, and converted if necessary to a string; the contents of the string are used as the regexp. A regexp that is computed in this way is called a dynamic regexp. For example:

```
identifier_regexp = "[A-Za-z_][A-Za-z_0-9]+"
$0 ~ identifier_regexp
```

sets `identifier_regexp` to a regexp that describes awk variable names, and tests if the input record matches this regexp.

1.48 gawk.info/Regexp Operators

Regular Expression Operators

You can combine regular expressions with the following characters, called regular expression operators, or metacharacters, to increase the power and versatility of regular expressions.

Here is a table of metacharacters. All characters not listed in the table stand for themselves.

^

This matches the beginning of the string or the beginning of a line within the string. For example:

```
^@chapter
```

matches the `@chapter` at the beginning of a string, and can be used to identify chapter beginnings in Texinfo source files.

\$

This is similar to `^`, but it matches only at the end of a string or the end of a line within the string. For example:

```
p$
```

matches a record that ends with a `p`.

.

This matches any single character except a newline. For example:

```
.P
```

matches any single character followed by a `P` in a string. Using concatenation we can make regular expressions like `U.A`, which matches any three-character sequence that begins with `U` and ends with `A`.

[...]

This is called a character set. It matches any one of the characters that are enclosed in the square brackets. For example:

```
[MVX]
```

matches any one of the characters M, V, or X in a string.

Ranges of characters are indicated by using a hyphen between the beginning and ending characters, and enclosing the whole thing in brackets. For example:

```
[0-9]
```

matches any digit.

To include the character `\`, `]`, `-` or `^` in a character set, put a `\` in front of it. For example:

```
[d\]]
```

matches either `d`, or `]`.

This treatment of `\` is compatible with other awk implementations, and is also mandated by the POSIX Command Language and Utilities standard. The regular expressions in awk are a superset of the POSIX specification for Extended Regular Expressions (EREs). POSIX EREs are based on the regular expressions accepted by the traditional `egrep` utility.

In `egrep` syntax, backslash is not syntactically special within square brackets. This means that special tricks have to be used to represent the characters `]`, `-` and `^` as members of a character set.

In `egrep` syntax, to match `-`, write it as `--`, which is a range containing only `-`. You may also give `-` as the first or last character in the set. To match `^`, put it anywhere except as the first character of a set. To match a `]`, make it the first character in the set. For example:

```
[]d^]
```

matches either `]`, `d` or `^`.

[^ ...]

This is a complemented character set. The first character after the `[` must be a `^`. It matches any characters except those in the square brackets (or newline). For example:

```
[^0-9]
```

matches any character that is not a digit.

|

This is the alternation operator and it is used to specify alternatives. For example:

```
^P|[0-9]
```

matches any string that matches either `^P` or `[0-9]`. This means it matches any string that contains a digit or starts with `P`.

The alternation applies to the largest possible regexps on either side.

(...)

Parentheses are used for grouping in regular expressions as in arithmetic. They can be used to concatenate regular expressions containing the alternation operator, `|`.

*

This symbol means that the preceding regular expression is to be repeated as many times as possible to find a match. For example:

```
ph*
```

applies the `*` symbol to the preceding `h` and looks for matches to one `p` followed by any number of `hs`. This will also match just `p` if no `hs` are present.

The `*` repeats the smallest possible preceding expression. (Use parentheses if you wish to repeat a larger expression.) It finds as many repetitions as possible. For example:

```
awk '/\(c[ad][ad]*r x\) / { print }' sample
```

prints every record in the input containing a string of the form `(car x)`, `(cdr x)`, `(cadr x)`, and so on.

+

This symbol is similar to `*`, but the preceding expression must be matched at least once. This means that:

```
wh+y
```

would match `why` and `whhy` but not `wy`, whereas `wh*y` would match all three of these strings. This is a simpler way of writing the last `*` example:

```
awk '/\(c[ad]+r x\) / { print }' sample
```

?

This symbol is similar to `*`, but the preceding expression can be matched once or not at all. For example:

```
fe?d
```

will match `fed` and `fd`, but nothing else.

\

This is used to suppress the special meaning of a character when matching. For example:

```
\$
```

matches the character \$.

The escape sequences used for string constants (see

```
    Constant Expressions
    ) are valid in regular expressions as well;
they are also introduced by a \ .
```

In regular expressions, the *, +, and ? operators have the highest precedence, followed by concatenation, and finally by |. As in arithmetic, parentheses can change how operators are grouped.

1.49 gawk.info/Case-sensitivity

Case-sensitivity in Matching

Case is normally significant in regular expressions, both when matching ordinary characters (i.e., not metacharacters), and inside character sets. Thus a w in a regular expression matches only a lower case w and not an upper case W.

The simplest way to do a case-independent match is to use a character set: [Ww]. However, this can be cumbersome if you need to use it often; and it can make the regular expressions harder for humans to read. There are two other alternatives that you might prefer.

One way to do a case-insensitive match at a particular point in the program is to convert the data to a single case, using the tolower or toupper built-in string functions (which we haven't discussed yet; see

```
Built-in Functions for String Manipulation
). For example:
```

```
tolower($1) ~ /foo/ { ... }
```

converts the first field to lower case before matching against it.

Another method is to set the variable IGNORECASE to a nonzero value (see

```
Built-in Variables
). When IGNORECASE is not zero, all regexp
operations ignore case. Changing the value of IGNORECASE dynamically
controls the case sensitivity of your program as it runs. Case is
significant by default because IGNORECASE (like most variables) is
initialized to zero.
```

```
x = "aB"
if (x ~ /ab/) ... # this test will fail
```

```
IGNORECASE = 1
```

```
if (x ~ /ab/) ... # now it will succeed
```

In general, you cannot use IGNORECASE to make certain rules case-insensitive and other rules case-sensitive, because there is no way to set IGNORECASE just for the pattern of a particular rule. To do this, you must use character sets or tolower. However, one thing you can do only with IGNORECASE is turn case-sensitivity on or off dynamically for all the rules at once.

IGNORECASE can be set on the command line, or in a BEGIN rule. Setting IGNORECASE from the command line is a way to make a program case-insensitive without having to edit it.

The value of IGNORECASE has no effect if gawk is in compatibility mode (see

```
    Invoking awk
    ). Case is always significant in compatibility
```

mode.

1.50 gawk.info/Comparison Patterns

Comparison Expressions as Patterns

```
=====
```

Comparison patterns test relationships such as equality between two strings or numbers. They are a special case of expression patterns (see

```
    Expressions as Patterns
    ). They are written with relational
```

operators, which are a superset of those in C. Here is a table of them:

```
x < y
    True if x is less than y.

x <= y
    True if x is less than or equal to y.

x > y
    True if x is greater than y.

x >= y
    True if x is greater than or equal to y.

x == y
    True if x is equal to y.

x != y
    True if x is not equal to y.

x ~ y
    True if x matches the regular expression described by y.

x !~ y
```


True if *x* does not match the regular expression described by *y*.

The operands of a relational operator are compared as numbers if they are both numbers. Otherwise they are converted to, and compared as, strings (see

Conversion of Strings and Numbers
, for the detailed

rules). Strings are compared by comparing the first character of each, then the second character of each, and so on, until there is a difference. If the two strings are equal until the shorter one runs out, the shorter one is considered to be less than the longer one. Thus, "10" is less than "9", and "abc" is less than "abcd".

The left operand of the `~` and `!~` operators is a string. The right operand is either a constant regular expression enclosed in slashes (`/regexp/`), or any expression, whose string value is used as a dynamic regular expression (see

How to Use Regular Expressions
)

The following example prints the second field of each input record whose first field is precisely `foo`.

```
awk '$1 == "foo" { print $2 }' BBS-list
```

Contrast this with the following regular expression match, which would accept any record with a first field that contains `foo`:

```
awk '$1 ~ "foo" { print $2 }' BBS-list
```

or, equivalently, this one:

```
awk '$1 ~ /foo/ { print $2 }' BBS-list
```

1.51 gawk.info/Boolean Patterns

Boolean Operators and Patterns

=====

A boolean pattern is an expression which combines other patterns using the boolean operators "or" (`||`), "and" (`&&`), and "not" (`!`). Whether the boolean pattern matches an input record depends on whether its subpatterns match.

For example, the following command prints all records in the input file `BBS-list` that contain both `2400` and `foo`.

```
awk '/2400/ && /foo/' BBS-list
```

The following command prints all records in the input file `BBS-list` that contain either `2400` or `foo`, or both.

```
awk '/2400/ || /foo/' BBS-list
```

The following command prints all records in the input file BBS-list that do not contain the string foo.

```
awk '! /foo/' BBS-list
```

Note that boolean patterns are a special case of expression patterns (see

Expressions as Patterns

); they are expressions that use the

boolean operators. See

Boolean Expressions

, for complete information

on the boolean operators.

The subpatterns of a boolean pattern can be constant regular expressions, comparisons, or any other awk expressions. Range patterns are not expressions, so they cannot appear inside boolean patterns. Likewise, the special patterns BEGIN and END, which never match any input record, are not expressions and cannot appear inside boolean patterns.

1.52 gawk.info/Expression Patterns

Expressions as Patterns

=====

Any awk expression is also valid as an awk pattern. Then the pattern "matches" if the expression's value is nonzero (if a number) or nonnull (if a string).

The expression is reevaluated each time the rule is tested against a new input record. If the expression uses fields such as \$1, the value depends directly on the new input record's text; otherwise, it depends only on what has happened so far in the execution of the awk program, but that may still be useful.

Comparison patterns are actually a special case of this. For example, the expression \$5 == "foo" has the value 1 when the value of \$5 equals "foo", and 0 otherwise; therefore, this expression as a pattern matches when the two values are equal.

Boolean patterns are also special cases of expression patterns.

A constant regexp as a pattern is also a special case of an expression pattern. /foo/ as an expression has the value 1 if foo appears in the current input record; thus, as a pattern, /foo/ matches any record containing foo.

Other implementations of awk that are not yet POSIX compliant are less general than gawk: they allow comparison expressions, and boolean combinations thereof (optionally with parentheses), but not necessarily other kinds of expressions.

1.53 gawk.info/Ranges

Specifying Record Ranges with Patterns

=====
 A range pattern is made of two patterns separated by a comma, of the form `begpat, endpat`. It matches ranges of consecutive input records. The first pattern `begpat` controls where the range begins, and the second one `endpat` controls where it ends. For example,

```
awk '$1 == "on", $1 == "off"
```

prints every record between on/off pairs, inclusive.

A range pattern starts out by matching `begpat` against every input record; when a record matches `begpat`, the range pattern becomes turned on. The range pattern matches this record. As long as it stays turned on, it automatically matches every input record read. It also matches `endpat` against every input record; when that succeeds, the range pattern is turned off again for the following record. Now it goes back to checking `begpat` against each record.

The record that turns on the range pattern and the one that turns it off both match the range pattern. If you don't want to operate on these records, you can write `if` statements in the rule's action to distinguish them.

It is possible for a pattern to be turned both on and off by the same record, if both conditions are satisfied by that record. Then the action is executed for just that record.

1.54 gawk.info/BEGIN-END

BEGIN and END Special Patterns

=====
 BEGIN and END are special patterns. They are not used to match input records. Rather, they are used for supplying start-up or clean-up information to your awk script. A BEGIN rule is executed, once, before the first input record has been read. An END rule is executed, once, after all the input has been read. For example:

```
awk 'BEGIN { print "Analysis of `foo`" }
     /foo/ { ++foobar }
     END   { print "`foo` appears " foobar " times." }' BBS-list
```

This program finds the number of records in the input file `BBS-list` that contain the string `foo`. The BEGIN rule prints a title for the report. There is no need to use the BEGIN rule to initialize the

counter foobar to zero, as awk does this for us automatically (see

```
Variables
).
```

The second rule increments the variable foobar every time a record containing the pattern foo is read. The END rule prints the value of foobar at the end of the run.

The special patterns BEGIN and END cannot be used in ranges or with boolean operators (indeed, they cannot be used with any operators).

An awk program may have multiple BEGIN and/or END rules. They are executed in the order they appear, all the BEGIN rules at start-up and all the END rules at termination.

Multiple BEGIN and END sections are useful for writing library functions, since each library can have its own BEGIN or END rule to do its own initialization and/or cleanup. Note that the order in which library functions are named on the command line controls the order in which their BEGIN and END rules are executed. Therefore you have to be careful to write such rules in library files so that the order in which they are executed doesn't matter. See

```
Invoking awk
, for more
```

information on using library functions.

If an awk program only has a BEGIN rule, and no other rules, then the program exits after the BEGIN rule has been run. (Older versions of awk used to keep reading and ignoring input until end of file was seen.) However, if an END rule exists as well, then the input will be read, even if there are no other rules in the program. This is necessary in case the END rule checks the NR variable.

BEGIN and END rules must have actions; there is no default action for these rules since there is no current record when they run.

1.55 gawk.info/Empty

The Empty Pattern
=====

An empty pattern is considered to match every input record. For example, the program:

```
awk '{ print $1 }' BBS-list
```

prints the first field of every record.

1.56 gawk.info/Actions

Overview of Actions

An awk program or script consists of a series of rules and function definitions, interspersed. (Functions are described later. See

User-defined Functions)

A rule contains a pattern and an action, either of which may be omitted. The purpose of the action is to tell awk what to do once a match for the pattern is found. Thus, the entire program looks somewhat like this:

```
[pattern ] [{ action }]
[pattern ] [{ action }]
...
function name (args) { ... }
...
```

An action consists of one or more awk statements, enclosed in curly braces ({ and }). Each statement specifies one thing to be done. The statements are separated by newlines or semicolons.

The curly braces around an action must be used even if the action contains only one statement, or even if it contains no statements at all. However, if you omit the action entirely, omit the curly braces as well. (An omitted action is equivalent to { print \$0 }.)

Here are the kinds of statements supported in awk:

- * Expressions, which can call functions or assign values to variables (see

Expressions as Action Statements
)

). Executing this kind of statement simply computes the value of the expression and then ignores it. This is useful when the expression has side effects (see

Assignment Expressions
)

- * Control statements, which specify the control flow of awk programs. The awk language gives you C-like constructs (if, for, while, and so on) as well as a few special ones (see

Control Statements in Actions
)

- * Compound statements, which consist of one or more statements enclosed in curly braces. A compound statement is used in order to put several statements together in the body of an if, while, do or for statement.

- * Input control, using the getline command (see

Explicit Input with `getline`
) , and the next statement (see

The next Statement
).

* Output statements, `print` and `printf`. See
Printing Output

.

* Deletion statements, for deleting array elements. See

The delete Statement

.

1.57 gawk.info/Expressions

Expressions as Action Statements

Expressions are the basic building block of awk actions. An expression evaluates to a value, which you can print, test, store in a variable or pass to a function. But beyond that, an expression can assign a new value to a variable or a field, with an assignment operator.

An expression can serve as a statement on its own. Most other kinds of statements contain one or more expressions which specify data to be operated on. As in other languages, expressions in awk include variables, array references, constants, and function calls, as well as combinations of these with various operators.

Constants

String, numeric, and regexp constants.

Variables

Variables give names to values for later use.

Arithmetic Ops

Arithmetic operations (+, -, etc.)

Concatenation

Concatenating strings.

Comparison Ops

Comparison of numbers and strings
with <, etc.

Boolean Ops

Combining comparison expressions

using boolean operators
 || ("or"), && ("and") and ! ("not").

Assignment Ops

Changing the value of a variable or a field.

Increment Ops

Incrementing the numeric value of a variable.

Conversion

The conversion of strings to numbers
 and vice versa.

Values

The whole truth about numbers and strings.

Conditional Exp

Conditional expressions select
 between two subexpressions under control
 of a third subexpression.

Function Calls

A function call is an expression.

Precedence

How various operators nest.

1.58 gawk.info/Constants

Constant Expressions

=====

The simplest type of expression is the constant, which always has the same value. There are three types of constants: numeric constants, string constants, and regular expression constants.

A numeric constant stands for a number. This number can be an integer, a decimal fraction, or a number in scientific (exponential) notation. Note that all numeric values are represented within awk in double-precision floating point. Here are some examples of numeric constants, which all have the same value:

```
105
1.05e+2
1050e-1
```

A string constant consists of a sequence of characters enclosed in double-quote marks. For example:

```
"parrot"
```

represents the string whose contents are parrot. Strings in gawk can be of any length and they can contain all the possible 8-bit ASCII characters including ASCII NUL. Other awk implementations may have difficulty with some character codes.

Some characters cannot be included literally in a string constant. You represent them instead with escape sequences, which are character sequences beginning with a backslash (`\`).

One use of an escape sequence is to include a double-quote character in a string constant. Since a plain double-quote would end the string, you must use `\"` to represent a single double-quote character as a part of the string. The backslash character itself is another character that cannot be included normally; you write `\\` to put one backslash in the string. Thus, the string whose contents are the two characters `"\"` must be written `"\\\""`.

Another use of backslash is to represent unprintable characters such as newline. While there is nothing to stop you from writing most of these characters directly in a string constant, they may look ugly.

Here is a table of all the escape sequences used in awk:

<code>\</code>	Represents a literal backslash, <code>\</code> .
<code>\a</code>	Represents the "alert" character, control-g, ASCII code 7.
<code>\b</code>	Represents a backspace, control-h, ASCII code 8.
<code>\f</code>	Represents a formfeed, control-l, ASCII code 12.
<code>\n</code>	Represents a newline, control-j, ASCII code 10.
<code>\r</code>	Represents a carriage return, control-m, ASCII code 13.
<code>\t</code>	Represents a horizontal tab, control-i, ASCII code 9.
<code>\v</code>	Represents a vertical tab, control-k, ASCII code 11.
<code>@{i}nnn</code>	Represents the octal value nnn, where nnn are one to three digits between 0 and 7. For example, the code for the ASCII ESC (escape) character is <code>\033</code> .
<code>\xhh ...</code>	Represents the hexadecimal value hh, where hh are hexadecimal digits (0 through 9 and either A through F or a through f). Like the same construct in ANSI C, the escape sequence continues until the first non-hexadecimal digit is seen. However, using more than

two hexadecimal digits produces undefined results. (The `\x` escape sequence is not allowed in POSIX awk.)

A constant regexp is a regular expression description enclosed in slashes, such as `/^beginning and end$/`. Most regexps used in awk programs are constant, but the `~` and `!~` operators can also match computed or "dynamic" regexps (see [How to Use Regular Expressions](#)).

Constant regexps may be used like simple expressions. When a constant regexp is not on the right hand side of the `~` or `!~` operators, it has the same meaning as if it appeared in a pattern, i.e. `($0 ~ /foo/)` (see [Expressions as Patterns](#)).

This means that the two code

segments,

```
if ($0 ~ /barfly/ || $0 ~ /camelot/)
    print "found"
```

and

```
if (/barfly/ || /camelot/)
    print "found"
```

are exactly equivalent. One rather bizarre consequence of this rule is that the following boolean expression is legal, but does not do what the user intended:

```
if (/foo/ ~ $1) print "found foo"
```

This code is "obviously" testing `$1` for a match against the regexp `/foo/`. But in fact, the expression `(/foo/ ~ $1)` actually means `(($0 ~ /foo/) ~ $1)`. In other words, first match the input record against the regexp `/foo/`. The result will be either a 0 or a 1, depending upon the success or failure of the match. Then match that result against the first field in the record.

Since it is unlikely that you would ever really wish to make this kind of test, gawk will issue a warning when it sees this construct in a program.

Another consequence of this rule is that the assignment statement

```
matches = /foo/
```

will assign either 0 or 1 to the variable `matches`, depending upon the contents of the current input record.

Constant regular expressions are also used as the first argument for the `sub` and `gsub` functions (see [Built-in Functions for String Manipulation](#)).

This feature of the language was never well documented until the

POSIX specification.

You may be wondering, when is

```
$1 ~ /foo/ { ... }
```

preferable to

```
$1 ~ "foo" { ... }
```

Since the right-hand sides of both `~` operators are constants, it is more efficient to use the `/foo/` form: `awk` can note that you have supplied a regexp and store it internally in a form that makes pattern matching more efficient. In the second form, `awk` must first convert the string into this internal form, and then perform the pattern matching. The first form is also better style; it shows clearly that you intend a regexp match.

1.59 gawk.info/Variables

Variables

=====

Variables let you give names to values and refer to them later. You have already seen variables in many of the examples. The name of a variable must be a sequence of letters, digits and underscores, but it may not begin with a digit. Case is significant in variable names; `a` and `A` are distinct variables.

A variable name is a valid expression by itself; it represents the variable's current value. Variables are given new values with assignment operators and increment operators. See

Assignment Expressions

.

A few variables have special built-in meanings, such as `FS`, the field separator, and `NF`, the number of fields in the current input record. See

Built-in Variables

, for a list of them. These built-in variables can be used and assigned just like all other variables, but their values are also used or changed automatically by `awk`. Each built-in variable's name is made entirely of upper case letters.

Variables in `awk` can be assigned either numeric or string values. By default, variables are initialized to the null string, which is effectively zero if converted to a number. There is no need to "initialize" each variable explicitly in `awk`, the way you would in C or most other traditional languages.

Assignment Options

Setting variables on the command line
and a summary of command line syntax.
This is an advanced method of input.

1.60 gawk.info/Assignment Options

Assigning Variables on the Command Line

You can set any awk variable by including a variable assignment among the arguments on the command line when you invoke awk (see

Invoking awk
) . Such an assignment has this form:

```
variable=text
```

With it, you can set a variable either at the beginning of the awk run or in between input files.

If you precede the assignment with the `-v` option, like this:

```
-v variable=text
```

then the variable is set at the very beginning, before even the BEGIN rules are run. The `-v` option and its assignment must precede all the file name arguments, as well as the program text.

Otherwise, the variable assignment is performed at a time determined by its position among the input file arguments: after the processing of the preceding input file argument. For example:

```
awk '{ print $n }' n=4 inventory-shipped n=2 BBS-list
```

prints the value of field number `n` for all input records. Before the first file is read, the command line sets the variable `n` equal to 4. This causes the fourth field to be printed in lines from the file `inventory-shipped`. After the first file has finished, but before the second file is started, `n` is set to 2, so that the second field is printed in lines from `BBS-list`.

Command line arguments are made available for explicit examination by the awk program in an array named ARGV (see

Built-in Variables
) .

awk processes the values of command line assignments for escape sequences (see

Constant Expressions
) .

1.61 gawk.info/Arithmetic Ops

Arithmetic Operators

=====

The awk language uses the common arithmetic operators when evaluating expressions. All of these arithmetic operators follow normal precedence rules, and work as you would expect them to. This example divides field three by field four, adds field two, stores the result into field one, and prints the resulting altered input record:

```
awk '{ $1 = $2 + $3 / $4; print }' inventory-shipped
```

The arithmetic operators in awk are:

$x + y$

Addition.

$x - y$

Subtraction.

$- x$

Negation.

$+ x$

Unary plus. No real effect on the expression.

$x * y$

Multiplication.

x / y

Division. Since all numbers in awk are double-precision floating point, the result is not rounded to an integer: $3 / 4$ has the value 0.75.

$x \% y$

Remainder. The quotient is rounded toward zero to an integer, multiplied by y and this result is subtracted from x . This operation is sometimes known as "trunc-mod." The following relation always holds:

$$b * \text{int}(a / b) + (a \% b) == a$$

One possibly undesirable effect of this definition of remainder is that $x \% y$ is negative if x is negative. Thus,

$$-17 \% 8 = -1$$

In other awk implementations, the signedness of the remainder may be machine dependent.

$x \wedge y$

$x ** y$

Exponentiation: x raised to the y power. $2 ^ 3$ has the value 8. The character sequence `**` is equivalent to `^`. (The POSIX standard only specifies the use of `^` for exponentiation.)

1.62 gawk.info/Concatenation

String Concatenation

=====

There is only one string operation: concatenation. It does not have a specific operator to represent it. Instead, concatenation is performed by writing expressions next to one another, with no operator. For example:

```
awk '{ print "Field number one: " $1 }' BBS-list
```

produces, for the first record in BBS-list:

```
Field number one: aardvark
```

Without the space in the string constant after the `:`, the line would run together. For example:

```
awk '{ print "Field number one:" $1 }' BBS-list
```

produces, for the first record in BBS-list:

```
Field number one:aardvark
```

Since string concatenation does not have an explicit operator, it is often necessary to insure that it happens where you want it to by enclosing the items to be concatenated in parentheses. For example, the following code fragment does not concatenate file and name as you might expect:

```
file = "file"
name = "name"
print "something meaningful" > file name
```

It is necessary to use the following:

```
print "something meaningful" > (file name)
```

We recommend you use parentheses around concatenation in all but the most common contexts (such as in the right-hand operand of `=`).

1.63 gawk.info/Comparison Ops

Comparison Expressions

=====

Comparison expressions compare strings or numbers for relationships such as equality. They are written using relational operators, which are a superset of those in C. Here is a table of them:

<code>x < y</code>	True if x is less than y.
<code>x <= y</code>	True if x is less than or equal to y.
<code>x > y</code>	True if x is greater than y.
<code>x >= y</code>	True if x is greater than or equal to y.
<code>x == y</code>	True if x is equal to y.
<code>x != y</code>	True if x is not equal to y.
<code>x ~ y</code>	True if the string x matches the regexp denoted by y.
<code>x !~ y</code>	True if the string x does not match the regexp denoted by y.
<code>subscript in array</code>	True if array array has an element with the subscript subscript.

Comparison expressions have the value 1 if true and 0 if false.

The rules gawk uses for performing comparisons are based on those in draft 11.2 of the POSIX standard. The POSIX standard introduced the concept of a numeric string, which is simply a string that looks like a number, for example, "+2".

When performing a relational operation, gawk considers the type of an operand to be the type it received on its last assignment, rather than the type of its last use (see

Numeric and String Values

). This type is

unknown when the operand is from an "external" source: field variables, command line arguments, array elements resulting from a split operation, and the value of an ENVIRON element. In this case only, if the operand is a numeric string, then it is considered to be of both string type and numeric type. If at least one operand of a comparison is of string type only, then a string comparison is performed. Any numeric operand will be converted to a string using the value of CONVFM (see

Conversion of Strings and Numbers

). If one operand of a

comparison is numeric, and the other operand is either numeric or both numeric and string, then gawk does a numeric comparison. If both operands have both types, then the comparison is numeric. Strings are

compared by comparing the first character of each, then the second character of each, and so on. Thus "10" is less than "9". If there are two strings where one is a prefix of the other, the shorter string is less than the longer one. Thus "abc" is less than "abcd".

Here are some sample expressions, how gawk compares them, and what the result of the comparison is.

```
1.5 <= 2.0
  numeric comparison (true)
```

```
"abc" >= "xyz"
  string comparison (false)
```

```
1.5 != " +2"
  string comparison (true)
```

```
"1e2" < "3"
  string comparison (true)
```

```
a = 2; b = "2"
a == b
  string comparison (true)
```

```
echo 1e2 3 | awk '{ print ($1 < $2) ? "true" : "false" }'
```

prints false since both \$1 and \$2 are numeric strings and thus have both string and numeric types, thus dictating a numeric comparison.

The purpose of the comparison rules and the use of numeric strings is to attempt to produce the behavior that is "least surprising," while still "doing the right thing."

String comparisons and regular expression comparisons are very different. For example,

```
$1 == "foo"
```

has the value of 1, or is true, if the first field of the current input record is precisely foo. By contrast,

```
$1 ~ /foo/
```

has the value 1 if the first field contains foo, such as foobar.

The right hand operand of the ~ and !~ operators may be either a constant regexp (/.../), or it may be an ordinary expression, in which case the value of the expression as a string is a dynamic regexp (see

How to Use Regular Expressions
)

In very recent implementations of awk, a constant regular expression in slashes by itself is also an expression. The regexp /regexp/ is an abbreviation for this comparison expression:

```
$0 ~ /regexp/
```

In some contexts it may be necessary to write parentheses around the regexp to avoid confusing the gawk parser. For example, `(/x/ - /y/) > threshold` is not allowed, but `((/x/) - (/y/)) > threshold` parses properly.

One special place where `/foo/` is not an abbreviation for `$0 ~ /foo/` is when it is the right-hand operand of `~` or `!~`. See

Constant Expressions
, where this is discussed in more detail.

1.64 gawk.info/Boolean Ops

Boolean Expressions

=====

A boolean expression is a combination of comparison expressions or matching expressions, using the boolean operators "or" (`||`), "and" (`&&`), and "not" (`!`), along with parentheses to control nesting. The truth of the boolean expression is computed by combining the truth values of the component expressions.

Boolean expressions can be used wherever comparison and matching expressions can be used. They can be used in `if`, `while do` and `for` statements. They have numeric values (1 if true, 0 if false), which come into play if the result of the boolean expression is stored in a variable, or used in arithmetic.

In addition, every boolean expression is also a valid boolean pattern, so you can use it as a pattern to control the execution of rules.

Here are descriptions of the three boolean operators, with an example of each. It may be instructive to compare these examples with the analogous examples of boolean patterns (see

Boolean Operators and Patterns
) , which use the same boolean operators
in patterns instead of expressions.

`boolean1 && boolean2`

True if both `boolean1` and `boolean2` are true. For example, the following statement prints the current input record if it contains both 2400 and foo.

```
if ($0 ~ /2400/ && $0 ~ /foo/) print
```

The subexpression `boolean2` is evaluated only if `boolean1` is true. This can make a difference when `boolean2` contains expressions that have side effects: in the case of `$0 ~ /foo/ && ($2 == bar++)`, the variable `bar` is not incremented if there is no foo in the record.

`boolean1 || boolean2`

True if at least one of `boolean1` or `boolean2` is true. For example, the following command prints all records in the input file `BBS-list` that contain either `2400` or `foo`, or both.

```
awk '{ if ($0 ~ /2400/ || $0 ~ /foo/) print }' BBS-list
```

The subexpression `boolean2` is evaluated only if `boolean1` is false. This can make a difference when `boolean2` contains expressions that have side effects.

`!boolean`

True if `boolean` is false. For example, the following program prints all records in the input file `BBS-list` that do not contain the string `foo`.

```
awk '{ if (! ($0 ~ /foo/)) print }' BBS-list
```

1.65 gawk.info/Assignment Ops

Assignment Expressions

=====

An assignment is an expression that stores a new value into a variable. For example, let's assign the value `1` to the variable `z`:

```
z = 1
```

After this expression is executed, the variable `z` has the value `1`. Whatever old value `z` had before the assignment is forgotten.

Assignments can store string values also. For example, this would store the value `"this food is good"` in the variable `message`:

```
thing = "food"
predicate = "good"
message = "this " thing " is " predicate
```

(This also illustrates concatenation of strings.)

The `=` sign is called an assignment operator. It is the simplest assignment operator because the value of the right-hand operand is stored unchanged.

Most operators (addition, concatenation, and so on) have no effect except to compute a value. If you ignore the value, you might as well not use the operator. An assignment operator is different; it does produce a value, but even if you ignore the value, the assignment still makes itself felt through the alteration of the variable. We call this a side effect.

The left-hand operand of an assignment need not be a variable (see

Variables

); it can also be a field (see

Changing the Contents of a Field

) or an array element (see

Arrays in awk

). These are all called lvalues, which means they can appear on the left-hand side of an assignment operator. The right-hand operand may be any expression; it produces the new value which the assignment stores in the specified variable, field or array element.

It is important to note that variables do not have permanent types. The type of a variable is simply the type of whatever value it happens to hold at the moment. In the following program fragment, the variable `foo` has a numeric value at first, and a string value later on:

```
foo = 1
print foo
foo = "bar"
print foo
```

When the second assignment gives `foo` a string value, the fact that it previously had a numeric value is forgotten.

An assignment is an expression, so it has a value: the same value that is assigned. Thus, `z = 1` as an expression has the value 1. One consequence of this is that you can write multiple assignments together:

```
x = y = z = 0
```

stores the value 0 in all three variables. It does this because the value of `z = 0`, which is 0, is stored into `y`, and then the value of `y = z = 0`, which is 0, is stored into `x`.

You can use an assignment anywhere an expression is called for. For example, it is valid to write `x != (y = 1)` to set `y` to 1 and then test whether `x` equals 1. But this style tends to make programs hard to read; except in a one-shot program, you should rewrite it to get rid of such nesting of assignments. This is never very hard.

Aside from `=`, there are several other assignment operators that do arithmetic with the old value of the variable. For example, the operator `+=` computes a new value by adding the right-hand value to the old value of the variable. Thus, the following assignment adds 5 to the value of `foo`:

```
foo += 5
```

This is precisely equivalent to the following:

```
foo = foo + 5
```

Use whichever one makes the meaning of your program clearer.

Here is a table of the arithmetic assignment operators. In each case, the right-hand operand is an expression whose value is converted

to a number.

`lvalue += increment`

Adds increment to the value of lvalue to make the new value of lvalue.

`lvalue -= decrement`

Subtracts decrement from the value of lvalue.

`lvalue *= coefficient`

Multiplies the value of lvalue by coefficient.

`lvalue /= quotient`

Divides the value of lvalue by quotient.

`lvalue %= modulus`

Sets lvalue to its remainder by modulus.

`lvalue ^= power`

`lvalue **= power`

Raises lvalue to the power power. (Only the ^= operator is specified by POSIX.)

1.66 gawk.info/Increment Ops

Increment Operators

=====

Increment operators increase or decrease the value of a variable by 1. You could do the same thing with an assignment operator, so the increment operators add no power to the awk language; but they are convenient abbreviations for something very common.

The operator to add 1 is written `++`. It can be used to increment a variable either before or after taking its value.

To pre-increment a variable `v`, write `++v`. This adds 1 to the value of `v` and that new value is also the value of this expression. The assignment expression `v += 1` is completely equivalent.

Writing the `++` after the variable specifies post-increment. This increments the variable value just the same; the difference is that the value of the increment expression itself is the variable's old value. Thus, if `foo` has the value 4, then the expression `foo++` has the value 4, but it changes the value of `foo` to 5.

The post-increment `foo++` is nearly equivalent to writing `(foo += 1) - 1`. It is not perfectly equivalent because all numbers in awk are floating point: in floating point, `foo + 1 - 1` does not necessarily equal `foo`. But the difference is minute as long as you stick to numbers that are fairly small (less than a trillion).

Any lvalue can be incremented. Fields and array elements are

incremented just like variables. (Use `$(i++)` when you wish to do a field reference and a variable increment at the same time. The parentheses are necessary because of the precedence of the field reference operator, `$.`)

The decrement operator `-` works just like `++` except that it subtracts 1 instead of adding. Like `++`, it can be used before the lvalue to pre-decrement or after it to post-decrement.

Here is a summary of increment and decrement expressions.

`++lvalue`

This expression increments lvalue and the new value becomes the value of this expression.

`lvalue++`

This expression causes the contents of lvalue to be incremented. The value of the expression is the old value of lvalue.

`-lvalue`

Like `++lvalue`, but instead of adding, it subtracts. It decrements lvalue and delivers the value that results.

`lvalue-`

Like `lvalue++`, but instead of adding, it subtracts. It decrements lvalue. The value of the expression is the old value of lvalue.

1.67 gawk.info/Conversion

Conversion of Strings and Numbers

Strings are converted to numbers, and numbers to strings, if the context of the awk program demands it. For example, if the value of either `foo` or `bar` in the expression `foo + bar` happens to be a string, it is converted to a number before the addition is performed. If numeric values appear in string concatenation, they are converted to strings. Consider this:

```
two = 2; three = 3
print (two three) + 4
```

This eventually prints the (numeric) value 27. The numeric values of the variables `two` and `three` are converted to strings and concatenated together, and the resulting string is converted back to the number 23, to which 4 is then added.

If, for some reason, you need to force a number to be converted to a string, concatenate the null string with that number. To force a string to be converted to a number, add zero to that string.

A string is converted to a number by interpreting a numeric prefix of the string as numerals: `"2.5"` converts to 2.5, `"1e3"` converts to 1000, and `"25fix"` has a numeric value of 25. Strings that can't be

interpreted as valid numbers are converted to zero.

The exact manner in which numbers are converted into strings is controlled by the awk built-in variable CONVFMT (see

Built-in Variables
). Numbers are converted using a special version of
 the printf function (see
 Built-in Functions
) with CONVFMT as the format
 specifier.

CONVFMT's default value is "%.6g", which prints a value with at least six significant digits. For some applications you will want to change it to specify more precision. Double precision on most modern machines gives you 16 or 17 decimal digits of precision.

Strange results can happen if you set CONVFMT to a string that doesn't tell printf how to format floating point numbers in a useful way. For example, if you forget the % in the format, all numbers will be converted to the same constant string.

As a special case, if a number is an integer, then the result of converting it to a string is always an integer, no matter what the value of CONVFMT may be. Given the following code fragment:

```
CONVFMT = "%2.2f"
a = 12
b = a ""
```

b has the value "12", not "12.00".

Prior to the POSIX standard, awk specified that the value of OFMT was used for converting numbers to strings. OFMT specifies the output format to use when printing numbers with print. CONVFMT was introduced in order to separate the semantics of conversions from the semantics of printing. Both CONVFMT and OFMT have the same default value: "%.6g". In the vast majority of cases, old awk programs will not change their behavior. However, this use of OFMT is something to keep in mind if you must port your program to other implementations of awk; we recommend that instead of changing your programs, you just port gawk itself!

1.68 gawk.info/Values

Numeric and String Values

=====

Through most of this manual, we present awk values (such as constants, fields, or variables) as either numbers or strings. This is a convenient way to think about them, since typically they are used in only one way, or the other.

In truth though, awk values can be both string and numeric, at the

same time. Internally, awk represents values with a string, a (floating point) number, and an indication that one, the other, or both representations of the value are valid.

Keeping track of both kinds of values is important for execution efficiency: a variable can acquire a string value the first time it is used as a string, and then that string value can be used until the variable is assigned a new value. Thus, if a variable with only a numeric value is used in several concatenations in a row, it only has to be given a string representation once. The numeric value remains valid, so that no conversion back to a number is necessary if the variable is later used in an arithmetic expression.

Tracking both kinds of values is also important for precise numerical calculations. Consider the following:

```
a = 123.321
CONVFMT = "%3.1f"
b = a " is a number"
c = a + 1.654
```

The variable `a` receives a string value in the concatenation and assignment to `b`. The string value of `a` is "123.3". If the numeric value was lost when it was converted to a string, then the numeric use of `a` in the last statement would lose information. `c` would be assigned the value 124.954 instead of 124.975. Such errors accumulate rapidly, and very adversely affect numeric computations.

Once a numeric value acquires a corresponding string value, it stays valid until a new assignment is made. If `CONVFMT` (see

Conversion of Strings and Numbers

) changes in the meantime, the old string value will still be used. For example:

```
BEGIN {
  CONVFMT = "%2.2f"
  a = 123.456
  b = a "" # force 'a' to have string value too
  printf "a = %s\n", a
  CONVFMT = "%.6g"
  printf "a = %s\n", a
  a += 0 # make 'a' numeric only again
  printf "a = %s\n", a # use 'a' as string
}
```

This program prints `a = 123.46` twice, and then prints `a = 123.456`.

See

Conversion of Strings and Numbers

, for the rules that specify how string values are made from numeric values.

1.69 gawk.info/Conditional Exp

Conditional Expressions

=====

A conditional expression is a special kind of expression with three operands. It allows you to use one expression's value to select one of two other expressions.

The conditional expression looks the same as in the C language:

```
selector ? if-true-exp : if-false-exp
```

There are three subexpressions. The first, `selector`, is always computed first. If it is "true" (not zero and not null) then `if-true-exp` is computed next and its value becomes the value of the whole expression. Otherwise, `if-false-exp` is computed next and its value becomes the value of the whole expression.

For example, this expression produces the absolute value of `x`:

```
x > 0 ? x : -x
```

Each time the conditional expression is computed, exactly one of `if-true-exp` and `if-false-exp` is computed; the other is ignored. This is important when the expressions contain side effects. For example, this conditional expression examines element `i` of either array `a` or array `b`, and increments `i`.

```
x == y ? a[i++] : b[i++]
```

This is guaranteed to increment `i` exactly once, because each time one or the other of the two increment expressions is executed, and the other is not.

1.70 gawk.info/Function Calls

Function Calls

=====

A function is a name for a particular calculation. Because it has a name, you can ask for it by name at any point in the program. For example, the function `sqrt` computes the square root of a number.

A fixed set of functions are built-in, which means they are available in every awk program. The `sqrt` function is one of these. See

Built-in Functions

, for a list of built-in functions and their descriptions. In addition, you can define your own functions in the program for use elsewhere in the same program. See

User-defined Functions

, for how to do this.

The way to use a function is with a function call expression, which consists of the function name followed by a list of arguments in parentheses. The arguments are expressions which give the raw materials for the calculation that the function will do. When there is more than one argument, they are separated by commas. If there are no arguments, write just `()` after the function name. Here are some examples:

```
sqrt(x^2 + y^2)      # One argument
atan2(y, x)         # Two arguments
rand()              # No arguments
```

Do not put any space between the function name and the open-parenthesis! A user-defined function name looks just like the name of a variable, and space would make the expression look like concatenation of a variable with an expression inside parentheses. Space before the parenthesis is harmless with built-in functions, but it is best not to get into the habit of using space to avoid mistakes with user-defined functions.

Each function expects a particular number of arguments. For example, the `sqrt` function must be called with a single argument, the number to take the square root of:

```
sqrt(argument)
```

Some of the built-in functions allow you to omit the final argument. If you do so, they use a reasonable default. See

Built-in Functions

for full details. If arguments are omitted in calls to user-defined functions, then those arguments are treated as local variables, initialized to the null string (see

User-defined Functions

).

Like every other expression, the function call has a value, which is computed by the function based on the arguments you give it. In this example, the value of `sqrt(argument)` is the square root of the argument. A function can also have side effects, such as assigning the values of certain variables or doing I/O.

Here is a command to read numbers, one number per line, and print the square root of each one:

```
awk '{ print "The square root of", $1, "is", sqrt($1) }'
```

1.71 gawk.info/Precedence

Operator Precedence (How Operators Nest)

=====

Operator precedence determines how operators are grouped, when different operators appear close by in one expression. For example, `*` has higher precedence than `+`; thus, `a + b * c` means to multiply `b` and `c`, and then add `a` to the product (i.e., `a + (b * c)`).

You can overrule the precedence of the operators by using parentheses. You can think of the precedence rules as saying where the parentheses are assumed if you do not write parentheses yourself. In fact, it is wise to always use parentheses whenever you have an unusual combination of operators, because other people who read the program may not remember what the precedence is in this case. You might forget, too; then you could make a mistake. Explicit parentheses will help prevent any such mistake.

When operators of equal precedence are used together, the leftmost operator groups first, except for the assignment, conditional and exponentiation operators, which group in the opposite order. Thus, `a - b + c` groups as `(a - b) + c`; `a = b = c` groups as `a = (b = c)`.

The precedence of prefix unary operators does not matter as long as only unary operators are involved, because there is only one way to parse them--innermost first. Thus, `$(++i)` means `$(++i)` and `++$x` means `++($x)`. However, when another operator follows the operand, then the precedence of the unary operators can matter. Thus, `$x^2` means `($x)^2`, but `-x^2` means `-(x^2)`, because `-` has lower precedence than `^` while `$` has higher precedence.

Here is a table of the operators of `awk`, in order of increasing precedence:

assignment

`=, +=, -=, *=, /=, %=, ^=, **=`. These operators group right-to-left. (The `**=` operator is not specified by POSIX.)

conditional

`?:`. This operator groups right-to-left.

logical "or".

`||`.

logical "and".

`&&`.

array membership

`in`.

matching

`~, !~`.

relational, and redirection

The relational operators and the redirections have the same precedence level. Characters such as `>` serve both as relationals and as redirections; the context distinguishes between the two meanings.

The relational operators are `<`, `<=`, `==`, `!=`, `>=` and `>`.

The I/O redirection operators are `<`, `>`, `>>` and `|`.

Note that I/O redirection operators in `print` and `printf` statements belong to the statement level, not to expressions. The redirection does not produce an expression which could be the operand of another operator. As a result, it does not make sense to use a redirection operator near another operator of lower precedence, without parentheses. Such combinations, for example `print foo > a ? b : c`, result in syntax errors.

concatenation

No special token is used to indicate concatenation. The operands are simply written side by side.

add, subtract

`+`, `-`.

multiply, divide, mod

`*`, `/`, `%`.

unary plus, minus, "not"

`+`, `-`, `!`.

exponentiation

`^`, `**`. These operators group right-to-left. (The `**` operator is not specified by POSIX.)

increment, decrement

`++`, `--`.

field

`$`.

1.72 gawk.info/Statements

Control Statements in Actions

Control statements such as `if`, `while`, and so on control the flow of execution in `awk` programs. Most of the control statements in `awk` are patterned on similar statements in C.

All the control statements start with special keywords such as `if` and `while`, to distinguish them from simple expressions.

Many control statements contain other statements; for example, the `if` statement contains another statement which may or may not be executed. The contained statement is called the body. If you want to include more than one statement in the body, group them into a single compound statement with curly braces, separating them with newlines or semicolons.

If Statement
 Conditionally execute
 some awk statements.

While Statement
 Loop until some condition is satisfied.

Do Statement
 Do specified action while looping until some
 condition is satisfied.

For Statement
 Another looping statement, that provides
 initialization and increment clauses.

Break Statement
 Immediately exit the innermost enclosing loop.

Continue Statement
 Skip to the end of the innermost
 enclosing loop.

Next Statement
 Stop processing the current input record.

Next File Statement
 Stop processing the current file.

Exit Statement
 Stop execution of awk.

1.73 gawk.info/If Statement

The if Statement

=====

The if-else statement is awk's decision-making statement. It looks like this:

```
if (condition) then-body [else else-body ]
```

condition is an expression that controls what the rest of the statement will do. If condition is true, then-body is executed; otherwise, else-body is executed (assuming that the else clause is present). The else part of the statement is optional. The condition is considered false if its value is zero or the null string, and true otherwise.

Here is an example:

```
if (x % 2 == 0)
    print "x is even"
else
```

```
print "x is odd"
```

In this example, if the expression `x % 2 == 0` is true (that is, the value of `x` is divisible by 2), then the first print statement is executed, otherwise the second print statement is performed.

If the `else` appears on the same line as `then-body`, and `then-body` is not a compound statement (i.e., not surrounded by curly braces), then a semicolon must separate `then-body` from `else`. To illustrate this, let's rewrite the previous example:

```
awk '{ if (x % 2 == 0) print "x is even"; else
      print "x is odd" }'
```

If you forget the `;`, `awk` won't be able to parse the statement, and you will get a syntax error.

We would not actually write this example this way, because a human reader might fail to see the `else` if it were not the first thing on its line.

1.74 gawk.info/While Statement

The while Statement
=====

In programming, a loop means a part of a program that is (or at least can be) executed two or more times in succession.

The `while` statement is the simplest looping statement in `awk`. It repeatedly executes a statement as long as a condition is true. It looks like this:

```
while (condition)
    body
```

Here `body` is a statement that we call the body of the loop, and `condition` is an expression that controls how long the loop keeps running.

The first thing the `while` statement does is test condition. If condition is true, it executes the statement body. (condition is true when the value is not zero and not a null string.) After body has been executed, condition is tested again, and if it is still true, body is executed again. This process repeats until condition is no longer true. If condition is initially false, the body of the loop is never executed.

This example prints the first three fields of each record, one per line.

```
awk '{ i = 1
      while (i <= 3) {
          print $i
```

```

        i++
    }
}'

```

Here the body of the loop is a compound statement enclosed in braces, containing two statements.

The loop works like this: first, the value of `i` is set to 1. Then, the `while` tests whether `i` is less than or equal to three. This is the case when `i` equals one, so the `i`-th field is printed. Then the `i++` increments the value of `i` and the loop repeats. The loop terminates when `i` reaches 4.

As you can see, a newline is not required between the condition and the body; but using one makes the program clearer unless the body is a compound statement or is very simple. The newline after the open-brace that begins the compound statement is not required either, but the program would be hard to read without it.

1.75 gawk.info/Do Statement

The do-while Statement
 =====

The do loop is a variation of the while looping statement. The do loop executes the body once, then repeats body as long as condition is true. It looks like this:

```

do
  body
while (condition)

```

Even if condition is false at the start, body is executed at least once (and only once, unless executing body makes condition true). Contrast this with the corresponding while statement:

```

while (condition)
  body

```

This statement does not execute body even once if condition is false to begin with.

Here is an example of a do statement:

```

awk '{ i = 1
     do {
         print $0
         i++
     } while (i <= 10)
}'

```

prints each input record ten times. It isn't a very realistic example, since in this case an ordinary while would do just as well. But this reflects actual experience; there is only occasionally a real use for a

do statement.

1.76 gawk.info/For Statement

The for Statement

=====

The for statement makes it more convenient to count iterations of a loop. The general form of the for statement looks like this:

```
for (initialization; condition; increment)
    body
```

This statement starts by executing initialization. Then, as long as condition is true, it repeatedly executes body and then increment. Typically initialization sets a variable to either zero or one, increment adds 1 to it, and condition compares it against the desired number of iterations.

Here is an example of a for statement:

```
awk '{ for (i = 1; i <= 3; i++)
      print $i
    }'
```

This prints the first three fields of each input record, one field per line.

In the for statement, body stands for any statement, but initialization, condition and increment are just expressions. You cannot set more than one variable in the initialization part unless you use a multiple assignment statement such as `x = y = 0`, which is possible only if all the initial values are equal. (But you can initialize additional variables by writing their assignments as separate statements preceding the for loop.)

The same is true of the increment part; to increment additional variables, you must write separate statements at the end of the loop. The C compound expression, using C's comma operator, would be useful in this context, but it is not supported in awk.

Most often, increment is an increment expression, as in the example above. But this is not required; it can be any expression whatever. For example, this statement prints all the powers of 2 between 1 and 100:

```
for (i = 1; i <= 100; i *= 2)
    print i
```

Any of the three expressions in the parentheses following the for may be omitted if there is nothing to be done there. Thus, `for (;x > 0;)` is equivalent to `while (x > 0)`. If the condition is omitted, it is treated as true, effectively yielding an infinite loop (i.e., a loop that will never terminate).

In most cases, a for loop is an abbreviation for a while loop, as shown here:

```
initialization
while (condition) {
    body
    increment
}
```

The only exception is when the continue statement (see

The continue Statement

) is used inside the loop; changing a for statement to a while statement in this way can change the effect of the continue statement inside the loop.

There is an alternate version of the for loop, for iterating over all the indices of an array:

```
for (i in array)
    do something with array[i]
```

See

Arrays in awk

, for more information on this version of the for loop.

The awk language has a for statement in addition to a while statement because often a for loop is both less work to type and more natural to think of. Counting the number of iterations is very common in loops. It can be easier to think of this counting as part of looping rather than as something to do inside the loop.

The next section has more complicated examples of for loops.

1.77 gawk.info/Break Statement

The break Statement

=====

The break statement jumps out of the innermost for, while, or do-while loop that encloses it. The following example finds the smallest divisor of any integer, and also identifies prime numbers:

```
awk '# find smallest divisor of num
{ num = $1
  for (div = 2; div*div <= num; div++)
    if (num % div == 0)
      break
  if (num % div == 0)
    printf "Smallest divisor of %d is %d\n", num, div
  else
    printf "%d is prime\n", num }'
```

When the remainder is zero in the first if statement, awk immediately breaks out of the containing for loop. This means that awk proceeds immediately to the statement following the loop and continues processing. (This is very different from the exit statement which stops the entire awk program. See

The exit Statement
.)

Here is another program equivalent to the previous one. It illustrates how the condition of a for or while could just as well be replaced with a break inside an if:

```
awk '# find smallest divisor of num
{ num = $1
  for (div = 2; ; div++) {
    if (num % div == 0) {
      printf "Smallest divisor of %d is %d\n", num, div
      break
    }
    if (div*div > num) {
      printf "%d is prime\n", num
      break
    }
  }
}'
```

1.78 gawk.info/Continue Statement

The continue Statement

=====

The continue statement, like break, is used only inside for, while, and do-while loops. It skips over the rest of the loop body, causing the next cycle around the loop to begin immediately. Contrast this with break, which jumps out of the loop altogether. Here is an example:

```
# print names that don't contain the string "ignore"

# first, save the text of each line
{ names[NR] = $0 }

# print what we're interested in
END {
  for (x in names) {
    if (names[x] ~ /ignore/)
      continue
    print names[x]
  }
}
```

If one of the input records contains the string ignore, this example skips the print statement for that record, and continues back to the

first statement in the loop.

This is not a practical example of `continue`, since it would be just as easy to write the loop like this:

```
for (x in names)
  if (names[x] !~ /ignore/)
    print names[x]
```

The `continue` statement in a `for` loop directs `awk` to skip the rest of the body of the loop, and resume execution with the increment-expression of the `for` statement. The following program illustrates this fact:

```
awk 'BEGIN {
  for (x = 0; x <= 20; x++) {
    if (x == 5)
      continue
    printf ("%d ", x)
  }
  print ""
}'
```

This program prints all the numbers from 0 to 20, except for 5, for which the `printf` is skipped. Since the increment `x++` is not skipped, `x` does not remain stuck at 5. Contrast the `for` loop above with the `while` loop:

```
awk 'BEGIN {
  x = 0
  while (x <= 20) {
    if (x == 5)
      continue
    printf ("%d ", x)
    x++
  }
  print ""
}'
```

This program loops forever once `x` gets to 5.

As described above, the `continue` statement has no meaning when used outside the body of a loop. However, although it was never documented, historical implementations of `awk` have treated the `continue` statement outside of a loop as if it were a next statement (see

The next Statement

). By default, `gawk` silently supports this usage.

However, if `-W posix` has been specified on the command line (see

Invoking `awk`

), it will be treated as an error, since the POSIX standard specifies that `continue` should only be used inside the body of a loop.

1.79 gawk.info/Next Statement

The next Statement

=====

The next statement forces awk to immediately stop processing the current record and go on to the next record. This means that no further rules are executed for the current record. The rest of the current rule's action is not executed either.

Contrast this with the effect of the getline function (see

Explicit Input with getline

). That too causes awk to read the next record immediately, but it does not alter the flow of control in any way. So the rest of the current action executes with a new input record.

At the highest level, awk program execution is a loop that reads an input record and then tests each rule's pattern against it. If you think of this loop as a for statement whose body contains the rules, then the next statement is analogous to a continue statement: it skips to the end of the body of this implicit loop, and executes the increment (which reads another record).

For example, if your awk program works only on records with four fields, and you don't want it to fail when given bad input, you might use this rule near the beginning of the program:

```
NF != 4 {
    printf("line %d skipped: doesn't have 4 fields", FNR) > "/dev/stderr"
    next
}
```

so that the following rules will not see the bad record. The error message is redirected to the standard error output stream, as error messages should be. See

Standard I/O Streams

.

According to the POSIX standard, the behavior is undefined if the next statement is used in a BEGIN or END rule. gawk will treat it as a syntax error.

If the next statement causes the end of the input to be reached, then the code in the END rules, if any, will be executed. See

BEGIN and END Special Patterns

.

1.80 gawk.info/Next File Statement

The next file Statement

=====

The next file statement is similar to the next statement. However, instead of abandoning processing of the current record, the next file statement instructs awk to stop processing the current data file.

Upon execution of the next file statement, FILENAME is updated to the name of the next data file listed on the command line, FNR is reset to 1, and processing starts over with the first rule in the program. See

Built-in Variables

.

If the next file statement causes the end of the input to be reached, then the code in the END rules, if any, will be executed. See

BEGIN and END Special Patterns

.

The next file statement is a gawk extension; it is not (currently) available in any other awk implementation. You can simulate its behavior by creating a library file named nextfile.awk, with the following contents. (This sample program uses user-defined functions, a feature that has not been presented yet. See

User-defined Functions

,

for more information.)

```
# nextfile --- function to skip remaining records in current file

# this should be read in before the "main" awk program

function nextfile() { _abandon_ = FILENAME; next }

_abandon_ == FILENAME && FNR > 1 { next }
_abandon_ == FILENAME && FNR == 1 { _abandon_ = "" }
```

The nextfile function simply sets a "private" variable(1) to the name of the current data file, and then retrieves the next record. Since this file is read before the main awk program, the rules that follows the function definition will be executed before the rules in the main program. The first rule continues to skip records as long as the name of the input file has not changed, and this is not the first record in the file. This rule is sufficient most of the time. But what if the same data file is named twice in a row on the command line? This rule would not process the data file the second time. The second rule catches this case: If the data file name is what was being skipped, but FNR is 1, then this is the second time the file is being processed, and it should not be skipped.

The next file statement would be useful if you have many data files to process, and due to the nature of the data, you expect that you would not want to process every record in the file. In order to move on to the next data file, you would have to continue scanning the unwanted records (as described above). The next file statement

accomplishes this much more efficiently.

----- Footnotes -----

(1) Since all variables in awk are global, this program uses the common practice of prefixing the variable name with an underscore. In fact, it also suffixes the variable name with an underscore, as extra insurance against using a variable name that might be used in some other library file.

1.81 gawk.info/Exit Statement

The exit Statement

=====

The exit statement causes awk to immediately stop executing the current rule and to stop processing input; any remaining input is ignored.

If an exit statement is executed from a BEGIN rule the program stops processing everything immediately. No input records are read. However, if an END rule is present, it is executed (see

BEGIN and END Special Patterns
) .

If exit is used as part of an END rule, it causes the program to stop immediately.

An exit statement that is part of an ordinary rule (that is, not part of a BEGIN or END rule) stops the execution of any further automatic rules, but the END rule is executed if there is one. If you do not want the END rule to do its job in this case, you can set a variable to nonzero before the exit statement, and check that variable in the END rule.

If an argument is supplied to exit, its value is used as the exit status code for the awk process. If no argument is supplied, exit returns status zero (success).

For example, let's say you've discovered an error condition you really don't know how to handle. Conventionally, programs report this by exiting with a nonzero status. Your awk program can do this using an exit statement with a nonzero argument. Here's an example of this:

```
BEGIN {
    if (("date" | getline date_now) < 0) {
        print "Can't get system date" > "/dev/stderr"
        exit 4
    }
}
```

1.82 gawk.info/Arrays

Arrays in awk

An array is a table of values, called elements. The elements of an array are distinguished by their indices. Indices may be either numbers or strings. Each array has a name, which looks like a variable name, but must not be in use as a variable name in the same awk program.

Array Intro

Introduction to Arrays

Reference to Elements

How to examine one element of an array.

Assigning Elements

How to change an element of an array.

Array Example

Basic Example of an Array

Scanning an Array

A variation of the for statement.

It loops through the indices of an array's existing elements.

Delete

The delete statement removes an element from an array.

Numeric Array Subscripts

How to use numbers as subscripts in awk.

Multi-dimensional

Emulating multi-dimensional arrays in awk.

Multi-scanning

Scanning multi-dimensional arrays.

1.83 gawk.info/Array Intro

Introduction to Arrays

=====

The awk language has one-dimensional arrays for storing groups of related strings or numbers.

Every awk array must have a name. Array names have the same syntax as variable names; any valid variable name would also be a valid array

name. But you cannot use one name in both ways (as an array and as a variable) in one awk program.

Arrays in awk superficially resemble arrays in other programming languages; but there are fundamental differences. In awk, you don't need to specify the size of an array before you start to use it. Additionally, any number or string in awk may be used as an array index.

In most other languages, you have to declare an array and specify how many elements or components it contains. In such languages, the declaration causes a contiguous block of memory to be allocated for that many elements. An index in the array must be a positive integer; for example, the index 0 specifies the first element in the array, which is actually stored at the beginning of the block of memory. Index 1 specifies the second element, which is stored in memory right after the first element, and so on. It is impossible to add more elements to the array, because it has room for only as many elements as you declared.

A contiguous array of four elements might look like this, conceptually, if the element values are 8, "foo", "" and 30:

```
+-----+-----+-----+-----+
|   8   | "foo" |   ""  |   30  | value
+-----+-----+-----+-----+
|       |       |       |       |
|   0   |   1   |   2   |   3   | index
```

Only the values are stored; the indices are implicit from the order of the values. 8 is the value at index 0, because 8 appears in the position with 0 elements before it.

Arrays in awk are different: they are associative. This means that each array is a collection of pairs: an index, and its corresponding array element value:

```
Element 4      Value 30
Element 2      Value "foo"
Element 1      Value 8
Element 3      Value ""
```

We have shown the pairs in jumbled order because their order is irrelevant.

One advantage of an associative array is that new pairs can be added at any time. For example, suppose we add to the above array a tenth element whose value is "number ten". The result is this:

```
Element 10     Value "number ten"
Element 4      Value 30
Element 2      Value "foo"
Element 1      Value 8
Element 3      Value ""
```

Now the array is sparse (i.e., some indices are missing): it has elements 1-4 and 10, but doesn't have elements 5, 6, 7, 8, or 9.

Another consequence of associative arrays is that the indices don't have to be positive integers. Any number, or even a string, can be an

index. For example, here is an array which translates words from English into French:

```
Element "dog" Value "chien"
Element "cat" Value "chat"
Element "one" Value "un"
Element 1      Value "un"
```

Here we decided to translate the number 1 in both spelled-out and numeric form--thus illustrating that a single array can have both numbers and strings as indices.

When awk creates an array for you, e.g., with the `split` built-in function, that array's indices are consecutive integers starting at 1. (See

Built-in Functions for String Manipulation
.)

1.84 gawk.info/Reference to Elements

Referring to an Array Element

=====

The principal way of using an array is to refer to one of its elements. An array reference is an expression which looks like this:

```
array[index]
```

Here, `array` is the name of an array. The expression `index` is the index of the element of the array that you want.

The value of the array reference is the current value of that array element. For example, `foo[4.3]` is an expression for the element of array `foo` at index 4.3.

If you refer to an array element that has no recorded value, the value of the reference is "", the null string. This includes elements to which you have not assigned any value, and elements that have been deleted (see

The delete Statement

). Such a reference automatically creates that array element, with the null string as its value. (In some cases, this is unfortunate, because it might waste memory inside awk).

You can find out if an element exists in an array at a certain index with the expression:

```
index in array
```

This expression tests whether or not the particular index exists, without the side effect of creating that element if it is not present. The expression has the value 1 (true) if `array[index]` exists, and 0

(false) if it does not exist.

For example, to test whether the array `frequencies` contains the index "2", you could write this statement:

```
if ("2" in frequencies) print "Subscript \"2\" is present."
```

Note that this is not a test of whether or not the array `frequencies` contains an element whose value is "2". (There is no way to do that except to scan all the elements.) Also, this does not create `frequencies["2"]`, while the following (incorrect) alternative would do so:

```
if (frequencies["2"] != "") print "Subscript \"2\" is present."
```

1.85 gawk.info/Assigning Elements

Assigning Array Elements

=====

Array elements are lvalues: they can be assigned values just like awk variables:

```
array[subscript] = value
```

Here `array` is the name of your array. The expression `subscript` is the index of the element of the array that you want to assign a value. The expression `value` is the value you are assigning to that element of the array.

1.86 gawk.info/Array Example

Basic Example of an Array

=====

The following program takes a list of lines, each beginning with a line number, and prints them out in order of line number. The line numbers are not in order, however, when they are first read: they are scrambled. This program sorts the lines by making an array using the line numbers as subscripts. It then prints out the lines in sorted order of their numbers. It is a very simple program, and gets confused if it encounters repeated numbers, gaps, or lines that don't begin with a number.

```
{
    if ($1 > max)
        max = $1
    arr[$1] = $0
}
```



```

END {
  for (x = 1; x <= max; x++)
    print arr[x]
}

```

The first rule keeps track of the largest line number seen so far; it also stores each line into the array `arr`, at an index that is the line's number.

The second rule runs after all the input has been read, to print out all the lines.

When this program is run with the following input:

```

5 I am the Five man
2 Who are you? The new number two!
4 . . . And four on the floor
1 Who is number one?
3 I three you.

```

its output is this:

```

1 Who is number one?
2 Who are you? The new number two!
3 I three you.
4 . . . And four on the floor
5 I am the Five man

```

If a line number is repeated, the last line with a given number overrides the others.

Gaps in the line numbers can be handled with an easy improvement to the program's END rule:

```

END {
  for (x = 1; x <= max; x++)
    if (x in arr)
      print arr[x]
}

```

1.87 gawk.info/Scanning an Array

Scanning all Elements of an Array

=====

In programs that use arrays, often you need a loop that executes once for each element of an array. In other languages, where arrays are contiguous and indices are limited to positive integers, this is easy: the largest index is one less than the length of the array, and you can find all the valid indices by counting from zero up to that value. This technique won't do the job in `awk`, since any number or string may be an array index. So `awk` has a special kind of `for` statement for scanning an array:

```

for (var in array)
    body

```

This loop executes `body` once for each different value that your program has previously used as an index in `array`, with the variable `var` set to that index.

Here is a program that uses this form of the `for` statement. The first rule scans the input records and notes which words appear (at least once) in the input, by storing a 1 into the array used with the word as index. The second rule scans the elements of `used` to find all the distinct words that appear in the input. It prints each word that is more than 10 characters long, and also prints the number of such words. See

```

        Built-in Functions
        , for more information on the built-in
function length.

```

```

# Record a 1 for each word that is used at least once.
{
    for (i = 1; i <= NF; i++)
        used[$i] = 1
}

# Find number of distinct words more than 10 characters long.
END {
    for (x in used)
        if (length(x) > 10) {
            ++num_long_words
            print x
        }
    print num_long_words, "words longer than 10 characters"
}

```

See

```

        Sample Program
        , for a more detailed example of this type.

```

The order in which elements of the array are accessed by this statement is determined by the internal arrangement of the array elements within `awk` and cannot be controlled or changed. This can lead to problems if new elements are added to array by statements in `body`; you cannot predict whether or not the `for` loop will reach them. Similarly, changing `var` inside the loop can produce strange results. It is best to avoid such things.

1.88 gawk.info/Delete

The delete Statement

=====

You can remove an individual element of an array using the `delete`

statement:

```
delete array[index]
```

You can not refer to an array element after it has been deleted; it is as if you had never referred to it and had never given it any value. You can no longer obtain any value the element once had.

Here is an example of deleting elements in an array:

```
for (i in frequencies)
  delete frequencies[i]
```

This example removes all the elements from the array frequencies.

If you delete an element, a subsequent for statement to scan the array will not report that element, and the in operator to check for the presence of that element will return 0:

```
delete foo[4]
if (4 in foo)
  print "This will never be printed"
```

It is not an error to delete an element which does not exist.

1.89 gawk.info/Numeric Array Subscripts

Using Numbers to Subscript Arrays

=====

An important aspect of arrays to remember is that array subscripts are always strings. If you use a numeric value as a subscript, it will be converted to a string value before it is used for subscripting (see

Conversion of Strings and Numbers
)

This means that the value of the CONVFMT can potentially affect how your program accesses elements of an array. For example:

```
a = b = 12.153
data[a] = 1
CONVFMT = "%2.2f"
if (b in data)
  printf "%s is in data", b
else
  printf "%s is not in data", b
```

should print 12.15 is not in data. The first statement gives both a and b the same numeric value. Assigning to data[a] first gives a the string value "12.153" (using the default conversion value of CONVFMT, "%.6g"), and then assigns 1 to data["12.153"]. The program then changes the value of CONVFMT. The test (b in data) forces b to be converted to a string, this time "12.15", since the value of CONVFMT only allows two

significant digits. This test fails, since "12.15" is a different string from "12.153".

According to the rules for conversions (see

Conversion of Strings and Numbers

), integer values are always converted

to strings as integers, no matter what the value of CONVFMT may happen to be. So the usual case of

```
for (i = 1; i <= maxsub; i++)
  do something with array[i]
```

will work, no matter what the value of CONVFMT.

Like many things in awk, the majority of the time things work as you would expect them to work. But it is useful to have a precise knowledge of the actual rules, since sometimes they can have a subtle effect on your programs.

1.90 gawk.info/Multi-dimensional

Multi-dimensional Arrays

=====

A multi-dimensional array is an array in which an element is identified by a sequence of indices, not a single index. For example, a two-dimensional array requires two indices. The usual way (in most languages, including awk) to refer to an element of a two-dimensional array named `grid` is with `grid[x,y]`.

Multi-dimensional arrays are supported in awk through concatenation of indices into one string. What happens is that awk converts the indices into strings (see

Conversion of Strings and Numbers

) and

concatenates them together, with a separator between them. This creates a single string that describes the values of the separate indices. The combined string is used as a single index into an ordinary, one-dimensional array. The separator used is the value of the built-in variable `SUBSEP`.

For example, suppose we evaluate the expression `foo[5,12]="value"` when the value of `SUBSEP` is `"@"`. The numbers 5 and 12 are converted to strings and concatenated with an `@` between them, yielding `"5@12"`; thus, the array element `foo["5@12"]` is set to `"value"`.

Once the element's value is stored, awk has no record of whether it was stored with a single index or a sequence of indices. The two expressions `foo[5,12]` and `foo[5 SUBSEP 12]` always have the same value.

The default value of `SUBSEP` is the string `"\034"`, which contains a nonprinting character that is unlikely to appear in an awk program or

in the input data.

The usefulness of choosing an unlikely character comes from the fact that index values that contain a string matching SUBSEP lead to combined strings that are ambiguous. Suppose that SUBSEP were "@"; then `foo["a@b", "c"]` and `foo["a", "b@c"]` would be indistinguishable because both would actually be stored as `foo["a@b@c"]`. Because SUBSEP is "\034", such confusion can arise only when an index contains the character with ASCII code 034, which is a rare event.

You can test whether a particular index-sequence exists in a "multi-dimensional" array with the same operator in used for single dimensional arrays. Instead of a single index as the left-hand operand, write the whole sequence of indices, separated by commas, in parentheses:

```
(subscript1, subscript2, ...) in array
```

The following example treats its input as a two-dimensional array of fields; it rotates this array 90 degrees clockwise and prints the result. It assumes that all lines have the same number of elements.

```
awk '{
    if (max_nf < NF)
        max_nf = NF
    max_nr = NR
    for (x = 1; x <= NF; x++)
        vector[x, NR] = $x
}

END {
    for (x = 1; x <= max_nf; x++) {
        for (y = max_nr; y >= 1; --y)
            printf("%s ", vector[x, y])
        printf("\n")
    }
}'
```

When given the input:

```
1 2 3 4 5 6
2 3 4 5 6 1
3 4 5 6 1 2
4 5 6 1 2 3
```

it produces:

```
4 3 2 1
5 4 3 2
6 5 4 3
1 6 5 4
2 1 6 5
3 2 1 6
```

1.91 gawk.info/Multi-scanning

Scanning Multi-dimensional Arrays

There is no special for statement for scanning a "multi-dimensional" array; there cannot be one, because in truth there are no multi-dimensional arrays or elements; there is only a multi-dimensional way of accessing an array.

However, if your program has an array that is always accessed as multi-dimensional, you can get the effect of scanning it by combining the scanning for statement (see

Scanning all Elements of an Array
) with

the split built-in function (see

Built-in Functions for String Manipulation
) . It works like this:

```
for (combined in array) {
    split(combined, separate, SUBSEP)
    ...
}
```

This finds each concatenated, combined index in the array, and splits it into the individual indices by breaking it apart where the value of SUBSEP appears. The split-out indices become the elements of the array separate.

Thus, suppose you have previously stored in array[1, "foo"]; then an element with index "1\034foo" exists in array. (Recall that the default value of SUBSEP contains the character with code 034.) Sooner or later the for statement will find that index and do an iteration with combined set to "1\034foo". Then the split function is called as follows:

```
split("1\034foo", separate, "\034")
```

The result of this is to set separate[1] to 1 and separate[2] to "foo". Presto, the original sequence of separate indices has been recovered.

1.92 gawk.info/Built-in

Built-in Functions

Built-in functions are functions that are always available for your awk program to call. This chapter defines all the built-in functions in awk; some of them are mentioned in other sections, but they are summarized here for your convenience. (You can also define new functions yourself. See

User-defined Functions
.)

Calling Built-in
How to call built-in functions.

Numeric Functions
Functions that work with numbers,
including `int`, `sin` and `rand`.

String Functions
Functions for string manipulation,
such as `split`, `match`, and `sprintf`.

I-O Functions
Functions for files and shell commands.

Time Functions
Functions for dealing with time stamps.

1.93 gawk.info/Calling Built-in

Calling Built-in Functions
=====

To call a built-in function, write the name of the function followed by arguments in parentheses. For example, `atan2(y + z, 1)` is a call to the function `atan2`, with two arguments.

Whitespace is ignored between the built-in function name and the open-parenthesis, but we recommend that you avoid using whitespace there. User-defined functions do not permit whitespace in this way, and you will find it easier to avoid mistakes by following a simple convention which always works: no whitespace after a function name.

Each built-in function accepts a certain number of arguments. In most cases, any extra arguments given to built-in functions are ignored. The defaults for omitted arguments vary from function to function and are described under the individual functions.

When a function is called, expressions that create the function's actual parameters are evaluated completely before the function call is performed. For example, in the code fragment:

```
i = 4
j = sqrt(i++)
```

the variable `i` is set to 5 before `sqrt` is called with a value of 4 for its actual parameter.

1.94 gawk.info/Numeric Functions

Numeric Built-in Functions

=====

Here is a full list of built-in functions that work with numbers:

int(x)

This gives you the integer part of *x*, truncated toward 0. This produces the nearest integer to *x*, located between *x* and 0.

For example, `int(3)` is 3, `int(3.9)` is 3, `int(-3.9)` is -3, and `int(-3)` is -3 as well.

sqrt(x)

This gives you the positive square root of *x*. It reports an error if *x* is negative. Thus, `sqrt(4)` is 2.

exp(x)

This gives you the exponential of *x*, or reports an error if *x* is out of range. The range of values *x* can have depends on your machine's floating point representation.

log(x)

This gives you the natural logarithm of *x*, if *x* is positive; otherwise, it reports an error.

sin(x)

This gives you the sine of *x*, with *x* in radians.

cos(x)

This gives you the cosine of *x*, with *x* in radians.

atan2(y, x)

This gives you the arctangent of *y* / *x* in radians.

rand()

This gives you a random number. The values of `rand` are uniformly-distributed between 0 and 1. The value is never 0 and never 1.

Often you want random integers instead. Here is a user-defined function you can use to obtain a random nonnegative integer less than *n*:

```
function randint(n) {
    return int(n * rand())
}
```

The multiplication produces a random real number greater than 0 and less than *n*. We then make it an integer (using `int`) between 0 and *n* - 1.

Here is an example where a similar function is used to produce random integers between 1 and *n*. Note that this program will print a new random number for each input record.


```
awk '
# Function to roll a simulated die.
function roll(n) { return 1 + int(rand() * n) }

# Roll 3 six-sided dice and print total number of points.
{
    printf("%d points\n", roll(6)+roll(6)+roll(6))
}'
```

Note: `rand` starts generating numbers from the same point, or seed, each time you run `awk`. This means that a program will produce the same results each time you run it. The numbers are random within one `awk` run, but predictable from run to run. This is convenient for debugging, but if you want a program to do different things each time it is used, you must change the seed to a value that will be different in each run. To do this, use `srand`.

`srand(x)`

The function `srand` sets the starting point, or seed, for generating random numbers to the value `x`.

Each seed value leads to a particular sequence of "random" numbers. Thus, if you set the seed to the same value a second time, you will get the same sequence of "random" numbers again.

If you omit the argument `x`, as in `srand()`, then the current date and time of day are used for a seed. This is the way to get random numbers that are truly unpredictable.

The return value of `srand` is the previous seed. This makes it easy to keep track of the seeds for use in consistently reproducing sequences of random numbers.

1.95 gawk.info/String Functions

Built-in Functions for String Manipulation

The functions in this section look at or change the text of one or more strings.

`index(in, find)`

This searches the string `in` for the first occurrence of the string `find`, and returns the position in characters where that occurrence begins in the string `in`. For example:

```
awk 'BEGIN { print index("peanut", "an") }'
```

prints 3. If `find` is not found, `index` returns 0. (Remember that string indices in `awk` start at 1.)

`length(string)`

This gives you the number of characters in `string`. If `string` is a

number, the length of the digit string representing that number is returned. For example, `length("abcde")` is 5. By contrast, `length(15 * 35)` works out to 3. How? Well, $15 * 35 = 525$, and 525 is then converted to the string "525", which has three characters.

If no argument is supplied, `length` returns the length of `$0`.

In older versions of `awk`, you could call the `length` function without any parentheses. Doing so is marked as "deprecated" in the POSIX standard. This means that while you can do this in your programs, it is a feature that can eventually be removed from a future version of the standard. Therefore, for maximal portability of your `awk` programs you should always supply the parentheses.

`match(string, regexp)`

The `match` function searches the string, `string`, for the longest, leftmost substring matched by the regular expression, `regexp`. It returns the character position, or index, of where that substring begins (1, if it starts at the beginning of `string`). If no match is found, it returns 0.

The `match` function sets the built-in variable `RSTART` to the index. It also sets the built-in variable `RLENGTH` to the length in characters of the matched substring. If no match is found, `RSTART` is set to 0, and `RLENGTH` to -1.

For example:

```
awk '{
    if ($1 == "FIND")
        regex = $2
    else {
        where = match($0, regex)
        if (where)
            print "Match of", regex, "found at", where, "in", $0
    }
}'
```

This program looks for lines that match the regular expression stored in the variable `regex`. This regular expression can be changed. If the first word on a line is `FIND`, `regex` is changed to be the second word on that line. Therefore, given:

```
FIND fo*bar
My program was a foobar
But none of it would doobar
FIND Melvin
JF+KM
This line is property of The Reality Engineering Co.
This file created by Melvin.
```

`awk` prints:

```
Match of fo*bar found at 18 in My program was a foobar
Match of Melvin found at 26 in This file created by Melvin.
```

```
split(string, array, fieldsep)
```

This divides `string` into pieces separated by `fieldsep`, and stores the pieces in `array`. The first piece is stored in `array[1]`, the second piece in `array[2]`, and so forth. The string value of the third argument, `fieldsep`, is a regexp describing where to split `string` (much as `FS` can be a regexp describing where to split input records). If the `fieldsep` is omitted, the value of `FS` is used. `split` returns the number of elements created.

The `split` function, then, splits strings into pieces in a manner similar to the way input lines are split into fields. For example:

```
split("auto-da-fe", a, "-")
```

splits the string `auto-da-fe` into three fields using `-` as the separator. It sets the contents of the array `a` as follows:

```
a[1] = "auto"
a[2] = "da"
a[3] = "fe"
```

The value returned by this call to `split` is 3.

As with input field-splitting, when the value of `fieldsep` is `" "`, leading and trailing whitespace is ignored, and the elements are separated by runs of whitespace.

```
sprintf(format, expression1,...)
```

This returns (without printing) the string that `printf` would have printed out with the same arguments (see

```
Using printf Statements for Fancier Printing
). For example:
```

```
sprintf("pi = %.2f (approx.)", 22/7)
```

returns the string `"pi = 3.14 (approx.)"`.

```
sub(regexp, replacement, target)
```

The `sub` function alters the value of `target`. It searches this value, which should be a string, for the leftmost substring matched by the regular expression, `regexp`, extending this match as far as possible. Then the entire string is changed by replacing the matched text with `replacement`. The modified string becomes the new value of `target`.

This function is peculiar because `target` is not simply used to compute a value, and not just any expression will do: it must be a variable, field or array reference, so that `sub` can store a modified value there. If this argument is omitted, then the default is to use and alter `$0`.

For example:

```
str = "water, water, everywhere"
sub(/at/, "ith", str)
```

sets `str` to "wither, water, everywhere", by replacing the leftmost, longest occurrence of `at` with `ith`.

The `sub` function returns the number of substitutions made (either one or zero).

If the special character `&` appears in replacement, it stands for the precise substring that was matched by `regexp`. (If the `regexp` can match more than one string, then this precise substring may vary.) For example:

```
awk '{ sub(/candidate/, "& and his wife"); print }'
```

changes the first occurrence of `candidate` to `candidate and his wife` on each input line.

Here is another example:

```
awk 'BEGIN {
    str = "daabaaa"
    sub(/a*/, "c&c", str)
    print str
}'
```

prints `dcaacbaaa`. This shows how `&` can represent a non-constant string, and also illustrates the "leftmost, longest" rule.

The effect of this special character (`&`) can be turned off by putting a backslash before it in the string. As usual, to insert one backslash in the string, you must write two backslashes. Therefore, write `\&` in a string constant to include a literal `&` in the replacement. For example, here is how to replace the first `|` on each line with an `&`:

```
awk '{ sub(/\|/, "\&"); print }'
```

Note: as mentioned above, the third argument to `sub` must be an lvalue. Some versions of `awk` allow the third argument to be an expression which is not an lvalue. In such a case, `sub` would still search for the pattern and return 0 or 1, but the result of the substitution (if any) would be thrown away because there is no place to put it. Such versions of `awk` accept expressions like this:

```
sub(/USA/, "United States", "the USA and Canada")
```

But that is considered erroneous in `gawk`.

`gsub`(`regexp`, `replacement`, `target`)

This is similar to the `sub` function, except `gsub` replaces all of the longest, leftmost, nonoverlapping matching substrings it can find. The `g` in `gsub` stands for "global," which means replace everywhere. For example:

```
awk '{ gsub(/Britain/, "United Kingdom"); print }'
```

replaces all occurrences of the string Britain with United Kingdom for all input records.

The gsub function returns the number of substitutions made. If the variable to be searched and altered, target, is omitted, then the entire input record, \$0, is used.

As in sub, the characters & and \ are special, and the third argument must be an lvalue.

substr(string, start, length)

This returns a length-character-long substring of string, starting at character number start. The first character of a string is character number one. For example, substr("washington", 5, 3) returns "ing".

If length is not present, this function returns the whole suffix of string that begins at character number start. For example, substr("washington", 5) returns "ington". This is also the case if length is greater than the number of characters remaining in the string, counting from character number start.

tolower(string)

This returns a copy of string, with each upper-case character in the string replaced with its corresponding lower-case character. Nonalphabetic characters are left unchanged. For example, tolower("MiXeD cAsE 123") returns "mixed case 123".

toupper(string)

This returns a copy of string, with each lower-case character in the string replaced with its corresponding upper-case character. Nonalphabetic characters are left unchanged. For example, toupper("MiXeD cAsE 123") returns "MIXED CASE 123".

1.96 gawk.info/I-O Functions

Built-in Functions for Input/Output

=====

close(filename)

Close the file filename, for input or output. The argument may alternatively be a shell command that was used for redirecting to or from a pipe; then the pipe is closed.

See

Closing Input Files and Pipes
, regarding closing input files

and pipes. See

Closing Output Files and Pipes
, regarding closing

output files and pipes.

system(command)

The `system` function allows the user to execute operating system commands and then return to the `awk` program. The `system` function executes the command given by the string command. It returns, as its value, the status returned by the command that was executed.

For example, if the following fragment of code is put in your `awk` program:

```
END {
    system("mail -s 'awk run done' operator < /dev/null")
}
```

the system operator will be sent mail when the `awk` program finishes processing input and begins its end-of-input processing.

Note that much the same result can be obtained by redirecting `print` or `printf` into a pipe. However, if your `awk` program is interactive, `system` is useful for cranking up large self-contained programs, such as a shell or an editor.

Some operating systems cannot implement the `system` function. `system` causes a fatal error if it is not supported.

Controlling Output Buffering with `system`

Many utility programs will buffer their output; they save information to be written to a disk file or terminal in memory, until there is enough to be written in one operation. This is often more efficient than writing every little bit of information as soon as it is ready. However, sometimes it is necessary to force a program to flush its buffers; that is, write the information to its destination, even if a buffer is not full. You can do this from your `awk` program by calling `system` with a null string as its argument:

```
system("") # flush output
```

`gawk` treats this use of the `system` function as a special case, and is smart enough not to run a shell (or other command interpreter) with the empty command. Therefore, with `gawk`, this idiom is not only useful, it is efficient. While this idiom should work with other `awk` implementations, it will not necessarily avoid starting an unnecessary shell.

1.97 gawk.info/Time Functions

Functions for Dealing with Time Stamps

A common use for `awk` programs is the processing of log files. Log files often contain time stamp information, indicating when a particular log record was written. Many programs log their time stamp in the form returned by the time system call, which is the number of

seconds since a particular epoch. On POSIX systems, it is the number of seconds since Midnight, January 1, 1970, UTC.

In order to make it easier to process such log files, and to easily produce useful reports, gawk provides two functions for working with time stamps. Both of these are gawk extensions; they are not specified in the POSIX standard, nor are they in any other known version of awk.

`systemtime()`

This function returns the current time as the number of seconds since the system epoch. On POSIX systems, this is the number of seconds since Midnight, January 1, 1970, UTC. It may be a different number on other systems.

`strftime(format, timestamp)`

This function returns a string. It is similar to the function of the same name in the ANSI C standard library. The time specified by `timestamp` is used to produce a string, based on the contents of the format string.

The `systemtime` function allows you to compare a time stamp from a log file with the current time of day. In particular, it is easy to determine how long ago a particular record was logged. It also allows you to produce log records using the "seconds since the epoch" format.

The `strftime` function allows you to easily turn a time stamp into human-readable information. It is similar in nature to the `sprintf` function, copying non-format specification characters verbatim to the returned string, and substituting date and time values for format specifications in the format string. If no `timestamp` argument is supplied, gawk will use the current time of day as the time stamp.

`strftime` is guaranteed by the ANSI C standard to support the following date format specifications:

`%a`

The locale's abbreviated weekday name.

`%A`

The locale's full weekday name.

`%b`

The locale's abbreviated month name.

`%B`

The locale's full month name.

`%c`

The locale's "appropriate" date and time representation.

`%d`

The day of the month as a decimal number (01-31).

`%H`

The hour (24-hour clock) as a decimal number (00-23).

`%I`

The hour (12-hour clock) as a decimal number (01-12).

%j

The day of the year as a decimal number (001-366).

%m

The month as a decimal number (01-12).

%M

The minute as a decimal number (00-59).

%p

The locale's equivalent of the AM/PM designations associated with a 12-hour clock.

%S

The second as a decimal number (00-61). (Occasionally there are minutes in a year with one or two leap seconds, which is why the seconds can go from 0 all the way to 61.)

%U

The week number of the year (the first Sunday as the first day of week 1) as a decimal number (00-53).

%w

The weekday as a decimal number (0-6). Sunday is day 0.

%W

The week number of the year (the first Monday as the first day of week 1) as a decimal number (00-53).

%x

The locale's "appropriate" date representation.

%X

The locale's "appropriate" time representation.

%y

The year without century as a decimal number (00-99).

%Y

The year with century as a decimal number.

%Z

The time zone name or abbreviation, or no characters if no time zone is determinable.

%%

A literal %.

If a conversion specifier is not one of the above, the behavior is undefined. (This is because the ANSI standard for C leaves the behavior of the C version of `strftime` undefined, and `gawk` will use the system's version of `strftime` if it's there. Typically, the conversion specifier will either not appear in the returned string, or it will appear literally.)

Informally, a locale is the geographic place in which a program is meant to run. For example, a common way to abbreviate the date September 4, 1991 in the United States would be "9/4/91". In many countries in Europe, however, it would be abbreviated "4.9.91". Thus, the %x specification in a "US" locale might produce 9/4/91, while in a "EUROPE" locale, it might produce 4.9.91. The ANSI C standard defines a default "C" locale, which is an environment that is typical of what most C programmers are used to.

A public-domain C version of strftime is shipped with gawk for systems that are not yet fully ANSI-compliant. If that version is used to compile gawk (see

Installing gawk

), then the following additional format specifications are available:

%D
Equivalent to specifying %m/%d/%y.

%e
The day of the month, padded with a blank if it is only one digit.

%h
Equivalent to %b, above.

%n
A newline character (ASCII LF).

%r
Equivalent to specifying %I:%M:%S %p.

%R
Equivalent to specifying %H:%M.

%T
Equivalent to specifying %H:%M:%S.

%t
A TAB character.

%k
is replaced by the hour (24-hour clock) as a decimal number (0-23). Single digit numbers are padded with a blank.

%l
is replaced by the hour (12-hour clock) as a decimal number (1-12). Single digit numbers are padded with a blank.

%C
The century, as a number between 00 and 99.

%u
is replaced by the weekday as a decimal number [1 (Monday)-7].

%V
is replaced by the week number of the year (the first Monday as the first day of week 1) as a decimal number (01-53). The method

for determining the week number is as specified by ISO 8601 (to wit: if the week containing January 1 has four or more days in the new year, then it is week 1, otherwise it is week 53 of the previous year and the next week is week 1).

```
%Ec %EC %Ex %Ey %EY %Od %Oe %OH %OI
%Om %OM %OS %Ou %OU %OV %Ow %OW %Oy
```

These are "alternate representations" for the specifications that use only the second letter (%c, %C, and so on). They are recognized, but their normal representations are used. (These facilitate compliance with the POSIX date utility.)

```
%v
```

The date in VMS format (e.g. 20-JUN-1991).

Here are two examples that use strftime. The first is an awk version of the C ctime function. (This is a user defined function, which we have not discussed yet. See [User-defined Functions](#), for more information.)

```
# ctime.awk
#
# awk version of C ctime(3) function

function ctime(ts,    format)
{
    format = "%a %b %e %H:%M:%S %Z %Y"
    if (ts == 0)
        ts = systime()          # use current time as default
    return strftime(format, ts)
}
```

This next example is an awk implementation of the POSIX date utility. Normally, the date utility prints the current date and time of day in a well known format. However, if you provide an argument to it that begins with a +, date will copy non-format specifier characters to the standard output, and will interpret the current time according to the format specifiers in the string. For example:

```
date '+Today is %A, %B %d, %Y.'
```

might print

```
Today is Thursday, July 11, 1991.
```

Here is the awk version of the date utility.

```
#!/bin/gawk -f
#
# date --- implement the P1003.2 Draft 11 'date' command
#
# Bug: does not recognize the -u argument.

BEGIN    \
{
```

```

format = "%a %b %e %H:%M:%S %Z %Y"
exitval = 0

if (ARGC > 2)
    exitval = 1
else if (ARGC == 2) {
    format = ARGV[1]
    if (format ~ /^\/+/)
        format = substr(format, 2)    # remove leading +
    }
print strftime(format)
exit exitval
}

```

1.98 gawk.info/User-defined

User-defined Functions

Complicated awk programs can often be simplified by defining your own functions. User-defined functions can be called just like built-in ones (see

Function Calls

), but it is up to you to define them--to tell awk what they should do.

Definition Syntax

How to write definitions and what they mean.

Function Example

An example function definition and what it does.

Function Caveats

Things to watch out for.

Return Statement

Specifying the value a function returns.

1.99 gawk.info/Definition Syntax

Syntax of Function Definitions

=====

Definitions of functions can appear anywhere between the rules of the awk program. Thus, the general form of an awk program is extended to

include sequences of rules and user-defined function definitions.

The definition of a function named `name` looks like this:

```
function name (parameter-list) {  
    body-of-function  
}
```

`name` is the name of the function to be defined. A valid function name is like a valid variable name: a sequence of letters, digits and underscores, not starting with a digit. Functions share the same pool of names as variables and arrays.

`parameter-list` is a list of the function's arguments and local variable names, separated by commas. When the function is called, the argument names are used to hold the argument values given in the call. The local variables are initialized to the null string.

The `body-of-function` consists of awk statements. It is the most important part of the definition, because it says what the function should actually do. The argument names exist to give the body a way to talk about the arguments; local variables, to give the body places to keep temporary values.

Argument names are not distinguished syntactically from local variable names; instead, the number of arguments supplied when the function is called determines how many argument variables there are. Thus, if three argument values are given, the first three names in `parameter-list` are arguments, and the rest are local variables.

It follows that if the number of arguments is not the same in all calls to the function, some of the names in `parameter-list` may be arguments on some occasions and local variables on others. Another way to think of this is that omitted arguments default to the null string.

Usually when you write a function you know how many names you intend to use for arguments and how many you intend to use as locals. By convention, you should write an extra space between the arguments and the locals, so other people can follow how your function is supposed to be used.

During execution of the function body, the arguments and local variable values hide or shadow any variables of the same names used in the rest of the program. The shadowed variables are not accessible in the function definition, because there is no way to name them while their names have been taken away for the local variables. All other variables used in the awk program can be referenced or set normally in the function definition.

The arguments and local variables last only as long as the function body is executing. Once the body finishes, the shadowed variables come back.

The function body can contain expressions which call functions. They can even call this function, either directly or by way of another function. When this happens, we say the function is recursive.

There is no need in `awk` to put the definition of a function before all uses of the function. This is because `awk` reads the entire program before starting to execute any of it.

In many `awk` implementations, the keyword `function` may be abbreviated `func`. However, POSIX only specifies the use of the keyword `function`. This actually has some practical implications. If `gawk` is in POSIX-compatibility mode (see `Invoking awk`), then the following statement will not define a function:

```
func foo() { a = sqrt($1) ; print a }
```

Instead it defines a rule that, for each record, concatenates the value of the variable `func` with the return value of the function `foo`, and based on the truth value of the result, executes the corresponding action. This is probably not what was desired. (`awk` accepts this input as syntactically valid, since functions may be used before they are defined in `awk` programs.)

1.100 gawk.info/Function Example

Function Definition Example

=====

Here is an example of a user-defined function, called `myprint`, that takes a number and prints it in a specific format.

```
function myprint(num)
{
    printf "%6.3g\n", num
}
```

To illustrate, here is an `awk` rule which uses our `myprint` function:

```
$3 > 0    { myprint($3) }
```

This program prints, in our special format, all the third fields that contain a positive number in our input. Therefore, when given:

```
1.2  3.4  5.6  7.8
9.10 11.12 -13.14 15.16
17.18 19.20 21.22 23.24
```

this program, using our function to format the results, prints:

```
5.6
21.2
```

Here is a rather contrived example of a recursive function. It prints a string backwards:

```

function rev (str, len) {
    if (len == 0) {
        printf "\n"
        return
    }
    printf "%c", substr(str, len, 1)
    rev(str, len - 1)
}

```

1.101 gawk.info/Function Caveats

Calling User-defined Functions

```
=====
```

Calling a function means causing the function to run and do its job. A function call is an expression, and its value is the value returned by the function.

A function call consists of the function name followed by the arguments in parentheses. What you write in the call for the arguments are awk expressions; each time the call is executed, these expressions are evaluated, and the values are the actual arguments. For example, here is a call to `foo` with three arguments (the first being a string concatenation):

```
foo(x y, "lose", 4 * z)
```

Caution: whitespace characters (spaces and tabs) are not allowed between the function name and the open-parenthesis of the argument list. If you write whitespace by mistake, awk might think that you mean to concatenate a variable with an expression in parentheses. However, it notices that you used a function name and not a variable name, and reports an error.

When a function is called, it is given a copy of the values of its arguments. This is called call by value. The caller may use a variable as the expression for the argument, but the called function does not know this: it only knows what value the argument had. For example, if you write this code:

```
foo = "bar"
z = myfunc(foo)
```

then you should not think of the argument to `myfunc` as being "the variable `foo`." Instead, think of the argument as the string value, "bar".

If the function `myfunc` alters the values of its local variables, this has no effect on any other variables. In particular, if `myfunc` does this:

```
function myfunc (win) {
    print win
    win = "zzz"
}
```

```
    print win
}
```

to change its first argument variable `win`, this does not change the value of `foo` in the caller. The role of `foo` in calling `myfunc` ended when its value, `"bar"`, was computed. If `win` also exists outside of `myfunc`, the function body cannot alter this outer value, because it is shadowed during the execution of `myfunc` and cannot be seen or changed from there.

However, when arrays are the parameters to functions, they are not copied. Instead, the array itself is made available for direct manipulation by the function. This is usually called call by reference. Changes made to an array parameter inside the body of a function are visible outside that function. This can be very dangerous if you do not watch what you are doing. For example:

```
function changeit (array, ind, nvalue) {
    array[ind] = nvalue
}

BEGIN {
    a[1] = 1 ; a[2] = 2 ; a[3] = 3
    changeit(a, 2, "two")
    printf "a[1] = %s, a[2] = %s, a[3] = %s\n", a[1], a[2], a[3]
}
```

prints `a[1] = 1, a[2] = two, a[3] = 3`, because calling `changeit` stores `"two"` in the second element of `a`.

1.102 gawk.info/Return Statement

The return Statement
=====

The body of a user-defined function can contain a return statement. This statement returns control to the rest of the `awk` program. It can also be used to return a value for use in the rest of the `awk` program. It looks like this:

```
    return expression
```

The expression part is optional. If it is omitted, then the returned value is undefined and, therefore, unpredictable.

A return statement with no value expression is assumed at the end of every function definition. So if control reaches the end of the function body, then the function returns an unpredictable value. `awk` will not warn you if you use the return value of such a function; you will simply get unpredictable or unexpected results.

Here is an example of a user-defined function that returns a value for the largest number among the elements of an array:

```
function maxelt (vec,  i, ret) {
    for (i in vec) {
        if (ret == "" || vec[i] > ret)
            ret = vec[i]
    }
    return ret
}
```

You call `maxelt` with one argument, which is an array name. The local variables `i` and `ret` are not intended to be arguments; while there is nothing to stop you from passing two or three arguments to `maxelt`, the results would be strange. The extra space before `i` in the function parameter list is to indicate that `i` and `ret` are not supposed to be arguments. This is a convention which you should follow when you define functions.

Here is a program that uses our `maxelt` function. It loads an array, calls `maxelt`, and then reports the maximum number in that array:

```
awk '
function maxelt (vec,  i, ret) {
    for (i in vec) {
        if (ret == "" || vec[i] > ret)
            ret = vec[i]
    }
    return ret
}

# Load all fields of each record into nums.
{
    for(i = 1; i <= NF; i++)
        nums[NR, i] = $i
}

END {
    print maxelt(nums)
}'
```

Given the following input:

```
1 5 23 8 16
44 3 5 2 8 26
256 291 1396 2962 100
-6 467 998 1101
99385 11 0 225
```

our program tells us (predictably) that:

```
99385
```

is the largest number in our array.

1.103 gawk.info/Built-in Variables

Built-in Variables

Most awk variables are available for you to use for your own purposes; they never change except when your program assigns values to them, and never affect anything except when your program examines them.

A few variables have special built-in meanings. Some of them awk examines automatically, so that they enable you to tell awk how to do certain things. Others are set automatically by awk, so that they carry information from the internal workings of awk to your program.

This chapter documents all the built-in variables of gawk. Most of them are also documented in the chapters where their areas of activity are described.

User-modified

Built-in variables that you change to control awk.

Auto-set

Built-in variables where awk gives you information.

1.104 gawk.info/User-modified

Built-in Variables that Control awk

=====

This is a list of the variables which you can change to control how awk does certain things.

CONVFMT

This string is used by awk to control conversion of numbers to strings (see

Conversion of Strings and Numbers

). It works by

being passed, in effect, as the first argument to the sprintf function. Its default value is "%.6g". CONVFMT was introduced by the POSIX standard.

FIELDWIDTHS

This is a space separated list of columns that tells gawk how to manage input with fixed, columnar boundaries. It is an experimental feature that is still evolving. Assigning to FIELDWIDTHS overrides the use of FS for field splitting. See

Reading Fixed-width Data

, for more information.

If gawk is in compatibility mode (see [Invoking awk](#)), then `FIELDWIDTHS` has no special meaning, and field splitting operations are done based exclusively on the value of `FS`.

FS

`FS` is the input field separator (see [Specifying how Fields are Separated](#)). The value is a single-character string or a multi-character regular expression that matches the separations between fields in an input record.

The default value is " ", a string consisting of a single space. As a special exception, this value actually means that any sequence of spaces and tabs is a single separator. It also causes spaces and tabs at the beginning or end of a line to be ignored.

You can set the value of `FS` on the command line using the `-F` option:

```
awk -F, 'program' input-files
```

If gawk is using `FIELDWIDTHS` for field-splitting, assigning a value to `FS` will cause gawk to return to the normal, regexp-based, field splitting.

IGNORECASE

If `IGNORECASE` is nonzero, then all regular expression matching is done in a case-independent fashion. In particular, regexp matching with `~` and `!~`, and the `gsub` index, `match`, `split` and `sub` functions all ignore case when doing their particular regexp operations. Note: since field splitting with the value of the `FS` variable is also a regular expression operation, that too is done with case ignored. See

[Case-sensitivity in Matching](#)

.

If gawk is in compatibility mode (see [Invoking awk](#)), then `IGNORECASE` has no special meaning, and regexp operations are always case-sensitive.

OFMT

This string is used by awk to control conversion of numbers to strings (see

[Conversion of Strings and Numbers](#)

) for printing with

the `print` statement. It works by being passed, in effect, as the first argument to the `sprintf` function. Its default value is `"%.6g"`. Earlier versions of awk also used `OFMT` to specify the format for converting numbers to strings in general expressions; this has been taken over by `CONVFMT`.

OFS

This is the output field separator (see Output Separators). It is output between the fields output by a print statement. Its default value is " ", a string consisting of a single space.

ORS

This is the output record separator. It is output at the end of every print statement. Its default value is a string containing a single newline character, which could be written as "\n". (See

Output Separators
.)

RS

This is awk's input record separator. Its default value is a string containing a single newline character, which means that an input record consists of a single line of text. (See

How Input is Split into Records
.)

SUBSEP

SUBSEP is the subscript separator. It has the default value of "\034", and is used to separate the parts of the name of a multi-dimensional array. Thus, if you access foo[12,3], it really accesses foo["12\0343"] (see Multi-dimensional Arrays).

1.105 gawk.info/Auto-set

Built-in Variables that Convey Information

=====

This is a list of the variables that are set automatically by awk on certain occasions so as to provide information to your program.

ARGC

ARGV

The command-line arguments available to awk programs are stored in an array called ARGV. ARGC is the number of command-line arguments present. See

Invoking awk

. ARGV is indexed from zero to ARGC - 1. For example:

```
awk 'BEGIN {
    for (i = 0; i < ARGC; i++)
        print ARGV[i]
}' inventory-shipped BBS-list
```

In this example, ARGV[0] contains "awk", ARGV[1] contains

"inventory-shipped", and ARGV[2] contains "BBS-list". The value of ARGV is 3, one more than the index of the last element in ARGV since the elements are numbered from zero.

The names ARGV and ARGV, as well the convention of indexing the array from 0 to ARGV - 1, are derived from the C language's method of accessing command line arguments.

Notice that the awk program is not entered in ARGV. The other special command line options, with their arguments, are also not entered. But variable assignments on the command line are treated as arguments, and do show up in the ARGV array.

Your program can alter ARGV and the elements of ARGV. Each time awk reaches the end of an input file, it uses the next element of ARGV as the name of the next input file. By storing a different string there, your program can change which files are read. You can use "-" to represent the standard input. By storing additional elements and incrementing ARGV you can cause additional files to be read.

If you decrease the value of ARGV, that eliminates input files from the end of the list. By recording the old value of ARGV elsewhere, your program can treat the eliminated arguments as something other than file names.

To eliminate a file from the middle of the list, store the null string ("") into ARGV in place of the file's name. As a special feature, awk ignores file names that have been replaced with the null string.

ARGIND

The index in ARGV of the current file being processed. Every time gawk opens a new data file for processing, it sets ARGIND to the index in ARGV of the file name. Thus, the condition FILENAME == ARGV[ARGIND] is always true.

This variable is useful in file processing; it allows you to tell how far along you are in the list of data files, and to distinguish between multiple successive instances of the same filename on the command line.

While you can change the value of ARGIND within your awk program, gawk will automatically set it to a new value when the next file is opened.

This variable is a gawk extension; in other awk implementations it is not special.

ENVIRON

This is an array that contains the values of the environment. The array indices are the environment variable names; the values are the values of the particular environment variables. For example, ENVIRON["HOME"] might be /u/close. Changing this array does not affect the environment passed on to any programs that awk may spawn via redirection or the system function. (In a future version of gawk, it may do so.)

Some operating systems may not have environment variables. On such systems, the array ENVIRON is empty.

ERRNO

If a system error occurs either doing a redirection for getline, during a read for getline, or during a close operation, then ERRNO will contain a string describing the error.

This variable is a gawk extension; in other awk implementations it is not special.

FILENAME

This is the name of the file that awk is currently reading. If awk is reading from the standard input (in other words, there are no files listed on the command line), FILENAME is set to "-". FILENAME is changed each time a new file is read (see

Reading Input Files
)

FNR

FNR is the current record number in the current file. FNR is incremented each time a new record is read (see

Explicit Input with getline
)

It is reinitialized to 0 each time a new input file is started.

NF

NF is the number of fields in the current input record. NF is set each time a new record is read, when a new field is created, or when \$0 changes (see

Examining Fields
)

NR

This is the number of input records awk has processed since the beginning of the program's execution. (see

How Input is Split into Records
)

NR is set each time a new record is read.

RLENGTH

RLENGTH is the length of the substring matched by the match function (see

Built-in Functions for String Manipulation
)

RLENGTH is set by invoking the match function. Its value is the length of the matched string, or -1 if no match was found.

RSTART

RSTART is the start-index in characters of the substring matched by the match function (see

Built-in Functions for String Manipulation

). RSTART is set by invoking the match function. Its value is the position of the string where the matched substring starts, or 0 if no match was found.

1.106 gawk.info/Command Line

Invoking awk

There are two ways to run awk: with an explicit program, or with one or more program files. Here are templates for both of them; items enclosed in [...] in these templates are optional.

Besides traditional one-letter POSIX-style options, gawk also supports GNU long named options.

```
awk [POSIX or GNU style options] -f progfile [--] file ...
awk [POSIX or GNU style options] [--] 'program' file ...
```

Options

Command line options and their meanings.

Other Arguments

Input file names and variable assignments.

AWKPATH Variable

Searching directories for awk programs.

Obsolete

Obsolete Options and/or features.

Undocumented

Undocumented Options and Features.

1.107 gawk.info/Options

Command Line Options

=====

Options begin with a minus sign, and consist of a single character. GNU style long named options consist of two minus signs and a keyword that can be abbreviated if the abbreviation allows the option to be uniquely identified. If the option takes an argument, then the keyword is immediately followed by an equals sign (=) and the argument's value. For brevity, the discussion below only refers to the traditional short

options; however the long and short options are interchangeable in all contexts.

Each long named option for gawk has a corresponding POSIX-style option. The options and their meanings are as follows:

`-F fs`

`-field-separator=fs`

Sets the FS variable to fs (see

Specifying how Fields are Separated
).

`-f source-file`

`-file=source-file`

Indicates that the awk program is to be found in source-file instead of in the first non-option argument.

`-v var=val`

`-assign=var=val`

Sets the variable var to the value val before execution of the program begins. Such variable values are available inside the BEGIN rule (see below for a fuller explanation).

The `-v` option can only set one variable, but you can use it more than once, setting another variable each time, like this: `-v foo=1 -v bar=2`.

`-W gawk-opt`

Following the POSIX standard, options that are implementation specific are supplied as arguments to the `-W` option. With gawk, these arguments may be separated by commas, or quoted and separated by whitespace. Case is ignored when processing these options. These options also have corresponding GNU style long named options. The following gawk-specific options are available:

`-W compat`

`-compat`

Specifies compatibility mode, in which the GNU extensions in gawk are disabled, so that gawk behaves just like Unix awk. See

Extensions in gawk not in POSIX awk
, which summarizes the
extensions. Also see
Downward Compatibility and Debugging
.

`-W copyleft`

`-W copyright`

`-copyleft`

`-copyright`

Print the short version of the General Public License. This option may disappear in a future version of gawk.

`-W help`

`-W usage`

`-help`

`-usage`
Print a "usage" message summarizing the short and long style options that gawk accepts, and then exit.

`-W lint`
`-lint`
Provide warnings about constructs that are dubious or non-portable to other awk implementations. Some warnings are issued when gawk first reads your program. Others are issued at run-time, as your program executes.

`-W posix`
`-posix`
Operate in strict POSIX mode. This disables all gawk extensions (just like `-W compat`), and adds the following additional restrictions:

- * `\x` escape sequences are not recognized (see
Constant Expressions
).
- * The synonym `func` for the keyword `function` is not recognized (see
Syntax of Function Definitions
).
- * The operators `**` and `**=` cannot be used in place of `^` and `^=` (see
Arithmetic Operators
, and also see
Assignment Expressions
).
- * Specifying `-Ft` on the command line does not set the value of `FS` to be a single tab character (see
Specifying how Fields are Separated
).

Although you can supply both `-W compat` and `-W posix` on the command line, `-W posix` will take precedence.

`-W source=program-text`
`-source=program-text`
Program source code is taken from the `program-text`. This option allows you to mix awk source code in files with program source code that you would enter on the command line. This is particularly useful when you have library functions that you wish to use from your command line programs (see
The AWKPATH Environment Variable
).

`-W version`
`-version`

Prints version information for this particular copy of gawk. This is so you can determine if your copy of gawk is up to date with respect to whatever the Free Software Foundation is currently distributing. This option may disappear in a future version of gawk.

-

Signals the end of the command line options. The following arguments are not treated as options even if they begin with -. This interpretation of - follows the POSIX argument parsing conventions.

This is useful if you have file names that start with -, or in shell scripts, if you have file names that will be specified by the user which could start with -.

Any other options are flagged as invalid with a warning message, but are otherwise ignored.

In compatibility mode, as a special case, if the value of fs supplied to the -F option is t, then FS is set to the tab character ("\t"). This is only true for -W compat, and not for -W posix (see

Specifying how Fields are Separated
)

If the -f option is not used, then the first non-option command line argument is expected to be the program text.

The -f option may be used more than once on the command line. If it is, awk reads its program source from all of the named files, as if they had been concatenated together into one big file. This is useful for creating libraries of awk functions. Useful functions can be written once, and then retrieved from a standard place, instead of having to be included into each individual program. You can still type in a program at the terminal and use library functions, by specifying -f /dev/tty. awk will read a file from the terminal to use as part of the awk program. After typing your program, type Control-d (the end-of-file character) to terminate it. (You may also use -f - to read program source from the standard input, but then you will not be able to also use the standard input as a source of data.)

Because it is clumsy using the standard awk mechanisms to mix source file and command line awk programs, gawk provides the -source option. This does not require you to pre-empt the standard input for your source code, and allows you to easily mix command line and library source code (see

The AWKPATH Environment Variable
)

If no -f or -source option is specified, then gawk will use the first non-option command line argument as the text of the program source code.

1.108 gawk.info/Other Arguments

Other Command Line Arguments

Any additional arguments on the command line are normally treated as input files to be processed in the order specified. However, an argument that has the form `var=value`, means to assign the value `value` to the variable `var`--it does not specify a file at all.

All these arguments are made available to your `awk` program in the `ARGV` array (see

`Built-in Variables`

). Command line options and the program text (if present) are omitted from the `ARGV` array. All other arguments, including variable assignments, are included.

The distinction between file name arguments and variable-assignment arguments is made when `awk` is about to open the next input file. At that point in execution, it checks the "file name" to see whether it is really a variable assignment; if so, `awk` sets the variable instead of reading a file.

Therefore, the variables actually receive the specified values after all previously specified files have been read. In particular, the values of variables assigned in this fashion are not available inside a `BEGIN` rule (see

`BEGIN and END Special Patterns`

), since such rules are

run before `awk` begins scanning the argument list. The values given on the command line are processed for escape sequences (see

`Constant Expressions`

).

In some earlier implementations of `awk`, when a variable assignment occurred before any file names, the assignment would happen before the `BEGIN` rule was executed. Some applications came to depend upon this "feature." When `awk` was changed to be more consistent, the `-v` option was added to accommodate applications that depended upon this old behavior.

The variable assignment feature is most useful for assigning to variables such as `RS`, `OFS`, and `ORS`, which control input and output formats, before scanning the data files. It is also useful for controlling state if multiple passes are needed over a data file. For example:

```
awk 'pass == 1 { pass 1 stuff }
     pass == 2 { pass 2 stuff }' pass=1 datafile pass=2 datafile
```

Given the variable assignment feature, the `-F` option is not strictly necessary. It remains for historical compatibility.

1.109 gawk.info/AWKPATH Variable

The AWKPATH Environment Variable

=====
 The previous section described how awk program files can be named on the command line with the `-f` option. In some awk implementations, you must supply a precise path name for each program file, unless the file is in the current directory.

But in gawk, if the file name supplied in the `-f` option does not contain a `/`, then gawk searches a list of directories (called the search path), one by one, looking for a file with the specified name.

The search path is actually a string consisting of directory names separated by colons. gawk gets its search path from the AWKPATH environment variable. If that variable does not exist, gawk uses the default path, which is `./local/lib/awk:/gnu/lib/awk`. (Programs written by system administrators should use an AWKPATH variable that does not include the current directory, `..`)

The search path feature is particularly useful for building up libraries of useful awk functions. The library files can be placed in a standard directory that is in the default path, and then specified on the command line with a short file name. Otherwise, the full file name would have to be typed for each file.

By combining the `-source` and `-f` options, your command line awk programs can use facilities in awk library files.

Path searching is not done if gawk is in compatibility mode. This is true for both `-W compat` and `-W posix`. See
 Command Line Options

Note: if you want files in the current directory to be found, you must include the current directory in the path, either by writing `.` as an entry in the path, or by writing a null entry in the path. (A null entry is indicated by starting or ending the path with a colon, or by placing two colons next to each other (`::`).) If the current directory is not included in the path, then files cannot be found in the current directory. This path search mechanism is identical to the shell's.

1.110 gawk.info/Obsolete

Obsolete Options and/or Features

=====
 This section describes features and/or command line options from the previous release of gawk that are either not available in the current version, or that are still supported but deprecated (meaning that they will not be in the next release).

For version 2.15 of gawk, the following command line options from version 2.11.1 are no longer recognized.

-c
Use -W compat instead.

-V
Use -W version instead.

-C
Use -W copyright instead.

-a
-e

These options produce an "unrecognized option" error message but have no effect on the execution of gawk. The POSIX standard now specifies traditional awk regular expressions for the awk utility.

The public-domain version of strftime that is distributed with gawk changed for the 2.14 release. The %V conversion specifier that used to generate the date in VMS format was changed to %v. This is because the POSIX standard for the date utility now specifies a %V conversion specifier. See

Functions for Dealing with Time Stamps
, for details.

1.111 gawk.info/Undocumented

Undocumented Options and Features

=====

This section intentionally left blank.

1.112 gawk.info/Language History

The Evolution of the awk Language

This manual describes the GNU implementation of awk, which is patterned after the POSIX specification. Many awk users are only familiar with the original awk implementation in Version 7 Unix, which is also the basis for the version in Berkeley Unix (through 4.3-Reno). This chapter briefly describes the evolution of the awk language.

V7-S5R3.1

The major changes between V7 and

System V Release 3.1.

S5R4

Minor changes between System V
Releases 3.1 and 4.

POSIX

New features from the POSIX standard.

POSIX-GNU

The extensions in gawk
not in POSIX awk.

1.113 gawk.info/V7-S5R3.1

Major Changes between V7 and S5R3.1

=====

The awk language evolved considerably between the release of Version 7 Unix (1978) and the new version first made widely available in System V Release 3.1 (1987). This section summarizes the changes, with cross-references to further details.

- * The requirement for ; to separate rules on a line (see
 awk Statements versus Lines
).
- * User-defined functions, and the return statement (see
 User-defined Functions
).
- * The delete statement (see
 The delete Statement
).
- * The do-while statement (see
 The do-while Statement
).
- * The built-in functions atan2, cos, sin, rand and srand (see
 Numeric Built-in Functions
).
- * The built-in functions gsub, sub, and match (see
 Built-in Functions for String Manipulation
).
- * The built-in functions close, which closes an open file, and
 system, which allows the user to execute operating system

- commands (see
 - Built-in Functions for Input/Output
 -).
 - * The ARGV, ARGV, FNR, RLENGTH, RSTART, and SUBSEP built-in variables (see
 - Built-in Variables
 -).
 - * The conditional expression using the operators ? and : (see
 - Conditional Expressions
 -).
 - * The exponentiation operator ^ (see
 - Arithmetic Operators
 -) and its
 - assignment operator form ^= (see
 - Assignment Expressions
 -).
 - * C-compatible operator precedence, which breaks some old awk programs (see
 - Operator Precedence (How Operators Nest)
 -).
 - * Regexps as the value of FS (see
 - Specifying how Fields are Separated
 -), and as the third argument to
 - the split function (see
 - Built-in Functions for String Manipulation
 -).
 - * Dynamic regexps as operands of the ~ and !~ operators (see
 - How to Use Regular Expressions
 -).
 - * Escape sequences (see
 - Constant Expressions
 -) in regexps.
 - * The escape sequences \b, \f, and \r (see
 - Constant Expressions
 -).
 - * Redirection of input for the getline function (see
 - Explicit Input with getline
 -).
 - * Multiple BEGIN and END rules (see
 - BEGIN and END Special Patterns
 -).
-

- * Simulated multi-dimensional arrays (see Multi-dimensional Arrays).

1.114 gawk.info/S5R4

Changes between S5R3.1 and S5R4

=====

The System V Release 4 version of Unix awk added these features (some of which originated in gawk):

- * The ENVIRON variable (see Built-in Variables).
- * Multiple -f options on the command line (see Invoking awk).
- * The -v option for assigning variables before program execution begins (see Invoking awk).
- * The - option for terminating command line options.
- * The \a, \v, and \x escape sequences (see Constant Expressions).
- * A defined return value for the srand built-in function (see Numeric Built-in Functions).
- * The toupper and tolower built-in string functions for case translation (see Built-in Functions for String Manipulation).
- * A cleaner specification for the %c format-control letter in the printf function (see Using printf Statements for Fancier Printing).
- * The ability to dynamically pass the field width and precision ("%*.d") in the argument list of the printf function (see Using printf Statements for Fancier Printing).
- * The use of constant regexps such as /foo/ as expressions, where

they are equivalent to use of the matching operator, as in `$0 ~ /foo/` (see
 Constant Expressions
).

1.115 gawk.info/POSIX

Changes between S5R4 and POSIX awk

=====

The POSIX Command Language and Utilities standard for awk introduced the following changes into the language:

- * The use of `-W` for implementation-specific options.
- * The use of `CONVFMT` for controlling the conversion of numbers to strings (see
 Conversion of Strings and Numbers
).
- * The concept of a numeric string, and tighter comparison rules to go with it (see
 Comparison Expressions
).
- * More complete documentation of many of the previously undocumented features of the language.

1.116 gawk.info/POSIX-GNU

Extensions in gawk not in POSIX awk

=====

The GNU implementation, gawk, adds these features:

- * The `AWKPATH` environment variable for specifying a path search for the `-f` command line option (see
 Invoking awk
).
- * The various gawk specific features available via the `-W` command line option (see
 Invoking awk
).
- * The `ARGIND` variable, that tracks the movement of `FILENAME` through `ARGV`. (see
 Built-in Variables

-).
- * The ERRNO variable, that contains the system error message when getline returns -1, or when close fails. (see Built-in Variables).
 - * The IGNORECASE variable and its effects (see Case-sensitivity in Matching).
 - * The FIELDWIDTHS variable and its effects (see Reading Fixed-width Data).
 - * The next file statement for skipping to the next data file (see The next file Statement).
 - * The systime and strftime built-in functions for obtaining and printing time stamps (see Functions for Dealing with Time Stamps).
 - * The /dev/stdin, /dev/stdout, /dev/stderr, and /dev/fd/n file name interpretation (see Standard I/O Streams).
 - * The -W compat option to turn off these extensions (see Invoking awk).
 - * The -W posix option for full POSIX compliance (see Invoking awk).

1.117 gawk.info/Installation

Installing gawk

This chapter provides instructions for installing gawk on the various platforms that are supported by the developers. The primary developers support Unix (and one day, GNU), while the other ports were contributed. The file ACKNOWLEDGMENT in the gawk distribution lists the electronic mail addresses of the people who did the respective ports.

Gawk Distribution

What is in the gawk distribution.

Unix Installation

Installing gawk under various versions of Unix.

VMS Installation

Installing gawk on VMS.

MS-DOS Installation

Installing gawk on MS-DOS.

Atari Installation

Installing gawk on the Atari ST.

1.118 gawk.info/Gawk Distribution

The gawk Distribution

=====

This section first describes how to get and extract the gawk distribution, and then discusses what is in the various files and subdirectories.

Extracting

How to get and extract the distribution.

Distribution contents

What is in the distribution.

1.119 gawk.info/Extracting

Getting the gawk Distribution

gawk is distributed as a tar file compressed with the GNU Zip program, gzip. You can get it via anonymous ftp to the Internet host prep.ai.mit.edu. Like all GNU software, it will be archived at other well known systems, from which it will be possible to use some sort of anonymous uucp to obtain the distribution as well. You can also order gawk on tape or CD-ROM directly from the Free Software Foundation. (The address is on the copyright page.) Doing so directly contributes to the support of the foundation and to the production of more free

software.

Once you have the distribution (for example, gawk-2.15.0.tar.z), first use gzip to expand the file, and then use tar to extract it. You can use the following pipeline to produce the gawk distribution:

```
# Under System V, add 'o' to the tar flags
gzip -d -c gawk-2.15.0.tar.z | tar -xvpf -
```

This will create a directory named gawk-2.15 in the current directory.

The distribution file name is of the form gawk-2.15.n.tar.Z. The n represents a patchlevel, meaning that minor bugs have been fixed in the major release. The current patchlevel is 0, but when retrieving distributions, you should get the version with the highest patchlevel.

If you are not on a Unix system, you will need to make other arrangements for getting and extracting the gawk distribution. You should consult a local expert.

1.120 gawk.info/Distribution contents

Contents of the gawk Distribution

gawk has a number of C source files, documentation files, subdirectories and files related to the configuration process (see

Compiling and Installing gawk on Unix
) , and several subdirectories related to different, non-Unix, operating systems.

various .c, .y, and .h files

The C and YACC source files are the actual gawk source code.

README
README.VMS
README.dos
README.rs6000
README.ultrix

Descriptive files: README for gawk under Unix, and the rest for the various hardware and software combinations.

PORTS

A list of systems to which gawk has been ported, and which have successfully run the test suite.

ACKNOWLEDGMENT

A list of the people who contributed major parts of the code or documentation.

NEWS

A list of changes to gawk since the last release or patch.

COPYING

The GNU General Public License.

FUTURES

A brief list of features and/or changes being contemplated for future releases, with some indication of the time frame for the feature, based on its difficulty.

LIMITATIONS

A list of those factors that limit gawk's performance. Most of these depend on the hardware or operating system software, and are not limits in gawk itself.

PROBLEMS

A file describing known problems with the current release.

gawk.1

The troff source for a manual page describing gawk.

gawk.texinfo

The texinfo source file for this Info file. It should be processed with TeX to produce a printed manual, and with makeinfo to produce the Info file.

Makefile.in

config
config.in
configure
missing
mungeconf

These files and subdirectories are used when configuring gawk for various Unix systems. They are explained in detail in

Compiling and Installing gawk on Unix

.

atari

Files needed for building gawk on an Atari ST. See

Installing gawk on the Atari ST
, for details.

pc

Files needed for building gawk under MS-DOS. See

Installing gawk on MS-DOS
, for details.

vms

Files needed for building gawk under VMS. See

Compiling Installing and Running gawk on VMS
, for details.

test

Many interesting awk programs, provided as a test suite for gawk. You can use make test from the top level gawk directory to run

your version of gawk against the test suite. If gawk successfully passes make test then you can be confident of a successful port.

1.121 gawk.info/Unix Installation

Compiling and Installing gawk on Unix

=====

Often, you can compile and install gawk by typing only two commands. However, if you do not use a supported system, you may need to configure gawk for your system yourself.

Quick Installation

Compiling gawk on a supported Unix version.

Configuration Philosophy

How it's all supposed to work.

New Configurations

What to do if there is no supplied configuration for your system.

1.122 gawk.info/Quick Installation

Compiling gawk for a Supported Unix Version

After you have extracted the gawk distribution, cd to gawk-2.15. Look in the config subdirectory for a file that matches your hardware/software combination. In general, only the software is relevant; for example sunos41 is used for SunOS 4.1, on both Sun 3 and Sun 4 hardware.

If you find such a file, run the command:

```
# assume you have SunOS 4.1
./configure sunos41
```

This produces a Makefile and config.h tailored to your system. You may wish to edit the Makefile to use a different C compiler, such as gcc, the GNU C compiler, if you have it. You may also wish to change the CFLAGS variable, which controls the command line options that are passed to the C compiler (such as optimization levels, or compiling for debugging).

After you have configured Makefile and config.h, type:

```
make
```

and shortly thereafter, you should have an executable version of gawk. That's all there is to it!

1.123 gawk.info/Configuration Philosophy

The Configuration Process

(This section is of interest only if you know something about using the C language and the Unix operating system.)

The source code for gawk generally attempts to adhere to industry standards wherever possible. This means that gawk uses library routines that are specified by the ANSI C standard and by the POSIX operating system interface standard. When using an ANSI C compiler, function prototypes are provided to help improve the compile-time checking.

Many older Unix systems do not support all of either the ANSI or the POSIX standards. The missing subdirectory in the gawk distribution contains replacement versions of those subroutines that are most likely to be missing.

The config.h file that is created by the configure program contains definitions that describe features of the particular operating system where you are attempting to compile gawk. For the most part, it lists which standard subroutines are not available. For example, if your system lacks the getopt routine, then GETOPT_MISSING would be defined.

config.h also defines constants that describe facts about your variant of Unix. For example, there may not be an st_blksize element in the stat structure. In this case BLKSIZE_MISSING would be defined.

Based on the list in config.h of standard subroutines that are missing, missing.c will do a #include of the appropriate file(s) from the missing subdirectory.

Conditionally compiled code in the other source files relies on the other definitions in the config.h file.

Besides creating config.h, configure produces a Makefile from Makefile.in. There are a number of lines in Makefile.in that are system or feature specific. For example, there is line that begins with ##MAKE_ALLOCA_C##. This is normally a comment line, since it starts with #. If a configuration file has MAKE_ALLOCA_C in it, then configure will delete the ##MAKE_ALLOCA_C## from the beginning of the line. This will enable the rules in the Makefile that use a C version of alloca. There are several similar features that work in this fashion.

1.124 gawk.info/New Configurations

Configuring gawk for a New System

(This section is of interest only if you know something about using the C language and the Unix operating system, and if you have to install gawk on a system that is not supported by the gawk distribution. If you are a C or Unix novice, get help from a local expert.)

If you need to configure gawk for a Unix system that is not supported in the distribution, first see
The Configuration Process

Then, copy `config.in` to `config.h`, and copy `Makefile.in` to `Makefile`.

Next, edit both files. Both files are liberally commented, and the necessary changes should be straightforward.

While editing `config.h`, you need to determine what library routines you do or do not have by consulting your system documentation, or by perusing your actual libraries using the `ar` or `nm` utilities. In the worst case, simply do not define any of the macros for missing subroutines. When you compile gawk, the final link-editing step will fail. The link editor will provide you with a list of unresolved external references--these are the missing subroutines. Edit `config.h` again and recompile, and you should be set.

Editing the `Makefile` should also be straightforward. Enable or disable the lines that begin with `##MAKE_whatever##`, as appropriate. Select the correct C compiler and `CFLAGS` for it. Then run `make`.

Getting a correct configuration is likely to be an iterative process. Do not be discouraged if it takes you several tries. If you have no luck whatsoever, please report your system type, and the steps you took. Once you do have a working configuration, please send it to the maintainers so that support for your system can be added to the official release.

See

Reporting Problems and Bugs

, for information on how to report

problems in configuring gawk. You may also use the same mechanisms for sending in new configurations.

1.125 gawk.info/VMS Installation

 Compiling, Installing, and Running gawk on VMS

This section describes how to compile and install gawk under VMS.

VMS Compilation	How to compile gawk under VMS.
VMS Installation Details	How to install gawk under VMS.
VMS Running	How to run gawk under VMS.
VMS POSIX	Alternate instructions for VMS POSIX.

1.126 gawk.info/VMS Compilation

Compiling gawk under VMS

To compile gawk under VMS, there is a DCL command procedure that will issue all the necessary CC and LINK commands, and there is also a Makefile for use with the MMS utility. From the source directory, use either

```
$ @[.VMS]VMSBUILD.COM
```

or

```
$ MMS/DESCRIPTION=[.VMS]DECSRIP.MMS GAWK
```

Depending upon which C compiler you are using, follow one of the sets of instructions in this table:

VAX C V3.x

Use either vmsbuild.com or descrip.mms as is. These use CC/OPTIMIZE=NOLINE, which is essential for Version 3.0.

VAX C V2.x

You must have Version 2.3 or 2.4; older ones won't work. Edit either vmsbuild.com or descrip.mms according to the comments in them. For vmsbuild.com, this just entails removing two ! delimiters. Also edit config.h (which is a copy of file [.config]vms-conf.h) and comment out or delete the two lines #define __STDC__ 0 and #define VAXC_BUILTINS near the end.

GNU C

Edit vmsbuild.com or descrip.mms; the changes are different from

those for VAX C V2.x, but equally straightforward. No changes to config.h should be needed.

DEC C

Edit vmsbuild.com or descrip.mms according to their comments. No changes to config.h should be needed.

gawk 2.15 has been tested under VAX/VMS 5.5-1 using VAX C V3.2, GNU C 1.40 and 2.3. It should work without modifications for VMS V4.6 and up.

1.127 gawk.info/VMS Installation Details

Installing gawk on VMS

To install gawk, all you need is a "foreign" command, which is a DCL symbol whose value begins with a dollar sign.

```
$ GAWK := $device:[directory]GAWK
```

(Substitute the actual location of gawk.exe for device:[directory].) The symbol should be placed in the login.com of any user who wishes to run gawk, so that it will be defined every time the user logs on. Alternatively, the symbol may be placed in the system-wide sylogin.com procedure, which will allow all users to run gawk.

Optionally, the help entry can be loaded into a VMS help library:

```
$ LIBRARY/HELP SYS$HELP:HELPLIB [.VMS]GAWK.HLP
```

(You may want to substitute a site-specific help library rather than the standard VMS library HELPLIB.) After loading the help text,

```
$ HELP GAWK
```

will provide information about both the gawk implementation and the awk programming language.

The logical name AWK_LIBRARY can designate a default location for awk program files. For the -f option, if the specified filename has no device or directory path information in it, gawk will look in the current directory first, then in the directory specified by the translation of AWK_LIBRARY if the file was not found. If after searching in both directories, the file still is not found, then gawk appends the suffix .awk to the filename and the file search will be re-tried. If AWK_LIBRARY is not defined, that portion of the file search will fail benignly.

1.128 gawk.info/VMS Running

Running gawk on VMS

Command line parsing and quoting conventions are significantly different on VMS, so examples in this manual or from other sources often need minor changes. They are minor though, and all awk programs should run correctly.

Here are a couple of trivial tests:

```
$ gawk -- "BEGIN {print ""Hello, World!""}"
$ gawk -"W" version      ! could also be -"W version" or "-W version"
```

Note that upper-case and mixed-case text must be quoted.

The VMS port of gawk includes a DCL-style interface in addition to the original shell-style interface (see the help entry for details). One side-effect of dual command line parsing is that if there is only a single parameter (as in the quoted string program above), the command becomes ambiguous. To work around this, the normally optional `-` flag is required to force Unix style rather than DCL parsing. If any other dash-type options (or multiple parameters such as data files to be processed) are present, there is no ambiguity and `-` can be omitted.

The default search path when looking for awk program files specified by the `-f` option is `"SYS$DISK:[],AWK_LIBRARY:"`. The logical name `AWKPATH` can be used to override this default. The format of `AWKPATH` is a comma-separated list of directory specifications. When defining it, the value should be quoted so that it retains a single translation, and not a multi-translation RMS searchlist.

1.129 gawk.info/VMS POSIX

Building and using gawk under VMS POSIX

Ignore the instructions above, although `vms/gawk.hlp` should still be made available in a help library. Make sure that the two scripts, `configure` and `mungeconf`, are executable; use `chmod +x` on them if necessary. Then execute the following commands:

```
$ POSIX
psx> configure vms-posix
psx> make awktab.c gawk
```

The first command will construct files `config.h` and `Makefile` out of templates. The second command will compile and link `gawk`. Due to a make bug in VMS POSIX V1.0 and V1.1, the file `awktab.c` must be given as an explicit target or it will not be built and the final link step will fail. Ignore the warning "Could not find lib m in lib list"; it is harmless, caused by the explicit use of `-lm` as a linker option which is not needed under VMS POSIX. Under V1.1 (but not V1.0) a problem with the yacc skeleton `/etc/yyparse.c` will cause a compiler warning for

awktab.c, followed by a linker warning about compilation warnings in the resulting object module. These warnings can be ignored.

Once built, gawk will work like any other shell utility. Unlike the normal VMS port of gawk, no special command line manipulation is needed in the VMS POSIX environment.

1.130 gawk.info/MS-DOS Installation

Installing gawk on MS-DOS

=====

The first step is to get all the files in the gawk distribution onto your PC. Move all the files from the pc directory into the main directory where the other files are. Edit the file make.bat so that it will be an acceptable MS-DOS batch file. This means making sure that all lines are terminated with the ASCII carriage return and line feed characters. restrictions.

gawk has only been compiled with version 5.1 of the Microsoft C compiler. The file make.bat from the pc directory assumes that you have this compiler.

Copy the file setargv.obj from the library directory where it resides to the gawk source code directory.

Run make.bat. This will compile gawk for you, and link it. That's all there is to it!

1.131 gawk.info/Atari Installation

Installing gawk on the Atari ST

=====

This section assumes that you are running TOS. It applies to other Atari models (STe, TT) as well.

In order to use gawk, you need to have a shell, either text or graphics, that does not map all the characters of a command line to upper case. Maintaining case distinction in option flags is very important (see

Invoking awk

). Popular shells like gulam or gemini will work, as will newer versions of desktop. Support for I/O redirection is necessary to make it easy to import awk programs from other environments. Pipes are nice to have, but not vital.

If you have received an executable version of gawk, place it, as usual, anywhere in your PATH where your shell will find it.

While executing, gawk creates a number of temporary files. gawk looks for either of the environment variables TEMP or TMPDIR, in that order. If either one is found, its value is assumed to be a directory for temporary files. This directory must exist, and if you can spare the memory, it is a good idea to put it on a RAM drive. If neither TEMP nor TMPDIR are found, then gawk uses the current directory for its temporary files.

The ST version of gawk searches for its program files as described in

The AWKPATH Environment Variable

. On the ST, the default value for the AWKPATH variable is ".,c:\lib\awk,c:\gnu\lib\awk". The search path can be modified by explicitly setting AWKPATH to whatever you wish. Note that colons cannot be used on the ST to separate elements in the AWKPATH variable, since they have another, reserved, meaning. Instead, you must use a comma to separate elements in the path. If you are recompiling gawk on the ST, then you can choose a new default search path, by setting the value of DEFPATH in the file ..\config\atari. You may choose a different separator character by setting the value of ENVSEP in the same file. The new values will be used when creating the header file config.h.

Although awk allows great flexibility in doing I/O redirections from within a program, this facility should be used with care on the ST. In some circumstances the OS routines for file handle pool processing lose track of certain events, causing the computer to crash, and requiring a reboot. Often a warm reboot is sufficient. Fortunately, this happens infrequently, and in rather esoteric situations. In particular, avoid having one part of an awk program using print statements explicitly redirected to "/dev/stdout", while other print statements use the default standard output, and a calling shell has redirected standard output to a file.

When gawk is compiled with the ST version of gcc and its usual libraries, it will accept both / and \ as path separators. While this is convenient, it should be remembered that this removes one, technically legal, character (/) from your file names, and that it may create problems for external programs, called via the system() function, which may not support this convention. Whenever it is possible that a file created by gawk will be used by some other program, use only backslashes. Also remember that in awk, backslashes in strings have to be doubled in order to get literal backslashes.

The initial port of gawk to the ST was done with gcc. If you wish to recompile gawk from scratch, you will need to use a compiler that accepts ANSI standard C (such as gcc, Turbo C, or Prospero C). If sizeof(int) != sizeof(int *), the correctness of the generated code depends heavily on the fact that all function calls have function prototypes in the current scope. If your compiler does not accept function prototypes, you will probably have to add a number of casts to the code.

If you are using gcc, make sure that you have up-to-date libraries. Older versions have problems with some library functions (atan2(), strftime(), the %g conversion in sprintf()) which may affect the operation of gawk.

In the `atari` subdirectory of the gawk distribution is a version of the `system()` function that has been tested with `gulam` and `msh`; it should work with other shells as well. With `gulam`, it passes the string to be executed without spawning an extra copy of a shell. It is possible to replace this version of `system()` with a similar function from a library or from some other source if that version would be a better choice for the shell you prefer.

The files needed to recompile gawk on the ST can be found in the `atari` directory. The provided files and instructions below assume that you have the GNU C compiler (`gcc`), the `gulam` shell, and an ST version of `sed`. The Makefile is set up to use `byacc` as a `yacc` replacement. With a different set of tools some adjustments and/or editing will be needed.

`cd` to the `atari` directory. Copy `Makefile.st` to `makefile` in the source (parent) directory. Possibly adjust `./config/atari` to suit your system. Execute the script `mkconf.g` which will create the header file `./config.h`. Go back to the source directory. If you are not using `gcc`, check the file `missing.c`. It may be necessary to change forward slashes in the references to files from the `atari` subdirectory into backslashes. Type `make` and enjoy.

Compilation with `gcc` of some of the bigger modules, like `awk_tab.c`, may require a full four megabytes of memory. On smaller machines you would need to cut down on optimizations, or you would have to switch to another, less memory hungry, compiler.

1.132 gawk.info/Gawk Summary

gawk Summary

This appendix provides a brief summary of the gawk command line and the awk language. It is designed to serve as "quick reference." It is therefore terse, but complete.

Command Line Summary

Recapitulation of the command line.

Language Summary

A terse review of the language.

Variables-Fields

Variables, fields, and arrays.

Rules Summary

Patterns and Actions, and their component parts.

Functions Summary

Defining and calling functions.

Historical Features

Some undocumented but supported "features".

1.133 gawk.info/Command Line Summary

Command Line Options Summary

=====

The command line consists of options to gawk itself, the awk program text (if not supplied via the `-f` option), and values to be made available in the ARGV and ARGV predefined awk variables:

```
awk [POSIX or GNU style options] -f source-file [--] file ...
awk [POSIX or GNU style options] [--] 'program' file ...
```

The options that gawk accepts are:

`-F fs`

`-field-separator=fs`

Use `fs` for the input field separator (the value of the FS predefined variable).

`-f program-file`

`-file=program-file`

Read the awk program source from the file `program-file`, instead of from the first command line argument.

`-v var=val`

`-assign=var=val`

Assign the variable `var` the value `val` before program execution begins.

`-W compat`

`-compat`

Specifies compatibility mode, in which gawk extensions are turned off.

`-W copyleft`

`-W copyright`

`-copyleft`

`-copyright`

Print the short version of the General Public License on the error output. This option may disappear in a future version of gawk.

`-W help`

`-W usage`

`-help`

`-usage`

Print a relatively short summary of the available options on the error output.

```

-W lint
-lint
    Give warnings about dubious or non-portable awk constructs.

-W posix
-posix
    Specifies POSIX compatibility mode, in which gawk extensions are
    turned off and additional restrictions apply.

-W source=program-text
-source=program-text
    Use program-text as awk program source code. This option allows
    mixing command line source code with source code from files, and is
    particularly useful for mixing command line programs with library
    functions.

-W version
-version
    Print version information for this particular copy of gawk on the
    error output. This option may disappear in a future version of
    gawk.

-
    Signal the end of options. This is useful to allow further
    arguments to the awk program itself to start with a -. This is
    mainly for consistency with the argument parsing conventions of
    POSIX.

```

Any other options are flagged as invalid, but are otherwise ignored.
See

```

    Invoking awk
    , for more details.

```

1.134 gawk.info/Language Summary

Language Summary

```

=====

```

An awk program consists of a sequence of pattern-action statements and optional function definitions.

```

pattern    { action statements }

```

```

function name(parameter list)    { action statements }

```

gawk first reads the program source from the program-file(s) if specified, or from the first non-option argument on the command line. The -f option may be used multiple times on the command line. gawk reads the program text from all the program-file files, effectively concatenating them in the order they are specified. This is useful for building libraries of awk functions, without having to include them in each new awk program that uses them. To use a library function in a

file from a program typed in on the command line, specify `-f /dev/tty`; then type your program, and end it with a Control-d. See
 Invoking awk

.

The environment variable `AWKPATH` specifies a search path to use when finding source files named with the `-f` option. The default path, which is `./local/lib/awk:/gnu/lib/awk` is used if `AWKPATH` is not set. If a file name given to the `-f` option contains a `/` character, no path search is performed. See

The `AWKPATH` Environment Variable
 , for a full

description of the `AWKPATH` environment variable.

`gawk` compiles the program into an internal form, and then proceeds to read each file named in the `ARGV` array. If there are no files named on the command line, `gawk` reads the standard input.

If a "file" named on the command line has the form `var=val`, it is treated as a variable assignment: the variable `var` is assigned the value `val`. If any of the files have a value that is the null string, that element in the list is skipped.

For each line in the input, `gawk` tests to see if it matches any pattern in the `awk` program. For each pattern that the line matches, the associated action is executed.

1.135 gawk.info/Variables-Fields

Variables and Fields

=====

`awk` variables are dynamic; they come into existence when they are first used. Their values are either floating-point numbers or strings. `awk` also has one-dimension arrays; multiple-dimensional arrays may be simulated. There are several predefined variables that `awk` sets as a program runs; these are summarized below.

Fields Summary

Input field splitting.

Built-in Summary

`awk`'s built-in variables.

Arrays Summary

Using arrays.

Data Type Summary

Values in `awk` are numbers or strings.

1.136 gawk.info/Fields Summary

Fields

As each input line is read, gawk splits the line into fields, using the value of the FS variable as the field separator. If FS is a single character, fields are separated by that character. Otherwise, FS is expected to be a full regular expression. In the special case that FS is a single blank, fields are separated by runs of blanks and/or tabs. Note that the value of IGNORECASE (see

Case-sensitivity in Matching
)

also affects how fields are split when FS is a regular expression.

Each field in the input line may be referenced by its position, \$1, \$2, and so on. \$0 is the whole line. The value of a field may be assigned to as well. Field numbers need not be constants:

```
n = 5
print $n
```

prints the fifth field in the input line. The variable NF is set to the total number of fields in the input line.

References to nonexistent fields (i.e., fields after \$NF) return the null-string. However, assigning to a nonexistent field (e.g., \$(NF+2) = 5) increases the value of NF, creates any intervening fields with the null string as their value, and causes the value of \$0 to be recomputed, with the fields being separated by the value of OFS.

See

Reading Input Files

, for a full description of the way awk defines and uses fields.

1.137 gawk.info/Built-in Summary

Built-in Variables

awk's built-in variables are:

ARGC

The number of command line arguments (not including options or the awk program itself).

ARGIND

The index in ARGV of the current file being processed. It is always true that `FILENAME == ARGV[ARGIND]`.

ARGV

The array of command line arguments. The array is indexed from 0 to `ARGC - 1`. Dynamically changing the contents of ARGV can control the files used for data.

CONVFMT

The conversion format to use when converting numbers to strings.

FIELDWIDTHS

A space separated list of numbers describing the fixed-width input data.

ENVIRON

An array containing the values of the environment variables. The array is indexed by variable name, each element being the value of that variable. Thus, the environment variable HOME would be in `ENVIRON["HOME"]`. Its value might be `/u/close`.

Changing this array does not affect the environment seen by programs which gawk spawns via redirection or the system function. (This may change in a future version of gawk.)

Some operating systems do not have environment variables. The array ENVIRON is empty when running on these systems.

ERRNO

The system error message when an error occurs using `getline` or `close`.

FILENAME

The name of the current input file. If no files are specified on the command line, the value of FILENAME is `-`.

FNR

The input record number in the current input file.

FS

The input field separator, a blank by default.

IGNORECASE

The case-sensitivity flag for regular expression operations. If IGNORECASE has a nonzero value, then pattern matching in rules, field splitting with FS, regular expression matching with `~` and `!~`, and the `gsub`, `index`, `match`, `split` and `sub` predefined functions all ignore case when doing regular expression operations.

NF

The number of fields in the current input record.

NR

The total number of input records seen so far.

OFMT

The output format for numbers for the print statement, `"%.6g"` by

default.

OFS

The output field separator, a blank by default.

ORS

The output record separator, by default a newline.

RS

The input record separator, by default a newline. RS is exceptional in that only the first character of its string value is used for separating records. If RS is set to the null string, then records are separated by blank lines. When RS is set to the null string, then the newline character always acts as a field separator, in addition to whatever value FS may have.

RSTART

The index of the first character matched by match; 0 if no match.

RLENGTH

The length of the string matched by match; -1 if no match.

SUBSEP

The string used to separate multiple subscripts in array elements, by default "\034".

See

Built-in Variables
, for more information.

1.138 gawk.info/Arrays Summary

Arrays

Arrays are subscripted with an expression between square brackets ([and]). Array subscripts are always strings; numbers are converted to strings as necessary, following the standard conversion rules (see

Conversion of Strings and Numbers
)

If you use multiple expressions separated by commas inside the square brackets, then the array subscript is a string consisting of the concatenation of the individual subscript values, converted to strings, separated by the subscript separator (the value of SUBSEP).

The special operator `in` may be used in an `if` or `while` statement to see if an array has an index consisting of a particular value.

```
if (val in array)
    print array[val]
```

If the array has multiple subscripts, use (i, j, ...) in array to test for existence of an element.

The in construct may also be used in a for loop to iterate over all the elements of an array. See

Scanning all Elements of an Array

.

An element may be deleted from an array using the delete statement.

See

Arrays in awk

, for more detailed information.

1.139 gawk.info/Data Type Summary

Data Types

The value of an awk expression is always either a number or a string.

Certain contexts (such as arithmetic operators) require numeric values. They convert strings to numbers by interpreting the text of the string as a numeral. If the string does not look like a numeral, it converts to 0.

Certain contexts (such as concatenation) require string values. They convert numbers to strings by effectively printing them with sprintf. See

Conversion of Strings and Numbers

, for the details.

To force conversion of a string value to a number, simply add 0 to it. If the value you start with is already a number, this does not change it.

To force conversion of a numeric value to a string, concatenate it with the null string.

The awk language defines comparisons as being done numerically if both operands are numeric, or if one is numeric and the other is a numeric string. Otherwise one or both operands are converted to strings and a string comparison is performed.

Uninitialized variables have the string value "" (the null, or empty, string). In contexts where a number is required, this is equivalent to 0.

See

Variables

, for more information on variable naming and

initialization; see

Conversion of Strings and Numbers

, for more information on how variable values are interpreted.

1.140 gawk.info/Rules Summary

Patterns and Actions

=====

Pattern Summary

Quick overview of patterns.

Regex Summary

Quick overview of regular expressions.

Actions Summary

Quick overview of actions.

An awk program is mostly composed of rules, each consisting of a pattern followed by an action. The action is enclosed in { and }. Either the pattern may be missing, or the action may be missing, but, of course, not both. If the pattern is missing, the action is executed for every single line of input. A missing action is equivalent to this action,

```
{ print }
```

which prints the entire line.

Comments begin with the # character, and continue until the end of the line. Blank lines may be used to separate statements. Normally, a statement ends with a newline, however, this is not the case for lines ending in a ,, {, ?, :, &&, or ||. Lines ending in do or else also have their statements automatically continued on the following line. In other cases, a line can be continued by ending it with a \ , in which case the newline is ignored.

Multiple statements may be put on one line by separating them with a ;. This applies to both the statements within the action part of a rule (the usual case), and to the rule statements.

See

Comments in awk Programs

, for information on awk's commenting

convention; see

awk Statements versus Lines

, for a description of the

line continuation mechanism in awk.

1.141 gawk.info/Pattern Summary

Patterns

awk patterns may be one of the following:

```

/regular expression/
relational expression
pattern && pattern
pattern || pattern
pattern ? pattern : pattern
(pattern)
! pattern
pattern1, pattern2
BEGIN
END

```

BEGIN and END are two special kinds of patterns that are not tested against the input. The action parts of all BEGIN rules are merged as if all the statements had been written in a single BEGIN rule. They are executed before any of the input is read. Similarly, all the END rules are merged, and executed when all the input is exhausted (or when an exit statement is executed). BEGIN and END patterns cannot be combined with other patterns in pattern expressions. BEGIN and END rules cannot have missing action parts.

For `/regular-expression/` patterns, the associated statement is executed for each input line that matches the regular expression. Regular expressions are extensions of those in `egrep`, and are summarized below.

A relational expression may use any of the operators defined below in the section on actions. These generally test whether certain fields match certain regular expressions.

The `&&`, `||`, and `!` operators are logical "and," logical "or," and logical "not," respectively, as in C. They do short-circuit evaluation, also as in C, and are used for combining more primitive pattern expressions. As in most languages, parentheses may be used to change the order of evaluation.

The `?:` operator is like the same operator in C. If the first pattern matches, then the second pattern is matched against the input record; otherwise, the third is matched. Only one of the second and third patterns is matched.

The `pattern1, pattern2` form of a pattern is called a range pattern. It matches all input lines starting with a line that matches `pattern1`, and continuing until a line that matches `pattern2`, inclusive. A range pattern cannot be used as an operand to any of the pattern operators.

See

Patterns

, for a full description of the pattern part of awk rules.

1.142 gawk.info/Regexp Summary

Regular Expressions

Regular expressions are the extended kind found in `egrep`. They are composed of characters as follows:

`c`
matches the character `c` (assuming `c` is a character with no special meaning in regexps).

`@{i}c`
matches the literal character `c`.

`.`
matches any character except newline.

`^`
matches the beginning of a line or a string.

`$`
matches the end of a line or a string.

`[abc ...]`
matches any of the characters `abc ...` (character class).

`[^abc ...]`
matches any character except `abc ...` and newline (negated character class).

`r1|r2`
matches either `r1` or `r2` (alternation).

`r1r2`
matches `r1`, and then `r2` (concatenation).

`r+`
matches one or more `r`'s.

`r*`
matches zero or more `r`'s.

`r?`
matches zero or one `r`'s.

`(r)`
matches `r` (grouping).

See

Regular Expressions as Patterns
, for a more detailed explanation

of regular expressions.

The escape sequences allowed in string constants are also valid in regular expressions (see

Constant Expressions
).

1.143 gawk.info/Actions Summary

Actions

Action statements are enclosed in braces, { and }. Action statements consist of the usual assignment, conditional, and looping statements found in most languages. The operators, control statements, and input/output statements available are patterned after those in C.

Operator Summary

awk operators.

Control Flow Summary

The control statements.

I-O Summary

The I/O statements.

Printf Summary

A summary of printf.

Special File Summary

Special file names interpreted internally.

Numeric Functions Summary

Built-in numeric functions.

String Functions Summary

Built-in string functions.

Time Functions Summary

Built-in time functions.

String Constants Summary

Escape sequences in strings.

1.144 gawk.info/Operator Summary

Operators

.....

The operators in awk, in order of increasing precedence, are:

= += -= *= /= %= ^=

Assignment. Both absolute assignment (var=value) and operator assignment (the other forms) are supported.

?:

A conditional expression, as in C. This has the form `expr1 ? expr2 : expr3`. If `expr1` is true, the value of the expression is `expr2`; otherwise it is `expr3`. Only one of `expr2` and `expr3` is evaluated.

||

Logical "or".

&&

Logical "and".

~ !~

Regular expression match, negated match.

< <= > >= != ==

The usual relational operators.

blank

String concatenation.

+ -

Addition and subtraction.

* / %

Multiplication, division, and modulus.

+ - !

Unary plus, unary minus, and logical negation.

^

Exponentiation (** may also be used, and **= for the assignment operator, but they are not specified in the POSIX standard).

++ -

Increment and decrement, both prefix and postfix.

\$

Field reference.

See

Expressions as Action Statements
, for a full description of all

the operators listed above. See

Examining Fields

, for a description of

the field reference operator.

1.145 gawk.info/Control Flow Summary

Control Statements

.....

The control statements are as follows:

```
if (condition) statement [ else statement ]
while (condition) statement
do statement while (condition)
for (expr1; expr2; expr3) statement
for (var in array) statement
break
continue
delete array[index]
exit [ expression ]
{ statements }
```

See

Control Statements in Actions
, for a full description of all the
control statements listed above.

1.146 gawk.info/I-O Summary

I/O Statements

.....

The input/output statements are as follows:

getline

Set \$0 from next input record; set NF, NR, FNR.

getline <file

Set \$0 from next record of file; set NF.

getline var

Set var from next input record; set NF, FNR.

getline var <file

Set var from next record of file.

next

Stop processing the current input record. The next input record is read and processing starts over with the first pattern in the awk program. If the end of the input data is reached, the END rule(s), if any, are executed.

next file

Stop processing the current input file. The next input record read comes from the next input file. FILENAME is updated, FNR is set to 1, and processing starts over with the first pattern in the awk program. If the end of the input data is reached, the END rule(s), if any, are executed.

print

Prints the current record.

print expr-list

Prints expressions.

print expr-list > file

Prints expressions on file.

printf fmt, expr-list

Format and print.

printf fmt, expr-list > file

Format and print on file.

Other input/output redirections are also allowed. For print and printf, >> file appends output to the file, and | command writes on a pipe. In a similar fashion, command | getline pipes input into getline. getline returns 0 on end of file, and -1 on an error.

See

Explicit Input with getline
, for a full description of the

getline statement. See

Printing Output
, for a full description of

print and printf. Finally, see

The next Statement
, for a

description of how the next statement works.

1.147 gawk.info/Printf Summary

printf Summary

.....

The awk printf statement and sprintf function accept the following conversion specification formats:

%c

An ASCII character. If the argument used for %c is numeric, it is treated as a character and printed. Otherwise, the argument is assumed to be a string, and the only first character of that string is printed.

`%d`
`%i`
A decimal number (the integer part).

`%e`
A floating point number of the form `[-]d.dddddE[+-]dd`.

`%f`
A floating point number of the form `[-]ddd.ddddd`.

`%g`
Use `%e` or `%f` conversion, whichever produces a shorter string, with nonsignificant zeros suppressed.

`%o`
An unsigned octal number (again, an integer).

`%s`
A character string.

`%x`
An unsigned hexadecimal number (an integer).

`%X`
Like `%x`, except use A through F instead of a through f for decimal 10 through 15.

`%%`
A single `%` character; no argument is converted.

There are optional, additional parameters that may lie between the `%` and the control letter:

`-`
The expression should be left-justified within its field.

`width`
The field should be padded to this width. If `width` has a leading zero, then the field is padded with zeros. Otherwise it is padded with blanks.

`.prec`
A number indicating the maximum width of strings or digits to the right of the decimal point.

Either or both of the `width` and `prec` values may be specified as `*`. In that case, the particular value is taken from the argument list.

See

Using `printf` Statements for Fancier Printing
, for examples and
for a more detailed description.

1.148 gawk.info/Special File Summary

Special File Names

.....

When doing I/O redirection from either `print` or `printf` into a file, or via `getline` from a file, gawk recognizes certain special file names internally. These file names allow access to open file descriptors inherited from gawk's parent process (usually the shell). The file names are:

`/dev/stdin`
The standard input.

`/dev/stdout`
The standard output.

`/dev/stderr`
The standard error output.

`/dev/fd/n`
The file denoted by the open file descriptor `n`.

In addition the following files provide process related information about the running gawk program.

`/dev/pid`
Reading this file returns the process ID of the current process, in decimal, terminated with a newline.

`/dev/ppid`
Reading this file returns the parent process ID of the current process, in decimal, terminated with a newline.

`/dev/pgrp`
Reading this file returns the process group ID of the current process, in decimal, terminated with a newline.

`/dev/user`
Reading this file returns a single record terminated with a newline. The fields are separated with blanks. The fields represent the following information:

\$1
The value of the `getuid` system call.

\$2
The value of the `geteuid` system call.

\$3
The value of the `getgid` system call.

\$4
The value of the `getegid` system call.

If there are any additional fields, they are the group IDs

returned by `getgroups` system call. (Multiple groups may not be supported on all systems.)

These file names may also be used on the command line to name data files. These file names are only recognized internally if you do not actually have files by these names on your system.

See

Standard I/O Streams

, for a longer description that provides the

motivation for this feature.

1.149 gawk.info/Numeric Functions Summary

Numeric Functions

.....

awk has the following predefined arithmetic functions:

`atan2(y, x)`

returns the arctangent of y/x in radians.

`cos(expr)`

returns the cosine in radians.

`exp(expr)`

the exponential function.

`int(expr)`

truncates to integer.

`log(expr)`

the natural logarithm function.

`rand()`

returns a random number between 0 and 1.

`sin(expr)`

returns the sine in radians.

`sqrt(expr)`

the square root function.

`srand(expr)`

use `expr` as a new seed for the random number generator. If no `expr` is provided, the time of day is used. The return value is the previous seed for the random number generator.

1.150 gawk.info/String Functions Summary

String Functions

.....

awk has the following predefined string functions:

gsub(r, s, t)

for each substring matching the regular expression *r* in the string *t*, substitute the string *s*, and return the number of substitutions. If *t* is not supplied, use *\$0*.

index(s, t)

returns the index of the string *t* in the string *s*, or 0 if *t* is not present.

length(s)

returns the length of the string *s*. The length of *\$0* is returned if no argument is supplied.

match(s, r)

returns the position in *s* where the regular expression *r* occurs, or 0 if *r* is not present, and sets the values of *RSTART* and *RLENGTH*.

split(s, a, r)

splits the string *s* into the array *a* on the regular expression *r*, and returns the number of fields. If *r* is omitted, *FS* is used instead.

sprintf(fmt, expr-list)

prints *expr-list* according to *fmt*, and returns the resulting string.

sub(r, s, t)

this is just like *gsub*, but only the first matching substring is replaced.

substr(s, i, n)

returns the *n*-character substring of *s* starting at *i*. If *n* is omitted, the rest of *s* is used.

tolower(str)

returns a copy of the string *str*, with all the upper-case characters in *str* translated to their corresponding lower-case counterparts. Nonalphabetic characters are left unchanged.

toupper(str)

returns a copy of the string *str*, with all the lower-case characters in *str* translated to their corresponding upper-case counterparts. Nonalphabetic characters are left unchanged.

system(cmd-line)

Execute the command *cmd-line*, and return the exit status.

1.151 gawk.info/Time Functions Summary

Built-in time functions

.....

The following two functions are available for getting the current time of day, and for formatting time stamps.

systeme()

returns the current time of day as the number of seconds since a particular epoch (Midnight, January 1, 1970 UTC, on POSIX systems).

strftime(format, timestamp)

formats timestamp according to the specification in format. The current time of day is used if no timestamp is supplied. See

Functions for Dealing with Time Stamps
, for the details on the
conversion specifiers that strftime accepts.

1.152 gawk.info/String Constants Summary

String Constants

.....

String constants in awk are sequences of characters enclosed between double quotes ("). Within strings, certain escape sequences are recognized, as in C. These are:

\

A literal backslash.

\a

The "alert" character; usually the ASCII BEL character.

\b

Backspace.

\f

Formfeed.

\n

Newline.

\r

Carriage return.

\t

Horizontal tab.

\v

Vertical tab.

`\xhex` digits

The character represented by the string of hexadecimal digits following the `\x`. As in ANSI C, all following hexadecimal digits are considered part of the escape sequence. (This feature should tell us something about language design by committee.) E.g., `"\x1B"` is a string containing the ASCII ESC (escape) character. (The `\x` escape sequence is not in POSIX awk.)

`@{i}ddd`

The character represented by the 1-, 2-, or 3-digit sequence of octal digits. Thus, `"\033"` is also a string containing the ASCII ESC (escape) character.

`@{i}c`

The literal character `c`.

The escape sequences may also be used inside constant regular expressions (e.g., the regexp `/[\t\f\n\r\v]/` matches whitespace characters).

See

Constant Expressions

.

1.153 gawk.info/Functions Summary

Functions

=====

Functions in awk are defined as follows:

```
function name(parameter list) { statements }
```

Actual parameters supplied in the function call are used to instantiate the formal parameters declared in the function. Arrays are passed by reference, other variables are passed by value.

If there are fewer arguments passed than there are names in `parameter-list`, the extra names are given the null string as value. Extra names have the effect of local variables.

The open-parenthesis in a function call of a user-defined function must immediately follow the function name, without any intervening white space. This is to avoid a syntactic ambiguity with the concatenation operator.

The word `func` may be used in place of `function` (but not in POSIX awk).

Use the `return` statement to return a value from a function.

See

User-defined Functions
, for a more complete description.

1.154 gawk.info/Historical Features

Historical Features
=====

There are two features of historical awk implementations that gawk supports. First, it is possible to call the length built-in function not only with no arguments, but even without parentheses!

```
a = length
```

is the same as either of

```
a = length()  
a = length($0)
```

This feature is marked as "deprecated" in the POSIX standard, and gawk will issue a warning about its use if `-W lint` is specified on the command line.

The other feature is the use of the continue statement outside the body of a while, for, or do loop. Traditional awk implementations have treated such usage as equivalent to the next statement. gawk will support this usage if `-W posix` has not been specified.

1.155 gawk.info/Sample Program

Sample Program

The following example is a complete awk program, which prints the number of occurrences of each word in its input. It illustrates the associative nature of awk arrays by using strings as subscripts. It also demonstrates the for x in array construction. Finally, it shows how awk can be used in conjunction with other utility programs to do a useful task of some complexity with a minimum of effort. Some explanations follow the program listing.

```
awk '  
# Print list of word frequencies  
{  
    for (i = 1; i <= NF; i++)  
        freq[$i]++  
}  
  
END {
```

```

    for (word in freq)
        printf "%s\t%d\n", word, freq[word]
    }

```

The first thing to notice about this program is that it has two rules. The first rule, because it has an empty pattern, is executed on every line of the input. It uses awk's field-accessing mechanism (see

Examining Fields
) to pick out the individual words from the line, and the built-in variable NF (see
Built-in Variables
) to know how many fields are available.

For each input word, an element of the array freq is incremented to reflect that the word has been seen an additional time.

The second rule, because it has the pattern END, is not executed until the input has been exhausted. It prints out the contents of the freq table that has been built up inside the first action.

Note that this program has several problems that would prevent it from being useful by itself on real text files:

- * Words are detected using the awk convention that fields are separated by whitespace and that other characters in the input (except newlines) don't have any special meaning to awk. This means that punctuation characters count as part of words.
- * The awk language considers upper and lower case characters to be distinct. Therefore, foo and Foo are not treated by this program as the same word. This is undesirable since in normal text, words are capitalized if they begin sentences, and a frequency analyzer should not be sensitive to that.
- * The output does not come out in any useful order. You're more likely to be interested in which words occur most frequently, or having an alphabetized table of how frequently each word occurs.

The way to solve these problems is to use some of the more advanced features of the awk language. First, we use tolower to remove case distinctions. Next, we use gsub to remove punctuation characters. Finally, we use the system sort utility to process the output of the awk script. First, here is the new version of the program:

```

awk '
# Print list of word frequencies
{
    $0 = tolower($0)      # remove case distinctions
    gsub(/^[^a-z0-9_ \t]/, "", $0) # remove punctuation
    for (i = 1; i <= NF; i++)
        freq[$i]++
}

END {
    for (word in freq)

```

```
        printf "%s\t%d\n", word, freq[word]
    }'
```

Assuming we have saved this program in a file named `frequency.awk`, and that the data is in `file1`, the following pipeline

```
awk -f frequency.awk file1 | sort +1 -nr
```

produces a table of the words appearing in `file1` in order of decreasing frequency.

The `awk` program suitably massages the data and produces a word frequency table, which is not ordered.

The `awk` script's output is then sorted by the `sort` command and printed on the terminal. The options given to `sort` in this example specify to sort using the second field of each input line (skipping one field), that the sort keys should be treated as numeric quantities (otherwise 15 would come before 5), and that the sorting should be done in descending (reverse) order.

We could have even done the sort from within the program, by changing the `END` action to:

```
END {
    sort = "sort +1 -nr"
    for (word in freq)
        printf "%s\t%d\n", word, freq[word] | sort
    close(sort)
}'
```

See the general operating system documentation for more information on how to use the `sort` command.

1.156 gawk.info/Bugs

Reporting Problems and Bugs

```
*****
```

If you have problems with `gawk` or think that you have found a bug, please report it to the developers; we cannot promise to do anything but we might well want to fix it.

Before reporting a bug, make sure you have actually found a real bug. Carefully reread the documentation and see if it really says you can do what you're trying to do. If it's not clear whether you should be able to do something or not, report that too; it's a bug in the documentation!

Before reporting a bug or trying to fix it yourself, try to isolate it to the smallest possible `awk` program and input data file that reproduces the problem. Then send us the program and data file, some idea of what kind of Unix system you're using, and the exact results

gawk gave you. Also say what you expected to occur; this will help us decide whether the problem was really in the documentation.

Once you have a precise problem, send e-mail to (Internet) `bug-gnu-utils@prep.ai.mit.edu` or (UUCP) `mit-eddie!prep.ai.mit.edu!bug-gnu-utils`. Please include the version number of gawk you are using. You can get this information with the command `gawk -W version '{} /dev/null`. You should send carbon copies of your mail to David Trueman at `david@cs.dal.ca`, and to Arnold Robbins, who can be reached at `arnold@skeeve.atl.ga.us`. David is most likely to fix code problems, while Arnold is most likely to fix documentation problems.

Non-bug suggestions are always welcome as well. If you have questions about things that are unclear in the documentation or are just obscure features, ask Arnold Robbins; he will try to help you out, although he may not have the time to fix the problem. You can send him electronic mail at the Internet address above.

If you find bugs in one of the non-Unix ports of gawk, please send an electronic mail message to the person who maintains that port. They are listed below, and also in the README file in the gawk distribution. Information in the README file should be considered authoritative if it conflicts with this manual.

The people maintaining the non-Unix ports of gawk are:

MS-DOS

The port to MS-DOS is maintained by Scott Deifik. His electronic mail address is `scottd@amgen.com`.

VMS

The port to VAX VMS is maintained by Pat Rankin. His electronic mail address is `rankin@eql.caltech.edu`.

Atari ST

The port to the Atari ST is maintained by Michal Jaegermann. His electronic mail address is `ntomczak@vm.ucs.ualberta.ca`.

If your bug is also reproducible under Unix, please send copies of your report to the general GNU bug list, as well as to Arnold Robbins and David Trueman, at the addresses listed above.

1.157 gawk.info/Notes

Implementation Notes

This appendix contains information mainly of interest to implementors and maintainers of gawk. Everything in it applies specifically to gawk, and not to other implementations.

Compatibility Mode

How to disable certain gawk extensions.

Future Extensions

New features we may implement soon.

Improvements

Suggestions for improvements by volunteers.

1.158 gawk.info/Compatibility Mode

Downward Compatibility and Debugging

=====

See

Extensions in gawk not in POSIX awk

, for a summary of the GNU

extensions to the awk language and program. All of these features can be turned off by invoking gawk with the `-W compat` option, or with the `-W posix` option.

If gawk is compiled for debugging with `-DDEBUG`, then there is one more option available on the command line:

`-W parsedebug`

Print out the parse stack information as the program is being parsed.

This option is intended only for serious gawk developers, and not for the casual user. It probably has not even been compiled into your version of gawk, since it slows down execution.

1.159 gawk.info/Future Extensions

Probable Future Extensions

=====

This section briefly lists extensions that indicate the directions we are currently considering for gawk. The file `FUTURES` in the gawk distributions lists these extensions, as well as several others.

RS as a regexp

The meaning of RS may be generalized along the lines of FS.

Control of subprocess environment

Changes made in gawk to the array `ENVIRON` may be propagated to subprocesses run by gawk.

Databases

It may be possible to map a GDBM/NDBM/SDBM file into an awk array.

Single-character fields

The null string, "", as a field separator, will cause field splitting and the split function to separate individual characters. Thus, `split(a, "abcd", "")` would yield `a[1] == "a"`, `a[2] == "b"`, and so on.

More lint warnings

There are more things that could be checked for portability.

RECLEN variable for fixed length records

Along with `FIELDWIDTHS`, this would speed up the processing of fixed-length records.

RT variable to hold the record terminator

It is occasionally useful to have access to the actual string of characters that matched the `RS` variable. The `RT` variable would hold these characters.

A restart keyword

After modifying `$0`, `restart` would restart the pattern matching loop, without reading a new record from the input.

A `|&` redirection

The `|&` redirection, in place of `|`, would open a two-way pipeline for communication with a sub-process (via `getline` and `print` and `printf`).

IGNORECASE affecting all comparisons

The effects of the `IGNORECASE` variable may be generalized to all string comparisons, and not just regular expression operations.

A way to mix command line source code and library files

There may be a new option that would make it possible to easily use library functions from a program entered on the command line.

GNU-style long options

We will add GNU-style long options to gawk for compatibility with other GNU programs. (For example, `-field-separator=:` would be equivalent to `-F:.`)

1.160 gawk.info/Improvements

Suggestions for Improvements

=====

Here are some projects that would-be gawk hackers might like to take on. They vary in size from a few days to a few weeks of programming, depending on which one you choose and how fast a programmer you are. Please send any improvements you write to the maintainers at the GNU project.

1. **Compilation of awk programs:** gawk uses a Bison (YACC-like) parser to convert the script given it into a syntax tree; the syntax tree is then executed by a simple recursive evaluator. This method incurs a lot of overhead, since the recursive evaluator performs many procedure calls to do even the simplest things.

It should be possible for gawk to convert the script's parse tree into a C program which the user would then compile, using the normal C compiler and a special gawk library to provide all the needed functions (regexps, fields, associative arrays, type coercion, and so on).

An easier possibility might be for an intermediate phase of awk to convert the parse tree into a linear byte code form like the one used in GNU Emacs Lisp. The recursive evaluator would then be replaced by a straight line byte code interpreter that would be intermediate in speed between running a compiled program and doing what gawk does now.

This may actually happen for the 3.0 version of gawk.

2. An error message section has not been included in this version of the manual. Perhaps some nice beta testers will document some of the messages for the future.
3. The programs in the test suite could use documenting in this manual.
4. The programs and data files in the manual should be available in separate files to facilitate experimentation.
5. See the FUTURES file for more ideas. Contact us if you would seriously like to tackle any of the items listed there.

1.161 gawk.info/Glossary

Glossary

Action

A series of awk statements attached to a rule. If the rule's pattern matches an input record, the awk language executes the rule's action. Actions are always enclosed in curly braces. See

Overview of Actions

.

Amazing awk Assembler

Henry Spencer at the University of Toronto wrote a retargetable assembler completely as awk scripts. It is thousands of lines long, including machine descriptions for several 8-bit microcomputers. It is a good example of a program that would have been better written in another language.

ANSI

The American National Standards Institute. This organization produces many standards, among them the standard for the C programming language.

Assignment

An awk expression that changes the value of some awk variable or data object. An object that you can assign to is called an lvalue. See

Assignment Expressions

.

awk Language

The language in which awk programs are written.

awk Program

An awk program consists of a series of patterns and actions, collectively known as rules. For each input record given to the program, the program's rules are all processed in turn. awk programs may also contain function definitions.

awk Script

Another name for an awk program.

Built-in Function

The awk language provides built-in functions that perform various numerical, time stamp related, and string computations. Examples are `sqrt` (for the square root of a number) and `substr` (for a substring of a string). See

Built-in Functions

.

Built-in Variable

`ARGC`, `ARGIND`, `ARGV`, `CONVFMT`, `ENVIRON`, `ERRNO`, `FIELDWIDTHS`, `FILENAME`, `FNR`, `FS`, `IGNORECASE`, `NF`, `NR`, `OFMT`, `OFS`, `ORS`, `RLENGTH`, `RSTART`, `RS`, and `SUBSEP`, are the variables that have special meaning to awk. Changing some of them affects awk's running environment. See

Built-in Variables

.

Braces

See "Curly Braces."

C

The system programming language that most GNU software is written in. The awk programming language has C-like syntax, and this manual points out similarities between awk and C when appropriate.

CHEM

A preprocessor for `pic` that reads descriptions of molecules and produces `pic` input for drawing them. It was written by Brian Kernighan, and is available from `netlib@research.att.com`.

Compound Statement

A series of awk statements, enclosed in curly braces. Compound statements may be nested. See

Control Statements in Actions

.

Concatenation

Concatenating two strings means sticking them together, one after another, giving a new string. For example, the string `foo` concatenated with the string `bar` gives the string `foobar`. See

String Concatenation

.

Conditional Expression

An expression using the `?:` ternary operator, such as `expr1 ? expr2 : expr3`. The expression `expr1` is evaluated; if the result is true, the value of the whole expression is the value of `expr2` otherwise the value is `expr3`. In either case, only one of `expr2` and `expr3` is evaluated. See

Conditional Expressions

.

Constant Regular Expression

A constant regular expression is a regular expression written within slashes, such as `/foo/`. This regular expression is chosen when you write the `awk` program, and cannot be changed during its execution. See

How to Use Regular Expressions

.

Comparison Expression

A relation that is either true or false, such as `(a < b)`. Comparison expressions are used in `if`, `while`, and `for` statements, and in patterns to select which input records to process. See

Comparison Expressions

.

Curly Braces

The characters `{` and `}`. Curly braces are used in `awk` for delimiting actions, compound statements, and function bodies.

Data Objects

These are numbers and strings of characters. Numbers are converted into strings and vice versa, as needed. See

Conversion of Strings and Numbers

.

Dynamic Regular Expression

A dynamic regular expression is a regular expression written as an ordinary expression. It could be a string constant, such as `"foo"`, but it may also be an expression whose value may vary. See

How to Use Regular Expressions

.

Escape Sequences

A special sequence of characters used for describing nonprinting

characters, such as `\n` for newline, or `\033` for the ASCII ESC (escape) character. See
Constant Expressions

.

Field

When `awk` reads an input record, it splits the record into pieces separated by whitespace (or by a separator regexp which you can change by setting the built-in variable `FS`). Such pieces are called fields. If the pieces are of fixed length, you can use the built-in variable `FIELDWIDTHS` to describe their lengths. See

How Input is Split into Records

.

Format

Format strings are used to control the appearance of output in the `printf` statement. Also, data conversions from numbers to strings are controlled by the format string contained in the built-in variable `CONVFMT`. See

Format-Control Letters

.

Function

A specialized group of statements often used to encapsulate general or program-specific tasks. `awk` has a number of built-in functions, and also allows you to define your own. See

Built-in Functions

. Also, see

User-defined Functions

.

gawk

The GNU implementation of `awk`.

GNU

"GNU's not Unix". An on-going project of the Free Software Foundation to create a complete, freely distributable, POSIX-compliant computing environment.

Input Record

A single chunk of data read in by `awk`. Usually, an `awk` input record consists of one line of text. See

How Input is Split into Records

.

Keyword

In the `awk` language, a keyword is a word that has special meaning. Keywords are reserved and may not be used as variable names.

`awk`'s keywords are: `if`, `else`, `while`, `do...while`, `for`, `for...in`, `break`, `continue`, `delete`, `next`, `function`, `func`, and `exit`.

Lvalue

An expression that can appear on the left side of an assignment

operator. In most languages, lvalues can be variables or array elements. In awk, a field designator can also be used as an lvalue.

Number

A numeric valued data object. The gawk implementation uses double precision floating point to represent numbers.

Pattern

Patterns tell awk which input records are interesting to which rules.

A pattern is an arbitrary conditional expression against which input is tested. If the condition is satisfied, the pattern is said to match the input record. A typical pattern might compare the input record against a regular expression. See

Patterns

.

POSIX

The name for a series of standards being developed by the IEEE that specify a Portable Operating System interface. The "IX" denotes the Unix heritage of these standards. The main standard of interest for awk users is P1003.2, the Command Language and Utilities standard.

Range (of input lines)

A sequence of consecutive lines from the input file. A pattern can specify ranges of input lines for awk to process, or it can specify single lines. See

Patterns

.

Recursion

When a function calls itself, either directly or indirectly. If this isn't clear, refer to the entry for "recursion."

Redirection

Redirection means performing input from other than the standard input stream, or output to other than the standard output stream.

You can redirect the output of the print and printf statements to a file or a system command, using the >, >>, and | operators. You can redirect input to the getline statement using the < and | operators. See

Redirecting Output of print and printf

.

Regular Expression

See "regexp."

Regex

Short for regular expression. A regexp is a pattern that denotes a set of strings, possibly an infinite set. For example, the regexp R.*xp matches any string starting with the letter R and ending with the letters xp. In awk, regexps are used in patterns and in conditional expressions. Regexps may contain escape sequences.

See

Regular Expressions as Patterns

.

Rule

A segment of an awk program, that specifies how to process single input records. A rule consists of a pattern and an action. awk reads an input record; then, for each rule, if the input record satisfies the rule's pattern, awk executes the rule's action. Otherwise, the rule does nothing for that input record.

Side Effect

A side effect occurs when an expression has an effect aside from merely producing a value. Assignment expressions, increment expressions and function calls have side effects. See

Assignment Expressions

.

Special File

A file name interpreted internally by gawk, instead of being handed directly to the underlying operating system. For example, /dev/stdin. See

Standard I/O Streams

.

Stream Editor

A program that reads records from an input stream and processes them one or more at a time. This is in contrast with batch programs, which may expect to read their input files in entirety before starting to do anything, and with interactive programs, which require input from the user.

String

A datum consisting of a sequence of characters, such as I am a string. Constant strings are written with double-quotes in the awk language, and may contain escape sequences. See

Constant Expressions

.

Whitespace

A sequence of blank or tab characters occurring inside an input record or a string.

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\$ (field operator)

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