

**Oberon-A.doc**

COLLABORATORS
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# Chapter 1

## Oberon-A.doc

### 1.1 Oberon-A

\$RCSfile: Oberon-A.doc \$

Description: Overall documentation for Oberon-A, release 1.5

Created by: fjc (Frank Copeland)

\$Revision: 1.7 \$

\$Author: fjc \$

\$Date: 1995/01/25 22:58:30 \$

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\*\*\* IMPORTANT NOTE FOR USERS OF OBERON-A 1.4 OR EARLIER VERSIONS \*\*\*

You are strongly advised to read the Updating section before proceeding any further.

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Links marked with "+" are new, those marked with "\*" have been changed.

Oberon		What is Oberon?
Oberon-A	*	What is Oberon-A?
Distribution		Distribution and Copyright
Requirements	*	What do I need to run Oberon-A?
Installation	*	How do I install Oberon-A?
Updating	*	How do I update an earlier version?
Changes	*	Changes since the last release
To Do	*	Bugs to fix and improvements to make
Tutorial	+	Three ways to say 'Hello world'
Programming	*	How do I create a program with Oberon-A?
Documentation	*	What else do I need to read?
Resources	*	What other resources are there?
The Author		Contacting the author
Mailing List		Networking with like-minded people
Bugs & Suggestions		Reporting bugs and suggestions

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Acknowledgements	Who did what and why
Bibliography	References used in developing Oberon-A
Revision control	How revision control is handled in Oberon-A
Release history	The history of Oberon-A

## 1.2 What is Oberon?

The following are taken from the FAQ file for the comp.lang.oberon Usenet newsgroup, Copyright © 1994 Michael Gallo and reproduced with permission.

What is Oberon?  
The programming language Oberon  
The programming language Oberon-2  
The 'Oberon family' of languages  
Bibliography

## 1.3 WHAT IS OBERON?

From "The Oberon Guide"

Oberon is simultaneously the name of a project and of its outcome. The project was started by Niklaus Wirth and [Jrg Gutknecht] late in 1985 with the goal of developing a modern and portable operating system for personal workstations. Its results are an implementation of the system for the Ceres computer and a programming language.

The development of the language Oberon needs perhaps a short justification. It became quite inevitable because the type-system of available languages turned out to be too restrictive to express the desired data model in a natural and safe way.

Easy introductions to both aspects of the Oberon project can be found in back issues of BYTE magazine. The operating system is overviewed in "Oberon: A Glimpse at the Future", volume 18 number 6 (May 1993). The Oberon language is examined in "Oberon", volume 16 number 3 (March 1991). Both articles are by BYTE's European correspondant, Dick Pountain.

## 1.4 THE PROGRAMMING LANGUAGE OBERON

From "From Modula to Oberon"

The programming language Oberon is the result of a concentrated effort to increase the power of Modula-2 and simultaneously to reduce its complexity. Several features were eliminated, and a few were added in order to increase the expressive power and flexibility of the language. This paper describes and motivates the changes. The language is defined

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in a concise report.

Whereas modern languages, such as Modula, support the notion of extensibility in the procedural realm, the notion is less well established in the domain of data types. In particular, Modula does not allow the definition of new data types as extensions of other, programmer-defined types in an adequate manner. An additional feature was called for, thereby giving rise to an extension of Modula.

. . . .

The evolution of a new language that is smaller, yet more powerful than its ancestor is contrary to common practices and trends, but has inestimable advantages. Apart from simpler compilers, it results in a concise defining document, an indispensable prerequisite for any tool that must serve in the construction of sophisticated and reliable systems.

Among the eliminations in the move from Modula-2 to Oberon are variant records, opaque types, enumeration types, subrange types, the basic type CARDINAL, local modules, and Modula's WITH statement. The major addition to Oberon is the concept of type extension (i.e., single inheritance) for records.

## 1.5 THE PROGRAMMING LANGUAGE OBERON-2

From "Differences between Oberon and Oberon-2"

Oberon-2 is a true extension of Oberon. . . .

One important goal for Oberon-2 was to make object-oriented programming easier without sacrificing the conceptual simplicity of Oberon. After three years of using Oberon and its experimental offspring Object Oberon we merged our experiences into a single refined version of Oberon.

The new features of Oberon-2 are type-bound procedures [i.e., virtual methods], read-only export of variables and record fields, open arrays as pointer base types, and a with statement with variants. The for statement is reintroduced after having been eliminated in the step from Modula-2 to Oberon.

## 1.6 THE 'OBERON FAMILY' OF LANGUAGES

Object Oberon is a now defunct, experimental extension of Oberon featuring "classes", structures somewhere between modules and records. It evolved into Oberon-2.

Seneca was also an experimental extension of Oberon. It focused on numerical programming on vector computer architectures. It evolved into Oberon-V.

Oberon-V is an experimental dialect (but not a superset) of Oberon. It is concerned with issues of numerical computing, array processing, and code verification. Since it was originally aimed at vector architectures in general and the Cray Y-MP in particular, no Oberon-V compiler has yet been implemented for the Oberon

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System.

## 1.7 What is Oberon-A?

Oberon-A is an Oberon-2 compiler and associated utilities for the Commodore Amiga personal computer. The Oberon-A compiler translates programs written in Oberon or Oberon-2. It also supports a number of language extensions that assist programming in the Amiga's unique environment. It produces MC68000 machine code directly without an intermediate assembly language stage. The object files it creates are in standard AmigaDOS format.

The Oberon-A Library is a collection of library modules that can be linked with programs created with Oberon-A. There are a number of useful modules, including the beginnings of an object-oriented application Framework.

The Oberon-A Interface is a collection of library modules that provides a complete interface to the Amiga's operating system. This is based on Commodore's 40.15 interfaces, for release 3.1 of the operating system.

The Oberon-A archive contains a programming environment utility (FPE), the compiler, an error lister (OEL, by Johan Ferreira), a pre-link utility, a recompilation utility, and the source code for the Library and Interface modules. Full source code is included for all modules and programs where available. The archive also contains other software needed to use Oberon-A, most importantly the BLink linker.

## 1.8 Distribution and Copyright

Oberon-A and the Oberon-A Library are:

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Oberon-A is free software; you can redistribute it and/or modify it under the terms of version 2 of the GNU General Public License as published by the Free Software Foundation.

The Oberon-A Library is also free software; you can redistribute it and/or modify it under the terms of version 2 of the GNU Library General Public License.

Oberon-A and the Oberon-A Library are distributed in the hope that they will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public Licenses for more details.

You should have received copies of the GNU General Public License and the GNU Library General Public License along with Oberon-A; if not, write to the Free Software Foundation, Inc., 675 Mass Ave, Cambridge, MA 02139, USA.

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The Oberon-A Interface is:

Copyright © 1994-1995, Frank Copeland

The Oberon-A Interface is also free software, but it is not subject to the GNU licence. Instead, it may be freely distributed, but only as part of the Oberon-A archive for use in creating software using the Oberon-A compiler.

Programs created with Oberon-A may be distributed under any terms their creator desires. However, as all such programs must be linked with one or more Oberon-A Library modules, the programmer should be aware of the requirements of clause 6 of the GNU Library General Public License. Oberon-A is intended mainly for personal use, and for the creation of other free software. Commercial programmers may prefer to use a commercial Oberon compiler.

Parts of the Oberon-A compiler and Library are based on source code developed at ETH Zuerich. Permission to use, copy, modify and distribute this software is granted by ETH (see the file ETH-Copyright.txt).

Oberon-A Error Lister (OEL) and Oberon-A Bump Revision (OBumpRev) are:

Copyright (C) 1994 Johan Ferreira

OEL and OBumpRev are free software and is distributed under the GNU General Public Licence. See OEL.guide and OBumpRev.guide for details.

The archive file containing Oberon-A also includes a number of other freely-distributable programs that are used by Oberon-A. These programs are copyrighted by their authors and distributed under conditions set by those authors. These programs include:

BLink, Copyright © 1986, The Software Distillery.  
intuisup.library, Copyright © 1992, Torsten Jürgeleit.

This document and others in the archive are in Commodore's AmigaGuide hypertext format. A shared code library and reader program are included in the archive. AmigaGuide, AmigaGuide.info and amigaguide.library are:

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## 1.9 What do I need to use Oberon-A?

Oberon-A requires a Commodore Amiga personal computer with at least 1MB of memory (more is recommended), running Release 2.04 (Kickstart 37+) or later of the Amiga operating system. All the Oberon-A programs now REQUIRE 2.04+, and will \*not\* run under AmigaOS 1.3. In addition, all

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programs created using Oberon-A also require AmigaOS 2.04. These restrictions may be relaxed in a future release.

Oberon-A can be run from floppies, if sufficient RAM is available for use as a RAM disk and for making the main programs resident. See Floppy Installation. However, a hard disk is highly recommended. The contents of the archive when decompressed will take up 2-2.5 MB of disk space. Further disk space will be required to develop programs.

A linker is needed to create executable programs from the object files generated by the compiler. A freely-distributable linker, BLink, is included in the Oberon-A archive. Unfortunately, this linker is poorly behaved and produces numerous Enforcer hits on high-end systems. It will be replaced in time. Commodore's ALink linker (distributed with the Native Developer's Kit) and Matt Dillon's dlink (distributed with the DICE compiler) have been shown to work with Oberon-A. It is not known if either causes Enforcer hits.

The FPE program requires `intuisup.library`. This is included in the Oberon-A archive.

The documentation files are written in Commodore's AmigaGuide hypertext format. Users of AmigaOS 2.1 or greater already have the software needed to view these files. A minimal AmigaGuide installation is included in the Oberon-A archive for users of earlier Kickstart versions. The complete AmigaGuide distribution can be found on AmiNet in the text/hyper directory, or in the Fred Fish collection.

There is no editor provided with Oberon-A. Many suitable editors are available as freely distributable software. The Memacs editor distributed with the operating system can also be used.

## 1.10 How do I install Oberon-A?

Oberon-A can be installed temporarily while you evaluate it. This mainly involves assigning logical device names and possibly copying shared libraries to your `libs:` directory. The Oberon-A library modules must also be compiled the first time Oberon-A is installed. The temporary installation process must be repeated each time you re-boot your Amiga. Permanent installation involves modifying your startup sequence.

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Temporary installation	Temporarily installing Oberon-A
Library modules	Compiling the library modules
Permanent Installation	Permanently installing Oberon-A
Uninstalling	Removing Oberon-A from your system
Floppy installation +	Installing Oberon-A on floppies

## 1.11 Temporarily installing Oberon-A under Kickstart 2.0+

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Run the script in the file Install, either by typing "Execute Oberon-A/Install/Install" at the Shell prompt or by double-Clicking its icon. The script sets up a few logical assignments and makes the libraries used by Oberon-A available with the ADD option of the AmigaDOS Assign command. It also creates file links to aliases for the compiler and link utility that are useful for Workbench users.

## 1.12 Compiling the library modules

To save space, the symbol and object files for the Oberon-A library modules are not included in the distribution. A script file is provided which will compile the modules and place the symbol and object files in the OLIB directory. To run the script, double-click on the CompileLibs icon. This script will take a considerable time to complete, depending on your hardware. You will be given a chance to back out if you want.

## 1.13 Permanently installing Oberon-A

Permanent installation requires the addition of two assigns and two paths to your S:User-Startup. They are:

```
Assign OBERON-A: Oberon-A
Assign OLIB:      OBERON-A:OLIB
Path  OBERON-A: OBERON-A:C add
```

OC-Lib and OL-Small are actually links to OC and OL respectively. The links are created for you when you run the Install script for the first time. If you have not run Install, do so, or execute the following commands from a Shell:

```
MakeLink OBERON-A:OC-Lib OBERON-A:OC
MakeLink OBERON-A:OL-Small OBERON-A:OL
```

The environment settings for Oberon-A can be handled in two ways:

- They can be left where they are in OBERON-A:env-archive, and the following command added to your S:User-Startup

```
Copy OBERON-A:env-archive TO ENV: ALL NOREQ QUIET
```

- They can be moved to your own ENVARC: directory.

As BLink reportedly produces Enforcer hits, you may wish to replace it with another linker. Suitable linkers include Commodore's alink, Dillon's dlink and AmigaOberon's OLink. This will involve installing the alternative linker and changing the preferences settings for the OL program. See OL.doc and OLPrefs.doc for details.

If you use it, FPE must be able to locate it's setup files. When extracted from the archive, these are placed in the directory

Oberon-A/S. FPE looks for its setup files in the directory "FPE:S", so the temporary installation assigns "FPE" to the Oberon-A directory. If you keep the same directory organisation, simply place the line

```
Assign FPE: Oberon-A
```

in your S:User-Startup file. If you move the Oberon-A/S directory you will need to adjust this accordingly.

FPE also requires `intuisup.library`. This must be copied to the `SYS:libs` directory, or to another directory to which `LIBS:` has been assigned. The simplest way to do this is to leave it in `OBERON-A:libs`, and place this line in your S:User-Startup:

```
Assign LIBS: OBERON-A:libs add
```

## 1.14 Removing Oberon-A from your system

THIS SPACE INTENTIONALLY LEFT BLANK (just kidding)

If you decide not to permanently install Oberon-A, it is a simple matter to remove all traces of it from your system. First, delete the Oberon-A directory and its contents. Next, if you copied `arp.library` and/or `intuisup.library` to your `LIBS:` directory, delete them. Finally, remove any Assign statements you put into your startup sequence.

Even if you are not impressed by Oberon-A, I would like to hear your comments and assessment of it. See Bug reports and suggestions.

## 1.15 Updating an earlier version of Oberon-A

The settings files for the FPE program now use a new, compact format. Settings files from earlier versions are now obsolete, and must be deleted.

The Oberon-A compiler in Release 1.5 generates object files in a somewhat different form than previous compilers, and uses a different symbol file format. Symbol and object files generated by earlier versions of the compiler are therefore OBSOLETE. This means that once more all existing modules must be recompiled with the new compiler.

The command-line templates for the OC and OL programs have been changed, and each now has an associated preferences tool. If you have created custom Shell scripts or other tools that call these programs, you will need to edit them. See `OC.doc`, `OCPrefs.doc`, `OL.doc` and `OLPrefs.doc`.

The compiler switches used in Release 1.4 and earlier have now been replaced by more verbose and readable pragmas. A utility program called `ConvertSwitches` has been written to automatically convert the old-style switches to the corresponding pragmas.

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From the Shell:

- CD to the directory containing the source code to be converted.
- Call 'ConvertSwitches #?.mod'.

From the Workbench:

- Make sure the following tooltype has been created in the ConvertSwitches icon: 'FILES=#?.mod'.
- Click on the directory containing the source code to be converted.
- Hold down the shift key and double-click ConvertSwitches.

In most cases this will be sufficient, however modules that contained the old \$P- switch will need to be edited. The \$P- switch will be replaced with the <\*STANDARD-\*> option, which must be moved to a position *\*before\** the MODULE keyword. If it is encountered after the MODULE keyword, the compiler will report an error. Switches that used the '=' character to return to the default value are converted to use the '+' character.

The syntax for making Amiga library function calls has also been changed. It is no longer necessary to specify the name of the library base variable in the call. Any existing source code must be edited to remove the base variable name from all library calls. Most if not all library interface modules follow the convention of calling the base variable 'base'. This means that in almost all cases a simple search and replace to delete all occurrences of the string 'base.' should be sufficient. However, care should be taken to avoid changing statements that are actually referencing fields in the library base variable.

See OC.doc for details.

Extensive modifications have been made to the Oberon-A Interface modules to bring them as close as possible to the interfaces used with the AmigaOberon compiler. The main changes are:

- Constant names have been changed to conform with the same naming conventions. This usually means that any prefix is deleted and the remaining identifier changed so that it starts with a lower-case letter. For example, 'idcmpActivate' becomes 'activate'. Unfortunately, the usage is not consistent, and each case has to be handled individually. As a last resort, the compiler will report as errors any use of the old identifiers.
  - The way in which record types are extended has been changed. For an example, see the Node and Message types in module Exec. The main difference is that the base type is now the first field in the extended type. This means that any access to the fields of the base type must be qualified with the name of the first field. For example, 'name := message.name' becomes 'name := message.node.name'.
  - Interface modules for shared code libraries no longer export an OpenLib() procedure. All such modules now attempt to open the library automatically. In cases where the library should always be available, failure to open it causes the program to halt with an error code of 100. In other cases the programmer should check that the library base variable is not NIL before calling any library
-

functions. A `'Lib.OpenLib(TRUE)'` statement can be replaced with `'ASSERT(Lib.base#NIL,100)'`.

- All references to the type `Exec.STRPTR` have been changed to `Exec.LSTRPTR`. The same change must be made in your own source code.

The interface to module `Strings` has been changed. The most important changes are in the order of parameters in the procedures. Some procedures have been renamed, and others moved to a separate `Strings2` module.

Module `Errors` must now be explicitly initialised by a call to `Errors.Init()`.

Module `Kernel` is now fully integrated with the compiler. `Kernel.New()` has been renamed to `Kernel.Allocate()`, and `Kernel.NewFromTag()` has been renamed to `Kernel.New()`.

A number of files have been renamed, and some have been removed from the archive. Renamed files are replaced with a dummy file containing message pointing to the new file.

See `Changes.doc` for a more complete listing of the changes made in this release.

Updating an existing Oberon-A installation should be done as follows:

1. If you have modules of your own that will need to be recompiled, run the ORU utility to create lists of modules that can be used with the compiler's `BATCH` option to automate the process. See `ORU.doc` for details.
2. Unpack the sub-archives in the Oberon-A archive into the Oberon-A directory.
3. Recompile all the library modules, using the `CompileLibs` script in the `Install` directory.
4. Make the changes mentioned above in any modules you have written and recompile them as well.
5. Delete any files that have been renamed or removed. See `Changes.doc` for a list of the files affected. A script file called `DeleteOld` can be found in the `Install` directory. This will delete old versions of files that have been renamed or removed. Please study this script carefully before using it. If you are in any doubt, don't use it, and make any necessary changes by hand.

## 1.16 Overview of the programming cycle

An Oberon program consists of one or more modules, each of which is compiled separately. Many modules are "library" modules, which can be re-used many times in different programs. Each program has a "main program" module which acts as the entry point to the program. Any module may be used for this: there is no specific language construct to

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indicate that a module is the main program module.

Each module is contained in a single text file. Modules may be edited by any standard text editor that produces plain ASCII files. The Oberon-A compiler (OC) is then used to check the module for syntax errors and to translate it into an object file containing machine code. If the compiler detects any errors, it produces an error file indicating their location and nature. The error lister (OEL) can then produce a description of the error and the context in which it occurs.

A program is created out of its component modules by linking it. This combines all the object files into a single file and resolves any references between modules. This function is performed by a linker program, such as BLink. The linker must be told which module is the main program module and which other modules are to be included in the program. The Oberon-A pre-link utility (OL) is used to generate the information the linker requires.

The entire process can be summarised as follows:

```
REPEAT
  FOR each module in the program needing work DO
    REPEAT
      Edit the module source code
      Run OC to compile the module
      IF there are errors THEN
        Run OEL to generate an error report
      END
    UNTIL no more syntax errors are reported
  END
  Run OL to generate information for the linker [*]
  Run the linker to link the program
  Test and evaluate the program
UNTIL satisfied with the result
```

\* This is only necessary the first time the program is linked and whenever modules are added to or removed from the program.

## 1.17 Other documents you should read

The following documents will be the most immediately useful to you:

Oberon-2 Report	The Oberon-2 language report
FPE	Using the programmer's environment
OC	Using the compiler
OCPrefs	Using the preferences tool for OC
OEL	Using the error lister
Error codes	Error codes output by the compiler
OL	Using the pre-link utility
OLPrefs	Using the preferences tool for OL
BLink	Using the linker

The AmigaGuide file Index.doc in the main Oberon-A directory contains an index of all the documentation and source code files

distributed with Oberon-A.

## 1.18 The Author

Oberon-A was mostly written by Frank Copeland.

All bug reports, suggestions and comments can be directed to:

Email : [fjc@wossname.apana.org.au](mailto:fjc@wossname.apana.org.au)

Snail Mail :

Frank J Copeland  
PO BOX 236  
RESERVOIR VIC 3073  
AUSTRALIA

Remember the J. It saves a lot of confusion at my end :-).

Note that the e-mail address has been changed to my private mailbox, to avoid confusion with the mailing list server.

I also regularly read the `comp.sys.amiga.programmer` newsgroup, and will respond to any Oberon-A related posts I see there.

## 1.19 The Oberon-A mailing list

A mailing list has been set up to provide support for users of Oberon-A and allow discussion of the compiler and the Oberon language in general. To find out more, send e-mail to:

[oberon-a-request@wossname.apana.org.au](mailto:oberon-a-request@wossname.apana.org.au)

The Subject: line may be empty, and the body of the message should contain only the following lines, starting in the left-hand column:

HELP  
HELP oberon-a

The listserver software will reply with information about its commands, how to subscribe, and a description of the list.

## 1.20 Reporting bugs and suggestions

You are encouraged to report any bugs you find, as well as any comments or suggestions for improvements you may have. I am also happy to answer any questions about the language itself. For information about Amiga programming in general you should consult the relevant Commodore and third-party documentation first. I can help if you have trouble translating examples written in C into Oberon.

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Before reporting a suspected bug, check the file `ToDo.doc` to see if it has already been noted. If it is a new insect, clearly describe its behaviour including the actions necessary to make it repeatable. Indicate in your report which release of Oberon-A you are using. Include an example of a program or short fragment of code that demonstrates the bug. If you discover a bug in BLink, please report it but there is nothing that can be done except find a workaround. The original authors no longer support BLink.

I would like to hear your opinion of Oberon-A, even if you decide not to use it. Suggestions for improvements and additions are also most welcome. I am especially interested in the following areas:

- \* Compatibility with different versions of the Amiga hardware and operating system. So far it has only operated on a stock A500 with AmigaDOS 2.05 and a 20MB hard disk.
- \* How good/useful/helpful/complete the documentation is.
- \* How suitable it is for use by programmers with varying levels of experience, from beginners to hackers.
- \* How correct and useable the operating system interface modules are. These modules were translated from the C header files provided by Commodore. The translation was done quickly and only a fraction of the modules have been tested in any way.
- \* How useful the library modules provided are, and suggestions for additional modules.
- \* Departures from the language specification.
- \* Extensions to the language supported by the compiler.
- \* Memory management. I am unable to use Enforcer or similar utilities on my A500, so I would like people who can to report any Enforcer hits they get. I am also concerned about possibly excessive memory fragmentation caused by the run-time memory allocator.

## 1.21 Acknowledgements

The Oberon-A compiler is a port of a compiler written for the Ceres workstation by Niklaus Wirth. The book "Project Oberon" written by Wirth and Jürg Gutknecht contains a description of this compiler and the full source code for it. The original source can also be obtained by anonymous ftp from [neptune.inf.ethz.ch](http://neptune.inf.ethz.ch). Many thanks to Professor Wirth for making this source code available.

The machine code generator for early versions of the compiler was a port of the corresponding parts of Charlie Gibb's A68K assembler. This code is no longer part of the compiler, but it was extremely useful in the early stages of development and debugging.

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Torsten Jürgeleit's `intuisup.library` is used to create and manage the user interface for FPE.

The following people have contributed modules and programs to Oberon-A:

Terje Bergstr\vm has contributed the interface module for the Universal Message System.

Johan Ferreira has contributed the Oberon-A error lister, OEL.

Helmuth Ritzer has contributed interface modules for Nico Francois' ReqTools library and the TextField Boopsi gadget.

Albert Weinert has contributed `Classface.asm` to allow access to Intuition's Boopsi functions.

Carsten Ziegeler has contributed the interface module for his GuiEnv library.

Apologies to anyone I have inadvertantly overlooked.

Thanks to those who have reported bugs and made suggestions for improving Oberon-A.

## 1.22 Bibliography

The following works have proved useful in developing Oberon-A:

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  - \* N. Wirth and J. Gutnecht. Project Oberon. Addison-Wesley, 1992.
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  - \* Commodore-Amiga, Inc. The AmigaDOS Manual, 3rd Edition. Bantam, 1991.
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-

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## 1.23 Revision Control

All the source code and document files in Oberon-A are managed using the freely-distributable HWGRCS package. This is a port of the Un\*x RCS system.

Each new release of the entire package will be identified by a two-part release number. Partial releases containing bug fixes will have an additional update number. For example, the second major release of Oberon-A will be known as "Oberon-A release 2.0". The first minor release of release 2 will be known as "Oberon-A release 2.1". The second update of release 2.1 will be called "Oberon-A release 2.1 update 2".

Individual programs are identified with a two part number of the form:

<version>.<revision>

The version number will change whenever substantial changes are made to the program. The revision number will initially start at 0 and will change whenever a bug-fix patch of the program is released.

Each module and documentation file has a two-part revision number, of the form:

<version>.<revision>

All the component modules and documentation files of a program will have the same version number as the program. The revision number will change whenever the file's text is modified. The version number of a documentation file not associated with any one program will be the same as the current overall release number.

## 1.24 Oberon-A Release History

- 0.0 Initial version, written in Modula-2. Never released.
  - 0.1 - 0.3 Intermediate versions, written in Oberon. Never released.
-

- 1.0 Initial beta-test release. Compiler upgraded to Oberon-2.
- 1.1 Bug fixes and some improvements to the compiler and utilities.
- 1.2 More bug fixes.
- 1.3
  - New compiler with varargs and improved symbol table handling.
  - Heavily revised Amiga interface modules.
- 1.4
  - Steady improvements to the compiler and utilities.
  - Upgraded the Amiga interface modules to Release 3.1.
  - Added more third-party interface modules.
- 1.5
  - Complete overhaul of the external code interface.
  - New system of compiler control and pragmas.
  - New Shell and Workbench interface for all programs.
  - Amiga Interfaces brought into line with AmigaOberon's.
  - New library modules.
  - Much improved run-time error handling.

## 1.25 Useful resources for Oberon-A Programmers

Apart from the documentation provided with Oberon-A, there are a number of other resources that you may find useful.

### Books

See the bibliography in the comp.lang.oberon FAQ for a list of books on the programming language and the Oberon System. Reiser and Wirth's "Programming in Oberon" is a good introduction to the language, pitched at a level suitable for students as well as more advanced programmers. Mössenböck's "Object-Oriented Programming in Oberon-2" is exactly what the title says :-).

### UseNet newsgroups

comp.lang.oberon

From the comp.lang.oberon FAQ:

"The Comp.lang.oberon newsgroup is a forum for discussing Oberon, both the programming language and the operating system, and any related issues. Although not strictly accurate, this newsgroup is part of the Comp.lang.\* hierarchy because it began as a spin-off of Comp.lang.modula2."

The FAQ is posted in the newsgroup periodically, and can be obtained by anonymous ftp from rtfm.mit.edu in the /pub/usenet directory.

comp.sys.amiga.programmer

This group is for discussing Amiga programming in general, and

---

there is occasional mention of Oberon and Oberon-A.

#### Internet ftp sites

ETH, where Oberon was developed, maintains an ftp site for distributing Oberon-related material, including the various versions of the Oberon System. Connect by anonymous ftp to neptune.inf.ethz.ch, and look in the /pub/Oberon directory.

The Swiss Oberon Users Group also maintains an archive of Oberon software. Connect by anonymous ftp to hades.ethz.ch, and look in the /pub/Oberon directory.

Oberon-A is primarily distributed through AmiNet, a network of ftp sites covering most of the Western world. Almost anything you could wish for as an Amiga programmer is available somewhere in the archive. The following sites are currently part of AmiNet:

USA (MO)	ftp.wustl.edu	pub/aminet/
USA (CA)	ftp.cdrom.com	pub/aminet/
USA (TX)	ftp.etsu.edu	pub/aminet/
Scandinavia	ftp.luth.se	pub/aminet/
Switzerland	ftp.eunet.ch	pub/aminet/
Switzerland	litamiga.epfl.ch	pub/aminet/
Germany	ftp.uni-erlangen.de	pub/aminet/
Germany	ftp.uni-paderborn.de	pub/aminet/
Germany	ftp.uni-kl.de	pub/aminet/
Germany	ftp.cs.tu-berlin.de	pub/aminet/
Germany	ftp.uni-oldenburg.de	pub/aminet/
Germany	ftp.coli.uni-sb.de	pub/aminet/
Germany	ftp.uni-stuttgart.de	cd aminet
UK	ftp.doc.ic.ac.uk	pub/aminet/
Australia	archie.au	pub/aminet/

The Amiga Modula-2 and Oberon Club Stuttgart produces a collection of over 100 disks containing freely-distributable code written in, oddly enough, Modula-2 and Oberon. The Oberon code is naturally for the AmigaOberon compiler, but there may be stuff that can be adapted for Oberon-A. The collection is currently available by anonymous ftp from ftp.rz.uni-wuerzburg.de. This site also carries the Fred Fish and Meeting Pearls CDs at times.

## 1.26 Bibliography

### THE PROGRAMMING LANGUAGE

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"From Modula to Oberon" by N. Wirth; Software: Practice and Experience; 18,7 (July 1988) 661-670.

"The Programming Language Oberon" by N. Wirth; Software: Practice and Experience; 18,7 (July 1988) 671-690.

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Structured Programming; 10,1 (January 1989) 40-46.

"Object Oberon -- A Modest Object-Oriented Language" by H.  
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#### THE OPERATING SYSTEM

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The Oberon System: User Guide and Programmer's Manual by M. Reiser;  
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"Implementing an Operating System on Top of Another" by M. Franz;  
Software: Practice and Experience; 23,6 (June 1993) 677-692.

Distributed Object-Oriented Programming in a Network of Personal  
Workstations by Spiros Lalis; Swiss Federal Institute of Technology  
(ETH Zurich); 1994 (in preparation).

## 1.27 Tutorial

---

This tutorial will take you through the steps needed to create the classic 'Hello World' program using Oberon-A. This will involve creating the file HelloWorld.mod in a text editor, and compiling, linking and running it under the Shell, Workbench and/or FPE environments.

Before you start, you need to select, install and configure a text editor. MEMacs on the Extras disk is suitable if you have no other editor. If you are going to use FPE, you must also configure it to correctly call your choice of editor. See Getting started with FPE.

If you have not already done so, install Oberon-A either temporarily or permanently. See Installation. Then select a directory to work in, creating one if necessary. Create a sub-directory called 'Code' in your work directory. Using a text editor, create a file called HelloWorld.mod, containing the following source text:

```
MODULE HelloWorld;

IMPORT Out;

BEGIN
  Out.String ("Hello world, Oberon-A is calling"); Out.Ln
END HelloWorld.
```

Once you have done this, proceed with one of the following tutorials:

Shell  
Workbench  
FPE

## 1.28 Workbench Tutorial

Make sure you can access the work directory and the 'HelloWorld.mod' file from the Workbench. Create icons if necessary. Then follow the following steps:

- Compile the module:

- o Open the Oberon-A drawer and the drawer for the work directory.
- o Select 'HelloWorld.mod', hold down the shift key, and double-click on the 'OC' icon.
- o If any errors are reported, make sure that the source text in 'HelloWorld.mod' is *exactly* as described in the Tutorial introduction, then repeat the process.

- Link the module:

- o Close the drawer for the work directory.
  - o Select the 'OL-Small' icon, then use the Workbench Icons-Information menu item to edit the icon's tooltypes. Create a new tooltype, and enter 'PROG=HelloWorld'. Click on the 'Save' button.
  - o Select (don't open) the drawer for the work directory. Hold down the shift key, and double-click on the 'OL-Small' icon.
  - o Open the drawer for the work directory, and confirm that two new
-

icons have appeared: one for 'HelloWorld' and one for 'HelloWorld.with'.

- o Edit the 'OL-Small' icon and delete the 'PROG=' tooltip you added earlier.

- Run the program:

- o Double-click the 'HelloWorld' icon.

If you don't like the console window that gets opened for you, edit the icon for 'HelloWorld' and add or edit a "WINDOW=" tooltip describing a console window that suits you. See the AmigaDOS manual for details.

The instructions for linking 'HelloWorld' given above assume that it has not been linked before, and has no icon. If there is already a copy of 'HelloWorld' in the work directory, follow these steps instead:

- Link the module:

- o Open the drawer for the work directory.
- o Select the 'OL-Small' icon, hold down the shift key, and double-click on the 'HelloWorld' icon. NOTE: don't do it the other way around, that will simply run 'HelloWorld'.

## 1.29 Shell Tutorial

Make sure the work directory is the current directory, then execute the following steps:

- Compile the module:

- o Type 'OC HelloWorld.mod'
- o If any errors are reported, make sure that the source text in 'HelloWorld.mod' is *exactly* as described in the Tutorial introduction, then repeat the process.

- Link the module:

- o Type 'OL HelloWorld SCAN LINK NOICONS SETTINGS=OLSmall.prefs'

- Run the program:

- o Type 'HelloWorld'

The instructions for linking 'HelloWorld' given above assume that it has not been linked before. If there is already a copy of 'HelloWorld' in the work directory, you can leave out the SCAN argument for OL.

## 1.30 FPE Tutorial

Run the FPE program from the Workbench or the Shell. Then execute the following steps

---



- Select the project:
  - o Select the 'Select Project' item from the 'Project' menu.
  - o Use the file requester to move to the work directory.
  - o Type 'HelloWorld' into the file name gadget and hit 'Ok'.
- Compile the module:
  - o Make sure that 'HelloWorld' appears in the 'Modules' list box, and is selected.
  - o Click on the 'Compile' button.
  - o If any errors are reported, make sure that the source text in 'HelloWorld.mod' is *exactly* as described in the Tutorial introduction, then repeat the process.
- Link the program:
  - o Make sure that 'HelloWorld' appears in the 'Project' box in the FPE window.
  - o Click on the 'Pre-Link' button.
  - o Click on the 'Link Small' button.
- Run the program:
  - o Click on the 'Run' button.

## 1.31 Programming with Oberon-A

Apart from an overview of the Oberon-A programming cycle, this section discusses a number of the more advanced issues that arise when writing Oberon-A programs. Any suggestions for additional areas to be covered or expanded on are very welcome.

---

Cleanup	Automatic cleanup of Oberon-A programs
Errors	Handling run-time errors
Debugging	Debugging Oberon-A programs
Profiling	Profiling Oberon-A programs
Resident	Making Oberon-A programs resident

## 1.32 Handling run-time errors

The Oberon-A compiler inserts many run-time checks into the code it generates. These checks trap a number of errors, such as arithmetic overflows and de-referencing NIL pointers. When such an error is detected, a processor trap instruction (TRAP, TRAPV or CHK) is executed.

If the program does not contain code to handle such traps, it will crash and will almost certainly crash the entire system with it. In order to avoid this, the program should install a trap handler which deals with such errors in a graceful and system-friendly way. A default trap

---

handler is provided in module Kernel. It simply halts the program, and executes the list of procedures installed with `Kernel.SetCleanup()`. See Automatic cleanup. This allows most programs to fail gracefully, and gives them the opportunity to clean up after themselves. Installing the handler is simple: just include a call to `Kernel.InstallTrapHandler()` in your program. This should be placed at the very beginning of the body of the main program module. The handler must be removed before the program exits, otherwise it may cause problems if the program is run from the Shell. This is achieved by calling `Kernel.RemoveTrapHandler()` from inside a cleanup procedure installed with `Kernel.SetCleanup()`. See Listing 1.

Using the default trap handler will not provide you with any information about the cause of the error, apart from a cryptic error code if the program is run from a Shell. Importing module Errors into your program will remedy this. Module Errors installs a cleanup procedure that looks at the return code generated by the run-time system and interprets it to produce a requester containing a meaningful error message. The error message will identify the type of error and in most cases will indicate the module and the position in the source text at which the error occurs. To activate this service, simply include a statement in your program that calls `Errors.Init()`. This should be placed at the very beginning of the body of the main program module. In this case there is no need to call `Kernel.InstallTrapHandler()` or `RemoveTrapHandler()`; this is handled automatically for you by module Errors. See Listing 2.

Run-time error checking imposes a significant amount of overhead, and adds considerably to the size of object files. This is especially true of NIL checking, although planned changes to the code generation will improve this. If you do not wish to incur these costs, you can switch off the generation of run-time error checks either from the command-line, in the preferences settings for the compiler, or within your source code. See `OC.doc` and `OCPrefs.doc` for details. However, before you do so, you might want to reflect on the wisdom of Hoare (I think) who wrote something like this: developing a program with error checking enabled, but turning it off for production code, is like giving life-jackets to sailors training on dry land, and taking them away when the sailors go to sea.

### 1.33 Debugging Oberon-A programs

Debugging can take two forms:

- Static debugging, which relies on run-time error checking, assertions and debugging print statements; and
- Interactive debugging, where the program is run under the control of a debugger.

---

#### Static debugging

Static debugging relies on the run-time checks generated by the compiler to detect and report as many errors as possible, as close to their source as possible. For this to work, the compiler must have all

---

run-time checks enabled. Edit the compiler's preferences settings to ensure that no run-time checks are included in the CLEAR setting. Remove any pragmas in the source code that disable run-time checks. Make sure the INITIALISE option is on. See OC.doc and OCPrefs.doc for details.

Run-time checks are only useful if the type and location of the error can be identified. Module Errors is designed to provide exactly this information, and should be imported by the main program module. See Listing 2. For most run-time errors, a requester will report the module it occurred in, the line and column in the module's source text at which it occurred, and the nature of the error.

Assertions are also useful for static debugging. Assertions can be used to test the parameters passed to a procedure to ensure that they meet formal pre-conditions imposed by the programmer. They can also be used to test that the results of function procedures meet similarly imposed post-conditions. Assertions are implemented with the standard procedure ASSERT, which may include an optional return code.

Module Errors supports assertions by implementing the following conventions:

- If the program exits with a return code of 97, it reports that a pre-condition has been violated. For example, ASSERT (... ,97) can be used to test a pre-condition.
- If the program exits with a return code of 98, it reports that a post-condition has been violated. For example, ASSERT (... ,98) can be used to test a post-condition.

In both cases the module and location of the assertion are reported in a requester.

Another useful convention recognised by module Errors is to place the statement HALT (99) in the body of an otherwise empty procedure. If the procedure is called, module Errors will report that an attempt has been made to call an un-implemented procedure.

Debugging print statements can be used to report on the state of a computation, with or without the support of assertions. For example, they can be used to print out the actual value of a parameter that is causing a pre-condition check to fail. This is often sufficient to indicate the cause of the problem. See listing 4 for an example.

Debugging print statements can easily be enabled and disabled by using the compiler's conditional compilation feature. Listing 4 also demonstrates this.

---

## Interactive debugging

The Oberon-A package does not include an interactive debugger, and there are no plans to produce one. However, there are a number of third-party debuggers available which can be used with Oberon-A. These include MykesBug (which is full of bugs itself) and PowerVisor.

---

In order to use an interactive debugger with an Oberon-A program, it is necessary to tell the compiler to output symbol hunks in the object code. This is achieved by compiling all modules with the `DEBUG` argument set. The program must then be linked in such a way that the symbol hunks are included in the final executable. With `BLink` this happens by default, unless the `NODEBUG` argument is set. Other linkers, such as `dlink`, must be specifically instructed to include the symbol hunks. See the documentation for the linker in use for details.

The symbols should be displayed by the debugger when it lists the code of the Oberon-A program. See `Symbol format` for a description of how the compiler constructs the symbols.

The default trap handler in module `Kernel` may interfere with the trap handler used by the debugger. In this case the program must be recompiled and re-linked without the trap handler. Comment out or delete any calls to `Kernel.InstallTrapHandler()` or `Errors.Init()`. It may also be necessary to remove any other trap handlers installed by the program.

## 1.34 Profiling Oberon-A programs

Oberon-A programs can be profiled using the freely distributable profiler `AProf` written by Michael Binz. This is available on AmiNet in the `dev/misc` directory.

In order to use `AProf` to profile an Oberon-A program, it is necessary to tell the compiler to output symbol hunks in the object code. This is achieved by compiling all modules with the `DEBUG` argument set. The program must then be linked in such a way that the symbol hunks are included in the final executable. With `BLink` this happens by default, unless the `NODEBUG` argument is set. Other linkers, such as `dlink`, must be specifically instructed to include the symbol hunks. See the documentation for the linker in use for details.

The symbols will be displayed by `AProf` in its main window, along with timing information. See `Symbol format` for a description of how the compiler constructs the symbols. The symbol pattern in the `AProfs` preferences dialog should be cleared; it is safe to display all symbols generated by the compiler.

The default trap handler in module `Kernel` interferes with the trap handler used by `AProf`. The program must be compiled and linked without the trap handler. Comment out or delete any calls to `Kernel.InstallTrapHandler()` or `Errors.Init()`. It may also be necessary to remove any other trap handlers installed by the program. You should therefore be confident that your program will run without causing any run-time errors before trying to profile it.

## 1.35 Automatic cleanup of Oberon-A programs

---

A program that allocates and uses system resources must usually explicitly de-allocate and return those resources before it exits. Failure to do so is a common bug, especially in regard to memory. Oberon-A programs that allocate memory using the NEW standard procedure virtually eliminate the possibility of memory leaks. However, resources other than memory must still be explicitly de-allocated. To deal with this problem, module Kernel provides a facility for installing cleanup procedures, which are automatically executed when a program exits.

A cleanup procedure must be assignment compatible with a procedure variable with the type

```
PROCEDURE (VAR rc : LONGINT)
```

It must be either exported (not recommended) or assignable (preferred).

When called, the procedure's parameter will be the return code that is to be passed back to AmigaDOS. The procedure will usually ignore the return code, but it may use it to determine how to behave, or even change it.

The body of the procedure should contain statements that return resources to the system. These resources must be accessed through global variables. It is a good idea to initialise all resource variables to NIL, and check if they contain non-NIL values before attempting to release them. The procedure should not call the standard procedures HALT or ASSERT, and should not allocate any resources. Great care should be taken to ensure that no run-time errors occur during the execution of a cleanup procedure.

A cleanup procedure is installed by calling the Kernel.SetCleanup() procedure with the name of the cleanup procedure as a parameter. See Listing 3. Any number of cleanup procedures may be installed at any given time.

The cleanup procedure will be called when the program exits, either normally, or as the result of a HALT or ASSERT statement. If the default trap handler is installed, it will also be called if the program halts as the result of a run-time error. Cleanup procedures are executed in the reverse of the order in which they were installed. The list of cleanup procedures will only be executed once, even if an error occurs while they are running.

## 1.36 Example of using the default trap handler

```
<* STANDARD- *> (* This is necessary if the cleanup procedure is made
    ** assignable rather than exported.
    *)
```

```
MODULE Example1;
```

```
    IMPORT Kernel ...;
```

```
    ...
```

```
PROCEDURE* Cleanup (VAR rc : LONGINT);
BEGIN
    ...
    Kernel.RemoveTrapHandler
END Cleanup;

...

BEGIN
    Kernel.InstallTrapHandler; (* Put this *first* *)
    ...
    Kernel.SetCleanup (Cleanup);
    ...
END Example1.
```

### 1.37 Example of using module Errors

```
MODULE Example2;

    IMPORT Errors ...;

    ...

BEGIN
    Errors.Init; (* Put this *first* *)
    ...
END Example1.
```

### 1.38 Example of installing a cleanup procedure

```
<* STANDARD- *> (* This is necessary if the cleanup procedure is made
                ** assignable rather than exported.
                *)

MODULE Example3;

    IMPORT Kernel ...;

    ...

VAR
    (* Declare global variables to hold resources. *)

    ...

PROCEDURE* Cleanup (VAR rc : LONGINT);
BEGIN
    (* De-allocate resources here *)
END Cleanup;

...
```

---

```

BEGIN
  ...
  Kernel.SetCleanup (Cleanup);
  ...
  (* Allocate resources here *)
  ...
END Example3.

```

### 1.39 Making Oberon-A programs resident

Programs created with Oberon-A are not re-entrant, and with the current code model used by the compiler cannot be made so. However, Oberon-A programs are by default re-executable. This means that they can be made resident, but they may only be run by one process at a time. If a resident Oberon-A program is run simultaneously by two or more processes, the second and subsequent instances will fail silently, hopefully without bringing the entire system down around your ears.

The PURE argument of the AmigaDOS Resident command must be used when making an Oberon-A program resident. For example:

```
Resident OBERON-A:OC PURE
```

It is not a good idea to set the pure bit for the program's executable file to get around this requirement. Oberon-A programs are not pure, and should not claim to be pure.

It is possible to write an Oberon-A program that is not re-executable. This may happen if a module with global variables is compiled without the INITIALISE option set. To ensure that a module can be used in a re-executable program, do one of the following:

- Compile it with the INITIALISE option ON.
- Compile it with the ClearVars pragma ON for the module's main body.
- Include statements to make sure that all global variables are initialised to some safe value. In particular, all `_traced_` pointer variables MUST be initialised to NIL.

### 1.40 Example of the use of debugging print statements

```

<* NEW DEBUG *> (* This creates a selector which is used to control the
                  ** compilation of debugging statements.
                  *)
<* DEBUG+ *>    (* Turn debugging statements ON. *)

(* Another option would be to turn this selector on and off from the
** command line using the SET and CLEAR arguments. In that case, the
** above compiler commands are not needed.
*)

MODULE Example4;

```

---

```
IMPORT
...
<* IF DEBUG THEN *> (* Assuming Out isn't normally imported *)
Out,
<* END *>
...;

...

PROCEDURE foo (x : INTEGER);
(* Pre-condition : 0 <= x < 32 *)
BEGIN
  <* IF DEBUG THEN *>
  Out.String ("x = "); Out.Int (x, 0); Out.Ln;
  <* END *>
  ASSERT ((x >= 0) & (x < 32), 97); (* Assert pre-condition *)
  ...
END foo.

...

END Example4.
```

## 1.41 Debugger symbols produced by the compiler

When the compiler is run with the DEBUG argument set, it outputs symbol hunks in the object file. These symbol hunks are read by a debugger or profiler to identify particular objects in the program. Symbols are created for the following types of objects:

Exported procedures (including assignable procedures)

Format: <module name>\_<procedure name>

Local procedures

Format: <module name>\_<procedure #>P\_<procedure name>

Type descriptors

Format: <module name>\_<type name>

Type-bound procedures

Format: <module name>\_<type name>\_<procedure name>

Initialisation code

Format: <module name>\_INIT-CODE

Cleanup code

Format: <module name>\_END

---



## Constants

Format: <module name>\_CONST

## Global variables

Format: <module name>\_VAR

Note: symbols are not produced for individual variables.

## Table of root pointers for the garbage collector

Format: <module name>\_GC-OFFSETS

## 1.42 Installing Oberon-A on floppies

Edmondo Tommasina reports that he has successfully installed Oberon-A on a twin-floppy Amiga 2000 with 3MB of RAM. The following setup is as Edmondo described it to me, with modifications to account for the differences between Release 1.4 and Release 1.5.

Two disks are required. The first is a program disk. The second holds the symbol and object files for the libraries.

### Disk 1

-----

#### OBERON:

c (dir)	
Amigaguide	BLink
ORU	
Catalogs (dir)	
...	
libs (dir)	
guienv.library	intuisup.library
macros (dir)	
DoLink.rexx	DoOC.rexx
DoOL.rexx	DoRun.rexx
ReadErr.aed	
olib (dir)	
ClassFace.o	LMath.o
Mark.o	rexxvars.o
s (dir)	
Alternate.fpe	AltORU.with
Default.fpe	Oberon-Shell
Oberon-Startup	ORU.with
FPE	FPE.info
Index.doc	Index.doc.info
Oberon-A.doc	Oberon-A.doc.info
OBumpRev	OEL
OC	OC.info
OC.prefs	OC.prefs.info
OCLib.prefs	OCLib.prefs.info
OCPrefs	OCPrefs.info
OD	OD.info
OL	OL.info

OL.prefs	OL.prefs.info
OLPrefs	OLPrefs.info
OLSmall.prefs	OLSmall.prefs.info
Setup	Setup.info

Disk 2

-----

OberonLib:

All the .sym and .obj files

Scripts

-----

The script OBERON:Setup is executed to set up the system.

Script name: setup

=====

```
;      Edmondo Tommasina 25.12.94
;      Oberon installation for floppy drives
;      Modified for Oberon-A release 1.5 by Frank Copeland
```

FailAt 5

Echo "Making logical directory assignments for:"

Echo " OBERON-A:"

Echo " FPE:"

Echo " OLIB:"

resident C:Assign PURE

Assign OBERON-A: OBERON:

Assign FPE: OBERON-A:

Assign OLIB: OBERON-A:OLIB

```
;-----
;      Make shared libraries available
```

Assign LIBS: OBERON-A:LIBS ADD

```
;-----
;      Make resident usefull commands or copy to ram:
```

echo "Copy to Ram: usefull commands"

copy to ram: OBERON-A:c/Blink

copy to ram: OBERON-A:#?.prefs

echo "Make resident usefull commands\n"

Resident C:dir PURE

Resident C:list PURE

Resident C:info PURE

Resident C:delete PURE

; Oberon-A programs can now be made resident

```
Resident OBERON-A:OC PURE
Resident OBERON-A:OL PURE
Resident OBERON-A:OD PURE
Resident OBERON-A:c/ORU PURE
Resident OBERON-A:c/OEL PURE

newshell FROM OBERON-A:s/oberon-shell

; end of setup
```

```
Script name: Oberon-Shell
=====
```

```
Prompt "*E[32m%N.%S>*E[31m "
cd ram:
stack 15000
assign OLIB: OberonLib: ADD
```

```
Libraries
-----
```

If there is enough RAM the quickest way to compile the library modules is to copy the source code to RAM:, compile, then copy the symbol and object files to the OberonLib: disk.

---