

e-POSIX

The definitive and complete
Eiffel to Standard C and
POSIX 1003.1 binding

written by Berend de Boer

Contents

1	Requirements and installation	1
1.1	Requirements	1
1.2	Compiling the C code	1
1.2.1	Compiling on Unix	1
1.2.2	Compiling on Windows	2
1.2.3	Library naming conventions	3
2	Using e-POSIX	4
2.1	Using <code>library.xace</code>	4
2.2	Vendor specific notes	5
2.2.1	ISE Eiffel	5
2.2.2	SmartEiffel	5
2.2.3	Visual Eiffel	6
2.3	Platform specific notes	6
2.3.1	Linux	6
2.3.2	FreeBSD	6
2.3.3	Cygwin	7
2.3.4	BeOS	7
2.3.5	QNX	7
2.3.6	Solaris	7
2.3.7	Win32	7
3	Design notes	8
3.1	Why an entire reimplementation?	8
3.2	Goals and guidelines	8
3.3	Class structure	9
3.4	Clients of this library	11
3.5	Forking	11
3.6	Books	13
4	Layers	14
4.1	Layers architecture	14
4.2	Standard C	14
4.3	Windows	14
4.3.1	Writing portable programs	14
4.3.2	Compiling POSIX programs in Windows	15
4.3.3	Native Windows	15
4.4	Introduction to the next chapters	17
5	Working with memory	18
5.1	Introduction	18
5.2	Allocating memory	18
5.3	Allocating memory	19
5.4	Using shared memory	19
5.5	Memory maps	20

6	Working with files	22
6.1	Introduction	22
6.2	Standard C notes	22
6.3	Compatibility with Gobo	22
6.4	Working with streams	22
6.5	Working with streams using Standard C only	27
6.6	Working with file descriptors	28
6.7	Windows systems: binary mode versus text mode	31
7	Working with files: advanced topics	33
7.1	Redirecting stderr to stdout	33
7.2	Talking to your modem	33
7.3	Non-blocking I/O	35
7.4	Asynchronous I/O	35
8	Working with the file system	37
8.1	Portability	37
8.2	Standard C	37
8.3	POSIX	39
9	Working with processes	43
9.1	Introduction	43
9.2	Executing a child command	43
9.3	Reading stdout of a child process	43
9.4	Catching a signal with Standard C	46
9.5	Catching a signal with POSIX	47
9.6	General wait for child handler	48
9.7	Forking a child process	49
10	Querying the operating system	52
10.1	Current time	52
10.2	Accessing environment variables	53
10.3	Capabilities	54
11	Working with the network	55
11.1	MIME parsing	55
11.2	Sockets	55
11.3	Echo client	55
11.4	Echo client and server	57
12	Working with the network: advanced topics	60
12.1	Introduction	60
12.2	FTP client	60
12.3	HTTP client	61
12.4	HTTP server	62
12.5	IMAP4 client	66
12.6	IRC client	67
12.7	SMTP client	68
12.8	Sending plain text email	68
12.9	Sending HTML email	70
12.10	Sending both text and HTML email	71

12.11	LDIF parser	72
13	Writing daemons	73
13.1	Introduction	73
13.2	Windows	73
13.3	Creating a daemon	73
13.4	Logging messages and errors	74
13.5	ULM based logging	75
14	Writing CGI programs	78
15	Error handling	85
15.1	Error handling with exceptions	85
15.2	Manual error handling	87
16	Security	90
16.1	Denial of service attacks	90
16.2	Authorization bypass attacks	91
17	Accessing C headers	92
17.1	Making C Headers available to Eiffel	92
17.2	Distinction between Standard C and POSIX headers	93
17.3	C translation details	94
A	Posix function to Eiffel class mapping list	95
	To do	101
	<i>ABSTRACT_DIRECTORY</i>	101
	<i>EPX_FILE_SYSTEM</i>	101
	<i>STDC_FILE</i>	101
	<i>STDC_LOCALE_NUMERIC</i>	101
	<i>STDC_PATH</i>	101
	<i>STDC_TIME</i>	101
	<i>POSIX_DAEMON</i>	101
	<i>POSIX_EXEC_PROCESS</i>	101
	<i>POSIX_FILE_DESCRIPTOR</i>	102
	<i>POSIX_MEMORY_MAP</i>	102
	<i>POSIX_SEMAPHORE</i>	102
	<i>POSIX_SIGNAL</i>	102
	<i>POSIX_STATUS</i>	102
	<i>POSIX_MQUEUE</i>	102
	Security	102
	Windows code	103
	Other	103
	Known bugs	103
	Bibliography	104
	Index	105

Introduction

It has been a great pleasure for me when I could announce the first public alpha release of this manual. And then came the betas and the first release. Writing libraries like this is boring stuff. Every Eiffel programmer should have had access to all those Standard C and POSIX routines long ago. Anyway, now you and me have. Whatever a C programmer can do, you can. And even more safe as this library protects you of inadvertently calling routines that are not portable (because they're simply not there :-)).

Writing libraries like this also seems to be a never ending story, as we now are at version 3.0. And my to do list hasn't shrunk, so stay tuned!

I actively support this library, so bug reports and wishes are gladly accepted. Planned extensions are 64 bit integer support in every place, so you won't be limited to files of 2GB in size. And of course, more and more support for the remaining functions in the Single Unix Specification not yet covered, such as `poll`. On the protocol side I like to have NNTP server support. And perhaps one day we'll have native SSL!

Have fun using this library and I like to hear about applications!

Licensing

This software is licensed under the Eiffel Forum Freeware License, version 2. This license can be found in the `forum.txt` file. Basically this license allows you to do anything with it, i.e. use it for commercial or Open Source software without restrictions. But don't sue me if something goes wrong. And give me some credits.

Also explicitly allowed is copying parts of this library to your own, for example copying certain Standard C or POSIX header wrappings. I prefer linking, but you don't have to retype everything if you don't want to link.

Support

e-POSIX is a fully supported program. You can send requests for help directly to me. But to help others profit from the discussion, and perhaps to get feedback when I'm short on time, it is suggested that support messages are sent to eposix@yahoogroups.com.

Latest versions and announcements are available from <http://groups.yahoo.com/group/eposix/>.

Commercial support

I'm available to give companies or organisations a one or two day course using POSIX and in particularly this library. Prices are \$1000 NZD a day, excluding VAT, travel and hotel expenses. Contact me at berend@pobox.com.

Acknowledgements

I like to thank people who, one way or another, have helped me in creating this library. They're listed in order they have been involved with this library or manual:

- **Eugene Melekhov** <eugene_melekhov@object-tools.com>: compiled it with Visual Eiffel. As Visual Eiffel is the most strict compiler, he found a great many oversights that SmallEiffel didn't catch.
- **mico/E team**: I got many ideas for my C interface from the mico/E project. Sometime ago **Andreas Schulz** wrote me that the micoe team wanted to use e-POSIX in mico/E. Andreas also reported problems and suggested improvements, especially in the **EPX_CGI** class. Andreas and Robert Switzer, thanks for the bug reports!
- **Ida de Boer** <ida@gameren.nl>: it was she who provided you with the POSIX to Eiffel mapping table in **appendix A**.
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- **Jörgen Tegnér** <teg@post.netlink.se> reported a problem with an example, and a bug in **POSIX_EXEC_PROCESS**.
- **Marcio Marchini** <mqm@magma.ca> contributed a lot to e-POSIX. He gave very useful advice, submitted code, and supplied patches to compile e-POSIX better on Windows. I think it is fair to say that you thank the Windows support in e-POSIX to Marcio.
- **Eric Bezault**: I've had some insightful discussions with Eric regarding architecture of libraries such as e-POSIX. I think we never agreed :-), but the alternative error handling is due to his comments!
- **Andreas Leitner**: Discussions about using e-POSIX which will lead to even closer integration with Gobo in subsequent releases.
- **[sven]**: various comments and suggestions.
- Colin Paul Adams: contributed classes such as the resolvers and fixes.
- Till G. Bay: contributed multiplexing support for e-POSIX's socket class.

Colophon

The text of this manual was entered with GNU Emacs 21.4.2 on BLinux. It was typeset with pdfTEX using the ConTEXt macro package, see <http://www.pragma-ade.com>. BON diagrams were created with METAPOST.

Requirements and installation

In this chapter:

1.1 Requirements

1.2 Compiling the C code

1.1 Requirements

e-POSIX has three requirements:

1. e-POSIX requires Gobo release 3.4 or higher. You can download Gobo at <http://www.gobosoft.com/>. Gobo must be installed.
2. e-POSIX requires that the environment variable `EPOSIX` is set to the root directory where the e-POSIX are unpacked.
3. On Windows, e-POSIX requires that the environment variable `GOBO_CC` is set to the name of the C compiler you are using. Failure to do so will result in link errors. Perhaps in a future **geant** release this will be set automatically.

1.2 Compiling the C code

Before e-POSIX can be used, a few C files need to be compiled into a library. The steps differ if you are using a Unix derivative, or a Windows based system.

1.2.1 Compiling on Unix

Before the C files can be compiled, e-POSIX must be configured. If you have just one Eiffel compiler on your system, this should be sufficient:

```
./configure --prefix=$EPOSIX
make
```

If you have multiple Eiffel compilers, you can specify the compiler with:

```
./configure --with-compiler=ve --prefix=$EPOSIX
```

The `--prefix` switch is a trick to make sure that you can type:

```
make install
```

after the make was successful. With this step the library is installed into the `\$EPOSIX/lib` directory. This is the location where e-POSIX's `src/library.xace` expects it. Without the `--prefix` switch the library will usually be installed in `/usr/local/lib`.

More information about `configure` options can be displayed with:

```
./configure --help
```

1.2.2 Compiling on Windows

For Windows system, I've supplied a tool —build with e-POSIX— that can build the necessary e-POSIX library for your Eiffel and C compiler.

Type:

```
makelib
```

to get help. Type:

```
makelib -ise -msc
```

to compile the C code with Microsoft's Visual C compiler targeting the ISE Eiffel compiler.

Only the Microsoft supplied library did work, i.e. link, with VisualEiffel:

```
makelib -ve -msc
```

Type:

```
makelib -se -bcb
```

to compile the C code with Borland's C compiler targeting SmartEiffel. It was tested with the free Borland C version 5.5 compiler.

Type:

```
makelib -se -lcc
```

to compile the C code with elj-win32's lcc C compiler.

If you have both the Borland C compiler and lcc installed, make sure the `make.exe` in your path is the correct one!

The generated library will have the name of the C compiler in its path. Make sure `GOBO_CC` has the correct value when compiling an e-POSIX program, see [table 1.1](#).

<code>bcb</code>	Borland C compiler.
<code>msc</code>	Microsoft C compiler.
<code>lcc</code>	lcc-win32 compiler.

Table 1.1 Possible values for the `GOBO_CC` environment variable

If you want to compile the e-POSIX library for use in a multi-threaded application, pass the `-mt` switch to `makelib.exe`:

```
makelib -ise -msc -mt
```

You must pass the `-mt` flag for ISE Eiffel 5.6 if you are using the Microsoft Visual C compiler. You also will have to copy the multi-threaded library to the single-threaded library:

```
cd lib
copy libmteposix_ise_msc.lib libposix_ise_msc.lib
```

This is only supported for the ISE Eiffel compiler. e-POSIX is not specifically written for use in multi-threaded programs nor tested much in such environments. There are certain areas (exit handling, signal handling) that are not multi-thread safe.

1.2.3 Library naming conventions

The name of this library starts with `libeposix`. On Unix the name of the Eiffel vendor is appended, so `libeposix_se.a` is the library for SmartEiffel. On Windows systems the name of the Eiffel vendor and the C compiler are appended. On Windows different C compilers have incompatible libraries, so they need to be distinguished. On Windows the e-POSIX library for ISE Eiffel compiled with the Microsoft Visual C compiler is called `libeposix_ise_msc.lib`.

The vendor names are derived from the names the Gobo Eiffel package uses, i.e. the `GOBO_EIFFEL` environment variable.

The C compiler is derived from the `GOBO_CC` environment variable.

In this chapter:

2.1 *Using library.xace*
2.2 *Vendor specific notes*
2.3 *Platform specific notes*

2

Using e-POSIX

2.1 Using library.xace

Since Gobo 3.0 Eiffel library writers have a new great tool at their dispose: `gexace`. Eiffel library writers have to write and maintain just a single file, `library.xace`. You can this file in the e-POSIX `src` subdirectory.

Typically, a `library.xace` is included in a `system.xace`. A typical example, including all required Gobo files, is:

```
<?xml version="1.0"?>

<system name="eposix_test">
  <description>
    system:      "eposix example program"
    author:      "Berend de Boer [berend@pobox.com]"
    copyright:   "Copyright (c) 2002-2007, Berend de Boer"
    license:     "Eiffel Forum Freeware License v2 (see forum.txt)"
    date:        "$Date: $"
    revision:    "$Revision: $"
  </description>

  <root class="${ROOT_CLASS}" creation="make"/>

  <option unless="${DEBUG}">
    <option name="assertion" value="none"/>
    <option name="garbage_collector" value="internal"/>
    <option name="finalize" value="true" unless="${GOBO_EIFFEL}=ve"/>
  </option>
  <option if="${DEBUG}">
    <option name="assertion" value="all"/>
    <option name="garbage_collector" value="internal"/>
    <option name="finalize" value="false"/>
  </option>

  <cluster name="example" location="${EPOSIX}/doc" unless="${GOBO_EIFFEL}=ve"/>

  <mount location="${EPOSIX}/src/library.xace"/>
  <mount location="${GOBO}/library/xml/library.xace"/>
  <mount location="${GOBO}/library/parse/library.xace"/>
  <mount location="${GOBO}/library/lexical/library.xace"/>
  <mount location="${GOBO}/library/structure/library.xace"/>
  <mount location="${GOBO}/library/kernel/library.xace"/>
```

```

<mount location="${GOBO}/library/string/library.xace"/>
<mount location="${GOBO}/library/time/library.xace"/>
<mount location="${GOBO}/library/utility/library.xace"/>
<mount location="${GOBO}/library/kernel.xace"/>

</system>

```

2.2 Vendor specific notes

2.2.1 ISE Eiffel

e-POSIX supports ISE Eiffel 5.6 and higher. e-POSIX has been tested under the following conditions:

1. I used Microsoft Windows 2000, Service Pack 2.
2. I used the Borland C 5.5 and Microsoft Visual C++ 6.0 compiler.

Note that you need the multithreaded version of the C binding library if you use ISE Eiffel 5.6 and the Microsoft Visual C compiler. Else you will get a linker message complaining about the unresolved external symbol `_errno`.

If you use ISE Eiffel 5.7, you can use the supplied `eposix.ecf` which will make inclusion of `eposix` in your projects much easier. However, the library path when you use the `eposix.ecf` is slightly different.

After generation of `libeposix`, see [section 1.2](#), do this on Unix:

```
cp lib/libeposix_ise.a ${ISE_LIBRARY}/lib/${ISE_PLATFORM}/libeposix.a
```

And on Windows:

```
copy lib\libeposix_ise.a ${ISE_LIBRARY}\lib\${ISE_PLATFORM}\${ISE_C_COMPILER}\libeposix.lib
```

2.2.2 SmartEiffel

e-POSIX was tested with SmartEiffel 1.2r7 on FreeBSD, Linux, QNX, Solaris and Windows.

Because SmartEiffel has a tendency to provide lots of non-ELKS routines in its kernel classes—a bad thing in my opinion—I had to write a new `ANY`. My `ANY` renames `GENERAL.remove_file`, so I wouldn't get a conflict with `POSIX_FILE_SYSTEM.remove_file`.

There is no reason for the presence of `GENERAL.remove_file`, I expect this to be removed soon¹, so my `ANY` can be deleted when this has happened.

If you use `lcc-win32` as your C compiler, note that for the Gobo `XM_UNICODE_CHARACTER_CLASSES` class SmartEiffel generates code that does not compile with `lcc-win32` due to some line length limit. This problem was still present with the latest `lcc-win32` compiler, version 3.8, compiled on December 23.

If you use SmartEiffel and if you don't use Gobo's `gexace` tool to generate SmartEiffel's Ace file, you might see a complaint about a routine `stdc_signal_switch_switcher` not being

¹ I wrote that two years ago...

found when linking. In that case you will need to put a `cecil.se` file in your directory. The contents of this file should be:

```
-- The name of our include C file:
cecil.h
-- The features called from C:
stdc_signal_switch_switcher STDC_SIGNAL_SWITCH switcher
stdc_exit_switch_at_exit STDC_EXIT_SWITCH at_exit
```

But I strongly suggest to make the switch to Gobo's `gexace` tool as this tool makes compilation for different Eiffel compilers a lot easier.

2.2.3 Visual Eiffel

e-POSIX has been tested with ObjectTool's free VisualEiffel 5.0b for Linux. VisualEiffel 4.1 might still work but is no longer tested.

Follow these steps to compile with VisualEiffel 5 on Windows:

1. Make sure the `VE_BIN` environment variable is set to the Bin directory in the VisualEiffel subdirectory. On my system it is set to `M:/Program Files/ObjectTools/VisualEiffel/Bin`.
2. Create the `libposix_ve_msc.lib` library using the Microsoft Visual C compiler:

```
makelib -ve -msc
```
3. Use `gexace` to generate an `.esd` file.
4. Make sure to set the linker supplier option to Microsoft in your `system.xace` file! So an option like this should be present:

```
<option name="linker" value="microsoft" if="\${GOBO_EIFFEL}=ve"/>
```

2.3 Platform specific notes

Although e-POSIX should, in principle, run on every platform that supports Standard C or POSIX, it cannot be tested on every platform by me alone. This section gives details about the platforms I've used. The main thing you might need to do is to edit e-POSIX's `src/library.xace` to the proper libraries for your platform are linked. The default `src/library.xace` is suited for Windows and Linux only. If you use any other platform, you will have to edit `src/library.xace`.

2.3.1 Linux

The latest version of e-POSIX was tested with kernel 2.6.20.1 and glibc 2.4.

2.3.2 FreeBSD

The latest version of e-POSIX was tested with FreeBSD 6.2-STABLE. FreeBSD doesn't support `fdatasync`, so we do a `fsync` there. Cases like that are automatically detected by the `configure` script.

You have to edit `/src/library.xace` to link the proper library for FreeBSD. Look at the comments.

After a `make clean` you have to use `gmake` instead of `make`.

2.3.3 Cygwin

The latest version of e-POSIX was tested with Cygwin 1.3.x. Some remarks:

1. Locking doesn't seem to be supported.
2. fifo's (`mkfifo`) are not supported.
3. No support for `fdatasync`, so we do a `fsync` there.

2.3.4 BeOS

The latest version of e-POSIX was tested with BeOS 5.03. BeOS has a nice POSIX compatibility layer. Some remarks:

1. Locking doesn't seem to be supported.
2. fifo's (`mkfifo`) are not supported.
3. Hard links are not supported, only symbolic links.
4. No support for `fdatasync`, so we do a `fsync` there.
5. Sockets work in BeOS, but they are not file descriptors. Stick to the `EPX_SOCKET` classes like `EPX_TCP_CLIENT_SOCKET`. Never pass a socket to an `ABSTRACT_FILE_DESCRIPTOR` as that will not work.

The trick is that `read` and `write` in `EPX_SOCKET` call `recv` and `sendmsg`. If you pass a socket to an `ABSTRACT_FILE_DESCRIPTOR`, the POSIX `read` and `write` routines will be called.

6. BeOS does not support non-blocking i/o on file descriptors or sockets. e-POSIX says it does if you ask `ABSTRACT_FILE_DESCRIPTOR.supports_nonblocking_io`, but it doesn't.

BeOS has some options for non-blocking sockets, but they're very primitive and it seems you can't turn blocking off once it has been turned on for example.

2.3.5 QNX

The latest version of e-POSIX was tested with QNX 6.2.1.

You have to edit `/src/library.xace` to link the proper library for QNX. Look at the comments.

2.3.6 Solaris

e-POSIX was tested against Solaris 10 for Intel. Make sure to add the `-std=c99` option to `CFLAGS`. Solaris seems to require this if the `POSIX-1.2001` define is set.

You have to edit `/src/library.xace` to link the proper library for Solaris. Look at the comments.

2.3.7 Win32

The latest version of e-POSIX was tested with Windows 2000, Service Pack 2. On Win32, Standard C is fully supported. With e-POSIX's abstract layer, parts of POSIX and the Single Unix Specification are also supported. Support isn't as extensive as using the Cygwin tools.

In this chapter:

3.1 *Why an entire reimplementation?*
3.2 *Goals and guidelines*
3.3 *Class structure*
3.4 *Clients of this library*
3.5 *Forking*
3.6 *Books*

3

Design notes

3.1 *Why an entire reimplementation?*

One might wonder why I reimplemented the entire Standard C and POSIX library when most vendors also have classes that deal with files, the file system, signals and such. Unfortunately, these classes are not complete nor very portable between vendors. For someone who wants to compile against all the major vendors —and there are good reasons to do this— there is currently no portable solution. That's why many portable Eiffel programs more or less contain the same code again and again. There are some attempts to write more portable libraries, for example the [Unix File/Directory Handling Cluster](#) by Friedrich Dominicus, but they also are not complete nor is the implementation satisfactory. For example they usually have much logic at the C level. I wanted only C glue code: all intelligence should be in the Eiffel code.

Another attempt is done by the Gobo cluster: it attempts to provide users with a set of classes that work across all Eiffel vendors by using only the native facilities offered by each implementation. This approach has the advantage that no C compilation is necessary. The disadvantages are:

1. The contract for these classes is probably not specifiable: for which platforms and which assumptions are the contracts valid? Are these contracts the same in all implementations?
2. It is incomplete, i.e. it doesn't cover most of the POSIX routines.

That's why I started to make the entire Standard C and POSIX routines available to Eiffel programmers. All these routines are nicely wrapped in classes. I spend a lot of time designing and refactoring these, comments and improvements about its structure are very appreciated.

The advantage of making POSIX available to Eiffel programmers is that someone doesn't need to think about creating a set of portable file and directory classes that work on every known operating system. POSIX is available on many platforms and for other systems there either is an emulation or a POSIX mapping available. It's better to reuse that, instead of reinventing work that took years to complete.

3.2 *Goals and guidelines*

The goals and guidelines for this library were:

1. A complete Standard C implementation for those who didn't have access to POSIX routines.
2. A complete POSIX implementation.

3. Do the job in such a way that it will become the official Eiffel POSIX mapping.
4. All classes should satisfy the demands posed by the query–command separation principle.
5. The native Standard C and POSIX routines should be available to those who don't want to go through a certain class layer.
6. The names in use in the POSIX world like file descriptor or memory map are used as class names. This should make it easy to find a class if one knows the POSIX name.
7. If a command fails, an exception code is raised. This differs from the POSIX routines where one is expected to test for error and query the `errno` variable. The only exception is `unlink`: when the file does not exist, no exception is raised.
8. POSIX assumptions should be made explicit. For Eiffel this means specifying explicit pre- and postconditions.
9. Use of constants to influence the way a method should be avoided by providing clearly named methods. So instead of passing a constants to the `POSIX_FILE.open` function to open a file read-only, one can also call `open_read`.
10. Attempt to create non-deferred class that refer to an entity that exists in the POSIX world. Creation of an object is binding to that entity, or creation of that entity.
11. Names should be clear, and Eiffel-like. They should not differ in just one character. POSIX names are also made available to ease use of this library for programmers that know POSIX well.

3.3 Class structure

e-POSIX makes available all the Standard C and POSIX headers in classes like `CAPI_STDIO` and `PAPI_UNISTD`. More details about the header translation are in [chapter 17](#).

However, making the plain C API available is not a very interesting addition to an Eiffel programmer's toolkit. Therefore, this library's second attempt was to make an effective OO-wrapper, while making a careful distinction between what is available in the Standard C and what is available in POSIX. This distinction is reflected in e-POSIX's directory structure, see [figure 3.1](#).



Figure 3.1 e-POSIX
directory structure

The raw Standard C API is available in `src/capi`, the OO-wrapper is available in `src/standardc`. The raw POSIX API is available in `src/papi`, the OO-wrapper is available in `src/posix`.

Every Standard C and POSIX wrapper is derived from a common root, see also [figure 3.2](#):

1. If a class builds upon facilities available on Standard C, its name starts with the prefix `STDC_` and it inherits from `STDC_BASE`.
2. If a class builds upon facilities available in POSIX, its name starts with the prefix `POSIX_` and it inherits from `POSIX_BASE`.
3. If a class builds upon facilities available in the Single Unix Specification, its name starts with the prefix `SUS_` and it inherits from `SUS_BASE`. The support for the Single Unix Specification is not yet complete, but is continually enhanced.
4. Because we live in a world dominated by Microsoft Windows, and Microsoft Windows does not do POSIX, this would mean that many users only could use e-POSIX's Standard C facilities. These facilities are extremely limiting, for example there is no change directory command in Standard C. Therefore e-POSIX makes available an abstraction layer that covers routines that have an equivalent in POSIX and the Single Unix Specification. These classes start with the name `EPX_`. They always inherit from classes starting with `ABSTRACT_`. These abstract classes implement the common code. See [chapter 4.3.3](#) for more details.

Note that by using Cygwin you have a full POSIX emulation layer on Windows. In that specific environment you can use e-POSIX's entire POSIX and Single Unix Specification layer.

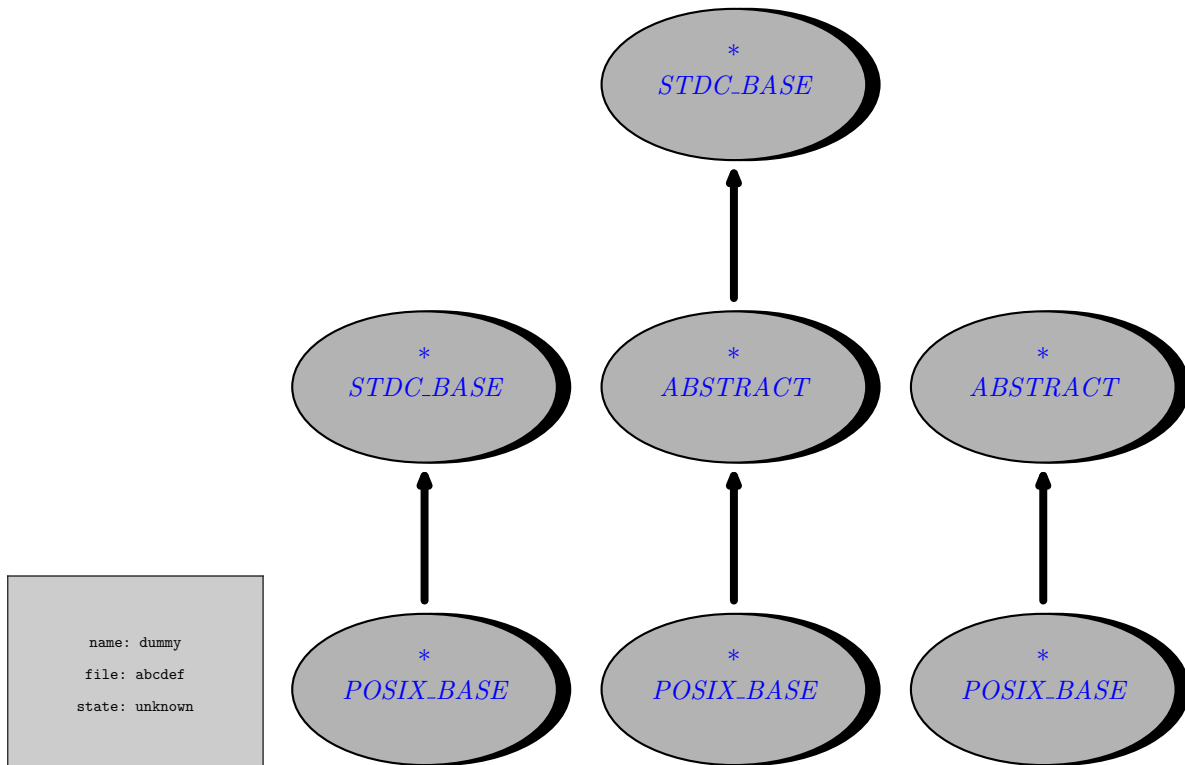


Figure 3.2 Inheritance structure

The wrapper classes should be fully command-query separated and use clear names. Often the POSIX name, if applicable, is also made available as an alias. If this is a good thing, I'm not sure. I hope it facilitates working with the wrapper classes if you already know POSIX.

Besides these directories, e-POSIX provides a number of extensions to the pure Standard C or POSIX routines. These can be found in the subdirectories that start with `src/epx`. A single letter indicates if the classes only built upon routines available in Standard C or POSIX:

1. `epxc`: Standard C based extensions like URI resolving, a MIME parser and XML generation.
2. `epxs`: Single Unix Specification based extension like an HTTP client.

3.4 Clients of this library

For client classes, two important classes are `STDC_CONSTANTS` and `POSIX_CONSTANTS`, see [figure 3.3](#). The wrapper classes tend to avoid having routines whose behavior drastically depends on passed constants. But if you need to use constants, your client class can just inherit from these classes and every Standard C and POSIX constant is available.

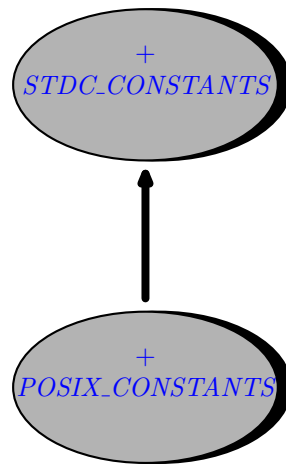


Figure 3.3 Standard C and POSIX constants

3.5 Forking

Implementing forking posed some interesting challenges. I started with the basic idea that every process has a pid:

```

class PROCESS

feature

  pid: INTEGER

end
  
```

I wanted to be able to write two kinds of forking. The first one is forking a child as in:

```

class PARENT
  
```

inherit

POSIX_CURRENT_PROCESS

feature

```

make is
  local
    child: POSIX_CHILD_PROCESS
  do
    print ("My pid: ")
    print (pid)
    print ("%N")
    fork (child)
    print ("child's pid: ")
    print (child.pid)
    print ("%N")
    child.wait_for (True)
  end
end

```

end

However, I also wanted to fork myself, because that basically is what forking is!

class *PARENT*

inherit

POSIX_CURRENT_PROCESS

POSIX_CHILD_PROCESS

feature

```

make is
  do
    fork (Current)
    wait
  end
end

```

```

execute is
  do
    -- forked code
  end
end

```

end

The above code gives a name clash, because *POSIX_CURRENT_PROCESS*.pid is a call to the POSIX routine `getpid`, while the child's pid is a variable, which gets a variable after forking. You can solve this name clash yourself, but it is most easy to inherit from *POSIX_FORK_ROOT*, a clash which has solved this clash already.

If you fork a child, you must wait for it. For a child process, you can use `POSIX _CHILD. wait _for`, if you fork yourself, you must use `POSIX _CURRENT _PROCESS. wait`. The variable `waited _child _pid` will be set with the pid of the child process that `wait` waited for.

3.6 Books

Books that have been helpful during the development of e-POSIX where (XXXXXXXXXX, 0000), (XXXXXXXXXX, 0000) and (XXXXXXXXXX, 0000), see the biography section at [page 104](#).

In this chapter:

4.1 Layers architecture

4.2 Standard C

4.3 Windows

4.4 Introduction to the next chapters

4 Layers

4.1 Layers architecture

e-POSIX is written in such a way that it is possible to write a pure Standard C based application (ANSI/ISO IS 9899: 1990), a pure POSIX application (Standard ISO/IEC-9945-1: 1990), or a pure Single Unix Specification version 3 application (http://www.unix-systems.org/single_unix_specification/). Although POSIX and the Single Unix Specification merged these specifications, they are still kept separate in e-POSIX, because the merge happened relatively recently and the pure POSIX functions are more very widely supported.

Based on these standards e-POSIX offers a compatibility layer. This layer offers a common framework for people that want to write code that works on both Unix and Windows systems. The compatibility layer uses all features that an operating system offers. If you use the network compatibility layer for example, you need a system that supports the Single Unix Specification.

4.2 Standard C

All Standard C classes start with `STDC_`. They are:

1. `STDC _TEXT _FILE`: access text files.
2. `STDC _BINARY _FILE`: access binary files.
3. `STC _TEMPORARY _FILE`: create a temporary file, a file that is removed when it is closed or when the program terminates.
4. `STDC _CONSTANTS`: access Standard C constants like error codes and such.
5. `STDC _BUFFER`: allocate dynamic memory.
6. `STDC _ENV _VAR`: access environment variables.
7. `STDC _FILE _SYSTEM`: delete and rename files.
8. `STDC _SHELL _COMMAND`: pass an arbitrary command to the native shell.
9. `STDC _SYSTEM`: access information about the system the program is running on.
10. `STDC _CURRENT _PROCESS`: access to current process related information like its standard input, output and error streams.
11. `STDC _TIME`: access current time. Also can format a given time in various formats.

4.3 Windows

4.3.1 Writing portable programs

e-POSIX offers three alternatives to writing programs that run on both Unix and Windows platforms:

1. Write programs that only rely on Standard C. If you use only Standard C classes your program is probably quite portable. Standard C doesn't offer that much however.
2. Write programs that are based on POSIX. You use a POSIX emulator to compile and run your program unchanged on Windows. The only thing you have to be aware of is the distinction between binary and text files.
3. Write programs that are based upon e-POSIX's EPX_XXXX layer. This layer is based on e-POSIX's ABSTRACT_XXXX classes, that covers code that is common between Windows and a POSIX platform.

Previous versions of e-POSIX used a factory class approach to access this common code. This is no longer needed. The ABSTRACT_XXXX are made effective through EPX_XXXX classes when compiling for Windows or for POSIX.

The following sections offer more details about the last two approaches.

4.3.2 *Compiling POSIX programs in Windows*

You can also use a very large subset of POSIX under Windows with a POSIX emulator. I've tested this using SmartEiffel and Cygwin's freely available emulator. Here the steps:

1. Download the Cygwin toolkit from <http://sources.redhat.com/cygwin>.
2. Set the compiler in `compiler.se` to `gcc`. Leave the system in `system.se` to Windows.
3. Configure e-POSIX as described in 1.2 and create `libeposix_se.a`

A few things are not available under Cygnus' POSIX emulation:

1. `POSIX_FILE_SYSTEM.create_fifo` is not supported. Any attempt to use it will return `ENOSYS`. I'm not sure if returning an error is the correct solution for applications that require POSIX compatibility, because you are only warned at run-time. Another solution would be to include a call to `mkfifo` and if you use it, let the linker complain.
2. There is no locking, so calls to `POSIX_FILE_DESCRIPTOR.get_lock` and such will fail.
3. Certain POSIX tests assume that a more Unix like environment is available, so not all tests will run. For example the standard Cygwin distribution doesn't have a `more` utility. If you make a symbolic link from `less` to `more` the child process test will run.
4. The current list of implemented functions is available from http://sources.redhat.com/cygwin/faq/faq_3.html#SEC17.

4.3.3 *Native Windows*

Previous versions of e-POSIX used a factory class approach to access Windows or POSIX specific code. This is obsolete.

If you want to write code that is portable between Windows and POSIX use the EPX_XXXX class layer. For example you can use the `EPX_FILE_DESCRIPTOR` to use file descriptors that are completely portable between these two OSes. Use `EPX_FILE_SYSTEM` to have access to file system specific code to change directories or get the temporary directory.

In general you can replace the `POSIX_` prefix with `EPX_` to compile most of the examples presented in the previous POSIX specific chapters. The classes currently available in the EPX_XXXX layer are:

- `EPX _CURRENT _PROCESS.`
- `EPX _EXEC _PROCESS.`
- `EPX _FILE _DESCRIPTOR.`
- `EPX _FILE _SYSTEM.`
- `EPX _PIPE.`

Figure one shows hoe the `EPX _FILE _DESCRIPTOR` class is derived from `ABSTRACT _FILE _DESCRIPTOR`. Both Windows and POSIX have an effective `EPX _FILE _DESCRIPTOR` class. Classes as `POSIX _FILE _DESCRIPTOR` implement POSIX specific functionality for a file descriptor.

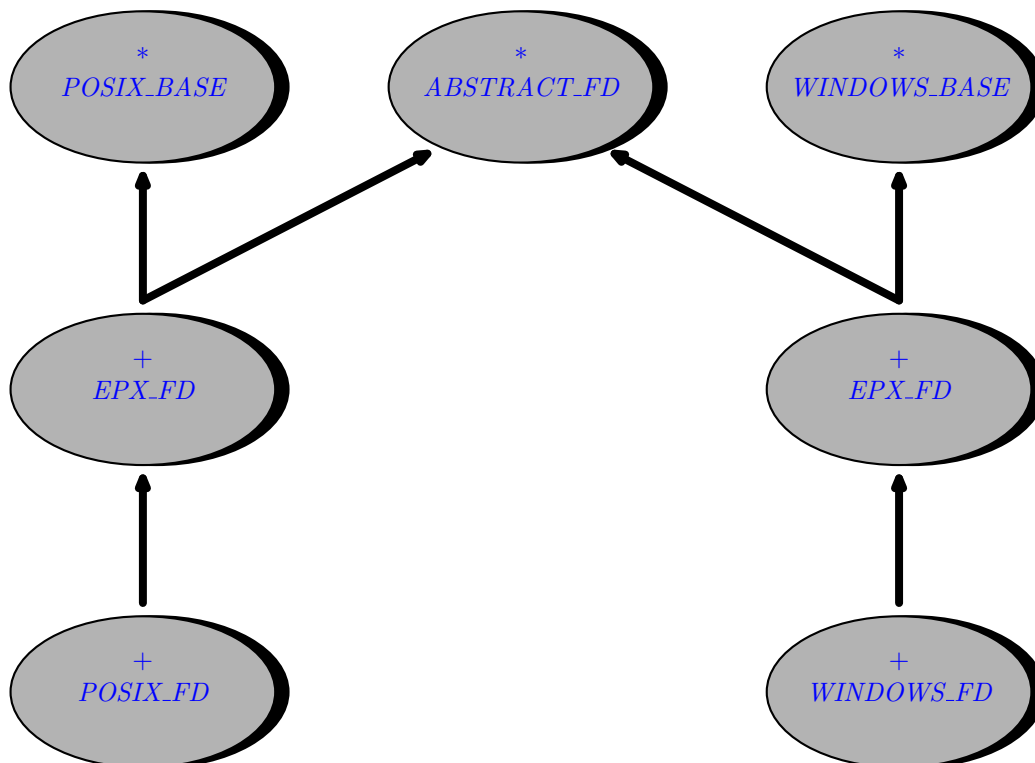


Figure 4.1 How `EPX_XXXX` classes are related to the POSIX and Windows classes

An example of using the `EPX _FILE _SYSTEM` class is shown below:

```

class EX_EPX1

inherit

    EPX_FILE_SYSTEM


creation

    make

feature
  
```

```
make is
local
  dir: STRING
do
  print ("Current directory: ")
  dir := current_directory
  print (dir)
  print ("%N")
  change_directory ("..")
  change_directory (dir)
  make_directory ("abc")
  rename_to ("abc", "def")
  remove_directory ("def")
end

end
```

In  all abstract classes are listed. There deferred features are made effective in the EPX class for the operating system you're compiling for.

4.4 Introduction to the next chapters

The following chapters are topic based: they discuss how to work with files for example and show examples for all layers and give hints what is and what isn't supported in each layer.

Instead of describing every class and every feature, I decided to show short and simple examples of common ways to use the various e-POSIX classes. Most examples assume a POSIX or Single Unix Specification environment. If you don't have POSIX available, you can try to replace the `POSIX_` prefix by `STDC_`. Most of the time the POSIX classes are based on the Standard C classes.

If you are looking for more examples, you might take a look at the classes in the `test_suite` directory. These classes should demonstrate and test almost every feature available in the POSIX classes.

In this chapter:

5.1 Introduction
5.2 Allocating memory
5.3 Allocating memory
5.4 Using shared memory
5.5 Memory maps

5

Working with mem- ory

5.1 Introduction

e-POSIX has several classes that allocate memory. The main class is `STDC_BUFFER` (or the equivalent `POSIX_BUFFER`). This class allocates a memory block that isn't moved by the garbage collector. This is very useful for an Eiffel compiler that has a moving garbage collector.

You can also get access to shared memory using `POSIX_SHARED_MEMORY`.

5.2 Allocating memory

You can dynamically allocate memory with `STDC_BUFFER` which works just like `POSIX_BUFFER`.

```
class EX_MEM2

creation

make

feature

make is
local
    mem: STDC_BUFFER
    byte: INTEGER
do
    create mem.allocate_and_clear (128)
    mem.poke_uint8 (2, 57)
    byte := mem.peek_uint8 (2)
    mem.resize (256)
    mem.deallocate
end

end
```

With the feature `STDC_BUFFER.allocate_and_clear` memory is allocated and cleared to all zeros.

STDC `_BUFFER` contains many routines to read bytes and strings from the memory it manages like `peek_int16`, `peek_uint16`, or `peek_int32`. It supports reading and writing 16 and 32 bit integers in little and big endian order with routines as `peek_int16_big_endian`, `peek_int16_little_endian`, and `poke_int32_big_endian`.

5.3 Allocating memory

Allocating dynamic memory is very useful, but not portably available for Eiffel programmers. With `POSIX_BUFFER` memory can be allocated, read and written to.

```
class EX_MEM

  creation

    make

  feature

    make is
      local
        mem: POSIX_BUFFER
        byte: INTEGER
      do
        create mem.allocate (256)
        mem.poke_uint8 (2, 57)
        byte := mem.peak_uint8 (2)
        mem.resize (512)
        mem.deallocate
      end

    end
```

For more information about the dynamic memory class, see [section 5.2](#).

5.4 Using shared memory

You can use shared memory to exchange data between different processes. It's dependent on your POSIX version if this is supported, so check for this capability explicitly!

```
class EX_SHARED_MEM1

  inherit

    POSIX_SYSTEM

    POSIX_CURRENT_PROCESS

    POSIX_FILE_SYSTEM

  creation
```

```

    make

feature

    make is
    local
        fd: POSIX_SHARED_MEMORY
    do
        if not supports_shared_memory_objects then
            stderr.puts ("Shared memory objects not supported.%N")
            exit_with_failure
        end

        create fd.create_read_write ("/test.berend")
        fd.put_string ("Hello world.%N")
        fd.close
        unlink_shared_memory_object ("/test.berend")
    end

end

```

Make sure you always start a shared memory object with a slash. Else the behaviour is undefined or processes might not be able to find your shared memory.

There is not yet an abstract layer implementing shared memory, but you can use [WINDOWS _PAGING_FILE_SHARED_MEMORY](#) on Windows to get a similar effect.

5.5 Memory maps

You can map a file to memory using [POSIX _MEMORY_MAP](#).

```

class EX_MEMORY_MAP1

inherit

    POSIX_SYSTEM

    POSIX_CURRENT_PROCESS

creation

    make

feature

    make is
    local
        fd: POSIX_FILE_DESCRIPTOR
        map: POSIX_MEMORY_MAP

```

```
byte: INTEGER
correct: BOOLEAN
do
  if supports_memory_mapped_files then

    -- Open a file.
    create fd.open_read_write ("ex_memory_map1.e")

    -- Create memory map.
    create map.make_shared (fd, 0, 64)

    -- Read a byte from the mapping.
    byte := map.peek_uint8 (2)
    correct := byte = ('a').code
    if not correct then
      print ("Oops.%N")
    end

    -- Cleanup.
    map.close
    fd.close
  end
end
end
```

There is no equivalent abstract layer class for memory mapping to support Windows yet.

In this chapter:

6.1 Introduction
6.2 Standard C notes
6.3 Compatibility with Gobo
6.4 Working with streams
6.5 Working with streams using Standard C only
6.6 Working with file descriptors
6.7 Windows systems: binary mode versus text mode

6 Working with files

6.1 Introduction

e-POSIX offers two different file classes: Standard C stream based and POSIX file descriptor classes. The main difference between stream and descriptor based classes is that the stream classes offer read and write caching. Output is not immediately written to disk or network for example.

6.2 Standard C notes

If you don't have access to a POSIX compatible system, you can use the underlying Standard C classes. Standard C is quite restricted in certain respects: you cannot change directories for example. On the other hand, this library gives you access to all Standard C routines, so you can use what's there and write an extremely portable program.

6.3 Compatibility with Gobo

Since version 2.0 e-POSIX is built upon foundations laid in Gobo. e-POSIX's `STDC_FILE/POSIX_FILE` and `ABSTRACT_FILE_DESCRIPTOR` are implementations of `KI_CHARACTER_INPUT_STREAM` and `KI_CHARACTER_OUTPUT_STREAM`.

The e-POSIX class `ABSTRACT_FILE_DESCRIPTOR` has support for non-blocking i/o, see [section 7.3](#). Gobo's `KI_CHARACTER_INPUT_STREAM` expects blocking i/o however. If you call `ABSTRACT_FILE_DESCRIPTOR.read_string` you will call the routine that has support for non-blocking i/o. Due to Eiffel's renaming mechanism, `ABSTRACT_FILE_DESCRIPTOR` will behave blocking when it is called as if it was a `KI_CHARACTER_INPUT_STREAM`.

6.4 Working with streams

The basic class for working with files, or streams as they are also called, is `POSIX_FILE`. There are two kinds of files: `POSIX_TEXT_FILE` and `POSIX_BINARY_FILE`. According to the POSIX standard, there is no distinction between binary and text files. But on certain systems you must use POSIX programs through an emulation layer. For example, on Windows Cygwin is a well-known POSIX emulator. To maintain compatibility with other Windows programs, Cygwin distinguishes between text and binary files. If you use Cygwin to compile your POSIX programs, this distinction is therefore still important.

The first example shows how to open a text file, see also the corresponding BON diagram in [figure 6.1](#).

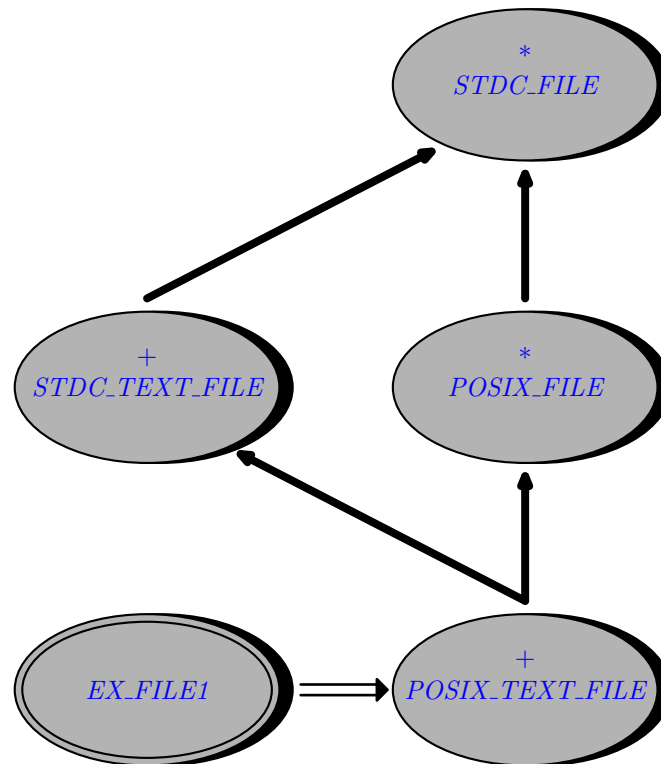


Figure 6.1 BON diagram of opening a text file.

```

class EX_FILE1

creation

make

feature

make is
local
  file: POSIX_TEXT_FILE
do
  create file.open_read ("/etc/group")
from
  file.read_line
until
  file.end_of_input
loop
  print (file.last_string)
  print ("%N")
  file.read_line
end
  
```

```

    file.close
end

```

```

end

```

It simply opens a file for reading and prints every line in it. Note that the line read does *not* include the end-of-line character. This is a change in behaviour from pre 2.0 e-POSIX versions.

[POSIX_FILE] has two functions that read strings. These are `read_line` and `read_string`. `read_line` only returns when it has read an end-of-line character. If it has to read a 2GB characters to reach that, it will return a 2GB string. `read_string` returns a string with the given number of characters, or less if the end of the file is reached. These two functions have one other difference as well: `read_line` removes the end-of-line character(s), while `read_string` returns the raw string, including end-of-line characters and such.

At the end of the example, the file is closed. You don't need to explicitly close a file as it will be closed when your object is garbage collected. But I think it's a good thing not to rely or depend on this, but to close your external resources as soon as you're done using them. For example many systems have easily reached limits on the number of files a process can have open.

Reading binary files is almost the same loop, only you read it in chunks:

```

class EX_FILE2

  creation

  make

  feature

    chunk_size: INTEGER is 512

    make is
    local
      file: POSIX_BINARY_FILE
      buffer: POSIX_BUFFER
    do
      create file.open_read ("/bin/sh")
      create buffer.allocate (chunk_size)
    from
      file.read_buffer (buffer, 0, chunk_size)
    until
      file.end_of_input
    loop
      file.read_buffer (buffer, 0, chunk_size)
    end
    file.close
  end

end

```

This example uses a more safe version of buffer reading, `POSIX_FILE.read_buffer`. There is an untyped variant `POSIX_FILE.read` which accepts a pure pointer. There is no need to mention that you need to watch buffer overflows carefully with this last one!

Correctly looping through files, takes care. For example the following loop is wrong:

```
class EX_WRONG1

creation

    make

feature

    make is
    local
        file: POSIX_TEXT_FILE
    do
        create file.open_read ("/etc/group")
        from
        until
            file.end_of_input
        loop
            file.read_string (256)
            print (file.last_string)
        end
        file.close
    end

end
```

After `POSIX_TEXT_FILE.read_string`, `end_of_input` might be True. But the precondition for `last_string` is that `end_of_input` is false. You will make an unnecessary extra loop. The correctly coded variant is:

```
class EX_WRONG2

creation

    make

feature

    make is
    local
        file: POSIX_TEXT_FILE
    do
        create file.open_read ("/etc/group")
        from
        until
            file.end_of_input
        loop
```

```

    file.read_string (256)
  if not file.end_of_input then
    print (file.last_string)
  end
end
file.close
end

```

end

I myself prefer the first example, as the check is only in the **until** part, and not repeated in the loop.

The following examples shows how a binary file is created and a string is written to it.

```
class EX_FILE3
```

```
inherit
```

```
  POSIX_FILE_SYSTEM
```

```
creation
```

```
  make
```

```
feature
```

```
  make is
```

```
    local
```

```
      file: POSIX_BINARY_FILE
```

```
    do
```

```
      create file.create_write (expand_path (" $HOME/myfile.tmp"))
```

```
      file.put_string ("hello world.%N")
```

```
      file.close
```

```
    end
```

```
end
```

Depending on the platform you are running a backslash is turned into a slash or vice versa.

This example also demonstrates how path names —file and directory names— can be expanded: if you call **POSIX_FILE_SYSTEM.expand_path**, any environment variables in the path are expanded. Backslashes and slashes are always translated, but environment variable expansion has to be done explicitly.

You can move the file pointer with two different methods: **POSIX_FILE.seek** and **set_position**. The **seek** works with files up to 2 GB, **set_position** has no such limits. Use **tell** to get a position that can be passed to **seek**. Use **get_position** to get a position that can be passed to **set_position**.

```
class EX_FILE5
```

```
creation
```



```

    make

feature

    make is
    local
        file: POSIX_BINARY_FILE
        pos1: INTEGER
        pos2: STDC_FILE_POSITION
    do
        create file.create_read_write ("test.bin")
        file.put_string ("one")
        pos1 := file.tell
        pos2 := file.get_position
        file.put_string ("two")
        file.seek (pos1)
        -- or file.set_position (pos2)
        file.read_string (3)
        if not file.last_string.is_equal ("two") then
            print ("unexpected read.%N")
        end
        file.close
    end

end

```

6.5 Working with streams using Standard C only

Working with text files is equal to the POSIX classes, only you use the STDC prefix.

```

class EX_FILE4

creation

    make

feature

    make is
    local
        file: STDC_TEXT_FILE
    do
        create file.open_read ("/etc/group")
        from
            file.read_line
        until
            file.end_of_input
        loop
            print (file.last_string)
        end
    end
end

```

```

    print ("%N")
    file.read_line
end
file.close
end

```

```

end

```

Its BON diagram, see [figure 6.2](#) is therefore quite equal to the POSIX one, see [figure 6.1](#).

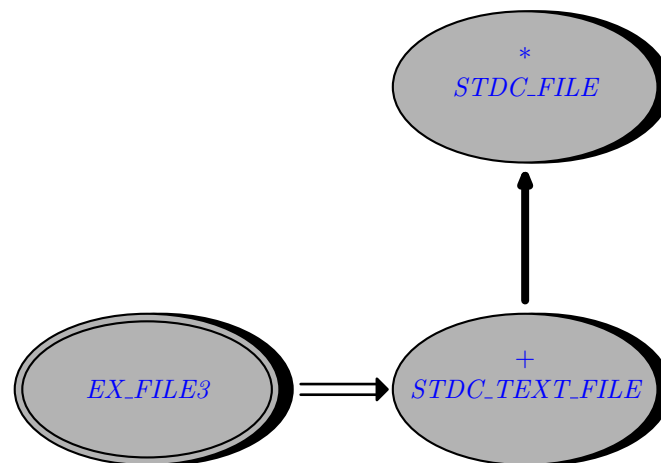


Figure 6.2 BON diagram of opening a Standard C text file.

6.6 Working with file descriptors

The file descriptors classes are quite equal to the file classes. The following example opens a file using `POSIX_FILE_DESCRIPTOR` and reads the first 64 bytes.

```

class EX_FD1

creation

    make

feature

    make is
    local
        fd: POSIX_FILE_DESCRIPTOR
    do
        create fd.open_read ("/etc/group")
        fd.read_string (64)
        print (fd.last_string)
        fd.close
    end
end

```

end

Unlike `POSIX_TEXT_FILE`, there is no easy way to detect end of line and end of file conditions. However, a file descriptor can easily be turned into a file as the following example demonstrates.

```
class EX_FD2

creation

    make

feature

    make is
    local
        fd: POSIX_FILE_DESCRIPTOR
        file: POSIX_TEXT_FILE
    do
        create fd.open_read ("/etc/group")
        create file.make_from_file_descriptor (fd, "r")
        from
            file.read_string (256)
        until
            file.end_of_input
        loop
            print (file.last_string)
            file.read_string (256)
        end
        file.close
        fd.close
    end

end
```

end

A file descriptor can also be used to lock, unlock or test for locks on a given file as the following example demonstrates. See also the accompanying BON diagram in [figure 6.3](#).

```
class EX_FD4

creation

    make

feature

    make is
    local
        some_lock,
        lock: POSIX_LOCK
        fd: POSIX_FILE_DESCRIPTOR
    do
```

```

create fd.create_read_write ("test.tmp")
fd.put_string ("Test")

create lock.make
lock.set_allow_read
lock.set_start (2)
lock.set_length (1)
some_lock := fd.get_lock (lock)
if some_lock /= Void then
  print ("There is already a lock? %N")
end

-- create exclusive lock
lock.set_allow_none
lock.set_start (0)
lock.set_length (4)
fd.set_lock (lock)

fd.close
end

end

```

`POSIX_FILE_DESCRIPTOR`. `get_lock` is command–query separated, that is why it returns a new lock when queried and there is a lock. If there is no lock `get_lock` returns `Void`. The passed lock is not modified.

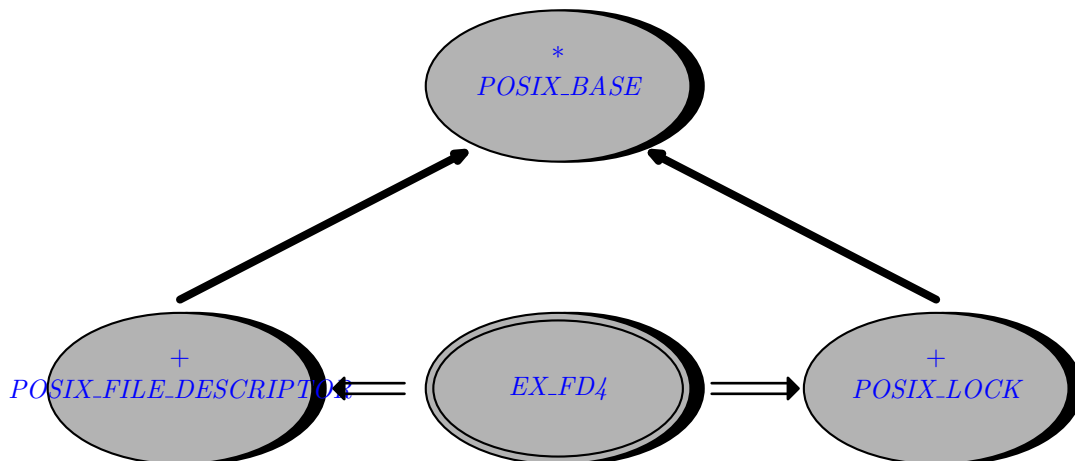


Figure 6.3 BON diagram of locking a portion of a file.

A file descriptor also gives you access to the attached terminal, if any. The following example demonstrates how to read a password without the password appearing on the screen.

```
class EX_FD3
```

```
inherit
```

POSIX_CURRENT_PROCESS

creation

make

feature

```
make is
do
    print ("Password: ")
    stdout.flush

    -- turn off echo
    fd_stdin.terminal.set_echo_input (False)
    fd_stdin.terminal.apply_flush

    -- read password
    fd_stdin.read_string (256)

    -- turn echo back on
    fd_stdin.terminal.set_echo_input (True)
    fd_stdin.terminal.apply_now

    print ("%NYour password was: ")
    print (fd_stdin.last_string)
end

end
```

6.7 Windows systems: binary mode versus text mode

If you are using Unix exclusively, you can skip this section.

Independent of what layer you use to write Windows programs, you have to deal with binary and text modes. And if you usually write Unix programs and want them to work on Windows too, you have to bother with it too.

On Windows, each line of a text files ends with a carriage return character followed by a line feed character. If you use a C text stream to read a file on Windows, a trick is employed: every occurrence of "%R%N" is replaced by a single "%N". If The same happens when writing to a text stream: you just have to write a single "%N" and the C run-time code replaces this by

So make sure you are using the proper classes if you use streams. Use `STDC _TEXT _FILE` if you want to read and write text files and use `STDC _BINARY _FILE` to read and write binary files.

File descriptors are binary only. So any descendant from `ABSTRACT _FILE _DESCRIPTOR` treats input and output as binary and does no translation whatsoever. If you use `ABSTRACT _FILE _DESCRIPTOR`. `read_line` to read lines, the end-of-line character may either be a

"%R%N" or just a end-of-line characters regardless of the platform. So reading a file with Windows end-of-line characters on Windows or Unix will work exactly the same.

There is no explicit support for creating text files using file descriptors with the proper Windows end of file characters. Use either `STDC _TEXT _FILE` to create platform dependent end-of-lines or write the proper end-of-line characters yourself.

This discussion also applies to standard input and output. If you want to use binary standard input or binary standard output, use the file descriptors available in `EPX _CURRENT _PROCESS` as `fd _stdin` and `fd _stdout`. If you use `stdin` and `stdout` you can handle text files only on Windows. On Unix it does not matter.

For Cygwin users the story is somewhat more difficult it seems. File descriptors can be text or binary. The default is binary however. The following information can be helpful to get the binary versus text file distinction correct:

- Mount the volume in binary mode.
- Set the environment variable CYGWIN to 'binary'.

More information about Cygwin and CR/LF handling can be found at http://sources.redhat.com/cygwin/faq/faq_toc.html#TOC62.

7

Working with files: advanced topics

In this chapter:

- 7.1 Redirecting stderr to stdout**
- 7.2 Talking to your modem**
- 7.3 Non-blocking I/O**
- 7.4 Asynchronous I/O**

7.1 Redirecting stderr to stdout

If you want to redirect all output written by your program or any child you spawn to stdout, you can use the `POSIX _FILE _DESCRIPTOR. make _as _duplicate` call:

```
class EX_REDIRECT1
```

```
inherit
```

```
    POSIX_CURRENT_PROCESS
```

```
creation
```

```
    make
```

```
feature
```

```
    make is
```

```
    do
```

```
        -- flush stream buffers, else output may be in wrong order
```

```
        stdout.flush
```

```
        stderr.flush
```

```
        fd_stderr.make_as_duplicate (fd_stdout)
```

```
        -- all output written to stderr goes to stdout now
```

```
    end
```

```
end
```

It's a good idea to call this at the beginning of your program, before you have written anything to stderr or stdout. If you do that, you don't have to flush the stream buffers.

7.2 Talking to your modem

With e-POSIX you can talk to your modem. The implementation contains not all the details to write a full-featured program as minicom, but they will be added upon request.

The following example tries to talk to your modem —which is expected to be at `/dev/modem`— and queries its manufacturer.

```
class EX_MODEM

inherit

    POSIX_CURRENT_PROCESS

creation

    make

feature

    make is
    local
        modem: POSIX_FILE_DESCRIPTOR
        term: POSIX_TERMIOS
    do
        -- assume there is a /dev/modem device
        create modem.open_read_write ("/dev/modem")
        term := modem.terminal
        term.flush_input
        print ("Input speed: ")
        print (term.speed_to_baud_rate (term.input_speed))
        print ("%N")
        print ("Output speed: ")
        print (term.speed_to_baud_rate (term.output_speed))
        print ("%N")

        term.set_input_speed (B9600)
        term.set_output_speed (B9600)
        term.set_receive (True)
        term.set_echo_input (False)
        term.set_echo_new_line (False)
        term.set_input_control (True)
        term.apply_flush

        -- expect modem to echo commands
        modem.put_string ("AT%N")
        modem.read_string (64)
        print ("Command: ")
        print (modem.last_string)
        modem.read_string (64)
        print ("Response (expect ok): ")
        print (modem.last_string)
        modem.put_string ("ATI0%N")
        modem.read_string (64)
        print ("Command: ")

```



```

    print (modem.last_string)
    modem.read_string (64)
    print ("Response: ")
    print (modem.last_string)
    modem.close
end

end

```

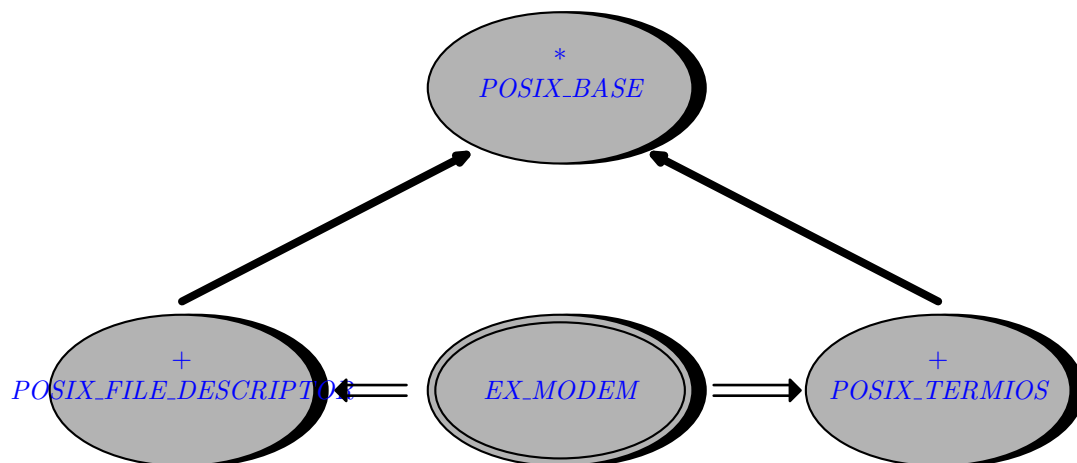


Figure 7.1 BON diagram of talking to a modem.

7.3 Non-blocking I/O

e-POSIX supports non-blocking i/o on its file descriptor classes, i.e. the descendants of `ABSTRACT_FILE_DESCRIPTOR`. Use `is_blocking_io` to query if the descriptor blocks on `read` or `write` if there is no data. Use `set_blocking_io` to change the behavior.

Use `supports_nonblocking_io` to query if the behavior with respect to blocking i/o can be changed. On Windows file i/o must be blocking. Only sockets on Windows can be non-blocking. On Unix all descriptors support non-blocking i/o.

See also [section 6.3](#) for non-blocking i/o when e-POSIX is used as a plugin for classes that expect a `KI_CHARACTER_INPUT_STREAM`. In such cases e-POSIX reverts to blocking i/o, even when non-blocking i/o has been enabled.

7.4 Asynchronous I/O

e-POSIX supports the asynchronous i/o features of POSIX. Not all Free Unices seem to support this feature, nor does their support seem to be error free.

Take a look at the following example:

```

class EX_ASYNC1

creation

```

```
make

feature

make is
  local
    fd: POSIX_FILE_DESCRIPTOR
    request: POSIX_ASYNC_IO_REQUEST
  do
    create fd.create_read_write ("test.tmp")
    create request.make (fd)
    request.set_offset (0)
    request.put_string ("hello world.")
    request.wait_for
    fd.close
  end
end
```

The basic idea is that each asynchronous request is a separate object, modeled by `POSIX_ASYNC_IO_REQUEST`. You prepare it through calls like `set_buffer`, `set_count` and `set_offset`. You execute the request by calling `read` or `write`.

You can wait for the request to be complete by calling `wait_for`. It should be possible to force open requests to be synchronized to the disk with `synchronize`, but this does give strange results on Linux. So far I haven't got access to a machine that also implements asynchronous i/o to test if my code is correct.

In this chapter:

8.1 *Portability*
8.2 *Standard C*
8.3 *POSIX*

8

Working with the file system

8.1 *Portability*

Use the `EPX_` classes to write code that is portable between POSIX systems and Windows.

8.2 *Standard C*

Standard C doesn't offer much for file systems. You can only delete and rename files.

```
class EX_DIR5

inherit

    STDC_FILE_SYSTEM

creation

    make

feature

    make is
    do
        rename_to ("qqtest.abc.tmp", "qqtest.xyz.tmp")
        remove_file ("qqtest.xyz.tmp")
    end

end
```

The BON diagram is shown in [figure 8.1](#).

But you can manipulate filenames including directories, although technically they're not part of Standard C. The following example shows how filenames can be manipulated with `STDC_PATH`:

```
class EX_FILENAME1

creation

    make
```

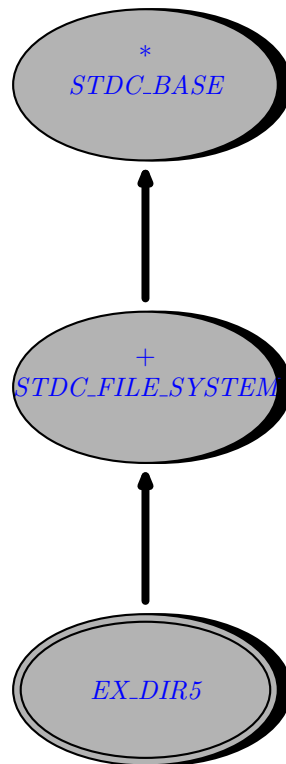


Figure 8.1 BON diagram of deleting and renaming files with Standard C.

feature

```

make is
local
  path: STDC_PATH
do
  create path.make_from_string ("/tmp/myfile.e")
  path.parse (<<".e">>)
  print_path (path)

  create path.make_expand (" $HOME/myfile.e")
  path.parse (<<".e">>)
  print_path (path)
end

print_path (a_path: STDC_PATH) is
do
  print ("Directory: ")
  print (a_path.directory)
  print ("", basename: ")
  print (a_path.basename)
  print ("", suffix: ")

```

```

    print (a_path.suffix)
    print ("%N")
end

```

end

The **parse** feature is used to parse a path into its components. Give it a suffix list to remove any matching suffices. Suffix matching is case-insensitive. If the suffix list is empty, no suffix matching will be done. This follows standard unix behaviour: if a filename has a dot in it, it does not necessarily mean that what follows after that dot is a suffix.

Create a path with **make _expand** to expand any environment variables in the given string to their values.

8.3 POSIX

POSIX defines many commands to navigate a file system. They're made available by the **POSIX_FILE_SYSTEM**. The following example navigates to the user's home directory, create a directory and removes it.

```

class EX_DIR1

inherit

    POSIX_FILE_SYSTEM

creation

    make

feature

    make is
    do
        change_directory (expand_path ("~"))
        make_directory ("qctest.xyz.tmp")
        remove_directory ("qctest.xyz.tmp")
    end

end

```

end

To get access to the file system, inheriting from the **POSIX_FILE_SYSTEM** class is easiest. There are also lots of functions to test for existence, readability or writability of files. Use **is_modifiable** to test if a file is readable and writable.

```

class EX_DIR2

inherit

    POSIX_FILE_SYSTEM

creation

```

make

feature

```

make is
  local
    perm: POSIX_PERMISSIONS
  do
    print_info (is_existing ("/tmp"), "existing")
    print_info (is_executable ("/bin/ls"), "executable")
    print_info (is_readable ("/etc/passwd"), "readable")
    print_info (is_writable ("/etc/passwd"), "writable")
    print_info (is_modifiable ("/etc/passwd"), "readable and writable")

    perm := permissions("/etc/passwd")

    if perm.allow_group_read then
      print ("Group is allowed to read /etc/passwd.%N")
    else
      print ("Group is not allowed to read /etc/passwd.%N")
    end

    if perm.allow_anyone_read_write then
      print ("Anyone is allowed to read file.tmp.%N")
    else
      print ("Anyone is not allowed to read file.tmp.%N")
    end

  end

  print_info (ok: BOOLEAN; what: STRING) is
  do
    print ("is_")
    print (what)
    print (" returned ")
    print (ok)
    print (".%N")
  end

end

```

Be aware that `POSIX_FILE_SYSTEM.is_readable` uses the real user and group IDs instead of the effective ones.

As can be seen in the above example, one can test for the permissions of a file using the `POSIX_PERMISSIONS` class. A new permissions class is created for every `POSIX_FILE_SYSTEM.permissions` call, so it is best to cache this object. If the permissions change on the file system, this class does not reflect reality anymore, because it caches the permissions. Use `POSIX_PERMISSIONS.refresh` to update the contents. Use `set_allow_group_write`, `set_allow_anyone_read` and such to set permissions.

e-POSIX also gives you access to the `stat` function using the `POSIX _STATUS` class.

```
class EX_DIR4

inherit

    POSIX_FILE_SYSTEM

creation

    make

feature

    make is
    local
        stat: POSIX_STATUS
    do
        stat := status ("/etc/passwd")
        print ("size: ")
        print (stat.size.out)
        print (".%N")
        print ("uid: ")
        print (stat.permissions.uid)
        print (".%N")
    end

end
```

The `POSIX _STAT`, and through it `POSIX _PERMISSIONS`, are also returned by `POSIX _FILE _DESCRIPTOR. status`.

Browsing a directory can be done by allocated a `POSIX _DIRECTORY` class through the `POSIX _FILE _SYSTEM. browse _directory` feature:

```
class EX_DIR3

inherit

    POSIX_FILE_SYSTEM

creation

    make

feature

    make is
    local
        dir: POSIX_DIRECTORY
    do
        from
```

```

        dir := browse_directory (".")
        dir.start
    until
        dir.exhausted
    loop
        print (dir.item)
        print ("%N")
        dir.forth
    end
    dir.close
end

```

end

As can be seen, `POSIX_DIRECTORY` follows EiffelBase conventions.

When browsing a directory, all entries in that directory are returned. You might want to be interested only in certain files. e-POSIX has the ability to define arbitrary filters. Standard e-POSIX comes with an extension filter that only shows files with a certain extension:

```

class EX_DIR6

inherit

    POSIX_FILE_SYSTEM

creation

    make

feature

    make is
    local
        dir: POSIX_DIRECTORY
    do
        from
            dir := browse_directory (".")
            dir.set_extension_filter (".e")
            dir.start
        until
            dir.exhausted
        loop
            print (dir.item)
            print ("%N")
            dir.forth
        end
        dir.close
    end
end

end

```

In this chapter:

9.1 Introduction
9.2 Executing a child command
9.3 Reading stdout of a child process
9.4 Catching a signal with Standard C
9.5 Catching a signal with POSIX
9.6 General wait for child handler
9.7 Forking a child process

9

Working with processes

9.1 Introduction

This chapter discusses starting processes, either by executing new ones or forking the current one. It also describes support for process communication using signals.

9.2 Executing a child command

Any command line can be executed by using the `POSIX_SHELL_COMMAND` class. Just pass a command line and `execute` it.

```
class EX_CMD
```

```
creation
```

```
make
```

```
feature
```

```
make is
local
  command: POSIX_SHELL_COMMAND
do
  create command.make ("/bin/ls *")
  command.execute
  print ("Exit code: ")
  print (command.exit_code)
  print ("%N")
end
```

```
end
```

9.3 Reading stdout of a child process

It is possible to read the standard output of a child process or write to its standard input. This is one of the easiest ways to communicate with child processes. The `EPX_EXEC_PROCESS` class makes this possible both under Windows and Unix. For example the

creation feature `make _capture _output` makes the standard output of the child available, while `make _capture _input` makes the standard input available.

```

class EX_EXEC1

inherit

    EPX_CURRENT_PROCESS

creation

    make

feature

    make is
    local
        ls: EPX_EXEC_PROCESS
    do
        -- list contents of current directory
        create ls.make_capture_output ("ls", <<"-l", ".">>)
        ls.execute
        print ("ls pid: ")
        print (ls.pid)
        print ("%N")
    from
        ls.fd_stdout.read_string (512)
    until
        ls.fd_stdout.end_of_input
    loop
        print (ls.fd_stdout.last_string)
        ls.fd_stdout.read_string (512)
    end

    -- close captured io
    ls.fd_stdout.close

    -- wait for process
    ls.wait_for (True)
end

end

```

The three features that give access to the child's standard input, standard output and standard error pipes are named `fd_stdin`, `fd_stdout` and `fd_stderr`.

It is important to wait for the child that has been executed at some point in time, just like any POSIX application would have to do. If you do not wait for a child process, memory in the kernel is not released and eventually you would run out of processes. Also only after the `EPX_EXEC_PROCESS.wait_for` command is the exit code of the process available.

It is possible to write to standard input and read standard output and standard error at the same time, but this requires extreme care. It usually leads to code that deadlocks, because the parent process is reading the standard output of the child and the child is waiting for the parent to write to its standard input. Or the child is blocked while writing to its standard output, because its output buffer is full. But the parent process isn't reading the child's standard output, because it is trying to write to the child's standard input.

Under POSIX it is possible to use the buffered features `stdin`, `stdout` and `stderr`. The following example is the same as the previous example, but uses the `POSIX_EXEC_PROCESS` class:

```
class EX_EXEC2

inherit

    POSIX_CURRENT_PROCESS

creation

    make

feature

    make is
    local
    ls: POSIX_EXEC_PROCESS
    do
        -- list contents of current directory
        create ls.make_capture_output ("ls", <<"-l", ".">>)
        ls.execute
        print ("ls pid: ")
        print (ls.pid)
        print ("%N")
    from
        ls.stdout.read_string (512)
    until
        ls.stdout.end_of_input
    loop
        print (ls.stdout.last_string)
        ls.stdout.read_string (512)
    end

    -- close captured io
    ls.stdout.close

    -- wait for process
    ls.wait_for (True)
end

end
```

It is possible to check if a child process has terminated or not. Pass `False` to the `suspend` parameter of the `EPX_EXEC_PROCESS.wait_for` feature and check `is_terminated` to see if the child process has stopped or not.

9.4 Catching a signal with Standard C

You can catch signals with Standard C. The following example demonstrates a program that can be safely interrupted by pressing Ctrl+C:

```
class EX_SIGNAL3

inherit

    EPX_CURRENT_PROCESS

    STDC_CONSTANTS

    STDC_SIGNAL_HANDLER

creation

    make

feature

    handled: BOOLEAN

    make is
    local
        signal: STDC_SIGNAL
    do
        create signal.make (SIGINT)
        signal.set_handler (Current)
        signal.apply

        print (" Wait 10s or press Ctrl+C.%N")
        sleep (10)
        if handled then
            print (" Ctrl+C pressed.%N")
        else
            print (" Ctrl+C not pressed.%N")
        end
    end

    signalled (signal_value: INTEGER) is
    do
        handled := True
    end

end
```

As Standard C doesn't have a sleep command, this program uses `EPX _CURRENT _PROCESS` to get either the `sleep` from POSIX or from Windows.

More explanation about the program itself can be found in [section 9.5](#).

9.5 Catching a signal with POSIX

Every class can become a signal handler by inheriting from `POSIX _SIGNAL _HANDLER`. Implement the `signalled` method as that is the function that is called when the signal occurs. Use `POSIX _SIGNAL. set _handler` to make your class a signal handler and call `apply` to start receiving signals when they occur.

The following examples demonstrates a program that can be safely interrupted by pressing Ctrl+C:

```
class EX_SIGNAL1

inherit

    POSIX_CURRENT_PROCESS

    POSIX_CONSTANTS

    POSIX_SIGNAL_HANDLER

creation

    make

feature

    handled: BOOLEAN

    make is
    local
        signal: POSIX_SIGNAL
    do
        create signal.make (SIGINT)
        signal.set_handler (Current)
        signal.apply

        print (" Wait 30s or press Ctrl+C.%N")
        sleep (30)
        if handled then
            print (" Ctrl+C pressed.%N")
        else
            print (" Ctrl+C not pressed.%N")
        end
    end
end
```

```

    signalled (signal_value: INTEGER) is
    do
        handled := True
    end

```

```

end

```

All precautions and warnings when handling signals in C apply equally well in Eiffel of course. While in a signal handler, the signal will not be delivered again. Call `STDC_SIGNAL_HANDLER.reestablish` to make your signal handler interruptable.

You can write a single signal handler, that handles multiple signals. This makes it possible to have signal handling code in just one place. Create a class that inherits from `POSIX_SIGNAL_HANDLER`. Pass this class to the `POSIX_SIGNAL.set_handler` for every signal you want to catch. The signal value is passed as parameter to `POSIX_SIGNAL_HANDLER.signalled`, so you can write an `inspect` statement based on the value.

9.6 General wait for child handler

If you do not want to wait for every child process explicitly, you can write a simple `SIGCHLD` handler that just does a wait (I found this idea in (Xxxxxxxxxx, 0000)):

```

class EX_SIGNAL2

inherit

    POSIX_CURRENT_PROCESS

    POSIX_CONSTANTS

    POSIX_SIGNAL_HANDLER

creation

    make

feature

    make is
    local
        signal: POSIX_SIGNAL
    do
        create signal.make (SIGCHLD)
        signal.set_handler (Current)
        signal.apply

        -- spawn child processes here
        -- you dont have to wait for them
    end

```

```

    signalled (signal_value: INTEGER) is
    do
        wait
    end

```

```

end

```

In Unix 98 you should be able to set the ignore handler for this signal. In pure POSIX systems the behaviour of the ignore handler is unspecified.

9.7 Forking a child process

Forking is very easy with this Eiffel POSIX implementation. The steps:

1. Write a child by inheriting from `POSIX_FORK_ROOT` and implementing its `execute` method.
2. The class that will do the forking, should inherit from `POSIX_CURRENT_PROCESS`.
3. Pass the child to the inherited feature `POSIX_CURRENT_PROCESS.fork` and the forking has begun.

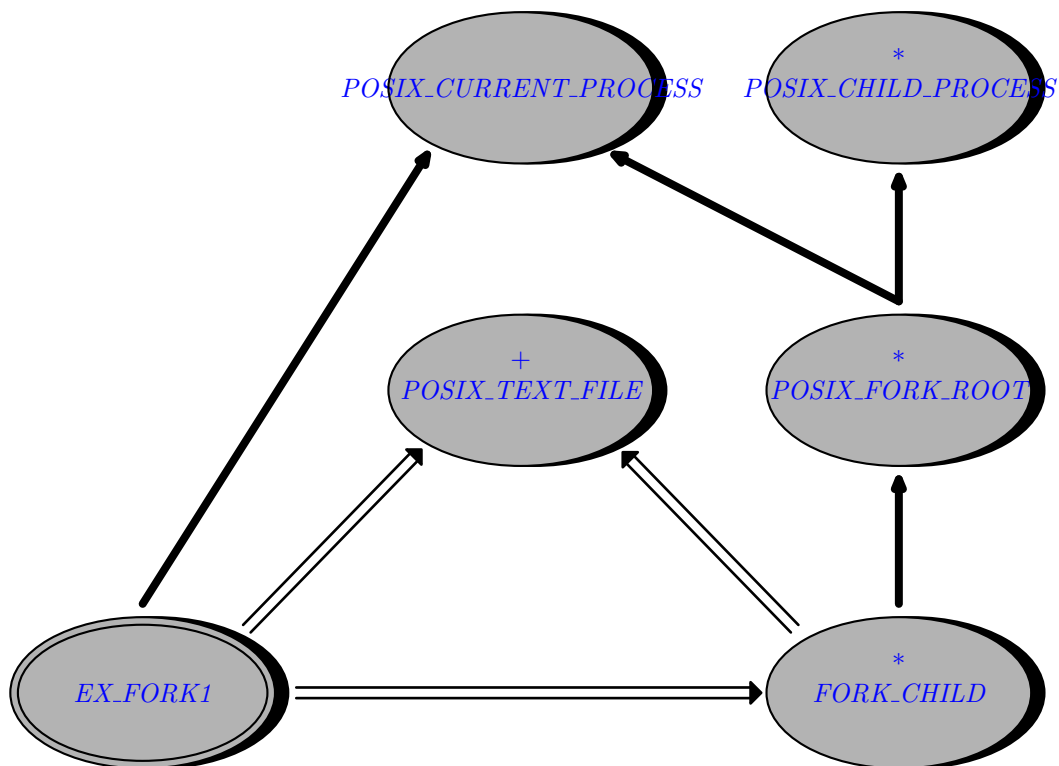


Figure 9.1 BON diagram of forking a child process.

The following class shows the process that forks the child.

```

class

```

```

    EX_FORK1

```

inherit*POSIX_CURRENT_PROCESS**POSIX_FILE_SYSTEM***creation***make***feature***make is***local***reader: POSIX_TEXT_FILE**stop_sign: BOOLEAN**child: FORK_CHILD***do***-- necessary for SmallEiffel before -0.75 beta 7**ignore_child_stop_signal**unlink ("berend.tmp")**create_fifo ("berend.tmp", S_IRUSR + S_IWUSR)***create** *child**fork (child)**-- we will now block until file is opened for writing***create** *reader.open_read ("berend.tmp")***from***stop_sign := False***until***stop_sign***loop***reader.read_string (128)**print (reader.last_string)**stop_sign := equal(reader.last_string, "stop%N")***end***reader.close**-- now wait for the writer to terminate**child.wait_for (True)**unlink ("berend.tmp")***end****end**

This class just displays anything that the writer, the child class, writes to the FIFO. When it recognizes stop, the reader stops after waiting for the child it has spawned. Note that

this is very important! Wait for any child you have spawned else you might get spurious errors if the process exits and a child has not yet finished.

The following class shows the forked child.

```
class FORK_CHILD
```

```
inherit
```

```
    POSIX_FORK_ROOT
```

```
feature
```

```
    execute is
```

```
        local
```

```
            writer: POSIX_TEXT_FILE
```

```
        do
```

```
            create writer.open_append ("berend.tmp")
```

```
            writer.put_string ("first%N")
```

```
            writer.put_string ("stop%N")
```

```
            writer.close
```

```
            -- we give the reader some time to process these messages
```

```
            sleep (10)
```

```
        end
```

```
end
```

In this chapter:

10.1 *Current time*

10.2 *Accessing environment variables*

10.3 *Capabilities*

10

Querying the operat- ing system

10.1 Current time

e-POSIX has a very complete class to work with times. A time can be set from the current time by using `POSIX_TIME.make_from_now`. Before a time can be printed, it needs to be converted to either local time or UTC. Do this by calling `to_local` or `to_utc`. Date and times can be printed using features as `default_format`, `local_date_string`, `local_time_string` or a custom format through `format`.

```
class EX_TIME1
```

```
creation
```

```
make
```

```
feature
```

```
make is
```

```
local
```

```
time1,
```

```
time2: POSIX_TIME
```

```
do
```

```
create time1.make_from_now
```

```
time1.to_local
```

```
print_time (time1)
```

```
time1.to_utc
```

```
print_time (time1)
```

```
create time2.make_time (0, 0, 0)
```

```
print_time (time2)
```

```
create time2.make_date_time (1970, 10, 31, 6, 55, 0)
```

```
time2.to_utc
```

```
print_time (time2)
```

```
if time2 < time1 then
```

```
print ("time2 is less than time1 as expected.%N")
```

```
else
```

```
print ("!! time2 is not less than time1.%N")
```

```
end
```

```
end
```

```

print_time (time: POSIX_TIME) is
do
  print ("Date: ")
  print (time.year)
  print ("-")
  print (time.month)
  print ("-")
  print (time.day)
  print (" ")
  print (time.hour)
  print (":")
  print (time.minute)
  print (":")
  print (time.second)
  print ("%N")
  print ("Weekday: ")
  print (time.weekday)
  print ("%N")
  print ("default string: ")
  print (time.default_format)
  print ("%N")
end

end

```

10.2 Accessing environment variables

Standard C supports reading environment variables with `STDC_ENV_VAR`.

```

class EX_ENV2

creation

  make

feature

  make is
  local
    env: STDC_ENV_VAR
  do
    create env.make ("HOME")
    print (env.value)
    print ("%N")
  end

end

```

The POSIX doesn't add any functionality here:

```
class EX_ENV1

creation

  make

feature

  make is
  local
    env: POSIX_ENV_VAR
  do
    create env.make ("HOME")
    print (env.value)
    print ("%N")
  end

end
```

It is not possible in POSIX to set an environment variable. This is possible with the Single Unix Specification classes. Using `SUS_ENV_VAR``set_value` it is possible to set environment variables.

10.3 Capabilities

Use the portable `EPX_SYSTEM` class to query for various system dependent constants like `max_open_files`. There are operating system dependent queries in `POSIX_SYSTEM` and `WINDOWS_SYSTEM`.

In this chapter:

11.1*MIME parsing*

11.2*Sockets*

11.3*Echo client*

11.4*Echo client and server*

11

Working with the network

11.1 *MIME parsing*

Many of the Internet's protocols send data in MIME format. e-POSIX offers a MIME parser in [EPX _MIME _PARSER](#) to parse such data and MIME message creation in [EPX _MIME _PART](#).

MIME messages consist of two parts: a header and a body. The body itself can consist of another header and body. Some examples of using this class are shown in [section 12.7](#).

11.2 *Sockets*

e-POSIX currently has fairly complete socket support. Not every option offered by the Single Unix Specification is supported yet, but as always we will attempt in every release to reach full support for every function offered.

As usual the EPX_XXXX classes are available on both Unix and Windows platform. The SUS_XXXX classes are available only on Single Unix Specification () systems and extend the EPX_XXXX classes with Unix specific functionality.

TCP functionality is available for both Windows and Unix. UDP is only available on Unix, as well as Unix streams.

11.3 *Echo client*

The following example demonstrates a simple echo client for TCP. An echo server must be running on your machine:

```
class EX_ECHO_CLIENT_TCP
```

```
creation
```

```
make
```

```
feature
```

```
hello: STRING is "Hello World.%N"
```

```
make is
```

```
local
```

```
host: EPX_HOST
```

```

service: EPX_SERVICE
echo: EPX_TCP_CLIENT_SOCKET
sa: EPX_HOST_PORT
do
  create host.make_from_name ("localhost")
  create service.make_from_name ("echo", "tcp")

  create sa.make (host, service)

  create echo.open_by_address (sa)
  echo.put_string (hello)
  echo.read_string (256)
  if not echo.last_string.is_equal (hello) then
    print ("!! got: ")
    print (echo.last_string)
  end
end

end

```

The following example demonstrates a simple echo client for UDP. An echo server must be running on your machine:

```

class EX_ECHO_CLIENT_UDP

creation

make

feature

hello: STRING is "Hello World.%N"

make is
local
  host: SUS_HOST
  service: SUS_SERVICE
  echo: SUS_UDP_CLIENT_SOCKET
  sa: EPX_HOST_PORT
do
  create host.make_from_name ("localhost")
  create service.make_from_name ("echo", "udp")

  create sa.make (host, service)

  create echo.open_by_address (sa)
  echo.put_string (hello)
  echo.read_string (256)
  if not echo.last_string.is_equal (hello) then
    print ("!! got: ")
    print (echo.last_string)
  end
end

```

```

    end
  end

end

```

11.4 Echo client and server

The following class demonstrates an echo server and client in a single class. It uses unix sockets (a fast interprocess communication) to achieve that.

```

class EX_ECHO_UNIX

inherit

  SUS_FILE_SYSTEM

  SUS_CONSTANTS

creation

  make

feature

  make is
    -- Echo client and server, unix style.
  local
    client_socket: SUS_UNIX_CLIENT_SOCKET
    server_socket: SUS_UNIX_SERVER_SOCKET
    client_fd: SUS_UNIX_SOCKET
    correct: BOOLEAN
  do
    if is_existing ("/tmp/eposix") then
      unlink ("/tmp/eposix")
    end
    create server_socket.listen_by_path ("/tmp/eposix", SOCK_STREAM)
    create client_socket.open_by_path ("/tmp/eposix", SOCK_STREAM)
    client_fd := server_socket.accept
    client_socket.put_string (hello)
    client_fd.read_string (256)
    correct := client_fd.last_string.is_equal (hello)
    if not correct then
      print ("Oops.%N")
    end
    client_fd.put_string (berend)
    client_socket.read_string (256)
    correct := client_socket.last_string.is_equal (berend)
    if not correct then
      print ("Oops.%N")
    end
  end
end

```

```

    client_socket.close
    client_fd.close
    server_socket.close
    unlink ("/tmp/eposix")
end

feature {NONE} -- Implementation

    hello: STRING is "Hello World.%N"
    berend: STRING is "hello berend.%N"

end

```

The following class is similar, but uses TCP.

```

class EX_ECHO_TCP

inherit

    SUS_CONSTANTS

creation

    make

feature

    make is
        -- Echo client and server, tcp style.
    local
        host: SUS_HOST
        service: SUS_SERVICE
        client_socket: SUS_TCP_CLIENT_SOCKET
        server_socket: SUS_TCP_SERVER_SOCKET
        sa: EPX_HOST_PORT
        client_fd: ABSTRACT_TCP_SOCKET
        correct: BOOLEAN
    do
        create host.make_from_name ("localhost")
        create service.make_from_port (port, "tcp")
        create sa.make (host, service)
        create server_socket.listen_by_address (sa)
        create client_socket.open_by_address (sa)
        client_fd := server_socket.accept
        client_socket.put_string (hello)
        client_fd.read_string (256)
        correct := client_fd.last_string.is_equal (hello)
    if not correct then
        print ("Oops.%N")
    end
    client_fd.put_string (berend)
end

```



```
    client_socket.read_string (256)
    correct := client_socket.last_string.is_equal (berend)
    if not correct then
        print ("Oops.%N")
    end

    client_socket.close
    client_fd.close
    server_socket.close
end

feature {NONE} -- Implementation

port: INTEGER is 9877
    -- Thanks to W. Richard Stevens

hello: STRING is "Hello World.%N"
berend: STRING is "hello berend.%N"

end
```

In this chapter:

12.1 *Introduction*
12.2 *FTP client*
12.3 *HTTP client*
12.4 *HTTP server*
12.5 *IMAP4 client*
12.6 *IRC client*
12.7 *SMTP client*
12.8 *Sending plain text email*
12.9 *Sending HTML email*
12.10 *Sending both text and HTML email*
12.11 *LDIF parser*

12

Working with the network: ad- vanced top- ics

12.1 *Introduction*

In version 2.0 e-POSIX has introduced the first of a series of classes for writing common Internet clients and servers.

Many of these classes are a work in progress, and might not have the robustness desired for critical applications.

12.2 *FTP client*

The e-POSIX FTP client supports almost all FTP operations, but currently has a fairly basic interface. Read and write operations return a stream for example. Reading and writing files to the file system is left as an exercise for the reader.

The following example demonstrates reading a directory from an FTP server and receiving a file:

```
class EX_FTP1

creation

make

feature

make is
local
ftp: EPX_FTP_CLIENT
do
-- ftp://ftp.nlm.nih.gov/nlmdata/sample/serfile/serfilesamp2005.xml
create ftp.make_anonymous (server_name, "guest")
ftp.open
if ftp.is_positive_completion_reply then
ftp.change_directory (directory_name)
ftp.name_list
```

```

    dump_data_connection (ftp.data_connection)
    ftp.read_reply
    ftp.retrieve (file_name)
    dump_data_connection (ftp.data_connection)
    ftp.read_reply
    ftp.quit
    ftp.close
  else
    print ("Connect fails.%N")
  end
end

```

```

dump_data_connection (stream: KI_CHARACTER_INPUT_STREAM) is
  -- Dump stream input.
  require
    stream_not_void: stream /= Void
  do
    from
      stream.read_character
    until
      stream.end_of_input
    loop
      print (stream.last_character)
      stream.read_character
    end
    stream.close
  end
end

```

feature -- Access

```

directory_name: STRING is "/pub/FreeBSD"

file_name: STRING is "README.TXT"

server_name: STRING is "ftp.freebsd.org"

end

```

EXP_FTP_CLIENT also supports creating (`make_directory`) or deleting directories (`remove_directory`), deleting (`remove_file`), renaming (`rename_to`), and uploading files (`store`).

12.3 HTTP client

The following example demonstrates retrieval of a file through HTTP using the `EXP_HTTP_10_CLIENT` class:

```

class EX_HTTP1

  creation

```

```
make
```

```
feature
```

```
url: STRING is "http://www.freebsd.org/index.html"
```

```
make is
```

```
local
```

```
uri: UT_URI
```

```
client: EPX_HTTP_10_CLIENT
```

```
do
```

```
create uri.make (url)
```

```
create client.make (uri.authority) -- www.freebsd.org
```

```
client.get (uri.path) -- /index.html
```

```
client.read_response
```

```
print (client.body.as_string)
```

```
end
```

```
end
```

It also demonstrates the use of the `UT_URI` class to parse an URI into its components.

12.4 HTTP server

e-POSIX offers a basic HTTP server in `EPX_HTTP_SERVER`. The following example demonstrates starting such a server and let it listen on the local interface.

```
class EX_HTTP_SERVER1
```

```
inherit
```

```
EPX_CURRENT_PROCESS
```

```
creation
```

```
make
```

```
feature
```

```
make is
```

```
local
```

```
server: EPX_HTTP_SERVER
```

```
do
```

```
create server.make (port_to_listen_on, document_root)
```

```
server.set_serve_xhtml_if_supported (False)
```

```
server.listen_locally
```

```
from
```

```
until
```

```
False
```

```
loop
```

```

    server.process_next_requests
    millisleep (100)
end
end

port_to_listen_on: INTEGER is 5566

document_root: STRING is "/var/www/html"

end

```

`EPX_HTTP_SERVER` will say to clients that it serves XHTML instead of HTML. Or in MIME types: `application/xhtml+xml` instead of `text/html`. In case that the HTML pages which are served are not actually XHTML, you will need to turn this option off with a call to `set_serve_xhtml_if_supported`.

In the main loop all available requests are served after which a brief sleep follows. Without the sleep the process would use 100% CPU.

The server will return the files under `/var/www/html` from the file system to the browser. It's also possible to create and register servlets which can respond to requests. A servlet is like a built-in CGI program. A servlet allows maximum control over the response send to the browser, not only the response header, but also the response code send to the client.

A servlet is built after REST principles. A servlet is designed to behave like a resource. You can bind it to a URL and after that it can handle any of the HTTP commands as GET, POST, or PUT that are send to it. By default a servlet will return error code 405, meaning "Method not allowed". The simplest servlet, which always returns 405 is therefore the following:

```

class EX_HTTP_SERVLET1

inherit

    EPX_HTTP_SERVLET

creation

    make

end

```

This servlet has to be registered with the HTTP server. The following example shows a virtual HTTP server, one that doesn't have a document root and therefore will never read the file system. It attaches the servlet to the url `/customers`.

```

class EX_HTTP_SERVER2

inherit

    EPX_CURRENT_PROCESS

creation

```

```
make
```

```
feature
```

```
make is
```

```
local
```

```
server: EPX_HTTP_SERVER
```

```
servlet: EX_HTTP_SERVLET2
```

```
do
```

```
create server.make_virtual (port_to_listen_on)
```

```
create servlet.make
```

```
server.register_fixed_resource ("/customers", servlet)
```

```
server.listen_locally
```

```
from
```

```
until
```

```
False
```

```
loop
```

```
server.process_next_requests
```

```
millisleep (100)
```

```
end
```

```
end
```

```
port_to_listen_on: INTEGER is 5566
```

```
end
```

You might have noticed it attached servlet `EX_HTTP_SERVLET2`. This servlet is shown below:

```
class EX_HTTP_SERVLET2
```

```
inherit
```

```
EPX_HTTP_SERVLET
```

```
redefine
```

```
get_header
```

```
end
```

```
creation
```

```
make
```

```
feature {EPX_HTTP_SERVER} -- Execution
```

```
get_header is
```

```
do
```

```
doctype
```

```
b_html
```

```
b_head
```

```
title ("Customers")
```

```

e_head
b_body
p ("1. John")
p ("2. Luke")
p ("3. Matthew")
p ("4. Pete")
e_body
e_html
write_default_header
add_content_length
end

end

```

Only the `EX_HTTP_SERVLET.get_header` method needs to be overwritten. The format is usually to write the body first and write the header last. This might seem counter-intuitive, but for persistent connections you need to supply a Content-Length if you write a body. Another solution would be to use the chunked transfer encoding, but that isn't explicitly supported yet, so you have to do the work yourself here.

So for dynamically created content, you usually write the body in the header, so you can setup the header. There is also a `EX_HTTP_SERVLET.get_body`, but it is usually not overridden for dynamic content.

The `EPX_HTTP_SERVER` class is responsible for sending the header and the body and to guard against any errors.

In the same manner you can write code to react to PUT, POST or DELETE requests. As browsers usually do not support PUT or DELETE requests, `EPX_HTTP_CONNECTION` will turn a POST request into a PUT or DELETE when it finds a special value. The implementation is in `remap_http_method`. This happens under the following circumstances:

1. The request is a POST request.
2. The POST request is a submit of form fields (regardless of the chosen encoding).
3. There is a form field that starts with the name "http-method:".

In these cases the substring after "http-method:" is taken to override the POST request into whatever is present as substring.

Figure 12.1 shows the BON diagram of the `EPX_HTTP_SERVER`. A server can have zero or more registered servlets and zero or more open connections.



Figure 12.1 BON diagram of `EPX_HTTP_SERVER`.

The server supports persistent connections. In HTTP/1.1 connections are persistent by default. If not requested otherwise, the server will keep the connection open and monitor it to see if any data is coming in. If no data has been sent in the last 15 seconds, the connection is forcibly closed.

The server can have zero or more servlets registered. A single servlet can be connected to multiple URLs by calling `EPX_HTTP_SERVER.register_fixed_resource` with the same servlet.

There is also a `register_dynamic_resource` call to register servlets where part of the data is present in the URL. For example the URL `/customer/1` looks much better than `/customer?id=1`. Register a servlet that takes part of the URL as input as follows:

```
server.register_dynamic_resource ("/customer/(id)", servlet)
```

Every name present between parentheses in such a path is appended to `EPX_HTTP_CONNECTION.request_form_fields`. To a servlet it does therefore not matter if a query is used to input the data, if it is part of a POST or if it was part of the URL. It all becomes input data.

12.5 IMAP4 client

e-POSIX implements an IMAP4 client that supports IMAP4 access. The following example connects to an IMAP4 server and performs various operations:

```
class EX_IMAP41

inherit

    POSIX_CURRENT_PROCESS

creation

    make

feature

    make is
    local
        client: EPX_IMAP4_CLIENT
    do
        create client.make (host)
        if client.is_open then
            client.login (login_name, password)
            if client.response.is_ok then
                client.list_subscribed
                client.examine ("INBOX")
                client.fetch_message (4)
                print (client.response.current_message.message)
                client.close_mailbox
                client.logout
            else
                print ("Login failed.%N")
            end
        client.close
    else
```



```

    print ("Cannot connect to server.%N")
end
end

feature -- Access

    host: STRING is "bmach"

    password: STRING is
    local
        password_env: STDC_ENV_VAR
    once
        create password_env.make ("IMAP4_PASSWORD")
        Result := password_env.value
    ensure
        password_not_void: Result /= Void
    end

end
end

```

The first operation is reading the list of available folders.. Next it examines the standard INBOX folder, i.e. open it for reading only. It reads message 4 and prints it. And finally it closes the mailbox.

The e-POSIX IMAP4 is fairly full featured, it can read and write messages and receive various pieces of information about the email such as just its header or its size.

12.6 IRC client

e-POSIX also has an IRC client implementation, `EPX_IRC_CLIENT`. The following example demonstrates logging on to the `#eiffel` channel on `irc.freenode.net` and printing all the messages.

```

class EX_IRC1

creation

    make

feature

    make is
    local
        irc: EPX_IRC_CLIENT
        eiffel: EPX_IRC_CHANNEL
    do
        create irc.make (host, username, password)
        irc.set_print_response (True)
        irc.set_real_name ("EiffelBot")
        irc.open
    end
end

```

```

if irc.is_open then
  irc.read_all
  irc.join("#eiffel")
  eiffel := irc.last_joined_channel
  irc.set_blocking_io (True)
from
  irc.read
until
  False
loop
  irc.read
end
-- We wont come here.,,
irc.close
end
end

host: STRING is "irc.freenode.net"

username: STRING is "eiffelbot"

password: STRING
-- n/a

end

```

The printing is done by calling `EPX_IRC_CLIENT.set_print_response`. Not something you probably will use except when debugging. Also we set `set_blocking_io` to True, but real IRC clients will be non-blocking.

Look at the test class `TEST_IRC_CLIENT` for more examples, or download the Eiffel Bot from the e-POSIX page.

12.7 SMTP client

`EPX_SMTP_CLIENT` implements support for sending email to an SMTP server. It only supports servers that can receive 8 bit messages. This class cannot convert 8 bit data to 7 bit data.

12.8 Sending plain text email

The following example demonstrates sending a plain text email with this class:

```

class EX_SMTP1

creation

  make

feature

```

```

make is
local
  message: EPX_MIME_EMAIL
  mail: EPX_SMTP_MAIL
  smtp: EPX_SMTP_CLIENT
do
  create message.make
  message.header.set_from ("Berend de Boer", "berend@pobox.com")
  message.header.set_to ("Berend de Boer", "berend@pobox.com")
  message.header.set_subject ("EX_SMTP1")
  message.create_singlepart_body
  message.text_body.append_string ("Hello!")
  create mail.make (sender_mailbox, recipient_mailbox, message)
  create smtp.make (smtp_server_name)
  smtp.open
  smtp.ehlo (my_domain)
  smtp.mail (mail)
  smtp.quit
  smtp.close
end

my_domain: STRING is "nederware.nl"

smtp_server_name: STRING is "localhost"

sender_mailbox: STRING is "berend"

recipient_mailbox: STRING is "berend"

end

```

There are three steps in creating an email:

1. Create the message using `EPX_MIME_EMAIL`, which basically is an `EPX_MIME_PART`. It has and has several convenience routines to quickly create such a message.
2. Create the mail using `EX_SMTP_MAIL`. This class is a container for the sender, the recipients and the actual message that is to be sent.
3. Create an instance of the `EPX_SMTP_CLIENT` class. The `EPX_SMTP_CLIENT.ehlo` command identifies the client with the server. Pass as argument the local domain, or if this is not available, the ip address of the client. The actual message is send after calling the `mail` command. It's argument is the Eclass`EPX_SMTP_MAIL` instance created in the previous step.

After the message has been sent, `EPX_SMTP_CLIENT.quit` is called to end the session and `close` is called to close the connection with the SMTP server.

The creation routine of `[EPX_SMTP_CLIENT]` takes as argument the SMTP server. Correctly finding the SMTP server for a given recipient involves querying a DNS server for MX records. e-POSIX does not support this at the moment. However, passing the local SMTP server is usually sufficient as this server knows how to figure this out.

12.9 Sending HTML email

The following example demonstrates sending an HTML text email with this class:

```
class EX_SMTP2

creation

make

feature

make is
local
  type_names: expanded EPX_MIME_TYPE_NAMES
  message: EPX_MIME_EMAIL
  mail: EPX_SMTP_MAIL
  smtp: EPX_SMTP_CLIENT
do
  create message.make
  message.header.set_from ("Berend de Boer", "berend@pobox.com")
  message.header.set_to ("Berend de Boer", "berend@pobox.com")
  message.header.set_subject ("EX_SMTP2")
  message.header.set_content_type (
    type_names.mime_type_text, type_names.mime_subtype_html,
    "us-ascii")
  message.create_singlepart_body
  message.text_body.append_string (html)
  create mail.make (sender_mailbox, recipient_mailbox, message)
  create smtp.make (smtp_server_name)
  smtp.open
  smtp.ehlo (my_domain)
  smtp.mail (mail)
  smtp.quit
  smtp.close
end

my_domain: STRING is "nederware.nl"

smtp_server_name: STRING is "localhost"

sender_mailbox: STRING is "berend"

recipient_mailbox: STRING is "berend"

html: STRING is "[
<html>
<head>
  <title>EX_SMTP2</title>
</head>
"
```

```

<body>
  <h1>Hello</h1>
  <p>HTML email, brought to you by eposix.</p>
</body>
]"

```

end

The main difference is setting the content type to be “text/html”. And the body must be HTML of course.

12.10 Sending both text and HTML email

As not all email clients can display HTML, most mailers send both a text and an HTML version. The following example demonstrates how this can be done in e-POSIX:

```

class EX_SMTP3

creation

  make

feature

  make is
  local
    type_names: expanded EPX_MIME_TYPE_NAMES
    message: EPX_MIME_EMAIL
    ct: EPX_MIME_FIELD_CONTENT_TYPE
    text_part,
    html_part: EPX_MIME_PART
    mail: EPX_SMTP_MAIL
    smtp: EPX_SMTP_CLIENT
  do
    create message.make
    message.header.set_from ("Berend de Boer", "berend@pobox.com")
    message.header.set_to ("Berend de Boer", "berend@pobox.com")
    message.header.set_subject ("EX_SMTP3")
    create ct.make_multipart (
      type_names.mime_subtype_alternative,
      "----=_my-boundary----")
    message.header.add_field (ct)
    message.create_multipart_body

    text_part := message.multipart_body.new_part
    text_part.header.set_content_type (
      type_names.mime_type_text, type_names.mime_subtype_plain,
      "ISO-8859-1")
    text_part.create_singlepart_body
    text_part.text_body.append_string (text)

```

```

html_part := message.multipart_body.new_part
html_part.header.set_content_type (
  type_names.mime_type_text, type_names.mime_subtype_html,
  "ISO-8859-1")
html_part.create_singlepart_body
html_part.text_body.append_string (html)

create mail.make (sender_mailbox, recipient_mailbox, message)
create smtp.make (smtp_server_name)
smtp.open
smtp.ehlo (my_domain)
smtp.mail (mail)
smtp.quit
smtp.close
end

my_domain: STRING is "nederware.nl"

smtp_server_name: STRING is "localhost"

sender_mailbox: STRING is "berend"

recipient_mailbox: STRING is "berend"

html: STRING is "[
<html>
<head>
  <title>EX_SMTP3</title>
</head>
<body>
  <h1>Hello</h1>
  <p>HTML email, brought to you by eposix.</p>
</body>
]"

text: STRING is "Hello%N%NHTML email, brought to you by eposix."

end

```

We set the content type to be “multipart/alternative”, and create two parts. The first part is content type “text/plain” and the second is the content type “text/html”.

12.11 LDIF parser

e-POSIX contains an LDIF (LDAP Data Interchange Format) parser, see RFC 2849.

In this chapter:

13.1 *Introduction*
13.2 *Windows*
13.3 *Creating a daemon*
13.4 *Logging messages and errors*
13.5 *ULM based logging*

13

Writing daemons

13.1 Introduction

e-POSIX has several classes that help with writing daemons or services. First of all there is the `POSIX_DAEMON` ancestor class. But as daemons have no user interface, there are also classes for error and information logging.

13.2 Windows

On Windows NT (and derivatives) the equivalent of unix daemons are called services. They are a lot harder to write and require an Eiffel compiler with multi-threading. It is not yet possible to write an NT service with e-POSIX.

The logging functionality described in this chapter does work on Windows NT though.

13.3 Creating a daemon

Creating a simple daemon is easy if you inherit from `POSIX_DAEMON`. Implement the `execute` method, and you're done. At run-time, call `detach` to fork off a child. You can call `detach` as many times as you want to spawn daemons.

```
class EX_DAEMON
```

```
inherit
```

```
    POSIX_DAEMON
```

```
    ARGUMENTS
```

```
creation
```

```
    make
```

```
feature -- the parent
```

```
    make is
```

```
    do
```

```
        -- necessary under SmallEiffel
```

```
        ignore_child_stop_signal
```

```

if argument_count = 0 then
  print ("Options:%N")
  print ("-d    start daemon%N")
else
  if equal(argument(1), "-d") then
    detach
    print ("Daemon started.%N")
    print ("Its pid: ")
    print (last_child_pid)
    print ("%N")
  end
end
end

feature -- the daemon

execute is
do
  -- daemon stays alive for 20 seconds
  sleep (20)
end

end

```

13.4 Logging messages and errors

Although POSIX doesn't have logging facilities, the Single Unix Specification does. This specification requires the presence of the `syslogd` daemon for centralizes logging facilities. The following example shows you to write messages to this daemon

```

class EX_SYSLOG

inherit

  SUS_CONSTANTS

  SUS_SYSLOG_ACCESSOR

creation

  make

feature

  make is
  do
    syslog.open ("test", LOG_ODELAY + LOG_PID, LOG_USER)

    syslog.debug_dump ("this is a debug message")
    syslog.info ("this is an informational message")
  end

```



```

        syslog.warning ("this is a warning")
        syslog.error ("this is an error message")

        syslog.close
    end

end

```

Always use the `SUS_SYSLOG_ACCESSOR` to access the syslog wrapper class `SUS_SYSLOG`. `SUS_SYSLOG` is a singleton, it makes no sense to open a connection to the syslog daemon twice.

13.5 ULM based logging

e-POSIX has portable routines for logging in Windows NT and Unix. This is build using the ULM (Universal Format for Logger Messages) specification. The specification itself can be found at <http://www.hsc.fr/gul/draft-abela-ulm-05.txt>. It is a fixed format for logging that makes it easier to extract data with other tools.

On Unix e-POSIX outputs messages to the syslog daemon, see [section 13.4](#). On Windows e-POSIX logs to the event log. This makes this kind of logging specific to Windows NT based systems. It will not work on Windows 9x based systems.

Below a short example of using ULM. The first step is to create a handler that does the actual logging. The class `EPX_LOG_HANDLER` is operating system specific. If you compile on Windows it gives NT event log logging, on Unix it gives syslog logging. There is no logging mechanism for Windows 9x, but it should not be hard to write one. Just implement `ULM_LOG_HANDLER` and implement the deferred routines.

The second step is connecting that handler to the class that does ULM logging, the `ULM_LOGGING` class. Logging is now set up.

```

class EX_ULM

creation

    make

feature -- Initialization

    make is
    local
        logger: ULM_LOGGING
        handler: EPX_LOG_HANDLER
        field: ULM_FIELD
        fields: ARRAY [ULM_FIELD]
    do
        -- Create handler and logger
        create handler.make (identification)
        create logger.make (handler, system_name)
    end
end

```

```

-- Log a simple message
logger.log_message (logger.Alert, subsystem_name, "Hello World.")

-- Log a message with a custom field
create fields.make (0, 0)
create field.make (logger.SRC_IP, "127.0.0.1")
fields.put (field, 0)
logger.log_event (logger.Usage, Void, fields)
end

feature -- Access

identification: STRING is "example"

system_name: STRING is "ex_ulm"

subsystem_name: STRING is "none"

end

```

Two messages are written. Below the slightly formatted output Unix:

```

Jul 21 21:12:34 dellius example: DATE=20030721091234 \
HOST=dellius.nederware.nl PROG="ex_ulm.none" LVL=Alert \
MSG="Hello World."
Jul 21 21:12:34 dellius example: DATE=20030721091234 \
HOST=dellius.nederware.nl PROG="ex_ulm" LVL=Usage \
SRC_IP=127.0.0.1

```

The first message is in the default format. This will always log the date, the host where the message originated and the program. The program field, PROG, consists of a system and subsystem name, separated by dots. This subsystem name is the second parameter to `ULM_LOGGING.log_message`. It may be Void, in which case no subsystem is added to the system name. The level field, LVL, contains the importance of the message. It is the first parameter to `ULM_LOGGING.log_message`. The class `ULM_LOG_LEVELS` has the complete list of levels. And in most cases the log ends with a simple message, MSG, that contains the message itself.

Feature `ULM_LOGGING.log_event` allows more control over the fields that are logged. That is demonstrated in the second message. You can pass the fields that are logged. You can use the fields listed in <http://www.hsc.fr/gul/draft-abela-ulm-05.txt>, or any other field. There is no MSG field if you don't specify one.

An interesting application of the ULM specification is the NetLogger library, see <http://www-didc.lbl.gov/NetLogger/>. It is a protocol to measure response times for a distributed application.

On Windows NT you can use the supplied `messages.dll` file to avoid this message in the event log:

```

The description for Event ID ( some_number4 ) in Source
( some_name ) cannot be found. The local computer may not have
the necessary registry information or message DLL files to
display messages from a remote computer.

```

Register this DLL under the HKLM/SYSTEM/CurrentControlSet/Services/Eventlog/Application key. Add a new key which should have the name you have supplied to the [EPX_LOG_HANDLER.make](#) routine. This key should have two values:

1. EventMessageFile, type REG_SZ. Its value is the full path to this messages.dll file.
2. TypesSupported, type DWORD. Its value should be 7.

In this chapter:

14

Writing CGI programs

Although writing a CGI program doesn't really belong to POSIX, they still are very common, so I decided to include a few classes to make this easier. And of course, they build upon the Standard C classes.

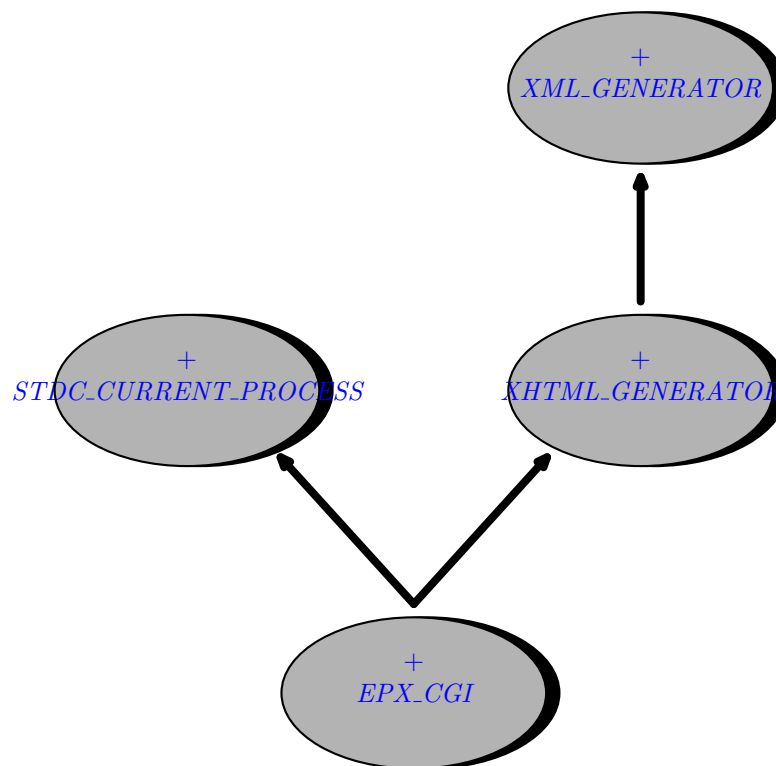


Figure 14.1 BON diagram of `EPX_CGI`.

You inherit from `EPX_CGI` and implement `execute`. As `EPX_CGI` itself inherits from `EPX_XHTML_WRITER` you can call use the features of that class to generate XHTML.

```
class EX_CGI1
```

```
inherit
```

```
EPX_CGI
```

```
creation
```

```
make

feature

  execute is
  do
    content_text_html

    doctype
    b_html

    b_head
    title ("e-POSIX CGI example.")
    e_head

    b_body

    p ("Hello World.")
    extend ("<p>you can use your <b>own</b> tags.</p>")
    b_p
    puts ("or use any tag by using:")
    e_p

    start_tag ("table")
    set_attribute ("border", Void)
    set_attribute ("cols", "3")
    start_tag ("tr")
    start_tag ("td")
    add_data ("start_tag")
    stop_tag
    start_tag ("td")
    add_data ("stop_tag")
    stop_tag
    stop_tag
    stop_tag

    e_body
    e_html

  end

end
```

Output is accumulated in a string and written to stdout after your `EPX_CGI.execute` method has finished. The partially built string is accessible with `EPX_XML_WRITER.unfinished_xml`. Generated output is XHTML, which usually displays fine with older browsers. If strict XHTML is problematic, you can call `doctype_transitional` instead of `doctype`.

It is important not to write to stdout as the output is only written after your `EPX_CGI.execute` has finished. If you want to write something to standard output, use the `EPX`

`_CGI.add_data` feature or its shortcut alias `puts`. If you want to write real tags, use `add_raw`. This last feature allows you to write anything, while `puts` escapes reserved characters like '>'.

If you use provided features like `b_a`, `b_p` and such, an attempt is made to produce good looking source. Also your input is somewhat validated against XHTML standards.

It is also easy to write a CGI program that displays a form and accepts submitted values. Even file upload is supported. The following example uses the GET method to submit data:

```
class EX_CGI2

inherit

    EPX_CGI

creation

    make

feature

    execute is
    do
        content__text__html

        doctype
        b_html

        b_head
        title ("e-POSIX CGI form example.")
        e_head

        b_body

        b_form_get ("ex_cgi2.bin")

        b_p
        puts ("Name: ")
        b_input ("text", "name")
        set_attribute ("size", "32")
        e_input
        e_p

        b_p
        puts ("City: ")
        input_text ("city", 40, "enter city here")
        e_p
```

```

    b_p
    b_button_submit ("action", "GO!")
    e_button_submit

    nbsp

    button_reset
    e_p

    e_form

    hr

    p ("In your last submit you entered:")
    b_p
    if not has_key ("name") then
        puts ("!!!!")
    end
    puts ("name: ")
    puts (value ("name"))
    puts (", ")
    puts ("city: ")
    puts (raw_value ("city"))
    e_p

    e_body
    e_html

end

end

```

You can use `EPX_CGI.b_input` to start an input element as shown for the input of a name. Or you can use `input_text` to start a simple text input as shown for the input of a city. Below the line you see the value a user has submitted, if any. Use `value` to get values with certain meta-characters removed. The output is still not safe to be passed straight to a Unix Shell though! You can use `raw_value` to get the contents as submitted by the user.

In the above example it doesn't matter much if you use `b_form_get` or `b_form_post`. But with the GET method, you cannot upload files. The following example demonstrates how files can be uploaded:

```
class EPX_CGI3
```

```
  inherit
```

```
    EPX_CGI
```

```
  creation
```

make

feature

execute is

do

content_text_html

assert_key_value_pairs_created
save_uploaded_files

doctype
b_html

b_head
title ("e-POSIX CGI file upload example.")
e_head

b_body

b_form ("post", "ex_cgi3.bin")
set_attribute ("enctype", "mime_type_multipart_form_data")

b_p
puts ("Filename: ")
b_input ("file", "filename")
set_attribute ("size", "32")
set_attribute ("maxlength", "128")
e_input
e_p

b_p
b_button_submit ("action", "Upload file(s)")
e_button_submit

nbsp

button_reset
e_p

e_form

e_body
e_html

end

save_uploaded_files is
local


```

kv: EPX_KEY_VALUE
buffer: STDC_BUFFER
target_name: STRING
target: STDC_BINARY_FILE
do
  create buffer.allocate (8192)
  from
    cgi_data.start
  until
    cgi_data.after
  loop
    kv := cgi_data.item_for_iteration
    if kv.file /= Void then
      from
        target_name := "/tmp/" + kv.value
        create target.create_write (target_name)
        kv.file.read_buffer (buffer, 0, 8192)
      until
        kv.file.end_of_input
      loop
        target.write_buffer (buffer, 0, kv.file.last_read)
        kv.file.read_buffer (buffer, 0, 8192)
      end
      target.close
      kv.file.close
    end
    cgi_data.forth
  end
  buffer.deallocate
end

end

```

It is important to set the encoding type. This example accepts a file and writes it to `/tmp`. Because multiple files can be present, this example just loops over all key value pairs and checks if a file is present. This example isn't fool-proof with multiple users submitting the same file, but you should get the idea.

Note that the first line is `EPX_CGI.content_text_html`: in case an exception occurs, the web server is still able to output something back to the user.

After that we make sure that the key value pairs are created with `assert_key_value_pairs_created`. They are automatically created if you call `value`, but in this case we want the key value pairs themselves. In `EX_CGI3.save_uploaded_files` we use the `EPX_KEYVALUE.file` feature to check if that key value pair is an uploaded file: if it is not `Void`, it points to a temporary file. As this file will be deleted when it is closed or when your program exits, we have to copy it to a new file. The filename is just the value part of this key value pair. The filename is guaranteed to be free of directory parts.

In the last example we just print all key/value pairs to the file `list.txt` in the temporary directory. We redirect the user to another file.

```
class EX_CGI4
```

```
inherit
```

```
EPX_CGI
```

```
EPX_FACTORY
```

```
creation
```

```
make
```

```
feature
```

```
execute is
```

```
do
```

```
    assert_key_value_pairs_created  
    save_values
```

```
    extend ("Location: /mydir/myfile.html")  
    new_line  
    new_line
```

```
end
```

```
save_values is
```

```
local
```

```
    fout: STDC_TEXT_FILE
```

```
    kv: EPX_KEY_VALUE
```

```
do
```

```
    create fout.create_write (fs.temporary_directory + "/list.txt")
```

```
from
```

```
    cgi_data.start
```

```
until
```

```
    cgi_data.after
```

```
loop
```

```
    kv := cgi_data.item_for_iteration
```

```
    fout.puts (kv.key)
```

```
    fout.puts ("%T")
```

```
    fout.puts (kv.value)
```

```
    fout.puts ("%N")
```

```
    cgi_data.forth
```

```
end
```

```
    fout.close
```

```
end
```

```
end
```

In this chapter:

15.1 Error handling with exceptions
15.2 Manual error handling

15

Error handling

This chapter describes the error handling strategies that are possible with e-POSIX. Basically there are two strategies: using the Eiffel exception mechanism or doing the error handling all yourself.

15.1 Error handling with exceptions

The opinion of the author of e-POSIX is that Eiffel's exception mechanism is very well suited to deal with things like files that cannot be opened or directories that do not exist. Others disagree, see [section 15.2](#). e-POSIX is designed such that when a POSIX routine returns an error code, an exception is thrown. Here my arguments why I favor this style of error handling:

1. We all know that exceptions are to be used for breach of contract. This idea is formulated in (XXXXXXXXXX, 0000) and is the best expressed opinion of exception handling I know.
So if you ask an e-POSIX method to open a file, it will do that for you. If it cannot open the file, for whatever reason, it will raise an exception. The same argument hold if you ask it to go to a directory, to start a program, or to open a connection to another machine.
This approach is also reflected in the names of e-POSIX's features. The name is `POSIX_TEXT_FILE.open_read` and not `POSIX_TEXT_FILE.attempt_open_read`.
2. It is usually not wise to trust clients with error handling. The larger a distance between a software failure and the error report, the more difficult it is to make a correct diagnosis of what went wrong (see (XXXXXXXXXX, 0000)). e-POSIX uses the fail early, fail hard approach.
3. Error handling is often forgotten or left to some global general error handling mechanism. In an interesting article (see (XXXXXXXXXX, 0000)) James Whittaker describes how he modified certain system calls to return legitimate, but unexpected return codes. Memory allocation failed for example, or opening a file returned with no more file handles. Applications failed within seconds, but it was usually completely unclear why.
4. It's a lot easier for programmer's. You don't have to write any error handling. If your program completed, you know that there wasn't a single system call that failed, that you didn't continue despite some error. This will make it possible to write programs that do their work correctly if no errors occur, or else do nothing.

First an example. Let's take a look at the code you have to write in case you want to handle failure of opening a file:

```
class EX_ERROR1
```

```
inherit
```

POSIX_CURRENT_PROCESS

creation

make

feature

make is

local

fd: POSIX_FILE_DESCRIPTOR

do

fd := attempt_create_file

end

attempt_create_file: POSIX_FILE_DESCRIPTOR is

local

attempt: INTEGER

still_exists: BOOLEAN

do

create *Result.create_with_mode* ("myfile", O_CREAT+O_TRUNC+O_EXCL,

0)

rescue

still_exists := errno.value = EEXIST

attempt := attempt + 1

if *still_exists* **and then** *attempt* <= 3 **then**

sleep (1)

retry

end

end

end

In this example we try to create a file exclusively. The create will fail if the file already exists. In case this happens, we retry 3 times. Before retrying we wait 1 second. Note that if the error is not `EEXIST`, we fail directly, without retrying.

In my opinion above's code is just the code you want to write usually: do not worry about errors, if something goes wrong, your application will fail.

My preferred way of error handling is (or sometimes should be) also reflected in the preconditions. For example the `POSIX_FILE_SYSTEM.browse_directory` has the precondition that the given path should exist and should be a directory. Quite reasonable I think. The argument against such preconditions is that it is somewhat strange: if a client has honoured the precondition by checking that the directory exists, it should be able to assume that it safely can call the routine. But between its own check and the actual call, the directory can be removed by another process.

This is the concurrent precondition paradox (see (XXXXXXXXXX, 0000)). In my opinion it would not be wise to remove this precondition. It is true that honouring it, will not make sure the contract is not broken. But it still serves a very usefull purpose: documentation.

For example the routine `POSIX_FILE_SYSTEM.remove_file` does not have the precondition that the file should exist. That isn't an oversight. This routine does not fail if the file no longer exists for good reason: it honours its postcondition after all. So when you call this routine, the file may or may not exist. The routine doesn't care.

15.2 Manual error handling

In spite of the arguments listed in the previous section, automatic error handling is perhaps tedious to use when you expect a lot of errors. And some programmers just do not like Eiffel's exception mechanism. Therefore e-POSIX implements a completely different style of error handling. In this case, e-POSIX continues when an error occurs, but it safes the errorcode, and you can check the errorcode of the first error when you wish. This first errorcode has to be reset by the programmer. An example:

```
class EX_ERROR2

inherit

  STDC_SECURITY_ACCESSOR

creation

  make

feature

  make is
    local
      fd: POSIX_FILE_DESCRIPTOR
    do
      security.error_handling.disable_exceptions
      create fd.create_write ("myfile")
      if fd.errno.first_value = 0 then
        fd.put_string ("1%N")
        fd.put_string ("2%N")
        fd.close
      else
        fd.errno.clear_first
      end
    end
  end

end
```

Exception handling is turned off by a call to `STDC_SECURITY_ACCESSOR.security.error_handling.disable_exceptions`. It can be enabled again by calling `security.error_handling.enable_exceptions`. In between, you're on your own, just like a C programmer. If `myfile` cannot be opened, nothing happens, and the `POSIX_FILE_DESCRIPTOR.put_string` feature is called. Depending if you have enabled precondition checking or not, `put_string` will fail. The precondition if `put_string` is that the file has to be open. Therefore, at certain points, you're still forced to deal with errors. Every

object has an `errno` variable. This variable points to the global `STDC _ERRNO` object (its a once routine). So there basically is just one `first_value` error value. Whatever object caused the error, you can check the `errno.first_value` of any e-POSIX object. The last error is still available in `errno.value`.

If there is no error, the program continues writing. If `POSIX _FILE_DESCRIPTOR.put_string` failed, the next one is still executed. If there is an error, we reset it with `STDC _ERRNO.clear_first`. This gives us the chance to catch another error value if an error occurs. If this method is not called, `first_value` will keep its original value.

The following example is the same as `EX _ERROR1`. It shows how to open a file exclusively with manual error handling.

```
class EX_ERROR3
```

```
inherit
```

```
    POSIX_CURRENT_PROCESS
```

```
    EXCEPTIONS
```

```
creation
```

```
    make
```

```
feature
```

```
    make is
```

```
        local
```

```
            fd: POSIX_FILE_DESCRIPTOR
```

```
        do
```

```
            security.error_handling.disable_exceptions
```

```
            fd := attempt_create_file
```

```
        end
```

```
attempt_create_file: POSIX_FILE_DESCRIPTOR is
```

```
    require
```

```
        manual_error: not security.error_handling.exceptions_enabled
```

```
    local
```

```
        attempt: INTEGER
```

```
        still_exists: BOOLEAN
```

```
    do
```

```
        from
```

```
            attempt := 1
```

```
            still_exists := True
```

```
        until
```

```
            not still_exists or else attempt > 3
```

```
        loop
```

```
            create Result.create_with_mode ("myfile", O_CREAT+O_TRUNC+O_EXCL,
```

```
0)
```

```
            still_exists := errno.first_value = EEXIST
```

```
        if still_exists then
            sleep (1)
            attempt := attempt + 1
        end
    end
    if still_exists then
        raise ("failed to create file")
    end
end
```

```
end
```

As you can see, manual error handling does not necessarily translate into less code.

The summary of this section is that you should check each distinctive step when using manual error handling. You don't have to check intermediate steps.

In this chapter:

16.1*Denial of service attacks*
16.2*Authorization bypass attacks*

16

Security

e-POSIX is well-suited to write server applications like CGI scripts and daemons. As these applications can be hosted on servers that are attached to the Internet, they could be prone to attack. Applications written with e-POSIX could be misused in a denial of service attack or to gain root access. e-POSIX offers certain protection mechanisms that enable your applications to fend off such penetrations.

This chapter shows you how applications can be misused and what mechanisms e-POSIX offers for certain attacks.

“Programmers typically focus on "positive" aspects of programs, that is, what is the functionality required for the task to be accomplished. Programmers rarely focus on the negative aspects of programs, that is, what functionality is not required for the program to accomplish its task. Attackers take advantage of programmers failure to consider negative functionality. Perhaps a reason that programmers avoid negative functionality is that there is no good way to specify what a program should not be permitted to do.”

16.1 Denial of service attacks

In a denial of service attack, crackers attempt to deplete one or more finite resources. Resources can be software related like database connections or TCP/IP connections, but ultimately resources are finite because of hardware limitations. This manual distinguishes the following hardware resources:

- Memory.
- CPU.
- Disk space.
- Network bandwidth.

A denial of service attack succeeds if a cracker depletes these resources in such a way that the server cannot handle request anymore, or handles them very slowly. For example, Linux 2.2 is easy to bring to its knees if you keep on allocating memory. In normal situations your application runs fine, and allocates only a limited amount of memory. But an attacker might have found a way to make your application allocate much more memory. Even if you are sure that the code you have written is not prone to such an attack, you might use a library based on e-POSIX that does have code that is exploitable.

e-POSIX has some limited support to set limits on memory, file handle (a memory issue) and cpu usage. When a set limit has been exceeded, an exception is raised.

To limit the amount of memory that can be allocated by the `STDC_BUFFER` class, inherit from `STDC_SECURITY_ACCESSOR` and call `security.memory.set_max_allocation`. Currently this limits the amount of memory that can be allocated with `STDC_BUFFER`. It does not limit the amount of memory that is allocated by `STRING` or other classes. You

can also limit the amount of memory that can be allocated with a single call by calling `security.memory.set_max_single_allocation`.

You can limit the number of file handles a program can open by calling `security.files.set_max_open_files`. This works only with files and sockets opened by e-POSIX classes as `STDC_FILE` and `POSIX_FILE_DESCRIPTOR`, not with files opened through other means. In this case you cannot rely on the garbage collection to close your file. Certain garbage collectors do not allow calling other classes in the `MEMORY.dispose` method. e-POSIX needs to do this to decrement its idea of the number of open handles. Only when you explicitly call `STDC_FILE.close` will the e-POSIX decrease its open file handles.

You can limit the amount of CPU time by calling `security.cpu.set_max_process_time`. It is not possible to automatically halt your application when this time has exceeded. You have to call `security.cpu.check_process_time` to actually check the processor time used.

Currently e-POSIX cannot check disk space or network bandwidth limitations.

Discuss here that decrementing only works for manual deallocations, I'm very sorry about that, but this is a problem of ISE. I'm thinking about ways to work around this.

16.2 Authorization bypass attacks

A hacker can bypass authorization if he or she, through your program, can gain the following access:

- Access to more information than your program is written to provide. Security is not breached here, but your program is used in an 'innovative' way. Note that if your program runs within the root security context (suid root), security can be breached!
- Security is breached when your program is used to get more access rights than your program is written to provide. Especially suid root programs are an attractive target here.

Usually Eiffel programs do not allocate buffers on the stack, so they are not prone to the so called 'buffer overflow' attack. As certain vendors might provide some 'native' class that allocate things on the stack, leave precondition checking always on in suid root programs.

Currently e-POSIX doesn't offer much protection for suid root programs. Much better security will be the topic of a next release.

In this chapter:

17.1 Making C Headers available to Eiffel
*17.2 Distinction between Standard C and
POSIX headers*
17.3 C translation details

17

Accessing C headers

This chapter explains the conventions that e-POSIX uses to access the C-headers.

17.1 Making C Headers available to Eiffel

The most portable and safest header translation comes when a C function is not called verbatim, but instead a translation function is used. For example to make the Standard C function `fopen` available within Eiffel a new header file is created which lists an Eiffel compatible way to call this routine:

```
#include "eiffel.h"
#include <stdio.h>
```

```
EIF_POINTER posix_fopen(EIF_POINTER filename, EIF_POINTER mode);
```

Instead of using C types, we use Eiffel types here, which are made available by including `eiffel.h`.

The corresponding C file contains the following implementation:

```
#include "my_new_header.h"

EIF_POINTER posix_fopen(EIF_POINTER filename, EIF_POINTER mode)
{
    return ( (EIF_POINTER) fopen (filename, mode));
}
```

It simply calls the original function, returning the result. Type conversion between Eiffel and C types shouldn't pose problems this way.

To be able to call this function from Eiffel, an **external** feature needs to be written. For example:

```
class HEADER_STDIO

feature {NONE} -- C binding for stream functions

    posix_fopen (path, a_mode: POINTER): POINTER is
        -- Opens a stream
    require
        valid_mode: a_mode /= default_pointer
    external "C"
    end

end
```


Group	directory	header prefix	class prefix
Standard C	<code>src/capi</code>	c	CAPI
POSIX	<code>src/[api</code>	p	PAPI
Single Unix Specification	<code>src/sapi</code>	s	SAPI
Windows	<code>src/wapi</code>	w	WAPI

Table 17.1 e-POSIX prefix conventions

17.3 *C translation details*

This translation wants to do as less as possible at the C level. It attempts to just make available the C constants and C functions and do the actual work in Eiffel.

A few details:

1. Constants, C macro definitions, are exported in the header file with the prefix ‘const_’ and next the macro name. The Eiffel API class exports these constants with the original, uppercased name.
2. Struct members are exported with getter and setter functions. The get function has the prefix ‘posix’, an underscore, the struct name, an underscore and as last the member name. The set function has the prefix ‘posix’, an underscore, ‘set’, an underscore, the struct name, an underscore and as last the member name.

In this chapter:

A Posix func- tion to Eiffel class map- ping list

The following table defines exactly where a given Posix function is used in a Eiffel class mapping. The table is sorted in alphabetic order. Note that when a STDC_ class is listed, the feature is also available in the corresponding POSIX_ class. The same is true for the EPX_ classes. The EPX_ classes provide functionality portable between Unix and Windows. The corresponding POSIX_ or SUS_ classes extend that functionality for or the Single Unix Specification.

Function	Header	Class	Comments
abort	<code><stdlib.h></code>	<code>STDC_CURRENT_PROCESS.abort</code>	
accept	<code><sys/socket.h></code>	<code>EPX_TCP_SERVER_SOCKET.accept</code>	
access	<code><unistd.h></code>	<code>ABSTRACT_FILE_SYSTEM.is_accessible</code>	
aio_cancel	<code><aio.h></code>	<code>POSIX_ASYNC_IO_REQUEST.cancel</code>	
aio_error	<code><aio.h></code>	<code>POSIX_ASYNC_IO_REQUEST.is_pending</code>	
aio_fsync	<code><aio.h></code>	<code>POSIX_ASYNC_IO_REQUEST.synchronize</code>	
aio_read	<code><aio.h></code>	<code>POSIX_ASYNC_IO_REQUEST.read</code>	
aio_return	<code><aio.h></code>	<code>POSIX_ASYNC_IO_REQUEST.return_status</code>	
aio_suspend	<code><aio.h></code>	<code>POSIX_ASYNC_IO_REQUEST.wait_for</code>	
aio_write	<code><aio.h></code>	<code>POSIX_ASYNC_IO_REQUEST.write</code>	
alarm	<code><unistd.h></code>	<code>POSIX_TIMED_COMMAND</code>	
asctime	<code><time.h></code>	<code>STDC_TIME.default_format</code>	
atexit	<code><stdlib.h></code>	<code>STDC_EXIT_SWITCH.install</code>	Use <code>STD... _ACCESS... to acces...</code>
bind	<code><sys/socket.h></code>	<code>EPX_TCP_SERVER_SOCKET.listen_by_address</code>	
calloc	<code><stdlib.h></code>	<code>STDC_BUFFER.allocate_and_clear</code>	
cfgetispeed	<code><termios.h></code>	<code>POSIX_TERMIOS.input_speed</code>	
cfgetospeed	<code><termios.h></code>	<code>POSIX_TERMIOS.output_speed</code>	
cfsetispeed	<code><termios.h></code>	<code>POSIX_TERMIOS.set_input_speed</code>	
cfsetospeed	<code><termios.h></code>	<code>POSIX_TERMIOS.set_output_speed</code>	
chdir	<code><unistd.h></code>	<code>POSIX_FILE_SYSTEM.change_directory</code>	
chmod	<code><sys/stat.h></code>	<code>POSIX_FILE_SYSTEM.change_mode</code>	
chown	<code><unistd.h></code>	<code>POSIX_PERMISSIONS_PATH.apply_owner_and_group</code>	
clearerr	<code><stdio.h></code>	<code>STDC_FILE.clear_error</code>	
clock	<code><time.h></code>	<code>STDC_CURRENT_PROCESS.clock</code>	
clock_getcpuclockid	<code><time.h></code>		
clock_getres	<code><time.h></code>	<code>SUS_SYSTEM.real_time_clock_resolution</code>	
clock_gettime	<code><time.h></code>	<code>SUS_SYSTEM.real_time_clock</code>	
clock_nanosleep	<code><time.h></code>		
clock_settime	<code><time.h></code>		
close	<code><unistd.h></code>	<code>EPX_FILE_DESCRIPTOR.close</code>	

closedir	<code><dirent.h></code>	POSIX_DIRECTORY
closelog	<code><syslog.h></code>	SUS_SYSLOG.close
confstr	<code><unistd.h></code>	
connect	<code><sys/socket.h></code>	EPX_TCP_CLIENT_SOCKET.open_by_address, open_by_name_and_port
creat	<code><fcntl.h></code>	EPX_FILE_DESCRIPTOR.create_read_write
ctermid	<code><unistd.h></code>	
ctime	<code><time.h></code>	
cuserid	<code><stdio.h></code>	
daylight	<code><time.h></code>	
difftime	<code><time.h></code>	STDC_TIME
dup	<code><unistd.h></code>	EPX_FILE_DESCRIPTOR.make_as_duplicate
dup2	<code><unistd.h></code>	EPX_FILE_DESCRIPTOR.make_as_duplicate
endgrent	<code><grp.h></code>	
endhostent	<code><netdb.h></code>	
endnetent	<code><netdb.h></code>	
endprotoent	<code><netdb.h></code>	
endpwent	<code><pwd.h></code>	
endservent	<code><netdb.h></code>	
execl	<code><unistd.h></code>	
execle	<code><unistd.h></code>	
execlp	<code><unistd.h></code>	
execv	<code><unistd.h></code>	
execve	<code><unistd.h></code>	
execvp	<code><unistd.h></code>	EPX_EXEC_PROCESS.execute
exit	<code><stdlib.h></code>	STDC_CURRENT_PROCESS.exit
_exit	<code><unistd.h></code>	
fchmod	<code><sys/stat.h></code>	
fchown	<code><sys/stat.h></code>	
fclose	<code><stdio.h></code>	STDC_FILE.close
fcntl	<code><unistd.h></code>	POSIX_FILE_DESCRIPTOR
fdatasync	<code><unistd.h></code>	POSIX_FILE_DESCRIPTOR.synchronize_data
fdopen	<code><stdio.h></code>	POSIX_FILE.make_from_file_descriptor
feof	<code><stdio.h></code>	STDC_FILE.eof
ferror	<code><stdio.h></code>	STDC_FILE.error
fflush	<code><stdio.h></code>	STDC_FILE.flush
fgetc	<code><stdio.h></code>	STDC_FILE.get_character
fgetpos	<code><stdio.h></code>	STDC_FILE.get_position
fgets	<code><stdio.h></code>	STDC_FILE.get_string
fileno	<code><stdio.h></code>	POSIX_FILE_DESCRIPTOR.make_from_file
flockfile	<code><stdio.h></code>	
fopen	<code><stdio.h></code>	STDC_FILE
fork	<code><unistd.h></code>	POSIX_CURRENT_PROCESS.fork
fpathconf	<code><unistd.h></code>	
fprintf	<code><stdio.h></code>	
fputc	<code><stdio.h></code>	STDC_FILE.putc
fputs	<code><stdio.h></code>	STDC_FILE.put_string
fread	<code><stdio.h></code>	STDC_FILE.read
free	<code><stdlib.h></code>	STDC_BUFFER.deallocate
freopen	<code><stdio.h></code>	STDC_FILE.reopen

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fseek	\$<\$stdio.h\$>\$	STDC_FILE. seek	Also see and see
fsetpos	\$<\$stdio.h\$>\$	STDC_FILE. set_position	
fstat	\$<\$sys/stat.h\$>\$	POSIX_STATUS	Return _DESCR.
fsync	\$<\$unistd.h\$>\$	POSIX_FILE_DESCRIPTOR. synchronize	
ftell	\$<\$stdio.h\$>\$	STDC_FILE. tell	
ftruncate	\$<\$unistd.h\$>\$		
ftrylockfile	\$<\$stdio.h\$>\$		
funlockfile	\$<\$stdio.h\$>\$		
fwrite	\$<\$stdio.h\$>\$	STDC_FILE. write	
getc	\$<\$stdio.h\$>\$		See fgetc
getchar	\$<\$stdio.h\$>\$		See fgetc
getcwd	\$<\$unistd.h\$>\$	POSIX_FILE_SYSTEM. current_directory	
getegid	\$<\$unistd.h\$>\$	POSIX_CURRENT_PROCESS. effective_group_id	
getenv	\$<\$stdlib.h\$>\$	STDC_ENV_VAR. value	
geteuid	\$<\$unistd.h\$>\$	POSIX_CURRENT_PROCESS. effective_user_id	
getgid	\$<\$unistd.h\$>\$	POSIX_CURRENT_PROCESS. real_group_id	
getgrgid	\$<\$grp.h\$>\$	POSIX_GROUP. make_from_gid	
getgrnam	\$<\$grp.h\$>\$	POSIX_GROUP. make_from_name	
getgroups	\$<\$unistd.h\$>\$	POSIX_CURRENT_PROCESS. is_in_group	
getlogin	\$<\$unistd.h\$>\$	POSIX_CURRENT_PROCESS. login_name	
getpgrp	\$<\$unistd.h\$>\$	POSIX_CURRENT_PROCESS. process_group_id	
getpid	\$<\$unistd.h\$>\$	POSIX_CURRENT_PROCESS. pid	
getppid	\$<\$unistd.h\$>\$	POSIX_CURRENT_PROCESS. parent_pid	
getpwnam	\$<\$pwd.h\$>\$	POSIX_USER. make_from_name	
getpwuid	\$<\$pwd.h\$>\$	POSIX_USER. make_from_uid	
gets	\$<\$stdio.h\$>\$		See fgetc
gettimeofday	\$<\$sys/time.h\$>\$		SUS_TIME
getuid	\$<\$unistd.h\$>\$	POSIX_CURRENT_PROCESS. real_user_id	
gmtime	\$<\$time.h\$>\$	STDC_TIME. to_utc	
inet_ntoa	\$<\$arpa/inet.h\$>\$	EPX_IP4_ADDRESS. out	
isatty	\$<\$unistd.h\$>\$	EPX_FILE_DESCRIPTOR. is_attached_to_terminal	
htonl	\$<\$netinet/in.h\$>\$	SAPI_IN. posix_htonl	
htons	\$<\$netinet/in.h\$>\$	SAPI_IN. posix_htons	
ioctl	\$<\$stropts.h\$>\$	SAPI_STROPTS. posix_ioctl	
kill	\$<\$signal.h\$>\$	POSIX_PROCESS. kill	
link	\$<\$unistd.h\$>\$	POSIX_FILE_SYSTEM. link	
lio_listio	\$<\$aio.h\$>\$		
localeconv	\$<\$locale.h\$>\$	STDC_LOCALE_NUMERIC	
localtime	\$<\$time.h\$>\$	STDC_TIME. to_local	
lseek	\$<\$unistd.h\$>\$	EPX_FILE_DESCRIPTOR. seek	Also see and see
malloc	\$<\$stdlib.h\$>\$	STDC_BUFFER. allocate	
memcpy	\$<\$string.h\$>\$	STDC_BUFFER. memory_copy	See also
memchr	\$<\$string.h\$>\$		
memcmp	\$<\$string.h\$>\$	CAPI_STRING. posix_memcmp	
memmove	\$<\$string.h\$>\$	STDC_BUFFER. memory_move	
memset	\$<\$string.h\$>\$	STDC_BUFFER. fill_with	
mkdir	\$<\$sys/stat.h\$>\$	POSIX_FILE_SYSTEM. make_directory	
mkfifo	\$<\$sys/stat.h\$>\$	POSIX_FILE_SYSTEM. create_fifo	
mkstemp	\$<\$stdlib.h\$>\$	SUS_TEMPORARY_FILE. make	
mktime	\$<\$time.h\$>\$	STDC_TIME. set_date_time	Also see _time.
mlockall	\$<\$sys/mman.h\$>\$		

mlock	<code><sys/mman.h></code>	
mmap	<code><sys/mman.h></code>	POSIX_MEMORY_MAP
mprotect	<code><sys/mman.h></code>	
mq_receive	<code><mqqueue.h></code>	
mq_close	<code><mqqueue.h></code>	
mq_getattr	<code><mqqueue.h></code>	
mq_notify	<code><mqqueue.h></code>	
mq_open	<code><mqqueue.h></code>	
mq_send	<code><mqqueue.h></code>	
mq_setattr	<code><mqqueue.h></code>	
mq_unlink	<code><mqqueue.h></code>	
msync	<code><sys/mman.h></code>	
munlockall	<code><sys/mman.h></code>	
munlock	<code><sys/mman.h></code>	
munmap	<code><sys/mman.h></code>	POSIX_MEMORY_MAP
nanosleep	<code><time.h></code>	SUS_CURRENT_PROCESS.nanosleep
ntohl	<code><netinet/in.h></code>	SAPI_IN.posix_ntohl
ntohs	<code><netinet/in.h></code>	SAPI_IN.posix_ntohs
open	<code><fcntl.h></code>	EPX_FILE_DESCRIPTOR.open
opendir	<code><dirent.h></code>	POSIX_DIRECTORY
openlog	<code><syslog.h></code>	SUS_SYSLOG.open
pathconf	<code><unistd.h></code>	POSIX_DIRECTORY.max_filename_length
pause	<code><unistd.h></code>	EPX_CURRENT_PROCESS.pause
perror	<code><stdio.h></code>	
pipe	<code><unistd.h></code>	EPX_PIPE.make
printf	<code><stdio.h></code>	
putc	<code><stdio.h></code>	
putchar	<code><stdio.h></code>	
puts	<code><stdio.h></code>	
raise	<code><signal.h></code>	STDC_SIGNAL.raise
rand	<code><stdlib.h></code>	STDC_CURRENT_PROCESS.random
read	<code><unistd.h></code>	EPX_FILE_DESCRIPTOR.read
readdir	<code><dirent.h></code>	POSIX_DIRECTORY
realloc	<code><stdlib.h></code>	STDC_BUFFER.resize
remove	<code><stdio.h></code>	POSIX_FILE_SYSTEM.remove_file
rename	<code><unistd.h></code>	POSIX_FILE_SYSTEM.rename_to
rewind	<code><stdio.h></code>	STDC_FILE.rewind
rewinddir	<code><dirent.h></code>	POSIX_DIRECTORY
rmdir	<code><unistd.h></code>	EPX_FILE_SYSTEM.remove_directory
scanf	<code><stdio.h></code>	
select	<code><sys/select.h></code>	EPX_SELECT
sem_close	<code><semaphore.h></code>	
sem_destroy	<code><semaphore.h></code>	
sem_getvalue	<code><semaphore.h></code>	
sem_init	<code><semaphore.h></code>	POSIX_UNNAMED_SEMAPHORE.create_shared
sem_open	<code><semaphore.h></code>	
sem_post	<code><semaphore.h></code>	POSIX_SEMAPHORE.release
sem_trywait	<code><semaphore.h></code>	POSIX_SEMAPHORE.attempt_acquire
sem_unlink	<code><semaphore.h></code>	
sem_wait	<code><semaphore.h></code>	POSIX_SEMAPHORE.acquire
setbuf	<code><stdio.h></code>	STDC_FILE.set_buffer
setgid	<code><unistd.h></code>	POSIX_CURRENT_PROCESS.set_group_id
setlocale	<code><locale.h></code>	STDC_CURRENT_PROCESS.set_locale
setpgid	<code><unistd.h></code>	PAPI_UNISTD.posix_setsid

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setsid	\$<\$unistd.h\$>\$	PAPI_UNISTD. posix_setsid
setuid	\$<\$unistd.h\$>\$	POSIX_CURRENT_PROCESS. set_user_id
setvbuf	\$<\$stdio.h\$>\$	STDC_FILE. set_no_buffering
shm_open	\$<\$sys/mman.h\$>\$	POSIX_SHARED_MEMORY. open_read_write
shm_unlink	\$<\$sys/mman.h\$>\$	POSIX_FILE_SYSTEM. unlink_shared_memory_object
sigaction	\$<\$signal.h\$>\$	POSIX_SIGNAL
sigaddset	\$<\$signal.h\$>\$	POSIX_SIGNAL_SET. add
sigdelset	\$<\$signal.h\$>\$	POSIX_SIGNAL_SET. prune
sigemptyset	\$<\$signal.h\$>\$	POSIX_SIGNAL_SET. make_empty
sigfillset	\$<\$signal.h\$>\$	POSIX_SIGNAL_SET. make_full
sigismember	\$<\$signal.h\$>\$	POSIX_SIGNAL_SET. has
signal	\$<\$signal.h\$>\$	STDC_SIGNAL. raise
sigpending	\$<\$signal.h\$>\$	POSIX_SIGNAL_SET. make_pending
sigprocmask	\$<\$signal.h\$>\$	POSIX_SIGNAL_SET. add_to_blocked_signals
sigqueue	\$<\$signal.h\$>\$	
sigsuspend	\$<\$signal.h\$>\$	POSIX_SIGNAL_SET. suspend
sigtimedwait	\$<\$signal.h\$>\$	
sigwait	\$<\$signal.h\$>\$	
sigwaitinfo	\$<\$signal.h\$>\$	
sleep	\$<\$unistd.h\$>\$	POSIX_CURRENT_PROCESS. sleep
sprintf	\$<\$stdio.h\$>\$	
srand	\$<\$stdlib.h\$>\$	STDC_CURRENT_PROCESS. set_random_seed
sscanf	\$<\$stdio.h\$>\$	
stat	\$<\$sys/stat.h\$>\$	POSIX_STATUS
strftime	\$<\$time.h\$>\$	STDC_TIME. format
sysconf	\$<\$unistd.h\$>\$	POSIX_SYSTEM
syslog	\$<\$syslog.h\$>\$	SUS_SYSLOG
system	\$<\$stdlib.h\$>\$	STDC_SHELL_COMMAND
tcdrain	\$<\$unistd.h\$>\$	
tcflow	\$<\$unistd.h\$>\$	
tcflush	\$<\$unistd.h\$>\$	POSIX_TERMIOS. flush_input
tcgetattr	\$<\$unistd.h\$>\$	POSIX_TERMIOS. make
tcgetpgrp	\$<\$unistd.h\$>\$	
tcsendbreak	\$<\$unistd.h\$>\$	
tcsetattr	\$<\$unistd.h\$>\$	POSIX_TERMIOS. apply_now
tcsetpgrp	\$<\$unistd.h\$>\$	
time	\$<\$time.h\$>\$	STDC_TIME. make_from_unix_time
timer_create	\$<\$signal.h\$>\$	
timer_create	\$<\$time.h\$>\$	
times	\$<\$times.h\$>\$	
tmpfile	\$<\$stdio.h\$>\$	STDC_TEMPORARY_FILE. make
tmpnam	\$<\$stdio.h\$>\$	STDC_FILE_SYSTEM. temporary_file_name
ttyname	\$<\$unistd.h\$>\$	POSIX_FILE_DESCRIPTOR. ttyname
tzset	\$<\$time.h\$>\$	
umask	\$<\$sys/stat.h\$>\$	
uname	\$<\$sys/utsname.h\$>\$	POSIX_SYSTEM
ungetc	\$<\$stdio.h\$>\$	STDC_FILE. ungetc
unlink	\$<\$unistd.h\$>\$	POSIX_FILE_SYSTEM. unlink
utime	\$<\$utime.h\$>\$	POSIX_FILE_SYSTEM. utime
vfprintf	\$<\$stdio.h\$>\$	
vprintf	\$<\$stdio.h\$>\$	

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<code>vsprintf</code>	<code><stdio.h></code>	
<code>wait</code>	<code><sys/wait.h></code>	<code>POSIX _CURRENT _PROCESS. wait</code>
<code>waitpid</code>	<code><sys/wait.h></code>	<code>POSIX _FORK _ROOT. wait _pid</code>
<code>write</code>	<code><unistd.h></code>	<code>EPX _FILE _DESCRIPTOR. write</code>

Not ap

This tabel does not contain the following category of functions:

1. Math functions.
2. String functions, including wide character/multibyte string. routines. The memory move/copy functions are included, some of them even supported.
3. No type conversion functions.
4. No functions from `<ctype.h>`.
5. No functions from `<setjmp.h>`.
6. No functions from `<stdarg.h>`.
7. No string formatting functions like `sscanf`. I suggest you use the Formatter library for that. You can download this library at <http://www.pobox.com/~berend/eiffel/>.

Functions in above categories are either not applicable, already present in Eiffel or are better off in a different library.

To do

ABSTRACT_DIRECTORY

1. `ABSTRACT_DIRECTORY.forth_recursive` raises an exception when it encounters a symbolic link that does no longer point to a file. Because it tries to retrieve the statistics, and that call fails.

EPX_FILE_SYSTEM

1. Make `EPX_DIRECTORY`.

STDC_FILE

1. `read_integer`, `read_double`, `read_boolean` should perhaps be different for the binary or text files. Now they're satisfy the mico/e definition, so useful for text files only.

STDC_LOCALE_NUMERIC

1. Complete the list of properties

STDC_PATH

1. make some escape char functionality with '%' or so.

STDC_TIME

1. Add elapsed seconds

POSIX_DAEMON

1. Closing the first three file descriptors is not likened by SmartEiffel. So leaves them open. Have to fix this some how.

POSIX_EXEC_PROCESS

1. Turn off Eiffel exception handling after the final `execvp`, else you get back signals not captured by child process as your signals, or so it seems (or perhaps you're killing the Eiffel process, but not the subprocess it generated??)
Killing subprocesses works sometimes, but not always.
Remove exception handling just before `execvp`?
2. how about capture to `/dev/null`?

3. can we capture i/o for every forked process? If so, move this code to POSIX_FORK_ROOT.
4. Perhaps option to influence environment variables to pass to subprocess?

POSIX_FILE_DESCRIPTOR

1. possible to open exclusively and so?
2. complete support for nonblocking i/o.

POSIX_MEMORY_MAP

1. Cannot change protection.
2. No locking.

POSIX_SEMAPHORE

1. not valid for named semaphore I think.
2. have to add various close/unlink functions.

POSIX_SIGNAL

1. Add synchronous waiting for signals like `sigwait`.
2. (Re)enable sending Eiffel exception on signal? i.e. `set_exception_handler` or so.
3. Resend signal as Eiffel exception in signal handler.

POSIX_STATUS

1. return `STDC_TIME` instead of unix time
2. Not all stat member fields are currently available.

POSIX_MQUEUE

1. Solaris x86 says it supports it, so have to work on that.

Security

Add base security class that specifies programs intent. Default is to allow anything, but security can be tightened:

1. Call to `open` or `creat` (used?), use real user id, not effective user id.
2. Assume we're free from buffer attacks if preconditions are enabled.
3. `exec/system` call only allowed when effective user is not root, unless otherwise specified. Or `exec` only allowed for specific files.
4. Protect against writing specific files/directories. Perhaps substitute vulnerable file-names for other ones.

5. Emulate atomic calls. Or add atomic `access` and `open` call. Shouldn't be done by setting `su??`
6. When appending/writing to files, check if symbolic link.
7. `ABSTRACT_FILE_SYSTEM.force_remove_directory` is potentially unsafe because it follows links so it can be used to destroy things not under that directory.
8. remove `tmpnam` function.
9. Make sure the once functions in `STDC_BASE` are called from within the security initialization, so they're allocated and do not generate an out-of-memory exception themselves.

Idea from 'Remediation of Application Specific Security Vulnerabilities at Runtime' article in IEEE Computer sep/oct 2000.

Windows code

1. `chmod` also available on Windows.
2. Add permissions to status: read/write.
3. `set_binary_mode` should do something for the posix factory, i.e., when compiling with cygwin. Perhaps separate `CYGWIN_API` or so in POSIX dir with the window specific stuff.
Currently cygwin uses text mode for file descriptors, the windows variant uses binary.
4. `utime` can be supported by using `SetFileTime`.

Other

1. remove ugly `const__` prefix from constants. Uppercase should be good enough.
Almost done, only `const_EOF` remains, not easy to replace perhaps.
2. Compare `POSIX_SIGNAL` with ISE `UNIX_SIGNAL`: They have an `is_caught` function, useful? Means this signal generates an exception.

Known bugs

- The error code is perhaps not always set for every `STDC_BASE.raise_posix_error`.
- does `STRING_HELPER` leak memory in to `_external`? How is memory used for these conversions being freed? Is memory used there?
- If a child process is signalled (terminated), the function `POSIX_FORK_ROOT.is_terminated_normally` sometimes returns `True`.

Bibliography

Index

[24, 69
) 55
abort
 STDC_CURRENT_PROCESS 95
accept
 EPX_TCP_SERVER_SOCKET 95
acquire
 POSIX_SEMAPHORE 98
add
 POSIX_SIGNAL_SET 99
add_data
 EPX_CGI 79
add_raw
 EPX_CGI 80
add_to_blocked_signals
 POSIX_SIGNAL_SET 99
allocate
 STDC_BUFFER 97
allocate_and_clear
 STDC_BUFFER 18, 95
apply
 POSIX_SIGNAL 47
apply_drain
 POSIX_TERMIOS 99
apply_flush
 POSIX_TERMIOS 99
apply_now
 POSIX_TERMIOS 99
apply_owner_and_group
 POSIX_PERMISSIONS_PATH 95
assert_key_value_pairs_created
 EPX_CGI 83
attempt_acquire
 POSIX_SEMAPHORE 98
attempt_lock
 POSIX_FILE_DESCRIPTOR 96
attempt_open_read
 POSIX_TEXT_FILE 85
b_a
 EPX_CGI 80
b_form_get
 EPX_CGI 81
b_form_post
 EPX_CGI 81
b_input
 EPX_CGI 81
b_p
 EPX_CGI 80
browse_directory
 POSIX_FILE_SYSTEM 41, 86
cancel
 POSIX_ASYNC_IO_REQUEST 95
change_directory
 POSIX_FILE_SYSTEM 95
change_mode
 POSIX_FILE_SYSTEM 95
clear_error
 STDC_FILE 95
clear_first
 STDC_ERRNO 88
clock
 STDC_CURRENT_PROCESS 95
close
 EPX_FILE_DESCRIPTOR 95
 EPX_SMTP_CLIENT 69
 STDC_FILE 91, 96
 SUS_SYSLOG 96
content_text_html
 EPX_CGI 83
copy_from
 STDC_BUFFER 97
create_fifo
 POSIX_FILE_SYSTEM 15, 97
create_read_write
 EPX_FILE_DESCRIPTOR 96
create_shared
 POSIX_UNNAMED_SEMAPHORE
 98
create_unshared
 POSIX_UNNAMED_SEMAPHORE
 98
create_write
 POSIX_SHARED_MEMORY 99
current_directory
 POSIX_FILE_SYSTEM 97
deallocate
 STDC_BUFFER 96
default_format
 POSIX_TIME 52

- STDC_TIME 95
- detach*
 - POSIX_DAEMON 73
- dispose*
 - MEMORY 91
- doctype*
 - EPX_XML_WRITER 79
- doctype_transitional*
 - EPX_XML_WRITER 79
- effective_group_id*
 - POSIX_CURRENT_PROCESS 97
- effective_user_id*
 - POSIX_CURRENT_PROCESS 97
- ehlo*
 - EPX_SMTP_CLIENT 69
- end_of_input*
 - POSIX_TEXT_FILE 25
- eof*
 - STDC_FILE 96
- _errno* 5
- errno*
 - POSIX_FILE_DESCRIPTOR 88
- errno.first_value*
 - POSIX_FILE_DESCRIPTOR 88
- errno.value*
 - POSIX_FILE_DESCRIPTOR 88
- error*
 - STDC_FILE 96
 - SUS_SYSLOG 99
- execute*
 - EPX_CGI 78, 79
 - EPX_EXEC_PROCESS 96
 - POSIX_DAEMON 73
 - POSIX_FORK_ROOT 49
 - POSIX_SHELL_COMMAND 43
- _exit* 96
- exit*
 - STDC_CURRENT_PROCESS 96
- exit_switch*
 - STDC_EXIT_SWITCH_ACCESSOR 95
- expand_path*
 - POSIX_FILE_SYSTEM 26
- fd_stderr*
 - EPX_EXEC_PROCESS 44
- fd_stdin*
 - EPX_CURRENT_PROCESS 32
 - EPX_EXEC_PROCESS 44
- fd_stdout*
 - EPX_CURRENT_PROCESS 32
- EPX_EXEC_PROCESS 44
- file*
 - EPX_KEYVALUE 83
- fill_with*
 - STDC_BUFFER 97
- first_value*
 - POSIX_FILE_DESCRIPTOR 88
 - STDC_ERRNO 88
- flush*
 - STDC_FILE 96
- flush_input*
 - POSIX_TERMIOS 99
- force_remove_directory*
 - ABSTRACT_FILE_SYSTEM 103
- fork*
 - POSIX_CURRENT_PROCESS 49, 96
- format*
 - POSIX_TIME 52
 - STDC_TIME 99
- forth_recursive*
 - ABSTRACT_DIRECTORY 101
- get_body*
 - EX_HTTP_SERVLET 65
- get_character*
 - STDC_FILE 96
- get_header*
 - EX_HTTP_SERVLET 65
- get_lock*
 - POSIX_FILE_DESCRIPTOR 15, 30, 96
- get_position*
 - POSIX_FILE 26
 - STDC_FILE 96
- get_string*
 - STDC_FILE 96
- has*
 - POSIX_SIGNAL_SET 99
- input_speed*
 - POSIX_TERMIOS 95
- input_text*
 - EPX_CGI 81
- install*
 - STDC_EXIT_SWITCH 95
- is_accessible*
 - ABSTRACT_FILE_SYSTEM 95
- is_attached_to_terminal*
 - EPX_FILE_DESCRIPTOR 97
- is_blocking_io*
 - ABSTRACT_FILE_DESCRIPTOR

- 35
- is_in_group*
 - POSIX_CURRENT_PROCESS 97
- is_modifiable*
 - POSIX_FILE_SYSTEM 39
- is_pending*
 - POSIX_ASYNC_IO_REQUEST 95
- is_readable*
 - POSIX_FILE_SYSTEM 40
- is_terminated*
 - EPX_EXEC_PROCESS 46
- is_terminated_normally*
 - POSIX_FORK_ROOT 103
- kill*
 - POSIX_PROCESS 97
- last_string*
 - POSIX_TEXT_FILE 25
- link*
 - POSIX_FILE_SYSTEM 97
- listen_by_address*
 - EPX_TCP_SERVER_SOCKET 95
- local_date_string*
 - POSIX_TIME 52
- local_time_string*
 - POSIX_TIME 52
- log_event*
 - ULM_LOGGING 76
- login_name*
 - POSIX_CURRENT_PROCESS 97
- log_message*
 - ULM_LOGGING 76
- mail*
 - EPX_SMTP_CLIENT 69
- make*
 - EPX_LOG_HANDLER 77
 - EPX_PIPE 98
 - POSIX_TERMIOS 99
 - STDC_TEMPORARY_FILE 99
 - SUS_TEMPORARY_FILE 97
- make_as_duplicate*
 - EPX_FILE_DESCRIPTOR 96
 - POSIX_FILE_DESCRIPTOR 33
- make_capture_input*
 - EPX_EXEC_PROCESS 44
- make_capture_output*
 - EPX_EXEC_PROCESS 44
- make_directory*
 - EXP_FTP_CLIENT 61
 - POSIX_FILE_SYSTEM 97
- make_empty*
 - POSIX_SIGNAL_SET 99
- make_expand*
 - STDC_PATH 39
- make_from_file*
 - POSIX_FILE_DESCRIPTOR 96
- make_from_file_descriptor*
 - POSIX_FILE 96
- make_from_gid*
 - POSIX_GROUP 97
- make_from_name*
 - POSIX_GROUP 97
 - POSIX_USER 97
- make_from_now*
 - POSIX_TIME 52
- make_from_uid*
 - POSIX_USER 97
- make_from_unix_time*
 - STDC_TIME 99
- make_full*
 - POSIX_SIGNAL_SET 99
- make_pending*
 - POSIX_SIGNAL_SET 99
- max_filename_length*
 - POSIX_DIRECTORY 98
- memory_copy*
 - STDC_BUFFER 97
- memory_move*
 - STDC_BUFFER 97
- nanosleep*
 - SUS_CURRENT_PROCESS 98
- notice*
 - SUS_SYSLOG 99
- open*
 - EPX_FILE_DESCRIPTOR 98
 - POSIX_FILE 9
 - SUS_SYSLOG 98
- open_by_address*
 - EPX_TCP_CLIENT_SOCKET 96
- open_by_name_and_port*
 - EPX_TCP_CLIENT_SOCKET 96
- open_read*
 - EPX_FILE_DESCRIPTOR 98
 - POSIX_FILE 9
 - POSIX_SHARED_MEMORY 99
 - POSIX_TEXT_FILE 85
- open_read_write*
 - EPX_FILE_DESCRIPTOR 98
 - POSIX_SHARED_MEMORY 99

open_write
EPX_FILE_DESCRIPTOR 98

out
EPX_IP4_ADDRESS 97

output_speed
POSIX_TERMIOS 95

parent_pid
POSIX_CURRENT_PROCESS 97

parse
STDC_PATH 39

pause
EPX_CURRENT_PROCESS 98

peek_int16
STDC_BUFFER 19

peek_int16_big_endian
STDC_BUFFER 19

peek_int16_little_endian
STDC_BUFFER 19

peek_int32
STDC_BUFFER 19

peek_wint16
STDC_BUFFER 19

permissions
POSIX_FILE_SYSTEM 40

pid
POSIX_CURRENT_PROCESS 12, 97

poke_int32_big_endian
STDC_BUFFER 19

posix_htonl
SAPI_IN 97

posix_htons
SAPI_IN 97

posix_ioctl
SAPI_STROPTS 97

posix_memcmp
CAPI_STRING 97

posix_ntohl
SAPI_IN 98

posix_ntohs
SAPI_IN 98

posix_setsid
PAPI_UNISTD 98, 99

process_group_id
POSIX_CURRENT_PROCESS 97

prune
POSIX_SIGNAL_SET 99

putc
STDC_FILE 96

puts
EPX_CGI 80

put_string
POSIX_FILE_DESCRIPTOR 87, 88
STDC_FILE 96

quit
EPX_SMTP_CLIENT 69

raise
STDC_SIGNAL 98, 99

raise_posix_error
STDC_BASE 103

random
STDC_CURRENT_PROCESS 98

raw_value
EPX_CGI 81

read
ABSTRACT_FILE_DESCRIPTOR 7, 35
EPX_FILE_DESCRIPTOR 98
POSIX_ASYNC_IO_REQUEST 36, 95
POSIX_FILE 25
STDC_FILE 96

read_buffer
POSIX_FILE 25

read_character
STDC_FILE 96

read_line
[24
ABSTRACT_FILE_DESCRIPTOR 31

read_string
[24
ABSTRACT_FILE_DESCRIPTOR 22
POSIX_TEXT_FILE 25
STDC_FILE 96

real_group_id
POSIX_CURRENT_PROCESS 97

real_time_clock
SUS_SYSTEM 95

real_time_clock_resolution
SUS_SYSTEM 95

real_user_id
POSIX_CURRENT_PROCESS 97

reestablish
STDC_SIGNAL_HANDLER 48

refresh
POSIX_PERMISSIONS 40

- register_dynamic_resource*
 - EPX_HTTP_SERVER 66
- register_fixed_resource*
 - EPX_HTTP_SERVER 66
- release*
 - POSIX_SEMAPHORE 98
- remap_http_method*
 - EPX_HTTP_CONNECTION 65
- remove_directory*
 - EPX_FILE_SYSTEM 98
 - EXP_FTP_CLIENT 61
- remove_file*
 - EXP_FTP_CLIENT 61
 - GENERAL 5
 - POSIX_FILE_SYSTEM 5, 87, 98
- remove_from_blocked_signals*
 - POSIX_SIGNAL_SET 99
- rename_to*
 - EXP_FTP_CLIENT 61
 - POSIX_FILE_SYSTEM 98
- reopen*
 - STDC_FILE 96
- request_form_fields*
 - EPX_HTTP_CONNECTION 66
- resize*
 - STDC_BUFFER 98
- restore_group_id*
 - POSIX_CURRENT_PROCESS 98
- restore_user_id*
 - POSIX_CURRENT_PROCESS 99
- return_status*
 - POSIX_ASYNC_IO_REQUEST 95
- rewind*
 - STDC_FILE 98
- save_uploaded_files*
 - EX_CGI3 83
- security.cpu.check_process_time*
 - STDC_FILE 91
- security.cpu.set_max_process_time*
 - STDC_FILE 91
- security.error_handling.disable_exceptions*
 - STDC_SECURITY_ACCESSOR 87
- security.error_handling.enable_exceptions*
 - STDC_SECURITY_ACCESSOR 87
- security.files.set_max_open_files*
 - STRING 91
- security.memory.set_max_allocation*
 - STDC_SECURITY_ACCESSOR 90
- security.memory.set_max_single_allocation*
 - STRING 91
- seek*
 - EPX_FILE_DESCRIPTOR 97
 - POSIX_FILE 26
 - STDC_FILE 97
- seek_from_current*
 - EPX_FILE_DESCRIPTOR 97
 - STDC_FILE 97
- seek_from_end*
 - EPX_FILE_DESCRIPTOR 97
 - STDC_FILE 97
- set_allow_anyone_read*
 - POSIX_PERMISSIONS 40
- set_allow_group_write*
 - POSIX_PERMISSIONS 40
- set_blocked_signals*
 - POSIX_SIGNAL_SET 99
- set_blocking_io*
 - ABSTRACT_FILE_DESCRIPTOR 35
 - EPX_IRC_CLIENT 68
- set_buffer*
 - POSIX_ASYNC_IO_REQUEST 36
 - STDC_FILE 98
- set_count*
 - POSIX_ASYNC_IO_REQUEST 36
- set_date*
 - STDC_TIME 97
- set_date_time*
 - STDC_TIME 97
- set_full_buffering*
 - STDC_FILE 99
- set_group_id*
 - POSIX_CURRENT_PROCESS 98
- set_handler*
 - POSIX_SIGNAL 47, 48
- set_input_speed*
 - POSIX_TERMIOS 95
- set_line_buffering*
 - STDC_FILE 99
- set_locale*
 - STDC_CURRENT_PROCESS 98
- set_lock*
 - POSIX_FILE_DESCRIPTOR 96
- set_native_locale*
 - STDC_CURRENT_PROCESS 98
- set_native_time*
 - STDC_CURRENT_PROCESS 98
- set_no_buffering*
 - STDC_FILE 99

- set_offset*
 - POSIX_ASYNC_IO_REQUEST 36
- set_output_speed*
 - POSIX_TERMIOS 95
- set_position*
 - POSIX_FILE 26
 - STDC_FILE 97
- set_print_response*
 - EPX_IRC_CLIENT 68
- set_random_seed*
 - STDC_CURRENT_PROCESS 99
- set_serve_xhtml_if_supported*
 - EPX_HTTP_SERVER 63
- set_time*
 - STDC_TIME 97
- set_user_id*
 - POSIX_CURRENT_PROCESS 99
- signalled*
 - POSIX_SIGNAL_HANDLER 47, 48
- sleep*
 - EPX_CURRENT_PROCESS 47
 - POSIX_CURRENT_PROCESS 99
- /src/library.xace* 6, 7, 7
- status*
 - EPX_FILE_DESCRIPTOR 97
 - POSIX_FILE_DESCRIPTOR 41
- STDC_ERRNO*
 - POSIX_FILE_DESCRIPTOR 88
- stderr*
 - EPX_EXEC_PROCESS 45
- stdin*
 - EPX_CURRENT_PROCESS 32
 - EPX_EXEC_PROCESS 45
- stdout*
 - EPX_CURRENT_PROCESS 32
 - EPX_EXEC_PROCESS 45
- store*
 - EXP_FTP_CLIENT 61
- supports_nonblocking_io*
 - ABSTRACT_FILE_DESCRIPTOR 7, 35
- SUS_ENV_VAR*
 - STDC_ENV_VAR 54
- suspend*
 - POSIX_SIGNAL_SET 99
- synchronize*
 - POSIX_ASYNC_IO_REQUEST 36, 95
 - POSIX_FILE_DESCRIPTOR 97
- synchronize_data*
 - POSIX_FILE_DESCRIPTOR 96
- tell*
 - POSIX_FILE 26
 - STDC_FILE 97
- temporary_file_name*
 - STDC_FILE_SYSTEM 99
- to_local*
 - POSIX_TIME 52
 - STDC_TIME 97
- touch*
 - POSIX_FILE_SYSTEM 99
- to_utc*
 - POSIX_TIME 52
 - STDC_TIME 97
- ttyname*
 - POSIX_FILE_DESCRIPTOR 99
- unfinished_xml*
 - EPX_XML_WRITER 79
- ungetc*
 - STDC_FILE 99
- unlink*
 - POSIX_FILE_SYSTEM 99
- unlink_shared_memory_object*
 - POSIX_FILE_SYSTEM 99
- utime*
 - POSIX_FILE_SYSTEM 99
- value*
 - EPX_CGI 81, 83
 - STDC_ENV_VAR 97
- wait*
 - POSIX_CURRENT_PROCESS 13, 100
- waited_child_pid*
 - POSIX_CURRENT_PROCESS 13
- wait_for*
 - EPX_EXEC_PROCESS 44, 46
 - POSIX_ASYNC_IO_REQUEST 36, 95
 - POSIX_CHILD 13
- wait_pid*
 - POSIX_FORK_ROOT 100
- write*
 - ABSTRACT_FILE_DESCRIPTOR 7, 35
 - EPX_FILE_DESCRIPTOR 100
 - POSIX_ASYNC_IO_REQUEST 36, 95
 - STDC_FILE 97
 - 95

- a**
- abort 95
- ABSTRACT_FILE_DESCRIPTOR 7, 16, 22, 31, 35
- accept 95
- access 95, 103
- aio_cancel 95
- aio_error 95
- aio_fsync 95
- aio.h 95, 97
- aio_read 95
- aio_return 95
- aio_suspend 95
- aio_write 95
- alarm 95
- ANY 5
- arpa/inet.h 97
- asctime 95
- atexit 95
- b**
- backslash 26
- BeOS 7
 - non-blocking i/o 7
- big endian 19
- binary file 26
- binary mode 31
- binary stdin 32
- binary stdout 32
- bind 95
- c**
- calloc 95
- CAPI_STDIO 9, 93
- C compiler
 - Borland 2, 5
 - lcc 2
 - Microsoft 2
 - Microsoft Visual C + 5
- cecil.se 6
- cfgetispeed 95
- cfgetospeed 95
- cfsetispeed 95
- cfsetospeed 95
- cgi 78
 - enumerating all values 83
 - file upload 80
 - redirect 83
- chdir 95
- chmod 95
- chown 95
- clearerr 95
- clock 95
- clock_getcpuclockid 95
- clock_getres 95
- clock_gettime 95
- clock_nanosleep 95
- clock_settime 95
- close 95
- closedir 96
- closelog 96
- compiler.se 15
- configure 1, 6
- confstr 96
- connect 96
- Content-Length 65
- creat 96, 102
- c_stdio.c 93
- c_stdio.h 93
- ctermid 96
- ctime 96
- Ctrl
 - C 46, 47
- ctype.h 100
- cuserid 96
- CYGWIN 32
- Cygwin 7
- cygwin 7, 10
- CYGWIN_API 103
- d**
- daylight 96
- DELETE request 65
- difftime 96
- directory
 - browse 41
 - change 39
 - create 39
 - remove 39
 - test_suite 17
- dirent.h 96, 98
- dup 96
- dup2 96
- e**
- EEXIST 86
- Eiffel Forum Freeware License iv
- eiffel.h 92
- elj-win32 2

endgrent 96
endhostent 96
endnetent 96
endprotoent 96
endpwent 96
endservent 96
ENOSYS 15
environment variable 26
 CFLAGS 7
 CYGWIN 32
 EPOSIX 1
Environment variable
 expansion 26
environment variable
 GOBO_CC 1, 2, 3
 GOBO_EIFFEL 3
 set 54
eposix.ecf 5
epxc 11
EPX_CGI v, 78
EPX_CURRENT_PROCESS 16, 32, 47
EPX_DIRECTORY 101
EPX_EXEC_PROCESS 16, 43
EPX_FILE_DESCRIPTOR 15, 16
EPX_FILE_SYSTEM 15, 16
EPX_HTTP_10_CLIENT 61
EPX_HTTP_CONNECTION 65
EPX_HTTP_SERVER 62, 63, 65
EPX_IRC_CLIENT 67
EPX_LOG_HANDLER 75
EPX_MIME_EMAIL 69
EPX_MIME_PARSER 55
EPX_MIME_PART 55, 69
EPX_PIPE 16
epxs 11
EPX_SELECT 98
EPX_SMTP_CLIENT 68, 69
EPX_SOCKET 7
EPX_SYSTEM 54
EPX_TCP_CLIENT_SOCKET 7
EPX_XHTML_WRITER 78
errno 9
error handling 85
execl 96
execle 96
execlp 96
execv 96
execve 96
execvp 96
EX_ERROR1 88
EX_HTTP_SERVLET2 64
exit 96
EXP_FTP_CLIENT 61
EX_SMTP_MAIL 69

f
fchmod 96
fchown 96
fclose 96
fcntl 96
fcntl.h 96, 98
fdatasync 6, 7, 7, 96
fdopen 96
feof 96
ferror 96
fflush 96
fgetc 96, 97
fgetpos 96
fgets 96, 97
file
 read entire 24
filename manipulation 37
fileno 96
file pointer 26
flockfile 96
flush 33
fopen 92, 96
fork 96
forum.txt iv
fpathconf 96
fprintf 96
fputc 96, 98
fputs 96, 98
fread 96
free 96
FreeBSD 6
freopen 96
fseek 97
fsetpos 97
fstat 97
fsync 6, 7, 7, 96, 97
ftell 97
ftruncate 97
ftrylockfile 97
funlockfile 97
fwrite 97

g
geant 1
getc 97

- getchar 97
- getcwd 97
- getegid 97
- getenv 97
- geteuid 97
- getgid 97
- getgrgid 97
- getgrnam 97
- getgroups 97
- getlogin 96, 97
- getpgrp 97
- getpid 12, 97
- getppid 97
- getpwnam 97
- getpwuid 97
- gets 97
- gettimeofday 97
- getuid 97
- gexace 4
- glibc 6
- gmtime 97
- Gobo 22, 35
- grp.h 96, 97
- h**
- htonl 97
- htons 97
- HTTP 11
- i**
- inet_ntoa 97
- ioctl 97
- isatty 97
- ISE Eiffel 2
- ISE Eiffel 5.6 5
- ISE Eiffel 5.7 5
- k**
- KI_CHARACTER_INPUT_STREAM 22, 35
- KI_CHARACTER_OUTPUT_STREAM 22
- kill 97
- l**
- LDAP 72
- LDIF 72
- libposix 5
- libposix_ise_msc.lib 3
- libposix_ise_msc.lib 2
- libposix_se.a 3, 15
- libposix_ve_msc.lib 6
- libmteposix_ise_msc.lib 2
- library.xace 4
- license iv
- link 97
- lio_listio 97
- little endian 19
- localeconv 97
- locale.h 97, 98
- localtime 97
- lock 29
- lseek 97
- m**
- make.exe 2
- makelib.exe 2
- malloc 97
- max_open_files 54
- memchr 97
- memcmp 97
- memcpy 97
- memmove 97
- memset 97
- MIME 11
- minicom 33
- mkdir 97
- mkfifo 7, 7, 15, 97
- mkstemp 97
- mktime 97
- mlock 98
- mlockall 97
- mmap 98
- modem 33
- mprotect 98
- mq_receive 98
- mq_close 98
- mq_getattr 98
- mq_notify 98
- mq_open 98
- mq_send 98
- mq_setattr 98
- mqueue.h 98
- mq_unlink 98
- msync 98
- multi-threaded programming 2
- munlock 98
- munlockall 98
- munmap 98

n

nanosleep 98
netdb.h 96
netinet/in.h 97, 98
non-blocking i/o 22, 35
ntohl 98
ntohs 98

o

open 98, 102, 103
opendir 98
openlog 98
Open Source *iv*

p

PAPI_UNISTD 9
pathconf 98
path name 26
pause 98
perror 98
pipe 98
poll *iv*
POSIX_ASYNC_IO_REQUEST 36
POSIX_BASE 10
POSIX_BINARY_FILE 22
POSIX_BUFFER 18, 18, 19
POSIX_CONSTANTS 11
POSIX_CURRENT_PROCESS 49
POSIX_DAEMON 73, 73
POSIX_DIRECTORY 41, 42, 96, 98
POSIX_EXEC_PROCESS *v*, 45
POSIX_FILE 22, 22
POSIX_FILE_DESCRIPTOR 16, 28,
91, 96
POSIX_FILE_SYSTEM 39
POSIX_FORK_ROOT 12, 49
POSIX_MEMORY_MAP 20, 98
POSIX_PERMISSIONS 40, 41
POSIX_SHARED_MEMORY 18
POSIX_SHELL_COMMAND 43
POSIX_SIGNAL 99
POSIX_SIGNAL_HANDLER 47, 48
POSIX_STAT 41
POSIX_STATUS 41, 97, 99
POSIX_SYSTEM 54, 99
POSIX_TEXT_FILE 22, 29
POSIX_TIMED_COMMAND 95
printf 98
p_stdio.c 93
p_stdio.h 93

putc 98

putchar 98
PUT request 63
puts 98
pwd.h 96, 97

q

QNX 7

r

raise 98
rand 98
read 7, 98
readdir 98
realloc 98
recv 7
redirect standard error 33
remove 98
rename 98
REST 63
rewind 98
rewinddir 98
rmdir 98

s

scanf 98
seek 26
select 98
semaphore.h 98
sem_close 98
sem_destroy 98
sem_getvalue 98
sem_init 98
sem_open 98
sem_post 98
sem_trywait 98
sem_unlink 98
sem_wait 98
sendmsg 7
servlet 63
setbuf 98
setgid 98
setjmp.h 100
setlocale 98
setpgid 98
setsid 99
setuid 99
setvbuf 99
shm_open 99
shm_unlink 99

- sigaction 99
- sigaddset 99
- SIGCHLD 48
- sigdelset 99
- sigemptyset 99
- sigfillset 99
- sigismember 99
- signal 99
- signal.h 97, 98, 99
- signal handler 47
- sigpending 99
- sigprocmask 99
- sigqueue 99
- sigsuspend 99
- sigtimedwait 99
- sigwait 99, 102
- sigwaitinfo 99
- slash 26
- sleep 99
- SmallEiffel v
- SmartEiffel 2
- Solaris 7
- sprintf 99
- srand 99
- src/library.xace 1, 6
- sscanf 99, 100
- stat 41, 99
- STC_TEMPORARY_FILE 14
- stdarg.h 100
- STDC_BASE 10
- STDC_BINARY_FILE 14, 31
- STDC_BUFFER 14, 18, 18, 90
- STDC_CONSTANTS 11, 14
- STDC_CURRENT_PROCESS 14
- STDC_ENV_VAR 14, 53
- STDC_FILE 22, 91, 96
- STDC_FILE_SYSTEM 14
- STDC_LOCALE_NUMERIC 97
- STDC_PATH 37
- STDC_SECURITY_ACCESSOR 90
- STDC_SHELL_COMMAND 14, 99
- stdc_signal_switch_switcher 5
- STDC_SYSTEM 14
- STDC_TEXT_FILE 14, 31, 32
- STDC_TIME 14, 96
- stderr 33
- stdin
 - binary 32
- stdio.h 93, 93, 95, 96, 97, 98, 99, 100
- stdioh 97
- stdlib.h 95, 96, 97, 98, 99
- stdout 33
 - binary 32
- stream buffer 33
- strftime 99
- STRING 90
- string.h 97
- stropts.h 97
- support
 - commercial iv
- SUS_BASE 10
- SUS_SYSLOG 75, 99
- SUS_SYSLOG_ACCESSOR 75
- SUS_TIME_VALUE 97
- sysconf 99
- syslog 99
- syslog.h 96, 98, 99
- sys/mman.h 97, 98, 99
- sys/select.h 98
- sys/socket.h 95, 96
- sys/stat.h 95, 96, 97, 99
- system 99
- system.se 15
- system.xace 4, 6
- sys/time.h 97
- sys/utsname.h 99
- sys/wait.h 100
- t
 - tcdrain 99
 - tcflow 99
 - tcflush 99
 - tcgetattr 99
 - tcgetpgrp 99
 - tcsendbreak 99
 - tcsetattr 99
 - tcsetpgrp 99
 - temporary file 14, 83
 - terminal 30
 - password 30
 - termios.h 95
 - TEST_IRC_CLIENT 68
 - text mode 31
 - time 99
 - time.h 95, 96, 97, 98, 99
 - timer_create 99
 - times 99
 - times.h 99
 - tmpfile 99
 - tmpnam 99

ttyname [99](#)

tzset [99](#)

u

ULM_LOGGING [75](#)

ULM_LOG_HANDLER [75](#)

ULM_LOG_LEVELS [76](#)

umask [99](#)

uname [99](#)

ungetc [99](#)

unistd.h [95](#), [96](#), [97](#), [98](#), [99](#), [100](#)

unlink [9](#), [99](#)

URI [11](#), [62](#)

utime [99](#)

utime.h [99](#)

UT_URI [62](#)

v

VE_BIN [6](#)

vfprintf [99](#)

Visual Eiffel [v](#)

VisualEiffel [2](#), [6](#)

vprintf [99](#)

vsprint [100](#)

w

wait [100](#)

waitpid [100](#)

Windows 2000 [7](#)

WINDOWS_PAGING_FILE_SHARED_MEMORY
[20](#)

WINDOWS_SYSTEM [54](#)

write [7](#), [100](#)

x

XM_UNICODE_CHARACTER_CLASSES
[5](#)

