

Development Tutorial (a.k.a Build FAQ)

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Foreword to the Development Tutorial

FAQ version 0.07b

FPC version 2.2.4/2.3.x (release/devel)

Lately, I noticed that there are more people playing with the more advanced aspects of the buildprocess of FPC, tracking daily SVN status, trying things that used to be only done by a small circle of core developpers and maybe a select few on the maillists and in the Lazarus project. Things like bootstrapping a new version, release building, crosscompiling, parameterising the build process, attempting to port to new OSes etc. This is logical, because due to (mainly) Peter's efforts, the building process is a lot more robust and flexible then it used to be. Since the first version of this faq I've debugged specially the crosscompiling part of the process a bit more.

The Development Tutorial was originally meant as the successor of the old 0.99.x make cycle FAQ, which had gotten horribly outdated. Moreover, the basic idea of the make cycle faq didn't work in practice. The FAQ contained only a step by step treatise of the basic features, and when something went wrong (e.g. a .ppu of an old version somewhere), users often had no idea how to solve the problem. So this faq is set up more as an indepth treatise of building FPC and related issues, with much more background information that can assist general problem hunting procedures. So if you think that this FAQ is too verbose and even pedantic at times, and should be limited to the bare essentials, my answer will be: been there, done that, didn't work :-)

This tutorial is not even close to being a replacement for the real manuals. Most of it will be in the manual though, except some of the outlook on future versions. Try to read the tutorial entirely at least once, including parts that are not so relevant to you. It is all connected, and reading the parts less useful for you might help you see the bigger picture.

The purpose of the faq is different from the docs because it tries to document use cases rather than a reference, and also because it is not fully synchronized with a compiler version.

If you have more questions, suggestions, try the FPC maillists <http://www.freepascal.org/maillist.html> or irc ¹

Versioning of the faq

The faq comes in two versions, the PDF at <http://www.stack.nl/marcov/buildfaq.pdf> one and an HTML version at <http://www.stack.nl/marcov/buildfaq.html>. The PDF version is the authoritative one and more often updated. The HTML version is mainly used to post URLs to specific topics on maillists and IRC. Unfortunately, the HTML export of LyX is not the stablest in the world, so sometimes exporting to html doesn't even succeed

- Versions 0.01 and 0.02 were continuously updated, both exist in multiple versions.
- Version 0.03 mainly is an update for the \$FPCTARGET and related directory layout modifications in 1.9.5, and improves the index and glossary significantly. Also 1.0.x topics are phased out.
- Version 0.04 is an update for 2.0 and post 2.0 development. Peter has big plans with the build process (replacing MAKE with a more FPC friendly solution), so 0.05 could be a major update. Also needs SVN tutorials.
- Version 0.05 is an update after some progress on cross compiling, and the emerging of an internal linker
- Version 0.06 is an update after a long break due to losing the LyX source as a result of a stolen computer. A PDF version was OCREd and reformatted, and some updating was done:
 - Compiler version numbers updated to 2.2.2
 - New packages structure.
 - Index expanded
 - More 1.0.10 and CVS removal
- Version 0.07 is some maintenance after 2.2.4 release
 - compiler version updated
 - some 2.3.x topics, which will be increased in the future.
 - Lyx 1.6.2 (mostly sorting of all-caps index entries)
 - newer buildscripts
- Updates 0.07a and b only have minor typo fixes, and was released in the day after the initial 0.07 version

¹irc.freenode.net channel #fpc, best populated in the late evenings CET.

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Part I

Ordinary building

Chapter 1

Base principles, naming, versions, requirements etc

1.1 Versions, branches, tags

Roughly there are four versions categories of FPC now:

pre-1.0 These are versions are usually numbered 0.99.x Versions before 0.99.8 don't have Delphi features. In general these are non supported, but specially versions (0.99.12 and 0.99.14 based versions) are essentially beta's for 1.0. However we are talking 10 year old betas here, and a lot has changed, even during the 1.0.x series.

1.0.x The so called FIXES_1_0_0 branch. These versions (1.0, 1.0.2, 1.0.4, 1.0.6 and 1.0.10) are bugfix releases of what is basically 1.0. However sometimes TP and Delphi compability fixes can break backwards compability. 1.0.x is frozen, and there will be no new releases or even fixes, after 1.0.10 from may 2003, and we strongly recommend upgrading to 2.0

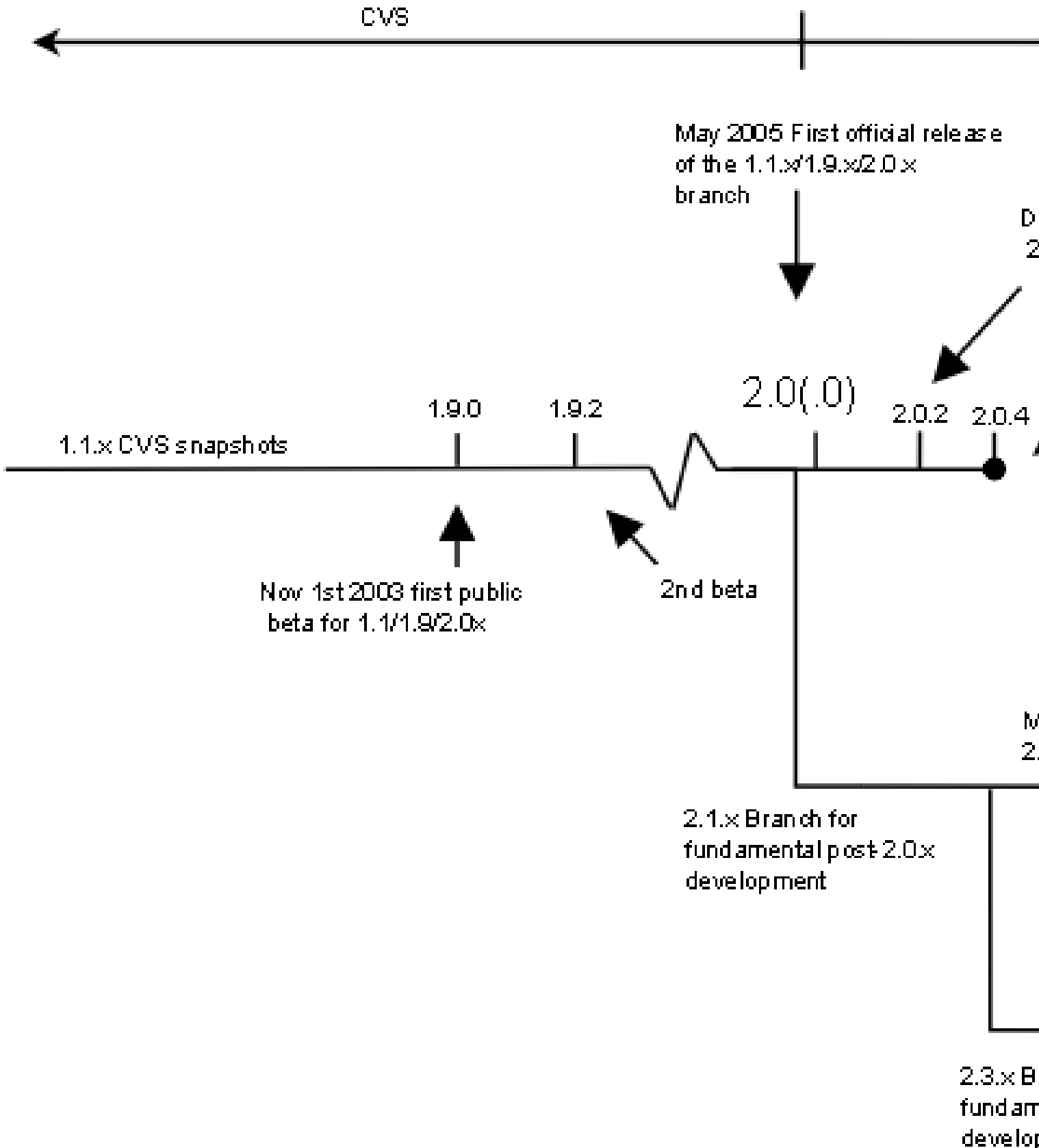
1.1.x/1.9.x/2.0.x This is the branch that yielded 2.0.x series. It used to be called the development branch before 2.0.0, but now that 2.0 is declared stable, the best name would be 2.0.x stable branch. Compared to the 1.0.x branch, it adds most of the missing Delphi features (dynamic arrays, interfaces, default parameters) and supports several processors. This branch has multiple version numbers, since while in alpha it was called 1.1.x, while in beta 1.9.x and the real releases were called 2.0.x. This branch is now closed , 2.0.4 will probably be the last release of the FIXES_2_0_0 branch

2.1.x/2.2.x This is the branch for the FPC 2.2.x series. Main highlights are support for internal linking for windows (win32/win64/wince). Win64 and WinCE are also new. fixes_2_2 branch. Currently 2.2.4 is expected to be the last of the 2.2.x branch, because merging is getting increasingly laboursome.

2.3.x The branch for post 2.2 development, will become 2.4.0 in time.

One can see what (post 2.0.0) branches exists via the <http://svn.freepascal.org/cgi-bin/viewvc.cgi/?root=fpc> Viewvc webinterface.

Releases are tagged with a RELEASE_x_y_z for release x.y.z. So release 1.0.2 is tagged RELEASE_1_0_2 in CVS. While 1.0.8 tags might exist in CVS, there is no official 1.0.8 version , this because creating the 1.0.8 release took a long time, and the package was rebuilt several times, while already downloadable via FTP. Because the core team was afraid all those versions with the same history would create confusion, it was decided to increase the version number for the final release to 1.0.10. The version history is illustrated in the following graph:



While 1.0.x also supports two processors (intel x86 and Motorola m68k), the 1.1.x branch contains a more fundamentally engineered approach to make FPC a multi architecture compiler. Currently it looks like the first release of the 1.1.x branch will support x86, ppc, Arm (Zaurus and similar devices) AMD64(x86-64)and Sparc (V8,V9).

1.2 Requirements

A supported OS and processor are of course the main requirements. Such info can be better gotten from the website, since the status changes frequently.¹

The FPC build process needs certain tools. While usually this is all provided by the OS, or installed by the FPC release package, I name them here explicitly to make it easier for people to debug build problems.

The main tools:

ld The GNU linker. Links a bunch of .o and .a's together to form a library (.dll or .so) or a finished program (like .exe on windows, extensionless on Unix)

as The GNU assembler. Assembles the textform representation in a .s or .as file to an .o file.

ar needed for creating static libraries (.a) from .o's. Static libraries are used when building for smartlinking.

make GNU make. Determines the order of what to build. Both on file as on directory level. Called gmake on *BSD

ppc386 or ppc<processor> in general, preferably the last release version. Bootstrapping from other compilers is not realistic, and, to my best knowledge, hasn't been attempted in years (1.0.x times)

The first three are found in the package "binutils", the version doesn't matter much as long as it is not a fossil. At least on major platforms. Some platforms package an old version, e.g. OpenBSD used to package fossils because it still used a.out as a binary format, though I heard that they finally got rid of that in version 3.4. These utils are rarely a source of errors, but depend on the target OS and CPU, which complicates cross-compiling a bit.

Make is usually obtained from the same source as binutils, but packaged separately. See the separate section on make below for some common caveats.

Windows users that build a system from scratch, should get the makew32.zip and asldw32.zip (or similar) files from the "separate" subdirectory of the last release to get the needed external tools.

Under *Mac OS X/Darwin*, the binutils and make are part of the Apple developertools, which for 10.3 are automatically installed when you install XCode. Fink (an open source software distribution for Mac OS X) is not strictly required for FPC operation, but most Unix libraries you might need (like mysql, ncurses etc) are part of Fink. The rumour is that in 10.4 these tools were finally based on recent GNU versions,

1.2.1 ld: The GNU linker.

The GNU linker is the final step in the building process of a FPC source to a runnable binary. As said before, a recent version that supports linkerscript files is the only prerequisite for an easy ride, except for win32, where the linker should understand `-base-file` and `-image-base` parameters. (these are also already supported over 2 years though). The supported Win32 platform as far as buildtools are concerned, is mingw32, not cygwin. FPC can link to cygwin libraries though.

One could maybe use other linkers than GNU, but that'd require reimplementing the part that calls the linker (this has been done e.g. for OpenBSD a.out in the 1.0.x compiler and Darwin's mach-O LD in 2.0+). However keep in mind that the connection between the assembler and the linker is a commonformat for the object file (.o). Changing to a linker that uses a different format might also require a different assembler, and in turn, a different assembler might require adaptations to the FPC part that writes the assembler code. However all these are doable, even for people that aren't complete compiler wizards.

If your platform is not a mainstream *nix or windows, try to find a linker that supports the `-ld-sections` parameter. The new smartlinking will be based on this LD parameter.

Starting with FPC 2.1.1, the compiler also has a linker internal for some platforms which is enabled using `-Xi`. This internal linker links way faster, and uses less memory, specially when using smartlinking². At the time of writing the Windows platforms (PE) are supported by this internal linker.

¹Actually, while writing this, I witnessed the first working "Hello world" program on the Sparc V8 architecture :-)

²About 250-275 MB as maximum amount of memory used to fully smartlink Lazarus, as opposed to +/- 1.5GB for GNU LD

1.2.2 as: GNU assembler

The assembler must be GNU (G)AS, and must be relatively recent. Really old x86 GNU assemblers might have hidden bugs that don't surface when used with gcc. Since GNU AS is a typical backend assembler, in the past addressing modes and opcodes that aren't emitted by gcc could be problematic.

An example of this is the OpenBSD 3.x series, where by just substituting a newer assembler from the ports tree FPC suddenly builds, while it fails with the packaged assembler. A relatively recent version is also nice because these probably support newer x86 instructions (SSE2,SSE3).

On some platforms (win32 and x86 ELF), FPC has an internal assembler, and avoids AS for performance reasons. This internal assembler is called the binwriter in FPC jargon. The binwriter is a bit more than a pure assembler though, since it can also directly write static libraries (*.a) . While noticable with ordinary compiles too, the performance problems that the binwriter solves are mainly noticable when smartlinking.

FPC also has the ability to generate code in TASM, NASM, MASM and WASM (watcom) format. However these aren't frequently tested, so your mileage may vary.

1.2.3 ar: GNU archiver

The archiver creates archive (.a) files out of object code files (.o). This is mainly done to reduce the number of files involved in the linking process, and on disc. Archive files are often called static libraries because they contain roughly the same code for static linking as the .so (or .DLL) files do for dynamic code. (a .dll and .so can be more than one .o too). The GNU linker can directly access .a libraries.

AR can be a problem sometimes, since the compiler passes all individual files on the commandline. Due to e.g. smartlinking and this really can be a lot, and be larger than the maximal allowed nr of parameters for the OS. (64k params is too little, 128k is still ok)

1.2.4 make: GNU make

The build process of Free Pascal uses plain (GNU make) makefiles that are generated by FPCmake. FPCmake generates the Makefiles from a global template and the Makefile.fpc in each directory. This Makefile.fpc is a simple INI file that extends and parameterises the global template³. There are plans for the future to get rid of the MAKE utility all together and replace it with a more specialised own version, but these are still in the initial stages. The current system is also quite nice and flexible.

The currently used make is GNU make, it's available for nearly all platforms. However there are some platform specific oddities listed below.

Linux The only without much oddities. Of all Unices, Linux uses relatively a lot GNU tools, and less tools descending from the original unix. If there is a make or make-package on Linux it is most likely GNU.

***BSD** The default make is a pmake variant which is slightly different from GNU's. The makefile template used by FPC isn't compatible with pmake at this moment. (hint, hint) GNU make is installable from the ports tree, usually as devel/gmake. Don't forget to put the bin directory of the ports-\$PREFIX (/usr/local/bin, /usr/pkg/bin etc) into your path, and substitute all use of make by "gmake". In practice this is no big problem, since gmake is generally available on BSD systems, installed as dependancy of a lot of development related packages.

BeOS On my installation (BeOS 5 Personal Edition) both binutils and GNU make came with the developer kit.

OS/2 I honestly don't know. There are EMX and native versions, and of course dos also. Afaik FPC used to be EMX based, but is currently gearing towards native. I'll have to research this myself first :-)

Dos/Go32V2 Uses DJGPP Go32V2 utilities. This because FPC uses the go32v2 extender, and for safe nesting of programs using an extender, all extenders have to be the same. Including the utils :-)

Netware Not even an idea. I never saw this port operational.

win32/win64 Use the mingw set, and preferably the one distributed with the most recent FPC release. See below.

wince My experiences are limited to CE as crosscompilation target. Some people have e.g. NAS boxes that might allow bootstrap FPC on a WinCE based host.

³which can be found in fpc/utils/fpcm/fpcmake.ini

Mac OS X Come with Apple Developer tools (which are installed with XCode on 10.3). Using generic Unix libraries like mysql, ncurses, postgresql etc might require FINK.

The situation on win32 often confuses people. This mainly because there are at least three available sets of the above utils (ar,ld,as,make) that run on Windows. Any mixing (one util from one category, one from the other) can also lead to unpredictable results. Anyway, the three candidates are:

Mingw (sometimes called mingw32) which is the one to use. Win32 native tools with a real win32 feel. (driveletters and backslashes in paths etc) Preferably versions distributed with FPC releases, since they might include FPC specific critical patches. E.g. at a certain point it turned out that mingw tools only searched for a capitalised PATH variable, and not one spelled like "Path" which is common on NT based Windows versions. See the win32 specific part of the FAQ on the FPC website for more info.

Cygwin provides maximal compabilitywith Unix, and can be seen as a Unix compability layer. FPC however is really native on windows, and having half a windows, and half a (compability) unix build system is hard to maintain. FPC does compile with a current Cygwin install though, but the resulting compiler is no cygwin program. Also cygwin programs need cygwin1.dll in the correct version . Note : FPC can link to cygwin, however doesn't need it for operation (except for the textmode IDE). Recently, Cygwin improved in native path support, if the paths are fully qualified. Mingw is still better, but cygwin is usable for emergency operation.

go32v2 Go32v2 is dos based, and used via the dos compability system of Windows, don't use it with the win32 compiler, it would be like using the win32 tools via Wine on Linux :-)

A common problem I encountered on win32 is putting the cygwin "bin" directoryin the win32 search path. The mingw make.exe finds the cygwin shell, and tries to execute certain programs with it. Cygwin has improved a lot recently though, and currently this seems to work again, at least if everything is situated on one drive (one can recompile FPC with only cygwin and a FPC commandline compiler).

Note that some other development tools (Borland, Microsoft, java) might also package a make version. Always put FPC as the first directory in the PATH.

Due to some new developments with parallel compiling using the FPC makefiles, **make 3.80 is strongly recommended as of FPC 2.1.1 (januari 2007 and later)**. Unix people with dual cores and up to date source trees might want to try "make -j 2".

1.2.5 FPC itself. ppc386, ppcppc, ppcsparc, fpc.

Free Pascal is written primarily in itself, in the Pascal dialects it supports. This has some consequences for beginning the bootstraps.

- A normal build of FPC is pretty much only doable with FPC as starting compiler.
- Bootstrapping from Delphi was possible for a while under certain circumstances, but requires some skill, since the makefiles don't support it. Delphi compability has been neglected, since too many Delphi bugs popped up, and keeping it compilable was a problem. Somewhere between 1.9.4 and 1.9.6 most Delphi workarounds were removed. D2005 was never tested. The possibility with Delphi as starting compiler probably failed because while Delphi would have been great from an availability point, it was easier to use FPC because of Delphi's bugs.
- Bootstrapping from TP should possible for 1.0.x versions and earlier. 1.1.x uses delphi classes. However already quite some mastership was required for this, since the compiler is a large program, and the single datasegment limitation of TP was severe.
- Bootstrapping from GNU GPC or p2c is not doable. Their TP modi are not even close to being TP/BP compatible enough, and FPC 1.1.x and beyond need Delphi compability.
- Bootstrapping though VP might be doable in theory, at least for 1.0.x with some considerable skill. This has never been tested though, since FPC is better on nearly all platforms anyway for basic recompilation, and less buggy.

The reasons for these choices belong in an advocacy document rather than here.⁴

However practically there is one major disadvantage: you need FPC to build FPC, and one major advantage: FPC generally needs much less tools installed to build, compared to e.g. a GCC build. One also needs only a suitable compiler binary to

⁴The FAQ lists some reasons, but IMHO not all.

bootstrap FPC, not even a fully fledged FPC installation. (on platforms that don't come with it, you need the GNU build tools though, see paragraphs above), and there are essentially **no library requirements**.

With the internal linker, in time even the GNU tool requirements may disappear, allowing a single compiler binary to fully bootstrap the whole FPC/Lazarus project.

The file you need to start an ordinary snapshot build is “ppc<processor>”, so ppc386 for x86, ppcppc for PowerPC. ppcsparc for Sun Sparc V8 systems, ppcx64 for x86_64 (64-bit x86) etc. Till now these files always have been statically linked. so there is only one Linux compiler, one FreeBSD compiler etc. Kernel, library and distribution versions don't matter. (except maybe major kernel changes in extreme, rare cases like Linux 1.0.x to 2.0.x)

For crossbuilds to the same processor but a different OS you don't need a special cross-compiler. Only for crossbuilding to different processors you'll need a different one.

Besides this, there is the “**fpc**” binary. This is a common frontend to all ppc<cpu> compilers on a system, one that compiles for the current architecture and one that compiles for the rest. The reason for this is that one can use one binary, and specify the processor with -P. So

```
fpc -Ppowerpc compileme.pp
```

will compile “compileme.pp” using the PowerPC (ppcppc) compiler if everything is set up correctly. But we'll get into that later :-)

The fpc binary can also be used to set compiler version:

```
fpc -V1.0 compileme.pp
```

will execute the default compiler (ppc<current processor>) with -1.0 suffixed. Combining with -P is possible. fpc -Ppowerpc -V1.0 will try to run a binary pcppc-1.0 as the real compiler. Specially on Unix this is nice, since only a couple of symlinks allow to switch versions easily.

Combined with a masterfully created fpc.cfg file one can build very powerful crosscompiling systems that autoselect the right targets. We'll get to that later.

1.2.6 Other tools

Sometimes there are other platform dependant tools. Most notably the Windows resource compiler windres and dlltool,

1.3 Obtaining source

1.3.1 Introduction

Right after the FPC 2.0 release, the FPC project change to use SVN as source version management system, for reasons mostly related to merging and branching.

Usually when building a snapshot, the source is obtained via SVN, and comes as a large sourcetree with fpc/ as the root directory of the repository. However the source is usually also downloadable as an archive from the main site⁵⁶. This archive is getting larger each month though, and is already 25M zipped.

A better way is to get the sources via SVN, which allows to upgrade sources to more recent versions incrementally. (i.o.w. the second time, it only downloads changes)

1.3.2 SVN Modules

The FPC and Lazarus source is spread out over several SVN modules:

Module	Description
fpc	The core FPC repository. Contains compiler, RTL, textmode IDE and most non visual libraries
fpcdocs	The FPC documentation source (in L ^A T _E X and fpdoc XML format)
fpcprojects	Projects not yet suitable for distribution together with FPC are parked here. (includes IRC bot)
fpcbuild	Contains fpc and fpcdocs tree as well as the install and demo dirs and a makefile for release packaging.
lazarus	The Lazarus project (visual classes library LCL and the Lazarus IDE/RAD)

⁵<ftp://ftp.freepascal.org/pub/fpc/snapshot/v22/source/fpc.zip>{<ftp://ftp.freepascal.org/pub/fpc/snapshot/v22/source/fpc.zip> (2.2.x)}

⁶<ftp://ftp.freepascal.org/pub/fpc/snapshot/v23/source/fpc.zip>{<ftp://ftp.freepascal.org/pub/fpc/snapshot/v23/source/fpc.zip> (2.3.x development series)}

1.3.3 Downloading source via SVN

To check out a module, use the follow line:

```
svn co http://svn.freepascal.org/svn/<module>/trunk <module>
#
# Examples:
#
# FPC
# svn co http://svn.freepascal.org/svn/fpc/trunk fpc
#
# fpcdocs
#
svn co http://svn.freepascal.org/svn/fpcdocs/trunk fpcdocs
#
# fpcprojects (has no branches, maybe you don't need /trunk at the end)
#
svn co http://svn.freepascal.org/svn/fpcprojects/trunk fpcprojects
#
# lazarus
#
svn co http://svn.freepascal.org/svn/lazarus/trunk lazarus
```

To check out a branch, replace “trunk” in the above lines with the branches/<branch name>. E.g. to check out the branch fixes_2_2:

```
svn co http://svn.freepascal.org/svn/fpc/branches/fixes_2_2 fpc-2.2.x
```

Specific releases are tagged with a tag that is formatted like RELEASE_2_2_4 , and can be checked out like this:

```
svn co http://svn.freepascal.org/svn/fpc/tags/RELEASE_2_2_4 fpc-2.2.4
```

1.3.4 Updating the source via SVN

The advantage of getting source via SVN is of course the incremental updating. This is very simple with SVN, simply use “svn up x”, if x is a directory where you have checked out something before. http path, fixes and branches are automatically read from the system.

Examples:

```
svn up fpc
#
svn up fpc-2.2.4
```

1.3.5 Reverting SVN checkouts

Something new in SVN is reverting. If local edits cause conflicts when updating your checkout, or if you want to be 100% sure that there are no local edits, you should revert your checkout, to make sure that your local copy is really in sync with the SVN server.

You should do this if you're having a problem that other people on IRC and maillists can't duplicate, and your starting compiler is correct.

Examples:

```
svn revert -R fpc
```

1.3.6 Exporting (win32 users, read this!)

Exporting is basically retrieving a local working copy from a checkout. Typical reasons to build in an export instead of a checkout are:

- You are doing a release build. E.g. making RPMs, debs, freebsd ports entries etc.
- You are building on win32, and want to use “make install” to install the build, AND you want to install examples.

The problem on windows is that some tools get confused by the read-only attributes set on administrative files by some SVN clients. Since `svn export` only copies the repository’s content, and not the administrative files, this is a good workaround. Exporting is effectively copying, so this workaround takes about the same time and space as manually copying the checkout.

The format of the export command is:

```
svn export path\to\checkout exportdirectory
```

Example:

```
svn export d:\fpc fpcexport
or
svn export /usr/local/src/fpc fpc
```

If the second argument already exists, SVN will refuse to do this. In that case use `-force` to force svn to update.

Note 1: I haven’t tested this yet, but cleaning the repository before exporting could speed up somewhat, specially on windows.

Note 2: For a **faster solution** see the build tricks section.

1.3.7 More info about SVN

More info about FPC and SVN can be found here http://www.freepascal.org/wiki/index.php/SVN_Migration

1.4 Extension conventions

FPC defines some extensions that need some clarification:

- .o** The actual code of a compiled unit or main program
- .a** The actual code of a compiled unit or main program when smartlinking.
- .ppu** The rest of the compiled unit that is not actual code. (like information about directives that were defined when compiling, the parsed interface etc)
- .s** Assembler code (to be assembled .o) generated by the compiler.
- .as** Assembler code in source form (there never was a pascal equivalent). Usually program startup code.
- .s** files. **.rst** resource string files for internationalisation.
- .\$\$\$** temporary files. Can be safely removed usually
- .res** Windows or OS/2 resource file
- link.res** Linker script file. Contains which files make up the binary, and what external libraries are used.
- ppas.sh** (or **.bat**) batchfile that calls the linker with the correct arguments.
- *.lrs** Lazarus resources, old style

The extensions on win32 originally ended in “w” (***.ow**, ***.ppw**), which was done to avoid confusion with dos compilers on the same system. However this has been superceded by a better directory structure which was needed for easy crosscompiling, and in the 1.1.x/1.9.x branch the extensions for win32 are renamed back to **.ppu/.a/.o**

So in the FPC distribution you will find a **.ppu**, an **.a** and an **.o** per compiled unit.

1.5 Directory layout

Essentially the FPC layout is quite flexible. The binary (ppc386, ppc68k or ppcppc) must be able to find a configuration file, and that file can specify the rest. So the layouts described here are the default layouts as installed by the releases, or as planned for future releases. (the latter of course are mainly the multi processor design)

The base installation of FPC has these main categories:

binaries The base binaries (fpc, ppc68k and ppcppc, ppcsparc, ppcx64) must be in the search PATH of the OS. If you execute fpc, fpc must be able to find the other ones (ppcppc, ppc386 etc), also via the PATH.

fpc.cfg The binary must be able to find the configurationfile in one of the defaultlocations as specified for that OS. (see platform dependant sections)

units The configurationfile must define the correct path to the RTL and other packages compiled for that platformand cpu. This is usually a tree. Crosscompile units also belong in this tree.

(binutils) The binutils (LD,AS,AR) have to be in the PATH, or their directory should be specified in the fpc.cfg file or on the commandline with the -FD parameter. On operating systems that don't install the binutils by default, these are installed by the FPC installation process in the same directory as the main binaries, so this is usually not a problem when not crosscompiling or mixing two FPC installations (e.g. a DOS and Windows installation on one machine). Note that specifying in the fpc.cfg file only works when compiling programs by hand. When compiling a new compiler, the fpc.cfg file is ignored by the makefile.

Besides these there are source tree, documentation,the compiler localisation (language) and example directories. However these are only interesting for real release distribution engineering,and don'tinfluence the workingsof the compileritself. This because the compiler has the source already in compiled form in the .o, .a and .ppu files in the units directory. The place of the source doesn't really matter. The only thing that needs the source directory for automated processing is lazarus, and one can enter any path in Lazarus' FPC source dialogue.

When writing paths in fpc.cfg, some substitutions are automatically done, e.g.

\$FPCTARGET is replaced by the architecture - operating system combination you are compiling for. (e.g. i386-linux)

\$FPCVERSION is replaced by the version of the FPC compiler reading it, and finally

\$FPCCPU is replaced by the processor which the compiler is targeting.

\$FPCOS is replaced by the operating system.

\$FPCFULLVERSION is replaced by a compiler version with an extra patchlevel. (2.2.x)

\$FPCDATE is replaced by the current date.

Since filesystems hierachies differ with the OS, I'll put some OS specific information in the following sections.

1.5.1 Unix (and full clones like Linux)

Under Unix, most directories are relative to the so called prefix. A prefix is a kind of root directory for package installing. Common prefixes are /usr, /usr/local, /usr/exp and /usr/pkg (the last one is common on NetBSD).

The usual convention is that programs that come with the base-distribution go into /usr, and hand-compiled or hand-installed packages go to /usr/local. However the definition of base-distribution varies with the distribution and OS. The main idea is to give root (the administrator) trusted users the ability to install and manage less important packages in /usr/local while keeping the base system only writable for the administrator (group) himself. Linux distributions are traditionally more likely to install packages into /usr instead of /usr/local, but not every distribution does that. "man hier" should list some of the conventions used on your Unix version.

If directories are relative to a prefix, they are noted as \$PREFIX/the/rest/of/the path. Note that this has nothing to do with \$FPC<x> substitutions in fpc.cfg. \$PREFIX is shellsript notation for "get content of environmentvariable PREFIX". Compiled units go into \$PREFIX/fpc/\$FPCVERSION/units/\$FPCTARGET. Units used for crosscompiling also go into \$PREFIX/fpc/\$FPCVERSION/units/\$FPCTARGET.

Binaries go into directory \$PREFIX/bin, however sometimes these are only symlinks to the actual files in \$PREFIX/lib/fpc/\$FPCVERSION directory to easily switch versions. Since the binary can find its own unit files using versioned info in fpc.cfg when properly set up, usually the default binary is the only thing that needs to be swapped.

The place where configuration files are searched on unix are: `/etc/fpc.cfg`, `~/fpc.cfg`. `$PREFIX/etc/fpc.cfg` is searched from 1.9.8 onwards. (note; `~` means home directory on Unix)

So let's take `$PREFIX=/usr/local`, `$VERSION=2.2.4`, `$FPCCPU=i386`, `$FPCOS=freebsd` and `$FPCTARGET=i386-freebsd` as an example, and see what file goes where:

File(s)	location	remarks
<code>fpc</code>	<code>/usr/local/bin</code>	
<code>ppc386</code>	<code>/usr/local/bin</code>	actually symlinked to <code>/usr/local/lib/fpc/2.2.4/ppc386</code>
<code>ppc386</code>	<code>/usr/local/bin</code>	actually symlinked to <code>/usr/local/lib/fpc/2.2.4/ppc386</code>
rtl for i386-freebsd	<code>/usr/local/lib/fpc/2.2.4/units/i386-freebsd/rtl</code>	
rtl for i386-linux	<code>/usr/local/lib/fpc/2.2.4/units/i386-linux/rtl</code>	(cross operating system compiling)
rtl for powerpc-netbsd	<code>/usr/local/lib/fpc/2.2.4/units/powerpc-netbsd/rtl</code>	(cross architecture and OS compiling, endianness)
rtl for x86_64-win64	<code>/usr/local/lib/fpc/2.2.4/units/x86_64-win64/rtl</code>	(cross arch, OS, wordsize)

Note: 1.9-1.9.4 stored libraries for cross compilation in `$PREFIX/lib/fpc/$FPCVERSION/cross/$cpu/$target`. Because all platforms are now fully qualified with architecture, a separate directory for CPU is no longer necessary, and FPC 1.9.5 and above store everything in `$PREFIX/lib/fpc/$FPCVERSION/units` and below.

1.5.2 Windows and Dos

The windows and dos case is pretty much the same. Except that `$FPCTARGET=i386-win32` for windows, and `$FPCTARGET=i386-go32v2` for dos. **It is advised to avoid using spaces in directory names. While (win32) fpc can handle it, some versions of the binutils and other tools can not (yet), or need carefully placed quotes.**

Both these two OSes have a specific directory with all FPC related files (including the documentation etc) in them, default is usually used to be `c:\pp`, but has been changed to `c:\fpc\2.2.4` since 2.0. I call this path `$INSTALLDIR`. Usually there aren't other versions in the same `$INSTALLDIR`. A different version means a different `$INSTALLDIR`, at least in the default situation.

All binaries go into `$INSTALLDIR\bin\%FPCTARGET`. This directory should be in the `PATH`. This directory is quite full, since there are other tools and utilities installed. However if the target is marked to require 8.3 compatible naming (Go32v2, OS/2), the binary path is not `%FPCTARGET` (e.g. `bin/i386-go32v2`) but just `%FPCOS` (e.g. `bin/go32v2`).

Compiled units go into `$INSTALLDIR\units\%FPCTARGET` and deeper, at least under 2.0+.

Configuration files are searched in the same directory as the binary (`$INSTALLDIR\bin\%FPCTARGET`), but if a environment variable `HOME` exists also in `%HOME%/fpc.cfg`.

So let's assume `$INSTALLDIR=c:\fpc\2.2.4` and the default `$FPCTARGET=win32`

File(s)	location	remarks
<code>fpc</code>	<code>c:\fpc\2.2.4\bin\i386-win32</code>	
<code>ppc386</code>	<code>c:\fpc\2.2.4\bin\i386-win32</code>	
<code>ppc386</code>	<code>c:\fpc\2.2.4\bin\i386-win32</code>	
rtl for i386-win32	<code>c:\fpc\2.2.4\units\i386-win32\rtl</code>	(cross architecture and OS compiling)
rtl for i386-linux	<code>c:\fpc\2.2.4\units\i386-linux\rtl</code>	(cross operating system compiling)
rtl for powerpc-netbsd	<code>c:\fpc\2.2.4\units\powerpc-netbsd\rtl</code>	
rtl for x86_64-win64	<code>c:\fpc\2.2.4\units\x86_64-win64\rtl</code>	
Cross binutils	<code>c:\fpc\2.2.4\cross</code>	(not installed by default setup)
libs for i386-win32	<code>c:\fpc\2.2.4\libs\i386-win32</code>	(not installed by default setup)
libs for i386-linux	<code>c:\fpc\2.2.4\libs\i386-linux</code>	(not installed by default setup)

1.5.3 Where are my units?

Starting with later versions of FPC 1.9.5, the `fpc` makefiles create a directory to store the created units. The main reason for this is building for multiple targets without cleaning in between.

So when just build (not installed), the rtl units files are in `fpc/rtl/freebsd/units/$FPCTARGET`. This is a silly example of course, since the RTL is platform specific, but this change is systematic, so for the RTL too.

1.6 The fpc.cfg configuration file

Note: Former versions used ppc386.cfg as configuration file. Even later 1.0.x versions already support fpc.cfg. In time ppc386.cfg will be dropped, so *please* use fpc.cfg.

A correct configuration file should at least do the follow things:

1. (**most important**) Provide the place where to find the correct precompiled units for the current selected operating system and architecture. In IDE's this option is usually called UNITPATH Option: **-Fu**
2. If other binutils then for the default platform need to be used (like in the case of crosscompiling), then fpc.cfg should allow the compiler to find them. I don't know what name IDE's typically use for this, but BINUTILS PATH or GNU UTILS PATH would be appropriate Option: **-FD**
3. Extra paths where static and shared libraries are searched. Often called library path Option: **-F1**
4. (minor) By default the compiler shows only very little errors, warnings and information. It's convenient to add some verbosity parameters to fpc.cfg. Option **-vihw -l**.⁷
5. (crosscompiling) Binutils for cross compiling are often prefix with cpu-operatingsystem(e.g. i686-ming32),this prefix can be specified using **-XP<prefix>** parameter, or using makefiles using BINUTILSPREFIX. Option **-XP**

There are other interesting possibilities of fpc.cfg, (like internationalised errormessages, setting the compiler in a different mode per default, always to try smartlinking etc) but these are the important ones for normal development.

Note: Keep in mind that when using the makefiles supplied with the FPC source, the fpc.cfg is **NOT** read. This is to avoid problems with two RTLs, the old and the new one, when bootstrapping the system.

1.6.1 Unit path -Fu

The -Fu case is pretty much as described in the directory layout paragraphs (1.5), there are two things in which the -Fu compiler option differs from the directory layout as described before. If I append an asterisk (*) to a path, it means that it should search all directories below that directory too, and that the layout for crosscompiled units is a bit different.

We can use the directive FPC_CROSSCOMPILING to detect crosscompilation. The FPC manual has a list of other defines that can be tested.

Unix: If we assume that the compiler is installed to PREFIX /usr/local, and we are using FreeBSD/i386 as host OS, this becomes:

```
# This is pretty generic for OSes with *nix filesystem layout
-Fu/usr/local/lib/fpc/$FPCVERSION/units/$FPCTarget/*
#...or suitable for crosscompiling. Note that the /cross/ dir is not necessary
# and only added as example.
#ifdef FPC_CROSSCOMPILING
# OS not default -> CROSS
-Fu/usr/local/lib/fpc/$FPCversion/cross/$fpctarget/units/*
#else
#ifdef cpu86
# Processor not default -> CROSS
-Fu/usr/local/lib/fpc/$FPCversion/cross/$fpctarget/units/*
#else
-Fu/usr/local/lib/fpc/$FPCVERSION/units/$FPCTarget/*
#endif
#endif
```

Win32 and Dos installed in c:\fpc\2.2.4

⁷The warning system is currently being expanded to have more flexibility.

```

-Fuc:\fpc\2.2.4\units\${FPCtarget}*
# or suitable for crosscompiling
# OS not default -> CROSS
-Fuc:\fpc\2.2.4\units\${fpc\target}*
# win32 binutils are in the path
#ifdef win32
# set path to crossutils. Assuming in one dir.
-FDc:\fpc\2.2.4\bin\cross
# this is not 100% safe. GNU and FPC target naming differ
-XP${FPCTARGET}-
#endif

```

Keep in mind that extra paths (e.g. for own custom packages) can be added. There is also no reason not to use `$FPCVERSION` in the win32 case. It is just an example.

1.6.2 Binutils path -FD

The problems with binutils

1. We only have to set -FD if we set up for crosscompiling. Either when cross compiling to a different processor or a different OS. So we have to determine default OS and CPU somehow.
2. Under Unix, there are usually specific dirs for crossutils, but the exact place and name differs with version. Win32 doesn't have something like that at all. For win32 I propose an example layout as described above.
3. FPC and GNU platform naming differ

Unix : As an example I take FreeBSD on an ordinary PC. The location below (`/usr/local/processor-operatingsystem`) is where the binutils base distribution installs cross compiled utils by default under FreeBSD. However sometimes how FPC names an OS can differ from how the binutils name it. In that case you have to be more verbose, which I have done for the case of crosscompiling to windows⁸ .

So our configuration file becomes:

```

#ifdef FPC_CROSSCOMPILING
# other binutils if OS differs
#ifdef win32
# win32 is an exception
# FPC OS name : win32 Binutils OS name : mingw32
# FPC processor: i386 Binutils processor: i686
-FD/usr/local/i686-unknown-mingw32/bin
#else # we hope that the fpc and binutils name match:-)
-FD/usr/local/${FPCTARGET}/cross
#endif
#else
#ifdef cpu86
# other binutils if processor differs
-FD/usr/local/${FPCTARGET}/cross
#endif #endif

```

Win32 and Dos: Pretty much the same. However contrary to Unix I haven't really tested this. Again I assume FPC to be installed in `c:\fpc\2.2.4` .However the binutils are in `d:\binutils` and deeper and named like under *BSD:

```

#ifdef win32
# other binutils if OS differs
-FDd:\binutils\${FPCTARGET}\bin
#else
#ifdef cpu86

```

⁸Lazy people simply would make a symlink from the fpc naming to the binutils naming. However being lazy is not allowed for tutorial writers.

```
# other binutils if processor differs
-FDd:\binutils\${FPCTARGET}\bin
#endif
#endif
```

Using makefiles

When using makefiles, one can set the `-FD` parameter by passing `CROSSBINDIR=<path>` to `make`. This ensures that the parameter is passed correctly from makefile to makefile (in nested directory hierarchies).

1.6.3 Binutils prefix, all binutils in one directory

A somewhat newer addition is the `-XP` parameter which sets a prefix for all binutils, so if you add `-XPbla-die-bla-` to the `fpc` commandline then all calls to `as` and `ld` will be prefixed with `bla-die-bla-`. The main reason for this is that by default, cross compiled binutils are named `<cpu>-<target>-<filename>`, and not just `<filename>`.

When doing a cross snapshot (or cycle), setting the make variable `BINUTILSPREFIX` will make sure that `-XP` is passed on the right moments.

If we assume the binutils for cross compiling are all in one directory, the above piece of code becomes:

```
#ifdef FPC_CROSSCOMPILING
# other binutils directory if processor or target OS differs
-FD/usr/local/cross/bin
# set prefix to select the right ones from that directory:
-XP${FPCTARGET}-
#endif
```

This assumes that binutils naming of platforms is the same as FPC's. It isn't however, there are a few exceptions:

Usual name	FPC name	Binutils name	ppc<x> name
(32-bit windows)	win32	cygwin or mingw32	(OS not CPU)
i386 or x86	i386	i386,i486,i586,i686	386
Sunos/Solaris	sunos	solaris	
PowerPC	powerpc	powerpc	ppc

So for these targets we would have to make exceptions. (see e.g. script code in the `fpcbuild/install` repository, e.g. `samplecfg` and `install.sh`)

1.6.4 Library path -Fl

The library path is where static libraries (and shared libs under unix) can be found. While this is very important for the Unix platform, the FPC compiler on windows and dos also can link to GCC (and variants) libraries, so FPC must be able to find them.

The library path is of course target and processor dependant. One couldn't link FreeBSD/x86 libraries to a Linux/Powerpc binary. So essentially we are doing the same trick as with the unit path. If the default targets are used, on unix it is set to the default directories, otherwise it is set to some hierarchy where the user is supposed to install his cross libraries.

Unix: As an example I take FreeBSD on an ordinary PC, because most BSDs, specially on ordinary PCs have a "compability" Linux libraryset to run proprietary Linux programs for which no FreeBSD version exists. This mode is called the Linuxator⁹. The Linuxator libs are usually SUSE based and in `/compat/linux/` and deeper. NetBSD has a huge set of such emulations. Anyway, here is the snippet, it assumes the user to build a hierarchy of cross libs under `/usr/local/crosslibs`

```
#undef specialoscpu
#ifdef FPC_CROSSCOMPILING
#define specialoscpu
# DEFAULT
# libraries outside base are installed with PREFIX=/usr/local
```

⁹The linuxator is strictly speaking an emulator. However the emulation layer is so thin (a few 10's of kbs) that there is no noticable performance loss. Since all libs are in memory twice (Linux+FreeBSD) it eats some extra memory though.

```

-Fl/usr/local/lib
# however X stuff is installed with PREFIX=/usr/X11R6
-Fl/usr/X11R6/lib
#endif
#ifdef linux
#ifdef cpu86
# CROSS, BUT SPECIAL, FreeBSD optionally has a Linux userland on board
# for the linuxator. Usually it is some SUSE version.
#define specialoscpu
-Fl/compat/linux/lib
-Fl/compat/linux/usr/lib
-Fl/compat/linux/usr/X11R6/lib
#endif
#endif
# libraries not existing on target by default. Reverting
# to special cross directories
#ifndef specialoscpu
-Fl/usr/local/crosslibs/$FPCTARGET/lib
-Fl/usr/local/crosslibs/$FPCTARGET/usr/lib
-Fl/usr/local/crosslibs/$FPCTARGET/usr/local/lib
-Fl/usr/local/crosslibs/$FPCTARGET/usr/X11R6/lib
#endif

```

Win32 and Dos: Exactly the same idea. Some directory with the hierarchy (d:\crosslibs for now), but none as default. If you have a suitable gcc equivalent (djgpp for dos, cygwin and mingw for win32), you could add it to the space for the default.

```

#ifndef win32
# other binutils if OS differs
-Fld:\crosslibs\${FPCTARGET}\lib
-Fld:\crosslibs\${FPCTARGET}\usr\lib
#etc
#else
#ifndef cpu86
# other binutils if processor differs
# maybe somebody does a port for win32/Sparc or so.
-Fld:\crosslibs\${FPCTARGET}\lib
-Fld:\crosslibs\${FPCTARGET}\usr\lib
#else
# DEFAULT
#endif
#endif

```

1.6.5 Verbosity options

Well, there is not much to tell. The default is ok, and I never change it (I wrote it down below for completeness), for more info see the manual. Note that any verbosity setting in fpc.cfg can be overridden on the commandline (e.g. for debugging, typically uses -va on the cmdline)

```

# write FPC logo lines.
-l
# Display Info, Warnings, Notes and Hints
-viwn

```

1.7 The order to compile parts of FPC

Packages is a bit of an ambiguous term when used in the FPC project¹⁰. Sometimes “packages” refers exclusively to the separate unit sets in the packages/ directory of the source tree, sometimes it also includes the other separately compilable

¹⁰See also <http://wiki.freepascal.org/packages> <http://wiki.freepascal.org/packages>

parts of the project (like compiler, rtl, fcl, ide, fvision, lazarus, installer and utils). In this paragraph it's the latter one.

The directory structure of the packages has been reorganized starting with FPC 2.2.4.¹¹ Most importantly, the fpcmake system now figures out its own dependencies, so all packages (including FCL and FV) could move to /fpc/packages. This greatly simplifies building and maintenance of the packages. The units of the FCL were also regrouped into multiple packages.

Of course there is still a certain sequence one should follow when building FPC, which is hardcoded in the top Makefile. This is because some packages need other packages and need to be built first. The usual order is:

1. bootstrap the compiler (make cycle) 3x compiler, 3x rtl
2. Rebuild the RTL smartlinking
3. Build the packages directory including the FCL and FV packages.
4. Build the textmode IDE.
5. utils/ directory including fpcmake in utils/fpcm

Lazarus can be built after the main build (with or without IDE). However install the main build *first*. Some directories are not built at all in a standard build of the fpc repository:

1. demoes and example directories of packages
2. the regression testing suite (tests/)

Examples are often compilable by descending into the package directory and executing "make examples".

1.7.1 Some interesting build scripts

Some of these principles are used in some of the scripts used to build releases, test crosscompiling etc.

- fpc/install/install.sh is the installer script for unix. Nicely demonstrates platform name (GNU->FPC) conversion
- fpc/install/cross/buildcrossbinutils is a script to mass-build cross binutils
- fpc/install/cross/buildcrosssnapshot is an attempt at building cross snapshots. Works in principle, however the shared linking of mkxmlrpc and the textmode IDE are troublesome.
- fpc/install/makepack is a release building script. It requires the target name (i386-linux, i386-win32 etc) as parameter

1.8 Smart linking

Smartlinking (ld/gcc documentation calls it dead code elimination) essentially means avoiding linking of unused code into the final binary.

The problem is that the GNU linker can do dead code elimination, but usually (read: with gcc) only does this on a compilation unit level. In other words, it still will link in the entire unit when only one file is used.

Newer binutils use can do deadcode elimination based on sections, however the problem with this is that it ups the version requirements on binutils, which is a problem specially for operating systems as classic MacOS, older Mac OS X versions, OS/2 etc. The new form is also not entirely stable yet.

Using the old style smartlinking, FPC circumvents this by generating a .o for each symbol in a unit. So each procedure, method, variable or typed constant gets its own .o file. Since this can be thousands of .o files in a unit (unit Windows has about 20000-30000), and the .o files are added to an .a archive using GNU AR.

All together this is a pretty complicated process:

1. a unit is compiled by fpc to a lot of assembler source (.s) files,
2. that get assembled by a lot of calls to AS to generate a lot of .o files

¹¹This reorganization was made possible with improvements in the fpcmake system. However in time, the fpcmake system will disappear, and be replaced with the fpmake/fppkg system that is already included for testing in 2.2.4+

3. that are read again by AR to form one .a file

.... which is why smartlinking performance really benefits from the binwriter (see II), which causes FPC to write the .a directly without thousands of calls to AS.

Besides tightening code, smartlinking also solves a problem when a unit interfaces to a shared library (unix .so or win32 .dll) and certain unused calls aren't available. An example would be if unit windows contains calls added in later Windows versions that you don't use for your program and you work on/for Windows 98. when not smartlinking, the whole of unit windows would be linked in, and the linker wouldn't be able to find the calls from later Windows versions in the Windows 98 kernel32.dll and user32.dll.

Be careful when trying to guess the savings of smartlinking. Often people forget unit initialisation (both of the unit in question, and the unit it USES) and all the classes, procedures and functions the initialisation uses are always linked in, and units (even if they are unused) are always initialised, since the compiler can't see that the effect of the initialisation on the working of the program is zero.

A word of caution: In C, an .o file usually corresponds to one .c or .cpp file, so one .a contains <n> .o's that correspond to <n> .c's. However under FPC, when smartlinking per unit (.pp , .pas) the file that is ultimately written is an .a which contains a lot of .o's. So an FPC .a corresponds to one unit only.¹² An .o however is the same unit as the .a without smartlinking.

A known problem with old style smartlinking is its **memory usage**. Ld doesn't manage a lot (100000+) of small object files (.o) efficiently, and memory requirements increase enormously. Smartlinking a fully static Lazarus wasn't possible because it bombed out on my OS' 512 MB memory limit for ordinary processes, a rough estimate of the memory needed was 1.5 GB. A rule of thumb for memory usage in extreme cases is between 50 and 100 times the size of the final binary.

It seems that ld can do deadcode elimination nowadays, however the compiler needs to be adopted for this, and there is also some movement in having an own internal linker. The advantages of this system is less memory use by LD, and the fact that .a files will disappear (in the new method, the smartlink data is added to the .o files). However no matter how fast this becomes usable, old style smartlinking is still needed for quite a while, for OSes with binutils that are not recent or complete.

¹²At least for now, developments in library generation might change this in time, but not before 2.4

Chapter 2

Standard building

The start of the FPC buildprocess is bootstrapping a compiler. Bootstrapping the compiler is the start of every build process, because changes in the compiler source must be activated before one can start compiling the libraries. Usually the bootstrap is only a minor part in an automatised snapshot or full build. However some knowledge about the process can be handy for crosscompiling purposes and development on FPC itself.

The other two typical build processes are building and installing a snapshot, and building a release. Somewhat less streamlined are building the IDE and documentation. Building Lazarus on the other hand is fairly easy.

For the average user, building a snapshot and/or lazarus are the interesting parts.

2.1 Cleaning

2.1.1 Make clean

In nearly any place in the FPC tree a “make clean” will try to remove compiler generated files of snapshot or cycle building. A “make distclean” in the upper level is even a bit more thorough, and also removes files generated while building releases (zips etc)

Note that the make files usually delete what they generate. So if e.g. the generation of certain files depends on certain makefile defines and/or compiler version, make sure that the right compiler and defines are passed to make.

A good check to see if the repository is clean, is to check standard output and -error of the svn update process. If you see errors, then revert the SVN checkout.

2.1.2 make distclean

make distclean is the more rigorous way of cleaning. If you experiencing build problems, always do this first. If you have snapshot scripts, add make distclean in the top level dir as a first line. This became a lot more important in 1.9.5, since recent 1.9.5's store their units in a separate units/\$fpctarget hierarchy. Cleaning before SVN update can speed up the SVN update process significantly, specially on Oses that have relatively slow directory searching (like windows and netbsd)

2.1.3 Cleaning of crosscompile builds

Note that the clean targets of the makefile only clean for current \$FPCTARGET. To rigorously clean everything, kill all .o, .a and .ppu files, and then SVN update again, to recover the few .o files in the FPC tree (mostly for testsuite tests relating to C linking)

2.2 Bootstrapping: make cycle

“make cycle” is a bootstrap of the compiler, and builds the rtl and compiler at least three times.

The only starting compiler that is guaranteed to work is the most recent release compiler for that series¹. So if you have a problem in any aspect of building the FPC source tree and you are not using the most recent release compiler, *please try first* with the most recent release compiler. It is possible to specify the name of the starting compiler (see below), so saving the release compiler under some name (I'll use *ppcrel* from now on in this tutorial) is advised.

The make cycle process compiles RTL and compiler three times:

RTL 1st Since the we start with only the starting compiler, a new RTL must be built first before we can link a program.

Compiler 1st A new compiler is created. However the new compiler is still compiled by the release compiler, so newer optimisation and changes aren't active yet in this binary. For that reason, both the RTL and the compiler have to be rebuilt.

RTL 2nd So we rebuild the RTL and...

Compiler 2nd the compiler. However to make sure the compiler is deterministic (compiles the same program to the same executable each time it is run), the compiler and RTL are compiled.....

RTL 3rd again....

Compiler 3rd and after building the compiler for the third time the 2nd and 3rd compiler are compared to see if there they are the same. If not, everything is compiled again. (for some rare secondary effects)

This entire process is run by simply type "make cycle" in the compiler directory. If you want to use an alternative compiler, specify it with `PP=[full/path/to/]<compiler>`. When using the `PP=` option, use a compiler in the `PATH` or an absolute path, not a relative path. Using a relative path usually won't work since during the process, the make utility changes directories. If you try to bootstrap without a full instalton, you sometimes need to specify `FPC=[full/path/to/]<compiler>`

Additional compiler options can be added using `OPT="<the options>"`, often used options are turning on debugging information with line information (`-gl`), and increase the verbosity level (`-va`). However since `-va` produces a `_lot_` of output, it is wise to pipe it to file.

Some examples: ²

```
# go to the right directory on unix
cd /fpc/fpc/compiler
# go to the right directory on windows
cd /d d:\repo\fpc\compiler
# do an ordinary make cycle:
make cycle
# Use a starting compiler in the OS search PATH
make cycle PP=ppcrel
# use a starting compiler with (unix) absolute path
# and enable line info and debugging
make cycle PP=/fpc/startcompilers/ppcrel OPT="--gl"
# Use LOTS of verbosity in the process and redirect it to file.
make cycle OPT="--va" >cycle.log
```

2.3 Compiling a snapshot; make all or make build

"Make all" is the most important build process, it essentially builds (but not installs) the general purpose parts of the standard SVN tree (see 1.7), except sideways related stuff like documentation, examples and tests. Installing is one additional makefile command.

In its simplest form, build a snapshot is checking out SVN (see 1.3.3), and changing to the top `fpc/` directory and call "make all". Installing to the default location is done by executing "make install".

```
cd /fpc/fpc make all
# lots of building. Think 3 minutes on a XP2000+, 10-15 minutes on a 500MHz machine.
make install
```

¹E.g. For the 1.9.x series, even though 1.9.6 and 1.9.8 will probably work, the only guaranteed starting compiler is 1.0.10!

²The lines starting with "#" in the example below are comments. Don't enter them

```
# Installs the snapshot to the default location
# (/usr/local/lib/fpc/$FPCVERSION and deeper probably)
#
# or on Windows:
cd /d d:\repo\fpc
make all
make install COPYTREE=echo
# (default is c:\pp\ and deeper)
```

If you track FPC SVN very closely, this is probably what you'll do quite often. However in some special cases, more parameters are needed. Essentially this is building a snapshot. If you trick “make install” into installing in a different directory, the contents of that directory are essentially the snapshot.

The simplest variation is a different starting compiler. This can be done by simply entering `PP=<compiler>` or `PP=/full/path/to/<compiler>` after the “make all” prompt:

```
cd /fpc/devel/fpc
make all PP=/my/starting/compiler
# lots of building. Think 3 minutes on a XP2000+, 10-15 minutes on a 500MHz machine.
make install
# Installs the snapshot to the default location
# (/usr/local/lib/fpc/$FPCVERSION and typically)
#
# or on Windows:
cd /d c:\repo\fpc
make all PP=ppc386
make install COPYTREE=echo
# (default is c:\pp\ and deeper)
```

A standard confusing detail when installing a snapshot is that the target directory (e.g. `/usr/local/lib/fpc/2.2.4`) depends on the version number. If you would follow the above sequence, and the generated compiler (say version 2.3.1) is not equal to the starting compiler (say version 2.2.4), then make install will install into the wrong directory. The same goes for windows (`c:\fpc\2.2.4 ...`) This can be solved by setting the compiler that is generated in the “make all” step as a starting compiler to the “make install” step. This will ensure that the “make install” sequence gets the correct versioning info. Since we can't use relative paths, this must be a full path:

```
cd /fpc/devel/fpc
make all PP=/my/starting/compiler/path/ppc386-someversion
#
# Now install using the NEW compiler for the correct version info:
make install PP=/fpc/devel/fpc/compiler/ppc386
#
# Installs the snapshot to the default location
# (/usr/local/lib/fpc/$FPCVERSION and deeper probably)
#
# and for windows:
cd /d c:\repo\fpc
make all PP=c:\fpc\startingcompilers\ppc386-someversion
#
# and installing use the NEW compiler
make install PP=c:\repository\fpc\compiler\ppc386
```

Another very common variation is installing into a different base directory (`$PREFIX`), this is done by setting a variable `INSTALL_PREFIX` to the desired directory:

```
cd /fpc/devel/fpc
make all PP=/my/starting/compiler
#
# Stack installs packages that don't come with the package system in /usr/exp
#
```

```

make install INSTALL_PREFIX=/usr/exp
#
# Or on Windows:
# My FPC directory is on d:\pp
#
cd /d c:\repo\fpc
make all PP=ppcrel
make install INSTALL_PREFIX=d:\pp
#
# Or lets make a snapshot to upload to some site on some unix:
#
#
cd /fpc/devel/fpc
make all PP=/my/starting/compiler
#
# Make a scratch directory in /tmp
#
mkdir /tmp/fpc
make install INSTALL_PREFIX=/tmp/fpc
#
# archive
#
cd /tmp/fpc
tar cvzf /tmp/newsnapshot.tar.gz *
# remove temp dir.
#
cd /tmp
rm -rf fpc
#

```

Finally, adding parameters to every compiler commandline is interesting too. This can be done by adding `OPT='<the parameters>'` to the commandline. Often used parameters for this purpose are `-d<xxx>` to define a value which can be tested using e.g. `{$IFDEF xxx}` in the source, and `-gl` to include debug info. `-va` is also often used to debug the snapshot building process. If you add `-va`, pipe the output to file, or the building will slow down due to the massive amounts of output written to screen.

Adding `-gl` when you are developping with FPC is a good habit, since it allows you to single step all of the FPC runtime libraries in GDB (roughly equivalent to the “use debug .DCUs” options in Delphi). The generated snapshot gets somewhat larger though.

```

cd /fpc/devel/fpc
make all OPT='-gl'
# lots of building.
make install
# Installs the snapshot to the default location
# (/usr/local/lib/fpc/$FPCVERSION and deeper probably)
#
# or on Windows:
cd c:\cvs\devel\fpc
make all OPT='-va' &> d:\buildlog.log
make install
#
# multiple parameters are passed like this:
#
#
make all OPT='-gl -va'

```

A word of caution: When I build snapshots for home use, I simply “make install” them over the old snapshot, at least if “make all” succeeds. If you encounter errors during build or install, or even after install (like the notorious “can’t find unit xxx”, while it is there), try to remove the units/ directory in the FPC homedir, and re-execute the “make install” used to install it. This should resolve the problem. If not check as much settings as you can check and read chapter 4

The problem is usually caused by units changing directories (or packages) in CVS. Since the usual procedure doesn't clean the units/ directory, after installation two instances of that unit exist, which could lead to conflicts.

A good habit is to backup source tree before updating and the FPC install directory (compiler + units/ directory) before installing a new snapshot. This just to make sure you will have a working compiler in case something goes wrong during building or installing. This can easily be automated using a script that updates - backups - builds - installs. Since I'm not that fond of unix scripting, I'll leave that as an exercise to the reader.

2.4 Current build procedure on win32

The situation on win32 with current SVN is a bit complex, so I decided to dedicate a separate paragraph listing the procedure, combining all the above data. The problem on win32 is that SVN marks its own config files as read-only, which leads to problems with installing examples, and the cp utils provided with 2.0 have some unix path <-> windows paths troubles. Most notable, they don't see \xxx\yyy as a windows path, but they do see d:\xxx\yyy as a windows path.

There are two solutions, the quick one simply omits the examples, the slow one does. Best is to do the slow one once in a while to have up to date examples, and for the rest use the quick solution. The slow solution also fixes some problems with older versions of the mingw utils.

Besides the read-only svn dirs problem, there is also a problem with Vista, and some mingw binaries have problems with the casing of PATH statements.

2.4.1 The slow solution: SVN exporting

Before we begin, lets define the directories (my defaults)

- d:\pp is the directory where I currently have installed FPC, and d:\pp\bin\i386-win32 is the FPC dir in my %PATH%.
- d:\fpcSVN is the directory where I checked out the SVN repository. I don't build in it.
- d:\fpc is the directory where I export the SVN repository too.
- d:\fpcrel is the directory containing FPC 2.2.4 for bootstrapping purposes.

Another important issue: **MAKE ABSOLUTELY SURE THAT THE CYGWIN DIRECTORY IS NOT IN THE PATH!!!!!!** The reason for this is that some mingw utils start using cygwin sh.exe when found, and that in turn swaps some utils from the FPC delivered mingw tools to cygwin ones.

Then, to make and install a snapshot, we update the SVN:

```
cd /d d:\
svn up fpcSVN
```

Then we export it:

```
# Cleaning improves performance,
cd fpc
make clean
cd ..
svn export --force fpcSVN fpc
```

Now, the building can start:

```
cd fpc
make clean all OPT='-gl' FPC=d:\fpcrel\bin\i386-win32\ppc386.exe
```

If this is successful we install: (all on one line)

```
make install OPT='-gl' INSTALL_PREFIX=d:\pp11 UPXPROG=echo FPC=d:\fpcrel\bin\i386-win32\ppc386
```

Some things to notice:

- **MAKE ABSOLUTELY SURE THAT THE CYGWIN DIRECTORY IS NOT IN THE PATH!!!!!!**
Mingw/msys can also give problems, but more rarely (see 2.6.4)
- The options (OPT='-gl') are passed both to the make and install lines. This because sometimes due to unit dependency glitches and utils, a minor amount of code is (re) built during install. This goes for **ALL** build options that are not installing related
- UPXPROG=echo avoids UPXing of the resulting binaries, so that the FPC binaries can be debugged. If you want as small FPC bins as possible, leave it away, and add SMART=1 to both make lines. Note that UPXing wastes memory that is more expensive than disk.³
- We add -force to the SVN export line to force overwriting of the previous repository. If building goes wrong, day after day, try erasing the export directory (d:\fpc) before exporting.

2.4.2 The Quick solution: COPYTREE

The quick solution exploits that the recursive copying is done using a command that is *only* used for copying the examples. And updating the (installed) examples is not that important when daily updating, one typically wants to avoid the slow SVN export step. The makefile macro that is used internally in the makefile for copying files recursively is COPYTREE, we then use the same trick as earlier to disable functionality by specifying the “echo” command:

```
make install COPYTREE=echo
```

2.4.3 VISTA specific topics: install.exe

Vista is quite draconian in some things, and there will be a lot more problems in the future, specially for release engineering. (think about temporary files in the root, not allowing writes in the appdir etc). However there is one little gotcha that also affects normal building.

This gotcha is actually the result of an attempt to minimize trouble for existing installers by automatically popping up UAC (otherwise you would have to do “run as administrator” which is not end user friendly), but it was implemented half-assed. Any EXE with install, setup or update in its name will pop up UAC, but.... *UAC prompts fail for console apps*.⁴

The FPC build system uses GNU install (as ginstall.exe) to install files with proper permissions, and that fails due to UAC. The definition of the problem also implies the solution:

1. Copy the (g)install.exe binary to a new name without the keywords, I use “myinst.exe”
2. Pass GINSTALL=myinst.exe to the make commandline :

```
make install GINSTALL=myinst.exe
```

Probably this will fixed in a while by mingw, e.g. by adding a manifest. (in 2.4.0 or 2.2.6 if 2.4.0 is delayed)

2.4.4 Putting it all together

Here is the batchfile that I use on Windows: (the FPC source tree is in d:\repo\fpc)

```
@echo on
set BASEDRV=c:
set SRCDIR=%BASEDRV%\repo\fpc
set PPCNAME=ppc386
set FPCSTART=c:\fpc\2.2.4\bin\i386-win32\%PPCNAME%
```

³http://wiki.freepascal.org/Size_mattershttp://wiki.freepascal.org/Size_Matters

⁴<http://technet2.microsoft.com/WindowsVista/en/library/00d04415-2b2f-422c-b70e-b18ff918c2811033.mspix> search for “keyword”

```

set LOGDIR=%BASEDRV%\repo
set INSTALLDIR=%BASEDRV%\pp11
REM some random opts.
set OPTS=-gl -dSAX_HTML_DEBUG -dUSE_MINGW_GDB
set COMMONOPTS=UPXPROG=echo COPYTREE=echo OPT="%OPTS%" GINSTALL=myinst.exe
rem === invariant part ===
cd /d %SRCDIR%
REM the building
make clean all %COMMONOPTS% FPC=%FPCSTART% 1> %LOGDIR%\buildlog.txt 2>&1
REM separate install step for crossversion purposes (and under Unix sudo)
make install %COMMONOPTS% INSTALL_PREFIX=%INSTALLDIR% FPC=%SRCDIR%/compiler/%PPCNAME% 1> %LOGDIR%\instal

```

Actually, I have several such files, another one for 64-bit, a more advanced one for crosscompiling to wince etc. The win64 is a copy that differs only in “x86_64-win64” in the path and ppcx64 instead of ppc386. Note that all variables are in the upper part of the batchfile, this makes it easier to port it to systems and just adapt the paths. Having several computers with slightly different path and drive layouts was the motivation to write them.

Unfortunately, pure batchfile is too limited to invest too much time in it.

2.5 Lazarus

Building lazarus is actually pretty much the same as building a snapshot, except that you have to enter directory lazarus/ instead of fpc/.

```

cd /repo/
svn update lazarus
cd lazarus
make all
# you might want to check if the return value of “make install” is zero before installing.
make install INSTALL_PREFIX=/usr/local
#

```

At the moment of writing this there was some problem with installing lazarus. It seems that the makefiles aren’t entirely up to date. I usually move the lazarus repository to /usr/local/lazarus, and set some symlinks to execute the right binary. This isn’t that bad, since you need to save the lazarus source for Lazarus’ operation anyway.

2.6 Typical problems and tips

2.6.1 cannot find -l<xxxx>

Since Lazarus need to link to shared libraries, building lazarus tests an aspect of the FPC configuration that hasn’t been tested by the parts above. A typical error is

```

Linking ./lazarus
/usr/libexec/elf/ld: cannot find -lglib12
lazarus.pp(334) Error: Error while linking
Closing script ./ppas.sh

```

This means that the linker, when building the final binary, couldn’t find libglib12.a or libglib12.so. This is officially not an FPC error, since glib is part of GTK, which belongs to the operating system. *So maybe the gtk (or a corresponding gtk-devel package) is simply not installed.* There are four other possibilities:

1. While the package is installed, the package manger didn’t create a symlink that refers the libglib.12.so.x to libglib12.so. A quick `cd /usr/local/lib; ln -s libglib12.so.2 libglib12.so` would have solved that in this case.
2. (the actual problem in the case above) The directory with the correct file isn’t searched for libraries by FPC, because you didn’t specify the directory in fpc.cfg using -Fl. A mere adding of -Fl/usr/local/lib to /etc/fpc.cfg solved the problem in this case.

3. You have a `{$LINKLIB xx}` in the source somewhere, or a `-l<xx>` parameter in some script or makefile that forces FPC to try to link the library, but it isn't necessary anymore, `grep` is your best friend in such cases.
4. Your distribution for some reason names its libraries differently. Again, symlinking the searched name to the real name is the solution.

2.6.2 CONTNRS or other FCL-BASE units not found

If the compiler can't find `contnrs`, this points to a problem with the `-Fu` paths. It probably means `-Fu` was wrong, but the makefiles managed to auto-add the RTL, and the `contnrs` (and other FCL-BASE) unit(s) are then the first unit that can't be found.

2.6.3 Piping stderr and stdout to the same file.

Piping stderr and stdout of the MAKE process to the same file is useful for debugging the exact sequence of events. This is easily done on Unix using `>&`.

Under Windows this is a bit more complex, but can still be done:

```
make install 1> filename.txt 2>&1
```

This line pipes the output of `install`'s stdout to `filename.txt` using `1>`, but redirects stderr (`2>`) to stdout (`&1`) first.

2.6.4 (Windows) building and install fails with “invisible” errors

I suddenly had problems when doing “make clean all install” in one go. Further investigation of the output showed “ignored errors” in make exit lines:

```
make: [fpc_clean] Error 1 (ignored)
```

however this would lead to an all stop after the *all* part:

```
make: *** [fpcmade.i386-win32] Error 1
```

This turned out to be a mingw related problem, a file “`sh.exe`” was left in the project source. Another solution would be to never use these commands in one go, but script them as separate ones.

I experimented with `sh.exe` because when using “make -j 2” it produces a warning that `-j` functionality is disabled if `sh.exe` is not found. I assume the makefile must be adapted to ignore “ignored errors” instead of “all errors” somewhere.

Note: Despite the usage of mingw tools, it is not recommended to have the mingw directories in the path. Some of the mingw tools (most notably `make.exe` when it detects `sh.exe`) apparently change behaviour if they detect other ones.

Chapter 3

Crosscompiling

(you need to have read the previous chapters too, since they already contain a lot of crosscompiling related info that I won't duplicate here)

3.1 Basic crosscompiling of a snapshot

Let's have two examples, freebsd to win32-mingw crosscompile, and a FreeBSD to AMD64 linux one.

Assume we have the following items set up correctly:

1. Cross binutils have been compiled, and are installed with `$PREFIX=~ /cross`. The correct prefix has been identified (probably something like `i686-ming32-and x86-64-linux-in` our example)
2. The FPC sources are in `fpc/`
3. FPC was installed in `/usr/local/lib/fpc/$FPCVERSION` and deeper

Then we execute:

```
cd ~/fpc
gmake distclean
# next all on one line
gmake all install OS_TARGET=win32 CROSSBINDIR=~ /cross/bin BINUTILSPREFIX=i686-ming32- INSTALL_PREFIX=/usr-
```

to build the first snapshot (note that `CPU_TARGET` isn't set, and that `OS_TARGET` uses the FPC platform naming (`win32`), while `BINUTILSPREFIX` uses the GNU one (since it is for the binutils). Also note that the `BINUTILSPREFIX` ends with a dash. This is on purpose.

Similarly, for `x86_64-linux` the line becomes

```
cd ~/fpc
gmake distclean
# next all on one line
gmake all install CPU_TARGET=x86_64 OS_TARGET=linux CROSSBINDIR=~ /cross/bin BINUTILSPREFIX=x86_64-linux-
```

3.2 Crosscompiling without cross-assembler.

Sometimes one doesn't want to really crosscompile, just test if something like the RTL compiles under target `<x>`. If this target is on the same architecture, one can try to use

```
gmake fpc_units OPT='-s'
```

The `-s` skips calling the assembler/linker and the use to the `fpc_units` makefile-target skips the assembling of the RTL's load-ecode. Another such trick is to pass `AS=echo` or `AS=gecho` to `gmake`. Note that in former (2.4.x/4.x) times, crosscompiling between Linux/x86 and FreeBSD/x86 was possible without cross assemblers and linkers. This to my knowledge hasn't been retested with newer versions of these OSes.

3.3 Crosscompiling Lazarus

3.3.1 Crosscompiling Lazarus from windows to Linux

First, we need a set of cross binutils. For windows->other platforms, these are on FPC FTP `ftp://freepascal.stack.nl/pub/fpc/contrib/cross/mingw/binutils-2.15-win32-i386-linux.zip`. Download and extract them to the same directory as your “ppc386” compiler binary. Verify their install by running `i386-linux-ld` on the command prompt.

Second, we need FPC and Lazarus source trees. Note that the FPC tree must be an exported tree, since we are going to use `make install`, and `make install` trips over SVN directories. So after checkout `svn export` the sources (see SVN paragraph for examples)

Now we are going to build and install FPC for crosscompiling (assume FPC is installed in `c:\fpc\2.2.4`)

```
make clean make OS_TARGET=linux all make OS_TARGET=linux install INSTALL_PREFIX=c:\fpc\2.2.4
```

Lazarus is a different matter however, since it uses shared libraries. So I copied Linux libraries from my target system and put them in `d:\linuxlib`. Which libraries I copied is described in the separate paragraph below.

Before we really start, we have to workaroud a different problem. The compiler still has a detection for pre-glibc systems which is easy to trip if you make a mistake. So go into `i386-linux rtl` directory (probably `c:\fpc\2.0.4\units\i386-linux\rtl`) and copy `cprt21.o` over `cprt0.o` so that both files are in fact `cprt21.o`.

Now we start with the Lazarus building, enter the `lazarus` directory and give a

```
make OS_TARGET=linux all OPT="-gl -Fld:\fpc\linuxlib -Xr/usr/lib -FL/usr/lib/ld-linux.so.2 -XLA=c,dl,gmodule"
```

The `-gl` is about adding `debuginfo` (good to have a traceback if something goes wrong), the `F` argument specifies the directory to look for the linux libraries, and the `-Xr` argument makes the linker create the binary so that it searches in `/usr/lib` for libraries. The `-FL` argument is the name of the dynamic linker, and the `-XLA` line adds two libraries (`dl` and `gmodule`) if `libc` is included.¹

This should build a Linux `lazarus`. However most likely, it will bomb out missing some library. The solutions to that are editing the linker file “`link.res`” and rerunning `ppas.sh` again, or adapting the `d:\fpc\linuxlib` dir with more or renamed libraries. The `link alias` options (as `-XLA` above) are really handy to avoid repeated editing.

3.3.2 Preparing a directory with Linux libraries

For the crosscompile I copied a bunch of files of the target linux distribution (and yes, these are possibly distribution and version dependant!). Some of these are also needed for the `textmode` IDE. If library files were named `libname.so.x.y` on linux I renamed them to `libname.so` in my Windows directory, since the symlinks used for that on Linux are not easily copied.

Most of these libs are in directories like `/lib`, `/usr/lib` and maybe `/usr/local/lib`, `/usr/X11R6/lib` and `/opt/gnome/lib`. `libgcc` however is in a GCC install dir, which can be found by doing a `gcc -v` and then look for a line like

```
“Reading specs from /usr/lib/gcc-lib/i486-linux/3.3.5/specs”
```

then some of the libs are in `/usr/lib/gcc-lib/i486-linux/3.3.5/` Anyway, these are the files I copied (FC4 iirc):

```
libpthread.so.0
libdl.so
libc.so
ld-linux.so.2
crtbegin.o
crtbeginS.o
crtbeginT.o
crtend.o
crtendS.o
```

¹Alternately, you can add `{linklib dl}` and `{linklib gmodule}` to the main `lazarus` sourcefile `lazarus.pp`

```

crti.o
crti.o
libgcc.a
libX11.so
libXi.so
libglib-1.2.so
libgmodule-1.2.so.0
libgdk_pixbuf.so
libgdk-1.2.so
libgtk-1.2.so
libXext.so
libm.so
libdl.so.2
libgmodule-1.2.so

```

Note that some directories are duplicate, with a suffix (like libgmodule-1.2.0) and not. I need them twice because some of the other libraries names the full name (so the form lib<name>.so.x) as an dependancy and we can't symlink on windows, so I simply copy it.

Making mistakes with renaming is not that bad, there will be chances to fix it. Make sure all crt* and a file "libc.so" are available or generating link.res will go wrong. In my case compilation for step 11 will go ok, but the linker will complain it can't find libgtk.so and because on the target system, libgtk is gtk 2.0, while we want gtk1.2 for lazarus (<=0.9.26) which is named libgtk-1.2. I solve this with the so called linkordering switch -XLAgtk=gtk-1.2 and similarly for gdk and glib. See the separate paragraph about this switch and its limitations for more info.

3.4 Interesting compiler and makefile options

3.4.1 Skipping built in directories: -Xd

On Unix targets, Free Pascal often automatically passes default libraries like /lib and /usr/lib as include directories to the linker. This can be a problem when experimenting with crosscompiling (and dual architecture) systems. The parameter -Xd convinces the compiler to not add these directories.

3.4.2 Difference in paths: -Xr<directory>

-Xr configures where the linker should look for libraries when crosscompiling. It translates to the ld -rpath-link parameter.

3.4.3 -Xt static linking

The -Xt parameter tries to link static as much as possible by passing -static to LD, the linker. A more finely grained control over what libraries are linked statically, and which ones are linked dynamically can at this time only be achieved by postediting the linker "link.res" file. Compile with -s, edit link.res, and then run ppas.bat or .sh to resume the linking process.

3.4.4 CROSSOPT

The Makefile of compiler/ allows to specify compiler options that are only used during the actual crosscompiling state using CROSSOPT= (so not during the initial bootstrap cycle that is not cross-)

3.4.5 LIBDIR

Allows to specify a dir to be used for linking. Don't know the exact cross-compile consequences, specially if the host OS needs a lib path to cycle (Solaris, OS X)

Chapter 4

Systematic problem solving for the FPC build proces

The questions of people that read the previous “make cycle faq” on the FPC maillists suggested that the main remaining problem is what to do if something goes wrong, and to determine the exact cause of the problem.

The usual problems are:

1. Wrong versions of FPC for a certain job or trying to combine compiler and rtl that don't belong together (2.3 with the 2.2.x RTL, or trying to generate windows binaries with the go32v2 binutils). Specially Lazarus users often try to build with a too old version anyway, despite the minimal version advise on the main Lazarus site.
2. Leftovers of the previous install/build frustrate the current build process (not deleting old directories etc, stale .ppu's or .o's) Be hygienic with respect to old .ppu, .o's, binaries and buildtrees!
3. Omitting details that don't have to be done for each install, (not fixing the symlink in /usr/local/bin/ that points to the real installation)
4. Directory inclusion problems (fpc.cfg inclusive). Directories not being searched, or wrong ones included
5. (windows) Having cygwin in the PATH, which causes fatal mixing of the mingw FPC build tools and their cygwin counterparts. Same for other development packages that e.g. provide “make”
6. (unix and strictly not a FPC problem) not installing operation system parts and libraries. Most notably the -devel libraries on Linux, or ports on *BSD.
7. (development versions only) Trying to compile something in a directory that contains files with the same name as files in the FPC cvs. The compiler find these, and thinks they are the RTL sources that need recompilation. Release versions are protected against this (by compiling the RTL with -Ur)

Double checking that you are not having these specific common problems is worth the effort.

4.1 Determining the problem, increasing the verbosity.

The standard systematic search for the problem starts with increasing the verbosity level, by passing `OPT=<switches>` after make. This works when executing the commandline compiler too.

The commonly used verbosity options are

`-vt` (show filesearching information, searched paths etc) If you expect problems with what directories are searched, you usually choose this to keep the amount of logged data down.

`-va` (show all info. REDIRECT THIS!)

This is the ultimate source if something goes wrong. The rest is pretty much guess work and experience. The verbose compiler messages are the best source by far, and the only one that allows some systematic problem searching. Nobody expects the Spanish Inquisition, but try to answer these questions for yourself when looking at the -va output.

- Is the correct compiler executed?
- Does the compiler version match with the version that you'd expect ? (You can also use `ppc386 -i` to check version). This includes verifying the compiler date!
- Are the operating system and processor you are compiling for correctly named in the output?
- Is the correct `fpc.cfg` (name and location) loaded and is it preprocessed as you think?
- Are linker, include and unit directories correct?
- If the compiler can't find a unit, does a line like "unit changed, recompiling" exist a bit higher? If so see the separate section on the "recompiling" problem.
- If you are using FPC supplied makefiles, keep in mind that the `fpc.cfg` file is ignored while building a "cycle" or a larger target that depends on cycle (like "make all") Add parameters to the make commandline, set environment variables, or fix config files (e.g. `/etc/ld.so.conf` if it is a linker directory problem) to fix this.

If you do use nested includefiles, is the nesting the same way as you expect? (a small filter program can be quite handy to "graph" how includefiles are included for complex files)

4.2 Checklist

Some other things easily checked without extra verbosity :

- (on unix) Check the compiler location with "which ppc386".
- Check the compiler version and date with `ppc386 -i`
- Look at your path variable (`echo $PATH` on unix, `echo %PATH%` on dos/windows), and check that the FPC directory for the target you choose is first. Specially make sure that
 1. there is no cygwin directory in the path at all (cygwin tools use non-dos path layout, and need special handling. FPC's mingw based versions of make and the binutils don't mix well with cygwin's)
 2. (Windows) there is no other directory of a development tool (Delphi, JBuilder, VC++) in your path. These can contain own versions of certain tools, mainly make that are not compatible. A `make -v` or `make --version` can be useful too.
 3. the PATH variable is spelled in all capital letters. If you have this problem, correct it in the windows environment dialogue (one of the tabs of System settings) A batchfile that can fix this on the go for if you don't have permissions to fix it directly on your work system is


```
set a=%PATH%
set Path=
set PATH=%A%
set a=
```
 4. Check your `fpc.cfg`. I know, you never edit that one, and it has worked always, but do so anyway. Quickly inserted "I have to get this working now!" changes are easily forgotten.

4.3 Recompiling

A standard gotcha for FPC newbies is when the compiler says it can't find unit xxx, while you are really 100% sure it is there, and the directory with that file is searched. (note : make 100% sure that this is the case, before continuing)

The most common causes are:

1. (by far the most common) stale `.o` and `.ppu`'s, or incorrect settings that include wrong directories. (with `.ppu` and `.o`'s). Run `make distclean`
2. includefiles and unit names that are not unique.
3. A difference in the defines.

If so, if you do the same build with `OPT='-va'` and search for "Recompiling"

[Unfinished]

Chapter 5

Misc topics

5.1 Programming models.

Over the last few years, FPC has started to support an increasing amount of platforms that use the Unix specific RTL parts. Some form of reorganisation was necessary, and because more processor platforms are in preparation for FPC, I decided to look into portability issues, specially creating 64-bit clean code, and alignment and endianness. The main reasons for researching portability for Object Pascal were Free Pascal's plans to port to 64-bits platforms like x86_64, Sparc64 and PowerPC G5.

The term 64-bit clean is somewhat misleading, because it is not limited to 64-bit architectures alone, but a general principle for writing code in a way that it runs on a lot of processors. The basic principle is to only allow conversion between a certain integer type and pointer, and always have a certain integer type (PtrInt) that is guaranteed to scale with pointer size.

In C, the standard "long", or a new "long long" type is used for this. Since pointers aren't generally regarded as "signed", it seems logical to pick an unsigned type to be compatible with a pointer. Signed or unsigned doesn't much matter for compability with C as long as integers are coded using two's complement, and because the interface between C and another language is untyped.

The reason to define a new type Long Long is simple, to allow legacy code that assumes that integer and long are equal in size to keep on working without modification.

A chosen set of types is refered to in C faqs as a "programmingmodel", and are named ILP-x, LLP-x or LP-x with x the processor's wordsize in bits, typically 32 or 64. ILP-x means that Integer, Long and Pointer are x bits wide, LP-x that Long and Pointer are x bits wide, and LLP that Long Long and Pointer are x bits wide.

Some typical programming models are listed in the table below.

Ctype	objpas	Size in model				
		ILP32	LP32	LP64	ILP64	LLP64
char	byte/char/smallint	8	8	8	8	8
short	shortint	16	16	16	16	16
int	integer/longint	32	16	32	64	32
long		32	32	64	64	64
long long		32	-(32)	-(64)	-(64)	64
pointer	pointer types	32	32	64	64	64

- Some points in the table need explaining:
- Standard programming model for current (intel family) PC processors is ILP32. All 32-bits OSes use it.
- The problem with long in C was that there are both large codebases that expect pointer and long to have the same size, while there are also large codebases that expect int and long to be the same size. The compability model LLP64 was designed to keep the long<->int compability by introducing a new type to remain compatible with pointer (long long)
- long long doesn't exist except in LLP64, and both long and longlong don't have an clear equivalent in Object Pascal yet. A new type would have to be created just like under C. Since Pascal has no long<-> ptr equivalence established yet, the long vs long long discussion is unimported. It was however decided to create both a signed (PtrInt) and an unsigned (PtrUInt) type that scale with pointer size

- LP32 is used as model for the win-16 APIs of Windows 3.1
- Most *nixes use LP64, mainly to conserve memory space compared to ILP64, since using full 64-bit ints is hardly necessary and a waste of memory. Examples: 64-bit Linux, FreeBSD, NetBSD, OpenBSD
- Win64 uses the LLP64 model, which was also known as P64. This model conserves type compability between long and int, but loses type compability between long and pointer types. Any cast between a pointer and an existing type requires modification.
- ILP64 is the easiest model to work with, since it retains all compability with the much used ILP32 model, except specific assumptions that the core types are 32-bit. However this model is quite memory-hungry, and both code and data size significantly increase. Typically used by commercial unices, like IBM AIX.
- There are no dos models in the table, since dos doesn't have a flat memory model. (a pointer can't be represented by a single value in these models. DJGPP extender models are ILP32 though.

5.2 Link ordering

Starting with 2.0.4 some switches were added that simplify dealing with changing library names. These switches are **BETA** and may change or **disappear** at any time, e.g. when a linker description language is implemented. They were mostly added to be able inventorize how useful such a system would be in practice, mostly it is meant to deal with changes in library names and keep a release running without repackaging it before a final decision is made. They are BETA also because the internal linker might totally change the linking backend in the near future.

The main problem it solves is that with FPC, names of libraries can be hardcoded in the FPC source in **\$linklib** or **EXTERNAL** declarations. While this is generally a good thing that makes it way easier for the user and avoids kludges like having to specify each and every library on the commandline like gcc, it can be annoying in times when librarynames go through a transition, and you use a distribution that renames libraries.

Besides the name, also the order of libraries might sometimes be a problem, specially when libraries don't specify their dependancies correctly. Most of these issues are with relative lowlevel libs like libgcc.

FPC 2.0.4 introduces several **beta** switches to deal with this. There are three new parameters:

1. -XLAlibname=[libname1][,libname2..]
2. -XLOlibname=<number>
3. -XLD

A limitation that remains is that there is no way to allow the user to decide which libraries are to be linked statically, and which are to be linked dynamically. This mainly for easier deployment on linux (non standard libs? -> force static). Another limitation recently surfaced is that this only goes for libraries. Object files, and their order are untouched

5.2.1 -XLA

The first parameter, -XLA, defines a substitution of library name. The libs on the right side are added to the parameters of the linker if the lib on the left side is in the list with libraries to link that is constructed from the source. The right side can be empty, and can also contain the libname that is already specified on the left. Examples:

- -XLAc=c,dl makes sure that libdl is added if libc is in the list, libc remains in the list.
- -XLA dl= removes libdl from the list of libraries to link even if it was `{linklib xx}`'ed in the source
- -XLA gtk-12=gtk12 translates a link to libgtk12 to search for libgtk-12

5.2.2 -XLO

The parameter XLO defines a weight. Libraries are sorted on weight into descending order. Defaults weight is 1000. If you decrease the weight, it will be lower in the list with libraries to link. This is mainly useful to link certain libraries (typically the more lowlevel ones) in a certain order, like e.g. with `libc_r` and `libc` on FreeBSD4, or to get programs to link that made a mess of their dependancies. This possibility removes the need for a few ad-hoc ordering hacks, and the special parameter for the FreeBSD 4->5 transition that was one such kludge, `-Xf` was reimplemented using this functionality. The compiler has default weights on a per target basis. This mainly means that `libc` usually will be somewhere near the end.

Example:

```
-XLOc=1050
```

puts `libc` before libraries that don't have a weight specified in `link.res` (since the default is 1000)

5.2.3 -XLD

The parameter `-XLD` simply makes the compiler forget the defaults for weights and aliases. This can be useful if something changes for a library that has a hardcoded weight, or when a built-in alias is not needed anymore.

5.2.4 Example: Fixing the FreeBSD GTK breakage with linkordering

The FreeBSD ports maintainers decided to force large changes related to linking using `libtool` on the ports tree in november 2005 (in UPDATING), but they were not into effect till April 2006. One of sideeffects of these changes were renaming of the GTK 1 libraries to `gtk-12`, `gdk-12` and `glib-12`, where they used to be `gtk12`, `gdk12` and `glib12`. These changes affected all users that tracked 5 and 6 stable, since they didn't wait for a major version transition to introduce this. Ports maintainers also refused to add a few symlinks for a while to ease the transitions, and pointed to gcc specific tools like `gtkconfig` and `libtool`. (these emit gcc commandlines).

Most users track STABLE by default out of practical purposes, and changing the FPC binary to call external programs and to parse them, would only make the whole process more fragile and harder to support. I myself decided to give up working on FPC ports tree entries because I really start wondering where I benefited from participating in the ports tree process. The work is immense, and the uses for the users are small if such changes break packages so hard and relatively often.

Since in time, more and more users will use either `-STABLE` or a release based on `-STABLE` after the change, in FPC 2.2.0 I changed the default name of the GTK libraries to their new names, and introduced `linkordering` switches to keep older installations working. So if you have a system from before this change, and don't track stable, you can workaroudthis by putting the following in your `fpc.cfg` or `.fpc.cfg`:

- `-XLAglib-12=glib12`
- `-XLAgdk-12=gdk12`
- `-XLAgtk-12=gtk12`

5.2.5 Example II: FreeBSD 4 vs 5 pthreads:-Xf

Another item is the `ppc<x>` parameter `-Xf`, which signals an alternate pthreads layout. Currently it only exists for FreeBSD. On versions 2.0 and 2.0.2 the parameter signals FreeBSD 5.x `libpthread` behaviour, and on 2.0.4 it signals 4.x `libc_r` behaviour. In 2.0.4 the parameter was reimplemented on top of the `linkordering` routines, so that when compiling for 4.x `libc_r` can be used, ¹ `en` when compiling for FreeBSD 5.x `libpthread` will be linked in. Also the ordering is fixed using internal equivalents of `-XLO`, and the defaults are also overridable with `-XLD`.

¹2.0.4 doesn't provide a out of the box 4.x setup anymore, though generally the functionality should be preserved.

Part II

Glossary

Note that this glossary tries to explain compiler and FPC project specific jargon, not Pascal/Delphi in general.

architecture Roughly the processor family. Note that for PC's, the x86 architecture (all 80x86 chips) is often misused, where the i386 architecture (80386 and higher) is meant. The PC version of FPC is i386 architecture, and doesn't run on older x86 processors. Other architectures are PowerPC (which is subdivided into power32 (=32-bits) and power64 (=64-bit)), m68k (68030+ in practice), Sparc V7, Sparc V8, Sparc V9 (the latter better known as Ultra Sparc). ARM versioning is more complex, since those processors can be built to order, a customer can choose from several cores, and add modules like FPU, memorysystem (endianness), DSP functionality etc.

AR The GNU archiver. Combines .o files into .a files. .a files are used for smartlinking, though that might change in the near future.

AS The GNU assembler. The backend assembler that is used if FPC needs an external assembler.

assembler a textual representation of the binary machinecode that is fed to the processor.

alias A function or variable with a name that doesn't adhere to standard name mangling, usually for internal functions or foreign language interfacing.

binwriter The part of FPC that directly writes .a's and .o's. Since using the binwriter eliminates executing AS (and possibly AR), building is much faster. The reason why it is not available for each platform is that there is no universal .o format. Every binary type often has its own .o variant, and all need special support in FPC.

branch(CVS,SVN) Normally versions of a file in CVS are a linear series of updates, a new version after each update. This can be thought of as the trunk of a tree. However at a certain point you might want to add an update that might e.g. break backwards compability or that introduces instability for some time. The solution then is to have two sequences of versions. One with that update (a development series of update), and one without. These separate series are the branches of a tree.

bootstrapping is the entire process of creating a compiler starting from another compiler (another version or a totally different compiler). See also **make cycle**

Carbon A Mac OS widgetset/API, which is essentially the cleansed subset of the classic Mac OS API that works with Mac OS X.

CLX A library from Borland that is a bit more multiplatform and should have replaced VCL. However users stayed away in droves. CLX is GPLed, and thus is not very usable for FPC, library wise.

COCOA A Mac OS X widgetset/API written for use with Objective C.

contrib directory A directory in SVN (module fpcprojects) where some ported Delphi packages are kept (ICS, Abbrevia, Decal). This directory is a subdirectory of the projects directory.

Cross

(**cross -compiling, -linking and -assembling**) Generating binaries or libraries for other operating system and/or processor than that you are currently working on.

(**crossbinutils**) binutils (ld,as,ar) that generate binaries for other operating systems and processors.

(**crossbindir**) Place where the crossbinutils can be found.

CVS A version management tool used by the FPC tool to manage the FPC source code before may 2005

Cygwin www.cygwin.com A distribution of unix tools for windows that tries to stay as close to the original Unix semantics. See also **mingw**

dead code elimination GCC or maybe general C jargon for smartlinking. The default dead code elimination of gcc is not as finely grained as FPC smartlinking though.

ELF binary format of most modern unices and unix likes. Except for Mac OS X (see Mach-O)

Export (libraries) Making symbols (procedures, variables) available to the outside. (e.g. outside the unit, outside the library/program) (SVN)

FCL Free Component Libraries. Non visual class libraries, provided for partial Delphi source compability, at least at a non visual/GUI level. See also **VCL**.

FPC

1. Free Pascal Compiler abbrev.
2. The fpc compiler frontend binary.

FPCMAKE util to convert Makefile.fpc to Makefile

FPMAKE The sucesor to fpcmake and make/makefiles in general that is supposed to render the latter obsolete in 2.2. The main features are a more maintainable and performant build system (crosscompiling inclusive)

FPPKG Another build tool scheduled for 2.2 which should allow auto download+compile of packages, a bit like what the FreeBSD ports tree with a apt-get like cmdline frontend would look like. (or portupgrade, which is the proper FreeBSD pendant)

FPDOC A documentation generation system used by FPC internally, but also usable for external use. fpdoc takes a XML file generated by makeskel, and postedited with fpde, processes the file and generates multiple documentation formats from it (html,text,T E X)

GO32v2 Pure Dos is 16-bit. FPC programs are 32-bit. The program that hides the 16-bit nature a bit, and does 32-bit DPMI dos memory management for 32-bits applications is called the Dos-Extender. FPC uses the GNU Go32 version 2 dos extender. (though others are possible in theory, like pmode. See manual)

Inline If procedure X calls procedure Y, and Y is flagged for inlining, then Y will be totally optimised away, and in the final code (in the binary), the code of Y will appear to be in X. If Y is called on two separate places in X, the code will appear twice in X. While nearly anything can be flagged “ inline;”, some kinds of procedures/methods are excluded from inlining, like virtual methods.

Internal linker A linker built in to the compiler, as opposed to an external linker like GNU LD. FPC uses an internal linker in FPC 2.2+ for the three windows platforms (win32/win64/wince)

Lazarus A multi widget GUI RAD for Free Pascal. Not a blind Delphi drop in replacement, but the support of GTK makes it useful. At the moment of writing this, Lazarus is developing rather fast, for up to date information, see their site Lazarus site

LCL The set of Visual classes used by Lazarus and the programs it generates. The LCL is generally independant of platform or GUI widget library. Starting with 0.9.28 on *nix the LCL will use GTK2, win32/64/ce on Windows, and Carbon on OS X. A QT based port is also available for *nix.

LD The GNU linker, which is nearly always the one used by FPC.

Mach-O binary format of OS X/Darwin make cycle A command to rebuild the FPC compiler and core RTL from source. (bootstrap, building a new compiler from an older, or other compiler)

make all A command to rebuild the entire base FPC sourcecode. This is roughly equivalent to the snapshots.

mangling see namemangling

mingw (mingw32,mingw64 depending on win32 or win64) A distribution of Unix tools for Windows that adapts more to “the windows way” than **cygwin**.

Namemangling Languages can have different namespaces that can contain the same name, however on the linker level there is only one namespace. Namemangling is the process that maps the multiple language level namespaces onto the single linker level namespace. An example is e.g. the unitssystem. Units can contain variables with the same name. Say unit A contains variable “buildfaq”, and unit B does too. Naming both “buildfaq” would make them clash on the linker level. A solution is to prefix the variable name with the unitname. So “buildfaq” in unit A will be called A_buildfaq, and in unit B B_buildfaq. Namemangling is compiler (and -version) specific, and since the namespace rules vary with the language also somewhat language specific. An exception is the C (not C++) language which barely has namespaces, and therefore often has little or no mangling. The C++ namemangling is a notorious case, since it changes from compiler to compiler and version to version.

NEWRA The new improved register allocator of the 1.1.x (2.0+) series. The new register allocator should improve compiler performance and maintainability by automatically arranging a fairly optimal register usage. Since this removes the need for manually keeping track of registers in the codegenerator,this improves maintainability a lot.

Packages is a bit of an ambiguous term when used in the FPC project. (see also <http://wiki.freepascal.org/packages> <http://wiki.freepascal.org/packages>)

1. Sometimes “packages” refers exclusively to the separate unit sets in the packages/ directory of the source tree,

2. sometimes it also includes the other separately compilable parts of the project (like compiler, rtl, fcl, ide, fvision, lazarus, installer and utils),
3. a third description is the Delphi language feature with the same name, a more automated form of dynamic libraries. In this document it's usually the second one.

PIC (Position Independent Code) a system for Unix (*BSD, Linux) that ensures relocatability of shared libraries, and allows easy minor version upgrades of libc libraries without recompiling the library.

Prefix

1. (**PREFIX**) place where the snapshot building (make all install) will use as root directory for the installation of the files. (default: \pp on windows, /usr/local on most unices) The dollar sign that is sometimes prepended is the (Unix) notation for environment or makefile variable, a bit like Windows/DOS %something%.
2. (**BINUTILSPREFIX**) A string that is prefixed to the binutils when crosscompiling. Usually in the form processor-operatingsystem-(like "i686-mingw32-")

Projects directory a directory in CVS where experimental and independent projects are stored. Usually Delphi code ported to FPC (see contrib directory), and Lazarus.

Ptint A integer type that has the same size (in bits) as the pointer type.

PtUInt is the unsigned form. Register allocator The engine that tries to make optimal use of the processor registers to avoid reloading from memory.

Register parameters A calling convention that tries to put parameters to procedures in registers. Delphi has a register calling convention by default. FPC is slowly starting to support register parameters now (thanks to NEWRA changes). Most non PC processor types also use register parameters. Since december 2003, FPC defaults to this convention on i386 too, for Delphi compatibility. During the last months of 2006, a bug was found in the Delphi compatibility of register parameters; when procedures use more than 4 parameters (one less for methods), the fact that FPC pushes the parameters in the opposite order of Delphi becomes a problem. This probably will be tackled in FPC 2.1.1 in spring 2007.

Register variables An optimization technique that avoids reloading variables from memory into the main CPU's registers by trying to keep frequently used variables in registers as much as possible. FPC 1.0.x had this in a primitive way based on reserving a few registers for variables. FPC 2.x has a way more intelligent system as a part of the register allocator.

RTL RunTime libraries. The base set of libraries used by FPC. These include e.g. the System unit, the dos unit, the sysutils unit and a platform dependant unit. The System unit also contains functions that the compiler calls internally to do more complex language operations like SET and string handling.

shared linking Linking with dynamic libraries (unix: .so shared libraries; win32: .dll shared libraries)

smart linking essentially avoids linking of unused code into the final binary. See the separate paragraph (1.8) elsewhere in this document for more details.

static linking The ordinary way of linking, producing one standalone binary, though sometimes smartlinking is also called "static" linking. This might be true for C, but FPC has two different modes because with FPC the granularity of smartlinking typically is higher.

Starting compiler A compiler that is used to build a new compiler.

Subversion(SVN) The current version management system.

tag(CVS,SVN) A tag simply identifies a bunch of different files that belong together. It's commonly used to mark a the set of versions that are released as a formal (pre)release. E.g. the FPC 1.0.10 release is tagged with RELEASE_1_0_10 etc.

target

1. Roughly the operating system and CPU that the binary must run on, typically in CPU-OS notation (e.g. i386-freebsd) There are exceptions though, like Dos has a target for each extender, and some compilers have multiple targets for Windows (gcc: mingw, cygwin) too. Some toolchain let the CPU reflect the CPU that is optimised for (i386,i486, i586 etc), some not. FPC does not (all i<x>86 platforms, x>=3, are called i386)

2. Lazarus adds the widget set too, e.g. x86-win32-win32 (i386+ processor, win32 OS, and win32 (GDI) widgetset) and x86_64-win64-win32 (means 64-bit x86 CPU, win64 OS, and win32 widgetset (GDI)).²

VCL Borland's classes libraries. Since these contain bot win32 GUI and non-GUI classes. the VCL roughly equates to the non visual FCL classes plus the visual classes in Lazarus' LCL.

Widgetset A library or API for visual output. (originates on Unix where core drawing, and windowing is separated)

win32

1. The API of Windows 9x and NT,2000,XP that is roughly the same over all versions. (though newer versions add more calls). A cut down win32 api is available for win3.1x and is called "win32s". FPC doesn't support win32s (actually: it was never tested is a better description)
2. The FPC target for this api
3. In Lazarus it is also the designation for the graphical part of the win32 api (which is actually called GDI, roughly the widgetset). Lazarus windows binaries for target win32 and win64, have as widget set.

Win64 The 64-bit variant of the win32 API. Very close to win32.

wince The windows api the mobile Windows versions (wince/pocketpc/windowmobile) are based on. Note that nowadays also "XP embedded" exists which is win32 based, but based on the NT kernel, so specially with tablet PCs make sure what you exactly have.

winNT The common underpinnings of NT4, windows 2000 (NT5) ,XP (NT5.1) ,2003 (NT5.2),Vista (NT6), 2008 and 7 (NT7)

²The fact that lazarus names the widgetset for win64 "win32" doesn't mean it is some form of 32-bit emulation. The differences were simply too small to define an additional target

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