GNU/Linux-libre from source code

for Pentium 4

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This is edition 1.9.1 (last updated October 2026) of *GNU/Linux-libre from source code for Pentium 4*.

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Various formats of this manual as well as its texinfo source are available on `http://cjarry.org/gnu-linux/gllfsc/pentium4/`.

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1 Introduction

1.1 GNU/Linux History

1.1.1 GNU

GNU (GNU's Not Unix) is a project launched by Richard Stallman in 1984 with the goal of building an entirely free operating system compatible with Unix[1]. "Free" here means "free as in freedom". In this context, a free operating system is an operating system you can use and share in freedom. A core part of his motivation is given in the GNU Manifesto[2]:

> I consider that the Golden Rule requires that if I like a program I must share it with other people who like it. Software sellers want to divide the users and conquer them, making each user agree not to share with others. I refuse to break solidarity with other users in this way. I cannot in good conscience sign a nondisclosure agreement or a software license agreement. For years I worked within the Artificial Intelligence Lab to resist such tendencies and other inhospitalities, but eventually they had gone too far: I could not remain in an institution where such things are done for me against my will.
>
> So that I can continue to use computers without dishonor, I have decided to put together a sufficient body of free software so that I will be able to get along without any software that is not free. I have resigned from the AI Lab to deny MIT any legal excuse to prevent me from giving GNU away.

A program is free software if the program's user has the four essential freedoms:

- The freedom to run the program, for any purpose (freedom 0).
- The freedom to study how the program works, and change it so it does your computing as you wish (freedom 1). Access to the source code is a precondition for this.
- The freedom to redistribute copies so you can help others (freedom 2).
- The freedom to distribute copies of your modified versions to others (freedom 3). By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this.

One of the most popular free software license is the GNU General Public License (GNU GPL[3]).

The free software movement is supported by the Free Software Foundation (FSF[4]).

1.1.2 HURD

The HURD is an acronym for HIRD (HURD of interfaces representing depth) of Unix-replacing daemons. It is the GNU project's replacement for the Unix kernel. It is a collection of servers that run on the Mach microkernel to implement file systems, network protocols, file access control, and other features that are implemented by the Unix kernel or similar kernels (such as Linux).

The purpose of the GNU HURD is to improve your freedom on your operating system by allowing you to either add or remove a feature of the kernel on the fly.

From early on, the HURD was developed to use GNU Mach as the microkernel. This was a technical decision made by Richard Stallman, who thought it would speed up the work by saving a large part of it. He has admitted that he was wrong about that.

---

[1] See `https://en.wikipedia.org/wiki/Unix`

[2] `http://www.gnu.org/gnu/manifesto.html`

[3] `http://www.gnu.org/licenses/gpl.html`

[4] `https://www.fsf.org`

Nevertheless, development of the HURD is increasingly attracting developers and GNU/HURD systems exist and are usable.

1.1.3 Linux

Linux is a monolithic kernel created by Linus Torvalds in 1991. Linus Torvalds initially wrote a terminal emulator, which he used to access the large UNIX servers of his university. He wrote the program specifically for the hardware he was using and independent of an operating system because he wanted to use the functions of his new PC with an 80386 processor. This later became the kernel Linux.

Initially, Torvalds first published the kernel Linux under its own licence, which had a restriction on commercial activity.

In the notes for the first release of the kernel Linux, Torvalds lists the GNU software that is required to run Linux:

> Sadly, a kernel by itself gets you nowhere. To get a working system you need a shell, compilers, a library etc. [...] Most of the tools used with linux are GNU software and are under the GNU copyleft.

In 1992, he suggested releasing the kernel under the GNU General Public License. He first announced this decision in the release notes of version 0.12. In the middle of December 1992 he published version 0.99 using the GNU GPL.

The kernel Linux is now a contribution of many professionals and volonteers around the world.

1.1.4 Linux-libre

Linux, the kernel developed and distributed by Linus Torvalds et al, contains non-Free Software[5], i.e., software that does not respect your essential freedoms, and it induces you to install additional non-Free Software that it doesn't contain.

GNU Linux-libre[6] is a project to maintain and publish 100% Free distributions of Linux, suitable for use in Free System Distributions[7], removing software that is included without source code, with obfuscated or obscured source code, under non-Free Software licenses, that do not permit you to change the software so that it does what you wish, and that induces or requires you to install additional pieces of non-Free Software.

You can visit `https://h-node.org` to see if your hardware works with Linux-libre: wireless card and graphics chip in particular.

1.1.5 References

For more information on the GNU project and its relation with the kernel Linux, you can read `http://www.gnu.org/gnu/thegnuproject.html` and `http://www.gnu.org/gnu/gnu-linux-faq.html`.

For more information on the history of the HURD, I recommend you to read `http://web.archive.org/web/20221122061739/http://www.h-online.com/open/features/GNU-HURD-Altered-visions-and-lost-promise-1030942.htm`.

For more information on the HURD, read `http://www.gnu.org/software/hurd/`.

For more information on the early versions of the kernel Linux, read `https://www.cs.cmu.edu/~awb/linux.history.html`.

---

[5] For more information about the presence of proprietary firmware in the kernel Linux, read `http://www.fsfla.org/ikiwiki/anuncio/2010-03-Linux-2.6.33-libre.en` and `http://www.gnu.org/distros/free-system-distribution-guidelines.html#nonfree-firmware`.

[6] `http://www.fsfla.org/ikiwiki/selibre/linux-libre/index.en.html`

[7] For a full list of free as in freedom GNU/Linux distributions, see `http://www.gnu.org/distros/`.

1.2 Purpose of this Document

One day I found a Dell Optiplex 745 minitower with a Pentium 4 CPU in a municipal waste. I just replaced the button battery and the computer was able to boot. I decided to adapt GLLFSC document I previously wrote for the Lemote Yeeloong 8133 (with a Loongson 3A CPU): GNU/Linux[8] Libre from Source Code for Pentium 4 was born.

GLLFSC is a document that you follow to produce a command-line operating system. This OS is completely Free Software[9] and has enough programs on it so that you can:

- boot
- connect to the internet, either with wired or wireless connection
- browse the web with lynx
- read your mail with inetutils
- and thanks to Package Users and recipes, build new packages to extend its base features: graphical interface with Xorg, dynamic window manager dwm, gtk, palemoon web browser, and many more.

Why did I create GLLFSC?

1. It is 100% Free Software, no restriction on how or how long I can use any program in it
2. It is simple: simple to tweak things to fit my needs. This simplicity leads to both speed and reliability, 2 qualities I value very much in an OS.
3. It is extensible: if something is missing, adding it is simple with the use of Package Users recipes

[8] Note: in this document, we use the term "GNU/Linux" to name the entire system and "Linux" to name the kernel. For more information, read `http://www.gnu.org/gnu/why-gnu-linux.html`.

[9] `http://www.gnu.org/philosophy/free-sw.html`

2 Prerequisites

2.1 Definitions

2.1.1 `sysroot`

The traditional way of building a GNU/Linux operating system consists on building a (cross-) compilation toolchain to build a temporary operating system which in turn will be used to build the target system[1]. This requires almost as much time to complete the temporary system as to build the target one. Using sysroot resolves this problem.

From GCC installation manual, under Cross-Compiler-Specific Options:

`--with-sysroot`
`--with-sysroot=`*`dir`*

> Tells GCC to consider *dir* as the root of a tree that contains (a subset of) the root filesystem of the target operating system. Target system headers, libraries and run-time object files will be searched in there. More specifically, this acts as if `--sysroot=`*`dir`* was added to the default options of the built compiler. The specified directory is not copied into the install tree, unlike the options `--with-headers` and `--with-libs` that this option obsoletes. The default value, in case `--with-sysroot` is not given an argument, is `${gcc_tooldir}/sys-root`. If the specified directory is a subdirectory of `${exec_prefix}`, then it will be found relative to the GCC binaries if the installation tree is moved.
>
> This option affects the system root for the compiler used to build target libraries (which runs on the build system) and the compiler newly installed with `make install`; it does not affect the compiler which is used to build GCC itself.

2.1.2 Toolchain

According to Wikipedia[2]:

> In software, a toolchain is the set of programming tools that are used to create a product (typically another computer program or system of programs). The tools may be used in a chain, so that the output of each tool becomes the input for the next, but the term is used widely to refer to any set of linked development tools.
>
> A simple software development toolchain consists of a text editor for editing source code, a compiler and linker to transform the source code into an executable program, libraries to provide interfaces to the operating system, and a debugger.

2.1.3 `build`, `host` and `target`

During a cross-compilation, `build` `host` and `target` are among the most used options: understanding the precise meaning of those parameters is very important. We could define them thus:

- `--build=`*`platform on which the program is compiled`*,
- `--host=`*`platform on which the program will run`*,
- `--target=`*`platform for which the program will create output`*.

Let's use GCC as an example to explain the role of those three parameters.

During GCC compilation, we use: '`./configure --build=`*`build-platform`* `--host=`*`host-platform`* `--target=`*`target-platform`* `[various compilation parameters]`'

[1] see Chapter 10 [Further Readings], page 93, for more details

[2] `https://en.wikipedia.org/wiki/Toolchain`

So in those configuration parameters:

- `--build` provides the name of the platform currently running. If we were using an Intel Pentium processor to compile the system, our *build-platform* would be something like '`i686-pc-linux-gnu`'.

  If this parameter is not specified, it will be guessed automatically.

- `--host` represents the type of machine we are going to run GCC on after the compilation succeeds. During a cross-compilation this has to be specified, because the current machine can not know which architecture we wish to target. We want to produce executables to run on *Pentium4*, but there is currently no way we can specify '`Pentium4`' directly; because of this we specify '`i386-unknown-linux-gnu`'.

  `--host` can also be left unspecified and, in that case, *host-platform* would automatically define itself as *build-platform*, but this is not cross-compilation anymore.

  > **Note:** when `--build` and `--host` are different, configuration files will maintain the cross-compilation mode.

- `--target` defines the system for which compiler tools will create output.

  target-platform parameter is useful only for a limited number of programs. Although this parameter is often present when issuing '`./configure --help`', hardly any packages will need it.

  This parameter is only useful for performing tasks with different platforms; for instance, executable files compiled for different platforms can have a totally different code.

If we summarize, we have:

- *build-platform*: automatically guessed from platform in use; has to be specified if not guessed.
- *host-platform*: if unspecified, automatically equals *build-platform*. When *build-platform* and *host-platform* values are identical, it is a local compilation; otherwise it is a cross-compilation.
- *target-platform*: defines the system for which compiler tools will create output; it equals *host-platform* if unspecified. GCC, binutils, and programs related to the platform's instructions have this parameter; most programs do not use this parameter.

2.1.4 FHS

The Filesystem Hierarchy Standard (FHS) has been created to specify the location and use of main directories on a GNU/Linux operating system. Common commands, user data, libraries have to be put inside a specific directory given in the standard. In this document, FHS is not respected: for instance, binaries are all located in `/usr/bin`, while `bin`, `/sbin` and `/usr/sbin` are symbolic links to it.

2.2 Commands

Because most commands are common for a regular Unix user, only uncommon commands are explained in this document. If you do not understand a command that is not explained, you can use the documentation available on your computer; in a terminal, typing '`man` *`command`*' should give you enough information. For GNU software, '`info` *`package`*' can also give additional information.

To know more about command line, I suggest you read "Introduction to the Command Line" which is available on `https://archive.flossmanuals.org.uk/command-line/`.

3 Preliminary Work

Important: In order to complete the first steps of this chapter, you will need to have root permissions.

3.1 Package Users Introduction

Package Users is an interesting way of managing packages. Quotation from the project:

- You want to know which packages your files belong to?
- You want to deinstall software that doesn't have make uninstall?
- You are bothered by programs installed setuid root behind your back?
- You don't like packages quietly overwriting files from other packages?
- You don't like package managers like RPM?

YOU WANT TOTAL CONTROL USING ONLY UNIX BUILTINS?

The idea is to create one pair '`user`':'`group`' per package to be installed: a Package User. Every Package User is part of an '`install`' group in order to be able to write in directories that are usually owned by the root user. In order to avoid that one package replaces a file or a directory installed by another one, the directories owned by the '`install`' group have the sticky attribute for users and groups other than the Package Users and the install group. For more details, read `https://www.linuxfromscratch.org/hints/downloads/files/more_control_and_pkg_man.txt`.

3.1.1 Package Installation

To install a package with Package Users, you first have to type:

```
install_package foo
```

This will:

- create the package user '`foo`',
- make package user '`foo`' a member of the '`install`' group,
- create the directory `/usr/src/foo`,
- copy the files from `/etc/pkgusr/skel-package` into `/usr/src/foo`,
- log you in as '`foo`'.

After that, you have to get the source file of the program '`foo`' and install it as the user '`foo`'. Most of the time, the steps are simple:

```
su foo
wget http://path-to-source.org/foo-version.tar.gz
tar xf foo-version.tar.gz
cd foo-version
./configure --prefix=
make
make install
cd ..
rm -rf foo-version
rm foo-version.tar.gz
exit 0
```

3.1.2 Package Removal

To remove the files installed by a package:

```
find / -user foo | xargs rm
```

Then remove the package user:

```
userdel foo
```

3.1.3 Package Information

To get information about files installed by package user *foo*, do:

```
list_package foo
```

Be aware that this command may take some time to complete because the hard drive is scanned for files owned by Package User *foo*.

3.2 Build OS

In the edition you are reading, GLLFSC 1.9.0 has been used to demonstrate that GLLFSC can build itself.

Because installing Package Users will modify the build OS, it is strongly recommended to have 3 partitions on your hard drive:

- one partition for the current OS you are using, for instance `/dev/sda1`
- one partition for the build OS, unmodified GLLFSC 1.9.0: for instance `/dev/sda2`
- one partition for the OS we will build, GLLFSC 1.9.1: for instance `/dev/sda3`

You can create and modify partitions with a program like `gparted`.

Then, to mount the hard drive partition dedicated to the build OS, for instance `/dev/sda2`:

```
mkdir /mnt/sda2
mount /dev/sda2 /mnt/sda2
```

Then, download GLLFSC 1.9.0 from `http://cjarry.org/gnu-linux/gllfsc/pentium4/gllfsc-pentium4-1.9.0-completed.tar.bz2` and extract it:

```
cd /mnt/sda2
tar xf /path/to/gllfsc-pentium4-1.9.0-completed.tar.bz2 --numeric-owner
cd
```

Finally, edit `/mnt/sda2/etc/fstab`, `/mnt/sda2/etc/runit/1` (to set your keyboard layout in particular), and `/boot/grub/grub.cfg` to your situation, so that you will be able to boot on GLLFSC 1.9.0:

```
nano /mnt/sda2/etc/fstab /mnt/sda2/etc/runit/1 /boot/grub/grub.cfg
```

> **Note:** commands in nano are displayed as in '^X'. The '^' character means `CTRL` key, so '^X' means *`CTRL`*-*`X`*: press *`CTRL`* and *`X`* keys simultaneously on the keyboard.

A minimal `/boot/grub/grub.cfg` for classical hard disk could be:

```
insmod ext2
set default=0
set timeout=5

menuentry 'GLLFSC 1.9.0' {
    echo 'Loading linux-libre-3.10.108-gnu...'
    linux (hd0,2)/boot/vmlinuz-3.10.108-gnu root=/dev/sda2 quiet
}
```

A minimal `/boot/grub/grub.cfg` for hard disk supporting AHCI (Advanced Host Controller Interface) could be:

```
insmod part_msdos
```

```
insmod ext2
set default=0
set timeout=5

menuentry 'GLLFSC 1.9.0' {
    echo 'Loading linux-libre-3.10.108-gnu...'
    linux (ahci0,msdos2)/boot/vmlinuz-3.10.108-gnu root=/dev/sda2 quiet
}
```

You can now reboot on `/dev/sda2` and login as root.

3.3 Tmux Usage

Tmux is a terminal multiplexer: it allows multiple terminal sessions to be accessed simultaneously in a single window. You can use it to read GLLFSC build instructions in a frame while building GLLFSC in another frame, both in the same window. First run it with:

```
tmux
```

Then, you can split your screen horizontally by pressing simultaneously `CTRL` and `B`, and then `%`. You can also split it vertically by pressing simultaneously `CTRL` and `B`, and then `"`. Finally you can navigate from one frame to another by pressing simultaneously `CTRL` and `B`, and then `LEFT ARROW`, `RIGHT ARROW`, `UP ARROW` or `DOWN ARROW`.

3.4 Work Directory Creation

To create the directory `/gllfsc` in which the system will be built:

```
mkdir -v /gllfsc
```

3.5 Setting up Required Environment Variables

`~/.bash_profile` is a personal initialization file that is read when Bash is invoked as an interactive login shell (`~` is the location of the user's home directory). To write the content of the default `~/.bash_profile` of package users:

```
cat > /etc/pkgusr/bash_profile << 'EOF'
exec env -i HOME=${HOME} TERM=${TERM} PS1=${PS1} /bin/bash
EOF
```

The first line creates the file `/etc/pkgusr/bash_profile` and opens it for writing until '`EOF`' (End Of File) is written in it.

The second line tells Bash to execute `/bin/bash` with the option `-i` (or `--ignore-environment`) which will make Bash start with an empty environment. Variables `HOME`, `TERM` and `PS1` define respectively the home directory of the current user, the terminal used and the primary prompt string displayed.

`~/.bashrc` is a personal initialization file that is read when Bash is invoked as an interactive shell but not a login one. To write the content of the file `~/.bashrc` for each Package User:

```
cat > /etc/pkgusr/bashrc << EOF
set +h
umask 022
alias less='less -ic'
#alias make='make -j4'
# Make prompt reflect that we are a package user.
export PROMPT_COMMAND='PS1="\[\e[35m\]\A-package \u:\W\[\e[00m\]> "'
#export PS1='\[\e[35m\]\A-\W\[\e[00m\]$ '
export LC_ALL=POSIX
```

```
export CROSS_HOST="$(echo $MACHTYPE |\
    sed "s/$(echo $MACHTYPE | cut -d- -f2)/cross/")"
export CROSS_TARGET="i686-unknown-linux-gnu"
#export MABI=n32
#export MABI=64
export MARCH=pentium4
export PATH=/gllfsc/cross-tools/bin:/usr/lib/pkgusr:/bin:/usr/bin
# Go to the home directory whenever we su to a package user.
#cd

unset CFLAGS
unset CXXFLAGS
EOF
#source ~/.bash_profile
```

‘`set +h`’ tells Bash to not locate nor remember commands (hash) as they are looked up for execution.

‘`umask 022`’ sets Bash process’ file creation mask to ‘`022`’. This results in permissions of ‘755’ for those files.

‘`PS1="\[\e[35m\]\A-package \u:\W\[\e[00m\]> "`’ sets the primary prompt strings. The primary prompt strings are the strings you see before the commands you type in the terminal. The part ‘`\A-package \u:\W`’ means that the time, in 24-hour HH:MM format will be displayed, then a ‘-’, the package user, a ‘:’ and finally the basename of `$PWD`, as in ‘`19:33-package groff:bin`’. The part ‘`\$`’ adds a dollar sign at the end, ‘`\[\e[35m\]`’ colors the strings in purple and ‘`\[\e[00m\]`’ gets the original color back. For other colors, you can browse `https://en.wikipedia.org/wiki/ANSI_escape_code`.

`LC_ALL` is a macro used to define a single locale to overwrite other `LC_*` and `LANG` environment variables so that language, numeric values, time and other locale-dependant values have all the same value. It is set to the standard POSIX locale.

The value of variable `CROSS_HOST` equals the value of variable `MACHTYPE` of the current machine (for instance ‘`i686-pc-linux-gnu`’) modulo the second word, which is replaced by ‘`cross`’ (i.e. ‘`i686-cross-linux-gnu`’).

The value of variable `CROSS_TARGET` equals the value of variable `MACHTYPE` of the machine for which the system is built (i.e. ‘`i686-unknown-linux-gnu`’).

The variable `MABI` defines the ABI (Application Binary Interface) for which the system will be built. `-mabi` is an option of GCC. n32/64 are for 64-bit CPUs only. 64 has 64-bit pointers and long integers, whereas n32 has 32-bit pointers and long integers. This does not apply to Pentium 4 machines.

The variable `MARCH` defines the architecture for which the system will be built. `-march` is an option of GCC (GNU Compiler Collection).

The variable `PATH` contains a colon-separated list of directories in which the shell looks for commands. The shell will first look for commands in `/gllfsc/cross-tools/bin`, then, if the command was not found, in `/usr/lib/pkgusr`, then in `/bin` and finally in `/usr/bin`. `/usr/lib/pkgusr` contains wrapper scripts to replace commands ‘`mkdir`’, ‘`chgrp`’, ‘`chown`’, ‘`chmod`’ and ‘`install`’, so that permissions on files and folders are handled properly when using Package Users.

`unset` command removes the variable associated, here `CFLAGS` and `CXXFLAGS`. Those variables are used by GCC as extra flags given to the C compiler and the C++ compiler respectively.

3.6 Build Partition Creation

Note: You can list existing partitions with '`fdisk -l`' or '`lsblk`'.

Warning: All data on the partition you chose in the next command will be deleted.

To dedicate the partition `/dev/sda3` to the system build, and to define the filesystem to be used for it as '`ext3`':

```
mke2fs -t ext3 /dev/sda3 -L gllfsc-1.9.1
```

Option `-t` is followed by the type of filesystem to be used. The filesystem '`ext3`' is used as it is one of the most common filesystem used with the kernel Linux.

3.7 Mounting Partition

To mount the hard drive partition used to build the system, for instance `/dev/sda3`:

```
mount /dev/sda3 /gllfsc
```

Note: You may wish to automatically mount `/dev/sda3` under `/gllfsc` each time you boot from `/dev/sda2`. In this case, you can add the following line to your `/etc/fstab`:

```
/dev/sda3   /   ext3   defaults   0   0
```

3.8 Creating Compilation and Download Directories

```
mkdir -v /gllfsc/{build,download}
```

3.9 Downloads

3.9.1 Downloading Packages

Connect to the wired internet first with:

```
ifconfig eth0 up
dhcpcd eth0
```

Test the connection with:

```
ping -c3 gnu.org
```

The packages listed below are those used in this document.

Download those files under `/gllfsc/download`. You can use '`wget -nv URL`' to do this.

Note: In order to download all the packages automatically, you can:

```
wget http://cjarry.org/gnu-linux/gllfsc/pentium4/automate-gllfsc.sh
# Edit it to suit your needs:
nano automate-gllfsc.sh
chmod u+x automate-gllfsc.sh
./automate-gllfsc.sh
```

Then you have to run the generated `0-get-packages.sh`:

```
chmod u+x 0-get-packages.sh
cd /gllfsc/download
~/0-get-packages.sh
cd
```

Check that all files have been downloaded with:

```
ls -1 | wc -l
```

The command above should give 73.

Note: If you have trouble with a savannah mirror, you can have a full list of them at `http://download.savannah.gnu.org/mirmon/savannah/`. If you have trouble with a GNU mirror, you can have a full list of them at `http://www.gnu.org/prep/ftp.html`.

- Autoconf: `http://ftpmirror.gnu.org/autoconf/autoconf-2.69.tar.gz`.
- Automake: `http://ftpmirror.gnu.org/automake/automake-1.14.tar.gz`.
- Bash: `http://ftpmirror.gnu.org/bash/bash-4.2.tar.gz`.
- Bc: `http://ftpmirror.gnu.org/bc/bc-1.07.1.tar.gz`.
- Binutils: `http://ftpmirror.gnu.org/binutils/binutils-2.24.tar.bz2`.
- Bison: `http://ftpmirror.gnu.org/bison/bison-2.7.tar.gz`.
- Bootscripts: `http://ftp.clfs.org/pub/clfs/conglomeration/bootscripts-cross-lfs/bootscripts-cross-lfs-2.0.0.tar.xz`.
- Bzip2: `ftp://sourceware.org/pub/bzip2/bzip2-1.0.6.tar.gz`.
- CA-Certificates: `https://anduin.linuxfromscratch.org/sources/other/certdata.txt`
- Coreutils: `http://ftpmirror.gnu.org/coreutils/coreutils-8.19.tar.xz`.
- DHCPCD: `https://github.com/NetworkConfiguration/dhcpcd/archive/refs/tags/v6.1.0.tar.gz`.
- Diffutils: `http://ftpmirror.gnu.org/diffutils/diffutils-3.3.tar.xz`.
- E2fsprogs: `http://downloads.sourceforge.net/e2fsprogs/e2fsprogs-1.42.8.tar.gz`
- Ed: `http://ftpmirror.gnu.org/ed/ed-1.1.tar.bz2`.
- File: `ftp://ftp.astron.com/pub/file/file-5.16.tar.gz`.
- Findutils: `http://ftpmirror.gnu.org/findutils/findutils-4.4.2.tar.gz`.
- Flex: `http://downloads.sourceforge.net/flex/flex-2.5.37.tar.bz2`.
- Gawk: `http://ftpmirror.gnu.org/gawk/gawk-4.1.0.tar.gz`.
- GCC: `http://ftpmirror.gnu.org/gcc/gcc-4.7.3/gcc-4.7.3.tar.bz2`.
- Gdbm: `http://ftpmirror.gnu.org/gdbm/gdbm-1.11.tar.gz`.
- Gettext: `http://ftpmirror.gnu.org/gettext/gettext-0.18.3.1.tar.gz`.
- Glibc: `http://ftpmirror.gnu.org/glibc/glibc-2.18.tar.bz2`.
- Gmp: `http://ftpmirror.gnu.org/gmp/gmp-5.1.3.tar.bz2`.
- Gperf: `http://ftp.gnu.org/gnu/gperf/gperf-3.0.4.tar.gz`.
- Grep: `http://ftpmirror.gnu.org/grep/grep-2.15.tar.xz`.
- Groff: `http://ftpmirror.gnu.org/groff/groff-1.22.2.tar.gz`.
- GRUB: `http://ftpmirror.gnu.org/grub/grub-2.00.tar.gz`.
- Gzip: `http://ftpmirror.gnu.org/gzip/gzip-1.6.tar.gz`.
- Iana-Etc: `http://sethwklein.net/iana-etc-2.30.tar.bz2`.
- Inetutils: `http://ftpmirror.gnu.org/inetutils/inetutils-2.2.tar.gz`.
- Iproute2: `https://www.kernel.org/pub/linux/utils/net/iproute2/iproute2-3.10.0.tar.bz2`.
- Kbd: `https://www.kernel.org/pub/linux/utils/kbd/kbd-2.0.1.tar.gz`.
- Kmod: `https://www.kernel.org/pub/linux/utils/kernel/kmod/kmod-15.tar.gz`.
- Less: `http://www.greenwoodsoftware.com/less/less-458.tar.gz`.
- Libevent: `https://github.com/libevent/libevent/releases/download/release-2.0.22-stable/libevent-2.0.22-stable.tar.gz`

- Libpipeline: http://download.savannah.gnu.org/releases/libpipeline/libpipeline-1.3.0.tar.gz.
- Libtasn1: http://ftpmirror.gnu.org/libtasn1/libtasn1-3.4.tar.gz.
- Libtool: http://ftpmirror.gnu.org/libtool/libtool-2.4.2.tar.gz.
- Linux-Libre[1]. https://www.kernel.org/pub/linux/kernel/v3.x/linux-3.10.108.tar.xz, http://linux-libre.fsfla.org/pub/linux-libre/releases/old/gen6/3.10.108-gnu/deblob-3.10 and http://linux-libre.fsfla.org/pub/linux-libre/releases/old/gen6/3.10.108-gnu/deblob-check.
- Lynx: http://invisible-mirror.net/archives/lynx/tarballs/lynx2.8.9rel.1.tar.bz2.
- M4: http://ftpmirror.gnu.org/m4/m4-1.4.17.tar.bz2.
- Make: http://ftpmirror.gnu.org/make/make-4.0.tar.bz2.
- Man-db: http://download.savannah.gnu.org/releases/man-db/man-db-2.6.7.1.tar.xz.
- Man-Pages: https://www.kernel.org/pub/linux/docs/man-pages/Archive/man-pages-3.54.tar.bz2.
- Mpc: http://ftpmirror.gnu.org/mpc/mpc-1.0.1.tar.gz.
- Mpfr: http://ftpmirror.gnu.org/mpfr/mpfr-3.1.2.tar.bz2.
- Nano: http://ftpmirror.gnu.org/nano/nano-2.3.2.tar.gz.
- Ncurses: http://ftpmirror.gnu.org/ncurses/ncurses-5.9.tar.gz.
- Openssl: https://github.com/openssl/openssl/releases/download/OpenSSL_1_1_1/openssl-1.1.1.tar.gz.
- Patch: http://ftpmirror.gnu.org/patch/patch-2.7.1.tar.bz2.
- Perl: http://www.cpan.org/src/5.0/perl-5.18.1.tar.gz.
- Procps-ng: https://sourceforge.net/projects/procps-ng/files/Production/procps-ng-3.3.0.tar.gz.
- Psmisc: https://sourceforge.net/projects/psmisc/files/psmisc/Archive/psmisc-22.20.tar.gz.
- Readline: http://ftpmirror.gnu.org/readline/readline-6.2.tar.gz.
- Runit: https://smarden.org/runit/runit-2.1.2.tar.gz
- Sed: http://ftpmirror.gnu.org/sed/sed-4.2.2.tar.bz2.
- Shadow: https://github.com/shadow-maint/shadow/releases/download/4.6/shadow-4.6.tar.xz.
- Sysvinit: http://download.savannah.gnu.org/releases/sysvinit/sysvinit-2.88dsf.tar.bz2.
- Tar: http://ftpmirror.gnu.org/tar/tar-1.27.1.tar.bz2.
- Texinfo: http://ftpmirror.gnu.org/texinfo/texinfo-4.13a.tar.gz.
- Tmux: https://github.com/tmux/tmux/releases/download/1.8/tmux-1.8.tar.gz
- Tzcode: http://www.iana.org/time-zones/repository/releases/tzcode2013h.tar.gz.
- Tzdata: http://www.iana.org/time-zones/repository/releases/tzdata2013h.tar.gz.
- Udev: https://www.kernel.org/pub/linux/utils/kernel/hotplug/udev-175.tar.gz.

[1] The kernel Linux is shipped with proprietary firmware. The version called Linux-Libre exists without them, recent versions are available for download at http://www.fsfla.org/ikiwiki/selibre/linux-libre/.

- Util-Linux: `https://www.kernel.org/pub/linux/utils/util-linux/v2.24/util-linux-2.24.tar.bz2`.
- Wireless_tools: `https://hewlettpackard.github.io/wireless-tools/wireless_tools.29.tar.gz`.
- Wpa_supplicant: `http://w1.fi/releases/wpa_supplicant-2.7.tar.gz`.
- Wget: `http://ftpmirror.gnu.org/wget/wget-1.19.5.tar.gz`.
- XZ-Utils: `https://tukaani.org/xz/xz-5.0.8.tar.bz2`.
- Zlib: `http://www.zlib.net/fossils/zlib-1.2.8.tar.gz`.

3.9.2 Downloading Patches

Download those files under `/gllfsc/download`.

- `http://www.fsfla.org/svn/fsfla/software/linux-libre/lemote/gnewsense/tags/3.10.108-gnu_0freeloong/100gnu+freedo.patch` this patch adds a picture of a GNU beside Freedo, Freedo being the mascot of Linux-Libre. The image can be seen on `http://www.fsfla.org/ikiwiki/selibre/linux-libre/100gnu+freedo`.

3.10 Final Preparations

3.10.1 Target Filesystem Hierarchy Creation

Note: You can automate the target filesystem creation with:

```
cd
csplit gllfsc-pentium4-1.9.1.texi '/subsection Target/' '{*}'

# Remove useless stuff:
nano xx02

# Make xx02 executable:
chmod u+x xx02

# Execute/run xx02:
./xx02
```

```
cd /gllfsc

# /usr is required for cmake, python and ruby at least
mkdir -v usr
cd usr
mkdir -v bin include lib share src
ln -sv bin sbin
ln -sv lib lib32
ln -sv lib lib64
cd ..

mkdir -v boot dev etc home local mnt opt proc root run static sys
mkdir -v cross-tools libexec

ln -sv usr/bin bin
ln -sv usr/bin sbin
ln -sv usr/include include
ln -sv usr/lib lib
```

```
ln -sv usr/lib lib32
ln -sv usr/lib lib64
ln -sv usr/share share
ln -sv usr/src src

install -dv -m 0777 tmp
install -dv -m 1777 var

cd var
mkdir -v cache local lock log mail run spool
mkdir -pv lib/misc lib/locate
cd ..

install -dv -m 0750 root

cd local
mkdir -v bin include lib src
ln -sv bin sbin
ln -sv lib lib32
mkdir -v share
cd share
mkdir -v doc info locale man misc terminfo zoneinfo
mkdir -v man/man{1..8}
cd ../..
ln -sv share/man man
mkdir service
cd
```

The command '`install -dv -m 1777 var`' creates the directory `var` with the permissions to read, write and execute for everyone. The '1' in '`1777`' is the sticky bit which allows deletion of the file or directory having this attribute only for the owner of the file or directory.

3.10.2 Target Filesystem Hierarchy Ownership

To make Package Users work on the target filesystem hierarchy, we need to change its ownership:

```
chown -Rv 0:10000 /gllfsc
chmod -Rv g+w,o+t /gllfsc 2>/dev/null
```

'`chown -Rv 0:10000 /gllfsc`' changes the ownership of the files and folders under `/gllfsc` to user '`0`' (root) and group '`10000`' (install).

'`chmod -Rv g+w,o+t /gllfsc`' changes the file mode bits of the files and folders under `/gllfsc` to give write rights to the group (with '`g+w`') and to add the sticky bit to others (with '`o+t`') so that the files and folders installed by a Package User cannot be replaced by another one.

3.10.3 Creating needed user, groups and log files

Note: You can automate the creation of needed user, groups and log files with:

```
csplit xx03 '/chapter Building/' '{*}'

# Remove useless stuff:
nano xx01

chmod u+x xx01
```

```
    ./xx01
echo root::0:0:root:/root:/bin/bash > /gllfsc/etc/passwd
```

The file `/etc/passwd` contains one line for each user account, with seven fields delimited by colons. These fields are:

- login name;
- optional encrypted password;
- numerical user ID;
- numerical group ID;
- user name or comment field;
- user home directory;
- optional user command interpreter.

The first line creates the file `/gllfsc/etc/passwd` and opens it for writing until '`EOF`' (End Of File) is written in it.

```
cat > /gllfsc/etc/group << EOF
root:x:0:
bin:x:1:
sys:x:2:
kmem:x:3:
tty:x:4:
tape:x:5:
daemon:x:6:
floppy:x:7:
disk:x:8:
lp:x:9:
dialout:x:10:
audio:x:11:
video:x:12:
utmp:x:13:
usb:x:14:
cdrom:x:15:
EOF
```

The file `/etc/group` is a text file which defines the groups on the system. There is one entry per line, with the following format: '`group_name:password:GID:user_list`'.

```
touch /gllfsc/var/run/utmp \
    /gllfsc/var/log/{btmp,lastlog,wtmp}
chmod -v 664 /gllfsc/var/run/utmp \
    /gllfsc/var/log/lastlog
cat > /root/.bash_profile << EOF
# Tab-complete package users when using su, finger or pinky
complete -o default -o nospace -A user su finger pinky
EOF
```

4 Building the Cross-Compilation Toolchain

In this chapter, the cross-compilation toolchain is built as well as core components of the target system. Those will then be used to build the target system. The build process of the cross-compilation toolchain takes about 2h30 on my Lenovo ThinkPad X200.

Note: You can automate parts of this chapter with:

```
wget http://cjarry.org/gnu-linux/gllfsc/pentium4/automate-gllfsc.sh
# Edit it to suit your needs:
nano automate-gllfsc.sh
chmod u+x automate-gllfsc.sh
./automate-gllfsc.sh
```

Then you have to split the generated `1-build-cross.sh` into instructions for each Package User:

```
csplit 1-build-cross.sh '/su -/' '{*}'
rm xx00 xx01 xx03
mv xx02 4.1-linux-headers
mv xx04 4.2-binutils
mv xx05 4.3-gcc-1
mv xx06 4.4-glibc
mv xx07 4.5-gcc-2
mv xx08 5.1-file
mv xx09 5.2-groff
mv xx10 5.3-shadow
mv xx11 5.4-m4
mv xx12 5.5-ncurses

chmod o+x 4.* 5.*
```

Then, with '`nano`', you can replace the first line beginning with '`su -`' by the two lines '`set -e`' and '`set -v`' at the beginning of each script so that it will exit on error and print each instruction before executing it:

```
nano 4.* 5.*
```

Change the rights on `/root` so that a Package User can read it:

```
chmod o+rx /root
```

Then, once inside the, for instance, linux-headers User personal directory:

```
/root/4.1-linux-headers
```

4.1 Target Linux-Headers

In this document, the kernel used is version 3.10.108 of Linux-libre.

Some changes made in the kernel since 3.14 require the non-free firmware of the radeon driver earlier at boot: without the firmware, the screen will remain blank on a machine that requires it, making the computer unusable.[1]

```
su - linux-headers
# 60 minutes mostly to deblob the kernel
cd /gllfsc/build

tar xf /gllfsc/download/linux-3.10.108.tar.xz
cd linux-3.10.108
```

[1] See `https://bugzilla.kernel.org/show_bug.cgi?id=77861` for details.

```
cp /gllfsc/download/deblob-3.10 .
cp /gllfsc/download/deblob-check .

chmod u+x deblob*

# 47 minutes for the following command
./deblob-3.10 --force

rm deblob*
cd ..

# About 1 minute for the following command (491 MB)
tar -cf linux-libre-3.10.108-gnu.tar linux-3.10.108

# 12 minutes for the following command (69 MB)
# (requires ~840 MB of RAM)
xz -9 linux-libre-3.10.108-gnu.tar

#mv linux-libre-3.10.108-gnu.tar /gllfsc/download
mv linux-libre-3.10.108-gnu.tar.xz /gllfsc/download

cd linux-3.10.108

make mrproper
make ARCH=i386 headers_check
make ARCH=i386 INSTALL_HDR_PATH=dest headers_install
cp -rv dest/include/* /gllfsc/include
cd ..
rm -rf linux-3.10.108
cd

# Fix permissions for Package Users:
chmod g+w,o+t /gllfsc/include/scsi

exit 0
```

If the build is interrupted for some reason and you want to log back in as user "linux-headers":

```
su - linux-headers
```

With the command `su`, it is possible to change the user ID. The option `-` provides an environment similar to what the user would expect had the user logged in directly.

'`60 minutes`' is the time it takes to build the package on Lenovo ThinkPad X200 with an Intel Core 2 Duo processor.

The command '`make mrproper`' cleans the sources.

We need to specify '`ARCH=i386`' as we are cross-compiling.

'`exit 0`' exits the Package User environment.

4.2 Cross Binutils

GNU Binutils (GNU binary utilities) is a collection of programs for manipulating binaries.

```
su - binutils
```

```
# 5 minutes
tar xf /gllfsc/download/binutils-2.24.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/binutils-2.24
mkdir -pv ../binutils-build
cd ../binutils-build
CC="gcc" AR="ar" \
    ../binutils-2.24/configure \
    --prefix=/gllfsc/cross-tools \
    --build=${CROSS_HOST} \
    --host=${CROSS_HOST} \
    --target=${CROSS_TARGET} \
    --enable-64-bit-bfd \
    --with-sysroot=/gllfsc \
    --disable-nls \
    --enable-shared
make configure-host
make
make install
cp -v ../binutils-2.24/include/libiberty.h \
    /gllfsc/include
cd ..
rm -rf binutils-build
rm -rf binutils-2.24
cd

# Fix permissions for Package Users:
cd /gllfsc/cross-tools
chmod g+w,o+t bin
chmod g+w,o+t i686-unknown-linux-gnu{,/lib}
chmod g+w,o+t share
chmod g+w,o+t share/man{,/man1}
chmod g+w,o+t share/info{,/dir}
cd

exit 0
```

'`CC="gcc"`' and '`AR="ar"`' are flags that tell the `configure` script to use the local commands `gcc` as the C compiler and `ar` as the program that handles archives.

`--prefix=/gllfsc/cross-tools` tells the configure script to install architecture-independant files in `/gllfsc/cross-tools`.

The option `--enable-64-bit-bfd` enables 64 bit for BFD (the Binary File Descriptor).

`--with-sysroot=/gllfsc` tells Binutils to consider `/gllfsc` as the root of a tree that contains (a subset of) the root filesystem of the target operating system. Target system headers, libraries and run-time object files will be searched in there.

The `--enable-nls` option enables Native Language Support (NLS), which lets Binutils output diagnostics in languages other than American English. Native Language Support is enabled by default if not doing a canadian cross build. The `--disable-nls` option disables NLS.

The option `--enable-shared` is used to build shared versions of libraries, if shared libraries are supported on the target platform. Use `--disable-shared` to build only static libraries.

4.3 Cross GCC (C support only)

GCC is the GNU Compiler Collection. It can compile many languages, of which only C and C++ will be enabled in this document.

In this section, we build a minimal GCC in order to build glibc.

> **Warning:** to build GMP (a GCC dependency), you need a version of GCC different from 4.3.2 on your system[2]:
>
> GCC 4.3.2 miscompiles GMP on 64-bit machines; please use a different gcc version (e.g., gcc 4.3.1 and gcc 4.3.3 both work properly). We have not been able to find any workaround for this gcc bug. Unfortunately, Debian 5.0 has decided to stay with this trouble gcc version, resulting in that many users strike this bug.

```
su - gcc
# 20 minutes
tar xf /gllfsc/download/gcc-4.7.3.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/gcc-4.7.3
tar xf /gllfsc/download/gmp-5.1.3.tar.bz2
mv gmp-5.1.3 gmp
tar xf /gllfsc/download/mpc-1.0.1.tar.gz
mv mpc-1.0.1 mpc
tar xf /gllfsc/download/mpfr-3.1.2.tar.bz2
mv mpfr-3.1.2 mpfr
# Fix undefined reference to `__stack_check_guard' when compiling
# glibc:
sed -i '/k prot/agcc_cv_libc_provides_ssp=yes' gcc/configure
mkdir -pv ../gcc-build
cd ../gcc-build
../gcc-4.7.3/configure \
    --prefix=/gllfsc/cross-tools \
    --build=${CROSS_HOST} \
    --host=${CROSS_HOST} \
    --target=${CROSS_TARGET} \
    --with-sysroot=/gllfsc \
    --disable-multilib \
    --with-newlib \
    --disable-nls \
    --disable-shared \
    --disable-threads \
    --enable-languages=c \
    --with-mpfr-include="/gllfsc/build/gcc-4.7.3/mpfr/src" \
    --with-mpfr-lib="/gllfsc/build/gcc-build/mpfr/src/.libs" \
    --disable-decimal-float
# fixes bid_decimal_globals: fenv.h: No such file or directory

make all-gcc
make all-target-libgcc
make install-gcc
make install-target-libgcc
cd ..
rm -r gcc-build
rm -r gcc-4.7.3
```

[2] https://gmplib.org/#STATUS

```
cd

# Fix permissions for Package Users:
chmod g+w,o+t /gllfsc/cross-tools/{include,lib}

exit 0
```

`--disable-multilib` specifies that multiple target libraries to support different target variants[3], calling conventions, etc. should not be built. The default is to build a predefined set of them.

`--with-newlib` specifies that '`newlib`' is being used as the target C library.

`--disable-threads` specifies that threading support should be disabled.

`--enable-languages=c` specifies that only the C compiler and its runtime libraries should be built.

GCC provides a low-level runtime library, `libgcc.a` or `libgcc_s.so.1` on some platforms. GCC generates calls to routines in this library automatically, whenever it needs to perform some operation that is too complicated to emit inline code for. This is built with '`make all-target-libgcc`' and installed with '`make install-target-libgcc`'

4.4 Target glibc

Glibc is the GNU C library. It provides macros, type definitions, and functions for tasks like string handling, mathematical computations, input/output processing, memory allocation and several other operating system services.

You need Gawk on your system to compile this library from source.

```
su - glibc
# 20 minutes
tar xf /gllfsc/download/glibc-2.18.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/glibc-2.18
# Make 4.0 can be used to build glibc 2.18:
sed -i.orig '4775s/3.79\* | 3.\[89\]\*/& | 4.0/' configure
#sed -i.orig "s/ -lgcc_eh\| -lgcc_s//g" Makeconfig
#echo "" > ports/sysdeps/mips/mips64/n64/Makefile
#echo "" > ports/sysdeps/mips/mips64/n32/Makefile
#echo "" > ports/sysdeps/mips/mips32/Makefile
#sed -i "/default) machine=/s/n32/${MABI}/g" \
#    ports/sysdeps/mips/preconfigure
mkdir -pv ../glibc-build
cd ../glibc-build

cat > config.cache << EOF
libc_cv_c_cleanup=yes
libc_cv_slibdir=/lib
EOF

cat > configparms << EOF
install_root=/gllfsc
libdir=/lib
EOF
```

[3] Such as different ABI, for instance n32 and 64.

```
BUILD_CC="gcc" \
    CC="${CROSS_TARGET}-gcc -march=${MARCH}" \
    AR="${CROSS_TARGET}-ar" \
    RANLIB="${CROSS_TARGET}-ranlib" \
    ../glibc-2.18/configure \
    --prefix= \
    --libexecdir=/lib/glibc \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --disable-nls \
    --disable-profile \
    --enable-add-ons \
    --with-tls \
    --enable-kernel=3.10 \
    --with-__thread \
    --with-binutils=/gllfsc/cross-tools/bin \
    --with-headers=/gllfsc/include \
    --enable-obsolete-rpc \
    --cache-file=config.cache

make

make install

cd ..
rm -rf glibc-build
rm -rf glibc-2.18
cd

cat > /gllfsc/etc/nsswitch.conf << EOF
passwd: files
group: files
shadow: files

hosts: files dns
networks: files

protocols: files
services: files
ethers: files
rpc: files
EOF

cat > /gllfsc/etc/ld.so.conf << EOF
/local/lib
EOF

# Make dir group-writable:
chmod g+w /gllfsc/share/info/dir
#mv /gllfsc/share/info/dir{,.glibc}

# Fix permissions for Package Users:
```

```
chmod g+w,o+t /gllfsc/include/sys
chmod g+w,o+t /gllfsc/share/info
chmod g+w,o+t /gllfsc/share/locale
chmod g+w,o+t /gllfsc/share/locale/*/LC_MESSAGES

exit 0
```

The file `config.cache` is used to attribute values to variables of the configure script.

'`libc_cv_forced_unwind=yes`' is used to avoid the error message '`error: forced unwind support is required`'.

'`libc_cv_c_cleanup=yes`' is used to avoid the error message '`error: the compiler must support C cleanup handling`'.

'`libc_cv_slibdir=/lib`' defines `/lib` as the directory in which the C library of the target system will be installed, instead of `/lib64` or `/lib32`.

You can install glibc in a different location than where you configured it to go by setting the `install_root` variable on the command line for '`make install`'. The value of this variable is prepended to all the paths for installation. This is useful when setting up a chroot environment or preparing a binary distribution. The directory should be specified with an absolute file name.

Files listed in '`install-lib`' are installed in the directory specified by '`libdir`' in `configparms` or `Makeconfig`.

'`CC="${CROSS_TARGET}-gcc -march=${MARCH}"`' sets `CC` to the cross-compiler for the target's architecture, processor and ABI we configured the library for. `AR` and `RANLIB` are set to cross-compiling versions of `ar` and `ranlib` as the native tools are not configured to work with object files for the target we configured for.

`--prefix=` tells the `configure` script to install glibc in the root directory (`/`) of the target system.

Unlike previous builds, `--host` now equals `${CROSS_TARGET}` instead of `${CROSS_HOST}`. This is because we are building the glibc version that the target system will use. We won't have to build it later.

Profiling can be of help to optimize a program by analysing memory use, the usage of particular instructions, etc. Option `--disable-profile` is used to disable this.

Option `--enable-add-ons` is used to enable all the add-on packages in the main source directory, which includes the glibc-ports used to support the MIPS architecture.

The option `--with-tls` tells the configure script to use TLS (thread-local storage). Thread-local storage is a computer programming method that uses memory local to a thread.

The '`3.10`' parameter given to option `--enable-kernel` describes the earliest version of the Linux kernel the generated library is expected to support. The higher the version number is, the less compatibility code is added, and the faster the code gets.

Option `--with-__thread` enables threads in glibc.

The option `--with-binutils=/gllfsc/cross-tools/bin` tells the `configure` script to use the binutils (assembler and linker) built in the cross-compilation toolchain process.

`--with-headers=/gllfsc/include` indicates the location of the kernel Linux' headers.

`--enable-obsolete-rpc` tells the `configure` script to install remote procedure call (RPC) headers. Those may be required by some programs.

`--cache-file=config.cache` specifies the file in which cache variables are listed for `configure`.

The file `/gllfsc/etc/nsswitch.conf` contains the configuration of NSS (Name Service Switch). NSS is a facility in Unix-like operating systems that provides a variety of sources for common configuration databases and name resolution mechanisms. These sources include

local operating system files (such as `/etc/passwd`, `/etc/group`, and `/etc/hosts`), the Domain Name System (DNS), the Network Information Service (NIS), and LDAP.

4.5 Cross GCC (C and C++ support)

In this section, we build a complete cross-compiler with support for C and C++ languages.

```
su - gcc
# 30 minutes
tar xf /gllfsc/download/gcc-4.7.3.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/gcc-4.7.3
tar xf /gllfsc/download/gmp-5.1.3.tar.bz2
mv gmp-5.1.3 gmp
tar xf /gllfsc/download/mpc-1.0.1.tar.gz
mv mpc-1.0.1 mpc
tar xf /gllfsc/download/mpfr-3.1.2.tar.bz2
mv mpfr-3.1.2 mpfr
mkdir -v ../gcc-build
cd ../gcc-build
../gcc-4.7.3/configure \
    --prefix=/gllfsc/cross-tools \
    --build=${CROSS_HOST} \
    --host=${CROSS_HOST} \
    --target=${CROSS_TARGET} \
    --with-sysroot=/gllfsc \
    --disable-nls \
    --enable-shared \
    --enable-__cxa_atexit \
    --disable-multilib \
    --enable-c99 \
    --enable-long-long \
    --enable-threads=posix \
    --enable-languages=c,c++ \
    --with-mpfr-include="/gllfsc/build/gcc-4.7.3/mpfr/src" \
    --with-mpfr-lib="/gllfsc/build/gcc-build/mpfr/src/.libs"
make
make install
cd ..
rm -rf gcc-build
rm -rf gcc-4.7.3
cd
exit 0
```

`--enable-__cxa_atexit` enables `__cxa_atexit`, rather than `atexit`, to register C++ destructors for local statics and global objects. This is essential for fully standards-compliant handling of destructors, but requires `__cxa_atexit` in libc.

`--enable-c99` enables support for the C99 standard.

`--enable-long-long` enables support for `long long int` types.

5 Building the Cross-Compilation Tools

The build process of the cross-compilation tools takes about 10 minutes on my Lenovo Thinkpad X200.

5.1 File

The command `file` is used to determine the type of a file: text, executable or data.

```
su - file
# 1 minute
tar xf /gllfsc/download/file-5.16.tar.gz -C /gllfsc/build
cd /gllfsc/build/file-5.16
./configure --prefix=/gllfsc/cross-tools
make
make install
cd ..
rm -rf file-5.16
cd

# Fix permissions for Package Users:
chmod g+w,o+t /gllfsc/cross-tools/share/man/man{3,4,5}

exit 0
```

5.2 Groff

Groff is the GNU version of the roff document formatting system which is used to produce man pages.

You need G++ on your system to compile this program from source.

```
su - groff
# 3 minutes
tar xf /gllfsc/download/groff-1.22.2.tar.gz -C /gllfsc/build
cd /gllfsc/build/groff-1.22.2
PAGE=A4 \
    ./configure \
    --prefix=/gllfsc/cross-tools \
    --without-x
make
make install
cd ..
rm -rf groff-1.22.2
cd
exit 0
```

'`PAGE=A4`' defines the default format of pages for printed output.

`--without-x` disables the dependency on the X window system.

5.3 Shadow

The package contains programs to handle users, groups and passwords in a secure way: passwords are encrypted.

```
su - shadow
```

```
# 1 minute
tar xf /gllfsc/download/shadow-4.6.tar.xz -C /gllfsc/build
cd /gllfsc/build/shadow-4.6

cat > shadow-4.6.patch << 'EOF'
diff -Nur shadow-4.6.orig/lib/commonio.c shadow-4.6/lib/commonio.c
--- shadow-4.6.orig/lib/commonio.c      2025-10-09 16:53:30.514854530 +0200
+++ shadow-4.6/lib/commonio.c   2025-10-09 13:18:06.084698074 +0200
@@ -266,16 +266,6 @@
                return NULL;
        }

-#ifdef HAVE_FCHOWN
-       if (fchown (fileno (fp), sb->st_uid, sb->st_gid) != 0) {
-               goto fail;
-       }
-#else                          /* !HAVE_FCHOWN */
-       if (chown (name, sb->st_mode) != 0) {
-               goto fail;
-       }
-#endif                         /* !HAVE_FCHOWN */
-
 #ifdef HAVE_FCHMOD
        if (fchmod (fileno (fp), sb->st_mode & 0664) != 0) {
                goto fail;
diff -Nur shadow-4.6.orig/lib/Makefile.am shadow-4.6/lib/Makefile.am
--- shadow-4.6.orig/lib/Makefile.am     2018-04-29 18:42:37.000000000 +0200
+++ shadow-4.6/lib/Makefile.am  2025-10-12 08:09:14.903424913 +0200
@@ -2,6 +2,7 @@
 AUTOMAKE_OPTIONS = 1.0 foreign

 DEFS =
+AM_CPPFLAGS = -DSYSCONFDIR=\"$(sysconfdir)\"

 noinst_LTLIBRARIES = libshadow.la

--- shadow-4.6.orig/lib/Makefile.in     2018-04-29 18:45:50.000000000 +0200
+++ shadow-4.6/lib/Makefile.in  2025-10-12 08:09:37.866137840 +0200
@@ -340,6 +340,7 @@
 top_build_prefix = @top_build_prefix@
 top_builddir = @top_builddir@
 top_srcdir = @top_srcdir@
+AM_CPPFLAGS = -DSYSCONFDIR=\"$(sysconfdir)\"
 AUTOMAKE_OPTIONS = 1.0 foreign
 noinst_LTLIBRARIES = libshadow.la
 libshadow_la_LDFLAGS = -version-info 0:0:0
diff -Nur shadow-4.6.orig/src/Makefile.am shadow-4.6/src/Makefile.am
--- shadow-4.6.orig/src/Makefile.am     2018-04-29 18:42:37.000000000 +0200
+++ shadow-4.6/src/Makefile.am  2025-10-11 22:30:08.389131714 +0200
@@ -3,11 +3,14 @@
        .indent.pro
```

```
 ubindir = ${prefix}/bin
-usbindir = ${prefix}/sbin
+usbindir = ${prefix}/bin
 suidperms = 4755
 sgidperms = 2755

 AM_CPPFLAGS = \
+        -DSYSCONFDIR=\"$(sysconfdir)\" \
+        -DSG=\"`echo sg | sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`\" \
+        -DVIGR=\"`echo vigr | sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`\" \
         -I${top_srcdir}/lib \
         -I$(top_srcdir)/libmisc \
         -DLOCALEDIR=\"$(datadir)/locale\"
@@ -124,13 +127,19 @@

 install-am: all-am
         $(MAKE) $(AM_MAKEFLAGS) install-exec-am install-data-am
-       ln -sf newgrp   $(DESTDIR)$(ubindir)/sg
-       ln -sf vipw     $(DESTDIR)$(usbindir)/vigr
+       ln -sf `echo newgrp | sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'` \
+                $(DESTDIR)$(ubindir)/`echo sg | \
+               sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`
+       ln -sf `echo vipw | sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'` \
+                $(DESTDIR)$(usbindir)/`echo vigr | \
+               sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`
         for i in $(suidbins); do \
-               chmod $(suidperms) $(DESTDIR)$(bindir)/$$i; \
+               chmod -f 4755 $(DESTDIR)$(bindir)/`echo $$i |\
+                sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`; \
         done
         for i in $(suidubins); do \
-               chmod $(suidperms) $(DESTDIR)$(ubindir)/$$i; \
+               chmod -f 4755 $(DESTDIR)$(ubindir)/`echo $$i |\
+                sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`; \
         done
 if WITH_TCB
         for i in $(shadowsgidubins); do \
diff -Nur shadow-4.6.orig/src/Makefile.in shadow-4.6/src/Makefile.in
--- shadow-4.6.orig/src/Makefile.in     2018-04-29 18:45:51.000000000 +0200
+++ shadow-4.6/src/Makefile.in  2025-10-11 22:26:21.423969169 +0200
@@ -509,10 +509,13 @@
         .indent.pro

 ubindir = ${prefix}/bin
-usbindir = ${prefix}/sbin
+usbindir = ${prefix}/bin
 suidperms = 4755
 sgidperms = 2755
 AM_CPPFLAGS = \
+       -DSYSCONFDIR=\"$(sysconfdir)\" \
+       -DSG=\"`echo sg | sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`\" \
+       -DVIGR=\"`echo vigr | sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`\" \
```

```
        -I${top_srcdir}/lib \
        -I$(top_srcdir)/libmisc \
        -DLOCALEDIR=\"$(datadir)/locale\"
@@ -1233,13 +1236,19 @@

 install-am: all-am
        $(MAKE) $(AM_MAKEFLAGS) install-exec-am install-data-am
-       ln -sf newgrp   $(DESTDIR)$(ubindir)/sg
-       ln -sf vipw     $(DESTDIR)$(usbindir)/vigr
+       ln -sf `echo newgrp | sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'` \
+               $(DESTDIR)$(ubindir)/`echo sg | \
+               sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`
+       ln -sf `echo vipw | sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'` \
+               $(DESTDIR)$(usbindir)/`echo vigr | \
+               sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`
        for i in $(suidbins); do \
-               chmod $(suidperms) $(DESTDIR)$(bindir)/$$i; \
+               chmod -f 4755 $(DESTDIR)$(bindir)/`echo $$i | \
+               sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`; \
        done
        for i in $(suidubins); do \
-               chmod $(suidperms) $(DESTDIR)$(ubindir)/$$i; \
+               chmod -f 4755 $(DESTDIR)$(ubindir)/`echo $$i | \
+               sed 's,^.*/,,;$(transform);s/$$/$(EXEEXT)/'`; \
        done
 @WITH_TCB_TRUE@        for i in $(shadowsgidubins); do \
 @WITH_TCB_TRUE@                chown root:shadow $(DESTDIR)$(ubindir)/$$i; \
EOF

patch -Np1 -i shadow-4.6.patch

sed -i.orig '/nscd_flush/s,^,//,' lib/commonio.c
cd src
sed -i.orig '/nscd_flush/s,^,//,' chfn.c chgpasswd.c chpasswd.c \
    chsh.c gpasswd.c groupadd.c groupdel.c groupmod.c grpck.c \
    grpconv.c grpunconv.c newusers.c passwd.c pwck.c pwconv.c \
    pwunconv.c useradd.c userdel.c usermod.c vipw.c
cd ..

sed -i.orig 's,"/etc,SYSCONFDIR",' lib/defines.h lib/getdef.c \
    lib/gshadow_.h lib/port.h libmisc/limits.c src/chsh.c \
    src/login_nopam.c src/logoutd.c src/suauth.c src/useradd.c

sed -i.orig '/amroot = .*uid/s,\((.*$\),1; /* \1 */,' src/chage.c \
    src/chsh.c src/passwd.c

sed -i.orig '/amroot.*bywho/s,\t(0 == bywho), 1 /* (0 == bywho) */,' \
    src/gpasswd.c
sed -i.orig 's,"sg",SG,' src/newgrp.c
sed -i.orig '/do_vipw = (/s,"vigr",VIGR,' src/vipw.c
sed -i.orig '/usbindir =/s,/sbin,/bin,' src/Makefile.{am,in}
```

```
sed -i.orig '/AM_CPPFLAGS =/s,=,= -DSYSCONFDIR=\\"$(sysconfdir)\\",' \
    libmisc/Makefile.{am,in}

#tar xf /gllfsc/download/gllfsc-pentium4-1.9.1-patches.tar.gz
#patch -Np1 -i shadow-4.6-sysroot_hacks-1.patch
#sed -i.orig \
#    's/bindir)\/\$\$i/bindir)\/mips64el-unknown-linux-gnu-\$\$i/' \
#    src/Makefile.am
#automake-1.11
#echo "shadow_cv_passwd_dir=/gllfsc/bin" > config.cache
#echo "ac_cv_func_lckpwdf=no" >> config.cache
./configure \
    --prefix=/gllfsc/cross-tools \
    --sbindir=/gllfsc/cross-tools/bin \
    --sysconfdir=/gllfsc/etc \
    --disable-shared \
    --without-audit \
    --without-libpam \
    --without-selinux \
    --program-prefix=${CROSS_TARGET}- \
    --cache-file=config.cache
sed -i.orig "/PASSWD_PROGRAM/s/passwd/${CROSS_TARGET}-&/" config.h
make
make install
cd ..
rm -rf shadow-4.6
cd
exit 0
```

`--without-audit`, `--without-libpam` and `--without-selinux` disable support for auditing, PAM (Pluggable authentication modules) and SELinux (Security-Enhanced Linux). We do not need those extra features.

`--program-prefix=${CROSS_TARGET}-` prepends the value of `CROSS_TARGET` (that is '`i386-unknown-linux-gnu`' in this document) to installed program names for cross-compilation.

5.4 M4

Bison 2.5 requires M4 to be built.

GNU M4 is a package containing an implementation of the m4 macro language. GNU M4 is used in GNU Autoconf' `configure` files.

```
su - m4
# 1 minute
tar xf /gllfsc/download/m4-1.4.17.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/m4-1.4.17
./configure --prefix=/gllfsc/cross-tools
make
make install
cd ..
rm -rf m4-1.4.17
cd
exit 0
```

5.5 Ncurses

GNU ncurses contains a library used to write text-based user interfaces in a terminal-independent manner.

```
su - ncurses
# 2 minutes
tar xf /gllfsc/download/ncurses-5.9.tar.gz -C /gllfsc/build
cd /gllfsc/build/ncurses-5.9
./configure \
    --prefix=/gllfsc/cross-tools \
    --without-shared \
    --disable-nls
make -C include
make -C progs tic
install -m755 progs/tic /gllfsc/cross-tools/bin
cd ..
rm -rf ncurses-5.9
cd
exit 0
```

`--without-shared` is used to avoid building the whole library as only `tic` is installed.

5.6 Cleaning up Cross-Compilation Toolchain

In order to save some space, binaries and libraries of cross-compilation tools can be stripped out.

> **Warning:** incorrect cleaning arguments used against library files can lead to library files breaking. For this reason, be careful of the command arguments. If you are not comfortable with this, you can skip this section as it will have no effect on the process of building the target system.

```
cd /gllfsc/cross-tools
strip --strip-all bin/*
strip --strip-debug lib/*
cd
```

`--strip-all` removes all symbols. This command reduces the size of the `bin` directory's content from 34 MB to 10 MB.

`--strip-debug` removes debugging symbols only. This command reduces the size of the `lib` directory's content from 14 MB to 13 MB.

6 Building the Target System

After having set up the cross-compilation toolchain and tools, the operating system for the target machine is built in this chapter. This build process takes about 2 hours on my Lenovo ThinkPad X200.

6.1 Setting up the Environment

Because this chapter is about the build of the target system and not the build of the cross-compilation toolchain and tools anymore, we need to update some environment variables.

For more convenience, we can set environment variables up in each Package User `~/.bashrc` file, so that this setup is preserved when logging in:

```
export CROSS_TARGET="i686-unknown-linux-gnu"
export MARCH="pentium4"

cat >> /etc/pkgusr/bashrc << EOF
export CC="${CROSS_TARGET}-gcc -march=${MARCH}"
export CXX="${CROSS_TARGET}-g++ -march=${MARCH}"
export AR="${CROSS_TARGET}-ar"
export AS="${CROSS_TARGET}-as"
export RANLIB="${CROSS_TARGET}-ranlib"
export LD="${CROSS_TARGET}-ld"
export STRIP="${CROSS_TARGET}-strip"
EOF
#source /etc/pkgusr/bash_profile
```

`CC` is the flag that indicates the C compiler to be used, `CXX` the C++ compiler, `AR` the archiver, `AS` the assembler, `RANLIB` the archives' index generator, `LD` the linker and `STRIP` the program for stripping.

All the programs to be used are prefixed with '`${CROSS_TARGET}-`' in order to use the cross-compilation toolchain instead of the toolchain of the host.

6.2 Automating the Build

You can automate parts of this chapter by splitting the script `2-build-target-system.sh` (see Chapter 4 [Building the Cross-Compilation Toolchain], page 17) into instructions for each Package User:

```
csplit 2-build-target-system.sh '/su -/' '{*}'
rm xx00
mv xx01 6.3-man-pages
mv xx02 6.4-zlib
mv xx03 6.5-binutils
mv xx04 6.6-gmp
mv xx05 6.7-mpfr
mv xx06 6.8-mpc
mv xx07 6.9-gcc
mv xx08 6.10-sed
mv xx09 6.11-e2fsprogs

mv xx10 6.12-coreutils
mv xx11 6.13-iana-etc
mv xx12 6.14-m4
```

```
mv xx13 6.15-bison
mv xx14 6.16-ncurses
mv xx15 6.17-libtool
mv xx16 6.18-readline
mv xx17 6.19-autoconf
mv xx18 6.20-automake
mv xx19 6.21-bash

mv xx20 6.22-bzip2
mv xx21 6.23-dhcpcd
mv xx22 6.24-diffutils
mv xx23 6.25-file
mv xx24 6.26-findutils
mv xx25 6.27-flex
mv xx26 6.28-gawk
mv xx27 6.29-gdbm
mv xx28 6.30-gettext
mv xx29 6.31-grep

mv xx30 6.32-groff
mv xx31 6.33-gzip
mv xx32 6.34-inetutils
mv xx33 6.35-iproute2
mv xx34 6.36-kbd
mv xx35 6.37-kmod
mv xx36 6.38-less
mv xx37 6.39-libpipeline
mv xx38 6.40-make
mv xx39 6.41-man-db

mv xx40 6.42-nano
mv xx41 6.43-patch
mv xx42 6.44-psmisc
mv xx43 6.45-shadow
mv xx44 6.46-sysvinit
mv xx45 6.47-tar
mv xx46 6.48-texinfo
mv xx47 6.49-udev
mv xx48 6.50-util-linux
mv xx49 6.51-xz-utils

mv xx50 6.52-bootscripts
mv xx51 6.53-linux-libre

# Edit 6.53-linux-libre and remove lines from "Processor" to
# "Bootup logo"
nano 6.53-linux-libre

mv xx52 6.54-grub
chmod o+x 6.*
```

Then, with '`nano`', you can remove lines beginning with '`su -`', and add the line '`set -e`' and the line '`set -v`' at the beginning of each script so that it will exit on error and print each instruction before executing it. To automate this step:

```
sed -i 's,su -.*,set -e\nset -v\n,' 6.*
```

Then, once inside the, for instance, man-pages User personal directory:

```
/root/6.2-man-pages
```

6.3 Man Pages

The man-pages package documents the kernel Linux and C library's interfaces that are used by user-space programs.

```
su - man-pages
# 1 minute
tar xf /gllfsc/download/man-pages-3.54.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/man-pages-3.54
make prefix=/gllfsc install
cd ..
rm -rf man-pages-3.54
cd
# shadow installs its own version of getspnam.3 and passwd.5:
mv -v /gllfsc/share/man/man3/getspnam.3{,.man-pages}
mv -v /gllfsc/share/man/man5/passwd.5{,.man-pages}

# Fix permissions for Package Users:
chmod g+w,o+t /gllfsc/share/man
chmod g+w,o+t /gllfsc/share/man/man*

exit 0
```

The option `prefix=/gllfsc` is used to install the man pages on the target directory instead of the `/usr` directory of the host.

6.4 Zlib

Zlib is a compression/decompression library.

```
su - zlib
# 1 minute
tar xf /gllfsc/download/zlib-1.2.8.tar.gz -C /gllfsc/build
cd /gllfsc/build/zlib-1.2.8
./configure --prefix=
make AR="${AR}"
make prefix=/gllfsc install
cd ..
rm -rf zlib-1.2.8
cd

# Fix permissions for Package User e2fsprogs:
chmod g+w,o+t /gllfsc/lib/pkgconfig

exit 0
```

In order to build zlib by cross-compilation, the flag `AR` has to be equal to '`${AR}`'.

6.5 Binutils

GNU Binutils (GNU binary utilities) is a collection of programs for manipulating binaries.

```
su - binutils
# 5 minutes
tar xf /gllfsc/download/binutils-2.24.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/binutils-2.24
mkdir -pv ../binutils-build
cd ../binutils-build
../binutils-2.24/configure \
    --prefix= \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --target=${CROSS_TARGET} \
    --enable-64-bit-bfd \
    --enable-shared \
    --disable-nls
make configure-host
make tooldir=
make DESTDIR=/gllfsc tooldir= install
cp -v ../binutils-2.24/include/libiberty.h /gllfsc/include
cd ..
rm -rf binutils-build
rm -rf binutils-2.24
cd
# For autoconf:
mv /gllfsc/share/info/standards.info{,.binutils} -v
# For groff:
#mv /gllfsc/share/info/dir{,.binutils} -v
exit 0
```

The option `--host` is now set to `CROSS_TARGET` because the host that will run this build will be the target system.

6.6 GMP

GMP (GNU multiple precision arithmetic library) is required to build GCC.

```
su - gmp
# 2 minutes
tar xf /gllfsc/download/gmp-5.1.3.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/gmp-5.1.3
./configure \
    --host=${CROSS_TARGET} \
    --prefix= \
    --enable-cxx
make
make DESTDIR=/gllfsc install
rm -v /gllfsc/lib/lib{gmp,gmpxx}.la
cd ..
rm -rf gmp-5.1.3
cd
exit 0
```

The option `--enable-cxx` enables support for the C++ language.

The files `/gllfsc/lib/lib{gmp,gmpxx}.la` are removed to avoid the following error when building MPFR: '`/lib/libgmp.so: could not read symbols: File in wrong format`'.

6.7 MPFR

GNU MPFR (Multiple Precision Floating-Point Reliably) is a portable C library for arbitrary-precision binary floating-point computation with correct rounding.

```
su - mpfr
# 1 minute
tar xf /gllfsc/download/mpfr-3.1.2.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/mpfr-3.1.2
./configure \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=/gllfsc install
rm -v /gllfsc/lib/libmpfr.la
cd ..
rm -rf mpfr-3.1.2
cd

# Fix permissions for Package User procps-ng:
chmod g+w,o+t /gllfsc/share/doc

exit 0
```

The file `/gllfsc/lib/libmpfr.la` is removed to avoid the following error when building MPC: '`/lib/libmpfr.so: could not read symbols: File in wrong format`'.

6.8 MPC

GNU MPC (Multiple Precision Complex Library) is a C library for the arithmetic of complex numbers with arbitrarily high precision and correct rounding of the result.

```
su - mpc
# 1 minute
tar xf /gllfsc/download/mpc-1.0.1.tar.gz -C /gllfsc/build
cd /gllfsc/build/mpc-1.0.1
./configure \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=/gllfsc install
cd ..
rm -rf mpc-1.0.1
cd
exit 0
```

6.9 GCC

GCC is the GNU Compiler Collection.

```
su - gcc
# 25 minutes
tar xf /gllfsc/download/gcc-4.7.3.tar.bz2 -C /gllfsc/build
```

```
cd /gllfsc/build/gcc-4.7.3
sed -i.orig 's/install_to_$(INSTALL_DEST) //' libiberty/Makefile.in
sed -i.orig 's@\./fixinc\.sh@-c true@' gcc/Makefile.in
mkdir -v ../gcc-build
cd ../gcc-build
../gcc-4.7.3/configure \
    --prefix= \
    --libexecdir=/lib \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --target=${CROSS_TARGET} \
    --enable-shared \
    --enable-threads=posix \
    --enable-__cxa_atexit \
    --enable-c99 \
    --enable-long-long \
    --disable-multilib \
    --enable-clocale=gnu \
    --enable-languages=c,c++ \
    --disable-libstdcxx-pch \
    --disable-nls
make
make DESTDIR=/gllfsc install
ln -sv gcc /gllfsc/bin/cc
cd ..
rm -rf gcc-build
rm -rf gcc-4.7.3
cd

# Fix permissions for Package Users:
chmod g+w,o+t /lib/gcc /include/c++

exit 0
```

'`sed -i.orig 's/install_to_$(INSTALL_DEST) //' libiberty/Makefile.in`' is used as we already installed the library `libiberty.a` with Binutils.

Using `--enable-clocale=gnu` option ensures that the correct locale will automatically be chosen.

Option `--disable-libstdcxx-pch` disables support for precompiled headers (PCH).

The line '`ln -sv gcc /gllfsc/bin/cc`' creates a symbolic link `cc` that points to `gcc`.

6.10 Sed

GNU sed is a stream editor: it is used to perform basic text transformations on an input stream (a file or input from a pipeline).

```
su - sed
# 1 minute
tar xf /gllfsc/download/sed-4.2.2.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/sed-4.2.2
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
```

```
    --prefix= \
    --bindir=/bin \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -rf sed-4.2.2
cd
exit 0
```

6.11 E2fsprogs

E2fsprogs is a package that contains tools to handle the ext2, ext3 and ext4 filesystems.

```
su - e2fsprogs
# 2 minutes
tar xf /gllfsc/download/e2fsprogs-1.42.8.tar.gz -C /gllfsc/build
cd /gllfsc/build/e2fsprogs-1.42.8
mkdir -v build
cd build
../configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --with-root-prefix="" \
    --enable-elf-shlibs \
    --disable-nls
make
make DESTDIR=/gllfsc install
make DESTDIR=/gllfsc install-libs
cd ../..
rm -rf e2fsprogs-1.42.8
cd
rm -v /gllfsc/lib/lib{blkid,com_err,e2p,ext2fs,ss,uuid}.so
# util-linux installs its own versions:
mv -v /gllfsc/bin/blkid{,.e2fsprogs}
mv -v /gllfsc/bin/findfs{,.e2fsprogs}
mv -v /gllfsc/bin/fsck{,.e2fsprogs}
mv -v /gllfsc/bin/uuidgen{,.e2fsprogs}
mv -v /gllfsc/lib/libuuid.a{,.e2fsprogs}
mv -v /gllfsc/lib/libblkid.a{,.e2fsprogs}
mv -v /gllfsc/bin/uuidd{,.e2fsprogs}
mv -v /gllfsc/lib/libuuid.so.1{,.e2fsprogs}
mv -v /gllfsc/lib/libblkid.so.1{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man1/uuidgen.1{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man3/uuid.3{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man3/uuid_clear.3{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man3/uuid_compare.3{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man3/uuid_copy.3{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man3/uuid_generate.3{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man3/uuid_is_null.3{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man3/uuid_parse.3{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man3/uuid_time.3{,.e2fsprogs}
```

```
mv -v /gllfsc/usr/share/man/man3/uuid_unparse.3{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man3/uuid_generate_random.3{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man3/uuid_generate_time.3{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man3/libblkid.3{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man8/uuidd.8{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man8/blkid.8{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man8/findfs.8{,.e2fsprogs}
mv -v /gllfsc/usr/share/man/man8/fsck.8{,.e2fsprogs}

mv -v /gllfsc/usr/include/blkid/blkid.h{,.e2fsprogs}
mv -v /gllfsc/usr/lib/pkgconfig/uuid.pc{,.e2fsprogs}
mv -v /gllfsc/usr/lib/pkgconfig/blkid.pc{,.e2fsprogs}

mv -v /gllfsc/usr/include/uuid/uuid.h{,.e2fsprogs}

# Fix permissions for Package User util-linux:
chmod g+w,o+t /gllfsc/usr/include/blkid
chmod g+w,o+t /gllfsc/usr/include/uuid

exit 0
```

`--with-root-prefix=""` is used to put e2fsprogs binaries inside `/sbin` instead of *`PREFIX`*`/sbin` which would be `/sbin`.

Option `--enable-elf-shlibs` enables e2fsprogs shared libraries.

'`make DESTDIR=/gllfsc install-libs`' is used to install libraries, those are not installed with '`make DESTDIR=/gllfsc install`'.

The sequence of commands that follows first removes symbolic links `/gllfsc/lib/lib{blkid,com_err,e2p,ext2fs,ss,uuid}.so` which point respectively to abolute paths `/lib/lib{blkid,com_err,e2p,ext2fs,ss,uuid}.so`. In order to use the libraries of the target operating system, we need to symlink `/gllfsc/lib/lib{blkid,com_err,e2p,ext2fs,ss,uuid}.so` to their relative paths files.

6.12 Coreutils

GNU coreutils (core utilities) includes the standard programs for text and file manipulation.

```
su - coreutils
# 3 minutes
tar xf /gllfsc/download/coreutils-8.19.tar.xz -C /gllfsc/build
cd /gllfsc/build/coreutils-8.19
cat > config.cache << EOF
fu_cv_sys_stat_statfs2_bsize=yes
gl_cv_func_mbrtowc_incomplete_state=yes
gl_cv_func_mbrtowc_nul_retval=yes
gl_cv_func_mbrtowc_null_arg=yes
gl_cv_func_mbrtowc_retval=yes
gl_cv_func_btowc_eof=yes
gl_cv_func_wcrtomb_retval=yes
gl_cv_func_wctob_works=yes
gl_cv_func_fstatat_zero_flag=yes
EOF
./configure \
    --build=${CROSS_HOST} \
```

```
    --host=${CROSS_TARGET} \
    --prefix= \
    --enable-no-install-program=groups,hostname,kill,uptime \
    --cache-file=config.cache \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -rf coreutils-8.19
cd
exit 0
```

The variables listed in the file `config.cache` are used in order to avoid that the `configure` script evaluate their values: otherwise the build may fail when cross-compiling.

We use `--enable-no-install-program=groups,kill,uptime` in order not to install commands `groups`, `kill` and `uptime`. Those commands will be installed by the packages shadow and procps.

6.13 iana-etc

The iana-etc package installs services and protocols using data from the Internet Assigned Numbers Authority (IANA).

```
su - iana-etc
# 1 minute
tar xf /gllfsc/download/iana-etc-2.30.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/iana-etc-2.30
make
make DESTDIR=/gllfsc install
cd ..
rm -rf iana-etc-2.30
cd
exit 0
```

6.14 M4

GNU M4 is a package containing an implementation of the m4 macro language. GNU M4 is used in GNU Autoconf' `configure` files.

```
su - m4
# 1 minute
tar xf /gllfsc/download/m4-1.4.17.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/m4-1.4.17
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=/gllfsc install
cd ..
rm -rf m4-1.4.17
cd
exit 0
```

6.15 Bison

GNU bison parser generator.

```
su - bison
# 1 minute
tar xf /gllfsc/download/bison-2.7.tar.gz -C /gllfsc/build
cd /gllfsc/build/bison-2.7
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --disable-nls
#echo '#define YYENABLE_NLS 1' >> config.h
make
make DESTDIR=/gllfsc install
cd ..
rm -rf bison-2.7
cd

# Fix permissions for Package User libtool:
chmod g+w,o+t /gllfsc/share/aclocal

exit 0
```

6.16 Ncurses

```
su - ncurses
# 2 minutes
tar xf /gllfsc/download/ncurses-5.9.tar.gz -C /gllfsc/build
cd /gllfsc/build/ncurses-5.9
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --with-shared \
    --enable-widec \
    --without-debug \
    --without-ada \
    --with-build-cc="gcc -D_GNU_SOURCE" \
    --libdir=/lib \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -rf ncurses-5.9
cd

ln -sv ncursesw/curses.h /gllfsc/include/curses.h
ln -sv ncursesw/ncurses.h /gllfsc/include/ncurses.h
ln -sv ncursesw/term.h /gllfsc/include/term.h
ln -sfv libncursesw.so /gllfsc/lib/libncurses.so
```

```
exit 0
```

Option `--enable-widec` enables wide characters support in ncurses.

Option `--without-ada` disables support for the Ada programming language inside ncurses.

The command '`ln -sfv libncursesw.so /gllfsc/lib/libncurses.so`' creates the symlink `libcurses.so` so that programs that do not know `libncursesw.so` can be linked against it.

6.17 Libtool

GNU libtool is a generic library support script. It hides the complexity of using shared libraries behind a consistent, portable interface.

```
su - libtool
# 1 minute
tar xf /gllfsc/download/libtool-2.4.2.tar.gz -C /gllfsc/build
cd /gllfsc/build/libtool-2.4.2
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=/gllfsc install
cd ..
rm -rf libtool-2.4.2
cd
exit 0
```

6.18 Readline

The GNU Readline library provides a set of functions for use by applications that allow users to edit command lines as they are typed in.

```
su - readline
# 1 minute
tar xf /gllfsc/download/readline-6.2.tar.gz -C /gllfsc/build
cd /gllfsc/build/readline-6.2
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --libdir=/lib
make
make DESTDIR=/gllfsc install
make DESTDIR=/gllfsc install-doc
cd ..
rm -rf readline-6.2
cd
exit 0
```

6.19 Autoconf

GNU autoconf is an extensible package of M4 macros that produce shell scripts to automatically configure software source code packages. These scripts can adapt the packages to many kinds of UNIX-like systems without manual user intervention.

```
su - autoconf
```

```
# 1 minute
tar xf /gllfsc/download/autoconf-2.69.tar.gz -C /gllfsc/build
cd /gllfsc/build/autoconf-2.69
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=/gllfsc install
cd ..
rm -rf autoconf-2.69
cd
# Fix autom4te: need GNU m4 1.4 or later: /gllfsc/cross-tools/bin/m4
sed -i 's,/gllfsc/cross-tools,,' /gllfsc/bin/autom4te
exit 0
```

6.20 Automake

GNU automake is a tool for automatically generating `Makefile.in` files compliant with the GNU Coding Standards[1].

You need Autoconf on your system to compile this program from source.

```
su - automake
# 1 minute
tar xf /gllfsc/download/automake-1.14.tar.gz -C /gllfsc/build
cd /gllfsc/build/automake-1.14
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=/gllfsc install
cd ..
rm -rf automake-1.14
cd
exit 0
```

6.21 Bash

GNU Bash (Bourne again shell) is an sh-compatible shell that incorporates useful features from the Korn shell (ksh) and C shell (csh).

```
su - bash
# 2 minutes
tar xf /gllfsc/download/bash-4.2.tar.gz -C /gllfsc/build
cd /gllfsc/build/bash-4.2
cat > config.cache << EOF
ac_cv_func_mmap_fixed_mapped=yes
ac_cv_func_strcoll_works=yes
ac_cv_func_working_mktime=yes
bash_cv_func_sigsetjmp=present
bash_cv_getcwd_malloc=yes
```

[1] `http://www.gnu.org/prep/standards/`

```
bash_cv_job_control_missing=present
bash_cv_printf_a_format=yes
bash_cv_sys_named_pipes=present
bash_cv_ulimit_maxfds=yes
bash_cv_under_sys_siglist=yes
bash_cv_unusable_rtsigs=no
gt_cv_int_divbyzero_sigfpe=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --bindir=/bin \
    --cache-file=config.cache \
    --without-bash-malloc \
    --with-installed-readline \
    --disable-nls
make
make \
    DESTDIR=/gllfsc \
    htmldir=/share/doc/bash-4.2 \
    install
ln -sv bash /gllfsc/bin/sh
cd ..
rm -rf bash-4.2
cd

exit 0
```

The variables listed in the file `config.cache` are used in order to avoid that the `configure` script evaluate their values: otherwise the build may fail when cross-compiling.

Option `--without-bash-malloc` tells the `configure` script not to use the `malloc` function shipped with Bash. Glibc's version will be used instead.

Option `--with-installed-readline` tells the configure script to use the installed readline library instead of the one shipped with Bash.

'`ln -sv bash /gllfsc/bin/sh`' creates a symlink `sh` to `bash`.

6.22 Bzip2

Bzip2 is a package that contains utilities to compress and decompress files with a better original size/compressed size ratio than gzip.

```
su - bzip2
# 1 minute
tar xf /gllfsc/download/bzip2-1.0.6.tar.gz -C /gllfsc/build
cd /gllfsc/build/bzip2-1.0.6
sed -i.orig "/^all:/s/ test//" Makefile
sed -i.orig 's:ln -s -f $(PREFIX)/bin/:ln -s :' Makefile
make \
    -f Makefile-libbz2_so \
    CC="${CC}" \
    AR="${AR}" \
    RANLIB="${RANLIB}"
```

```
make clean
make \
    CC="${CC}" \
    AR="${AR}" \
    RANLIB="${RANLIB}"
make \
    PREFIX=/gllfsc \
    install
cp -av libbz2.so* /gllfsc/lib
ln -sv ../../lib/libbz2.so.1.0 /gllfsc/lib/libbz2.so
rm -v /gllfsc/bin/{bunzip2,bzcat,bzip2}
cp -v bzip2-shared /gllfsc/bin/bzip2
ln -sv bzip2 /gllfsc/bin/bunzip2
ln -sv bzip2 /gllfsc/bin/bzcat
cd ..
rm -rf bzip2-1.0.6
cd
exit 0
```

'`sed -i.orig "/^all:/s/ test//" Makefile`' is used to skip tests when building.

'`sed -i.orig 's:ln -s -f $(PREFIX)/bin/:ln -s :' Makefile`' is used in order to have relative path symlinks instead of absolute ones.

Option `-f Makefile-libbz2_so` is used to build shared libraries.

Flags `CC`, `AR` and `RANLIB` are used so that bzip2 is built using cross-compilation tools instead of the host's ones.

'`make clean`' is used to clean up temporary files.

The second build commands are used to build static libraries.

6.23 DHCPCD

DHCPCD is a wrapper for the DHCP (Dynamic Host Configuration Protocol) client daemon.

```
su - dhcpcd
# 1 minute
tar xf /gllfsc/download/v6.1.0.tar.gz -C /gllfsc/build
cd /gllfsc/build/dhcpcd-6.1.0
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --bindir=/sbin \
    --sysconfdir=/etc \
    --dbdir=/var/lib/dhcpcd \
    --libexecdir=/lib/dhcpcd \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -rf dhcpcd-6.1.0
cd
exit 0
```

6.24 Diffutils

GNU Diffutils is a package of several programs related to finding differences between files.

```
su - diffutils
# 1 minute
tar xf /gllfsc/download/diffutils-3.3.tar.xz -C /gllfsc/build
cd /gllfsc/build/diffutils-3.3
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -rf diffutils-3.3
cd
exit 0
```

6.25 File

```
su - file
# 1 minute
tar xf /gllfsc/download/file-5.16.tar.gz -C /gllfsc/build
cd /gllfsc/build/file-5.16
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=/gllfsc install
cd ..
rm -rf file-5.16
cd
exit 0
```

6.26 Findutils

The GNU Find Utilities are typically used to provide directory search and file locating capabilities.

```
su - findutils
# 1 minute
tar xf /gllfsc/download/findutils-4.4.2.tar.gz -C /gllfsc/build
cd /gllfsc/build/findutils-4.4.2
cat > config.cache << EOF
gl_cv_func_wcwidth_works=yes
gl_cv_header_working_fcntl_h=yes
ac_cv_func_fnmatch_gnu=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
```

```
    --libexecdir=/lib/locate \
    --localstatedir=/var/lib/locate \
    --cache-file=config.cache \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -rf findutils-4.4.2
cd
exit 0
```

6.27 Flex

Flex is a tool for generating scanners. A scanner, sometimes called a tokenizer, is a program which recognizes lexical patterns in text.

```
su - flex
# 1 minute
tar xf /gllfsc/download/flex-2.5.37.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/flex-2.5.37
# From http://sourceforge.net/p/flex/bugs/151/
sed -i.orig '1s/$/\n#undef malloc\n#undef realloc/' \
    lib/realloc.c
cat > config.cache << EOF
ac_cv_path_M4="/bin/m4"
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --cache-file=config.cache \
    --disable-nls
make
make DESTDIR=/gllfsc install
ln -sv libfl.a /gllfsc/lib/libl.a
cd ..
rm -r flex-2.5.37
cd

cat > /gllfsc/bin/lex << EOF
#!/bin/sh
exec /bin/flex -l \$@
EOF
chmod -v 755 /gllfsc/bin/lex
exit 0
```

`config.cache` forces flex to use `/bin/m4` instead of `/gllfsc/cross-tools/bin/m4` on the target machine.

For compatibility issues, we create the symlink `libl.a`.

We then create target system's `/bin/lex` that will execute `flex` with option `-l` in order to behave with maximal compatibility like `lex`.

6.28 Gawk

GNU awk (Gawk) is a program used to select particular records in a file and perform operations upon them.

```
su - gawk
# 2 minutes
tar xf /gllfsc/download/gawk-4.1.0.tar.gz -C /gllfsc/build
cd /gllfsc/build/gawk-4.1.0
sed -i.orig \
    '/check-recursive all-recursive/s/ check-for-shared-lib-support//' \
    extension/Makefile.in
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --libexecdir=/lib \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -r gawk-4.1.0
cd
exit 0
```

The sed expression is used to avoid the error '`Building the extensions is not supported on this platform`'.

6.29 Gdbm

GNU dbm is a library of database functions.

```
su - gdbm
# 1 minute
tar xf /gllfsc/download/gdbm-1.11.tar.gz -C /gllfsc/build
cd /gllfsc/build/gdbm-1.11
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -r gdbm-1.11
cd
# fix man-db's /lib/libpipeline.so: error adding symbols: File in
# wrong format
rm /gllfsc/lib/libgdbm.la
exit 0
```

6.30 Gettext

GNU gettext utilities are a set of tools that provides a framework to help packages produce multi-lingual messages.

```
su - gettext
# 7 minutes
tar xf /gllfsc/download/gettext-0.18.3.1.tar.gz -C /gllfsc/build
cd /gllfsc/build/gettext-0.18.3.1
cat > config.cache << EOF
am_cv_func_iconv_works=yes
gl_cv_func_wcwidth_works=yes
gt_cv_func_printf_posix=yes
gt_cv_int_divbyzero_sigfpe=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --cache-file=config.cache \
    --disable-nls
make
#cp gettext-tools/gnulib-lib/.libs/libgettextlib.la{,i}
#cp gettext-tools/src/.libs/libgettextsrc.la{,i}
make DESTDIR=/gllfsc install
cd ..
rm -rf gettext-0.18.3.1
cd
exit 0
```

6.31 Grep

GNU `grep` command searches one or more input files for lines containing a match to a specified pattern.

```
su - grep
# 1 minute
tar xf /gllfsc/download/grep-2.15.tar.xz -C /gllfsc/build
cd /gllfsc/build/grep-2.15
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --bindir=/bin \
    --disable-perl-regexp \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -rf grep-2.15
cd
exit 0
```

Option `--disable-perl-regexp` disables support of Perl-style regular expressions (regexp).

6.32 Groff

Groff is the GNU version of the roff document formatting system which is used to produce man pages.

```
su - groff
# 2 minutes
tar xf /gllfsc/download/groff-1.22.2.tar.gz -C /gllfsc/build
cd /gllfsc/build/groff-1.22.2
PAGE=A4 \
    ./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make \
    TROFFBIN=troff \
    GROFFBIN=groff \
    GROFF_BIN_PATH=
make prefix=/gllfsc install
ln -sv soelim /gllfsc/bin/zsoelim
ln -sv eqn /gllfsc/bin/geqn
ln -sv tbl /gllfsc/bin/gtbl
cd ..
rm -rf groff-1.22.2
cd
# man-db installs its own version of zsoelim:
mv -v /gllfsc/bin/zsoelim{,.groff}
exit 0
```

The variables `TROFFBIN=troff` and `GROFFBIN=groff` tell `make` to use `troff` and `groff` commands installed in the Chapter 5 [Building the Cross-Compilation Tools], page 25, to build documentation.

The variable `GROFF_BIN_PATH` before `PATH` is checked for programs `groff` is calling (preprocessors, `troff`, and output devices). If not set, it defaults to the directory where the `groff` binary is located.

The symlinks are used for compatibility.

6.33 Gzip

GNU Gzip is a data compression program.

```
su - gzip
# 1 minute
tar xf /gllfsc/download/gzip-1.6.tar.gz -C /gllfsc/build
cd /gllfsc/build/gzip-1.6
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=/gllfsc install
cd ..
rm -rf gzip-1.6
cd
exit 0
```

6.34 Inetutils

GNU Inetutils is a collection of common network programs.

```
su - inetutils
# 1 minute
tar xf /gllfsc/download/inetutils-2.2.tar.gz -C /gllfsc/build
cd /gllfsc/build/inetutils-2.2
#sed -i '/gets is a security hole/d' lib/stdio.in.h
sed -i '/PATH_PROCNET_DEV/s/\ no//' paths
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=/gllfsc install
cd ..
rm -rf inetutils-2.2
cd
# util-linux installs its own verion of logger:
mv -v /gllfsc/bin/logger{,.inetutils}
mv -v /gllfsc/usr/share/man/man1/logger.1{,.inetutils}
exit 0
```

'`sed -i '/PATH_PROCNET_DEV/s/\ no//' paths`' is used to fix the following error when issuing '`make`': '`'PATH_PROCNET_DEV' undeclared (first use in this function)`'.

6.35 Iproute2

Iproute2 is a collection of utilities for controlling TCP and UDP IP networking and traffic.

You need Bison and Flex on your system to compile this program from source.

```
su - iproute2
# 1 minute
tar xf /gllfsc/download/iproute2-3.10.0.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/iproute2-3.10.0
sed -i.orig '/^TARGETS/s@arpd@@g' misc/Makefile
make \
    DESTDIR=/gllfsc \
    CC="${CC}" \
    DOCDIR=/share/doc/iproute2 \
    MANDIR=/share/man
make \
    DESTDIR=/gllfsc \
    DOCDIR=/share/doc/iproute2 \
    MANDIR=/share/man \
    install
cd ..
rm -rf iproute2-3.10.0
cd
exit 0
```

'`sed -i.orig '/^TARGETS/s@arpd@@g' misc/Makefile`' is used to disable the build of `arpd` as it requires Berkeley DB to be installed.

`DOCDIR` and `MANDIR` indicate the location in which the documentation and the manual pages will be installed, respectively. Those are no absolute paths but use the value of `DESTDIR` as a prefix.

6.36 Kbd

Kbd contains keytable files and keyboard utilities.

You need Check on your system to compile this program from source.

```
su - kbd
# 1 minute
tar xf /gllfsc/download/kbd-2.0.1.tar.gz -C /gllfsc/build
cd /gllfsc/build/kbd-2.0.1

# Do not check for CHECK:
sed -i.orig '14s/^/#/' configure.ac
autoconf configure.ac > configure

./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --disable-vlock \
    --disable-nls
sed -i.orig '/^SUBDIRS/s/ tests//' Makefile.in
make
make DESTDIR=/gllfsc install
cd ..
rm -rf kbd-2.0.1
cd
exit 0
```

'`sed -i.orig '/SUBDIRS/s/ tests//' Makefile.am`' is used to prevent files in the `tests` directory to be built.

Option `--disable-vlock` disables the build of vlock. vlock needs PAM library headers to be present on the build system and is not necessary for us, so we do not build it.

6.37 Kmod

Kmod (previously known as module-init-tools) provides userspace-side assistance in loading kernel modules and their dependencies.

```
su - kmod
# 1 minute
tar xf /gllfsc/download/kmod-15.tar.gz -C /gllfsc/build
cd /gllfsc/build/kmod-15
zlib_CFLAGS="-I/gllfsc/include" \
    zlib_LIBS="-L/gllfsc/lib -lz" \
    ./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --with-zlib \
    --disable-manpages
make
make \
    DESTDIR=/gllfsc \
    INSTALL=install \
    install
```

```
cd ..
rm -rf kmod-15
cd

# For bootscripts:
ln -sv kmod /gllfsc/bin/lsmod
ln -sv kmod /gllfsc/bin/depmod
ln -sv kmod /gllfsc/bin/insmod
ln -sv kmod /gllfsc/bin/modprobe
ln -sv kmod /gllfsc/bin/modinfo
ln -sv kmod /gllfsc/bin/rmmod

# Fix permissions for Package User util-linux:
chmod g+w,o+t /gllfsc/usr/share/bash-completion/completions

exit 0
```

'`zlib_CFLAGS`' and '`zlib_LIBS`' are defined to avoid the error message: '`The pkg-config script could not be found or is too old. Make sure it is in your PATH or set the PKG_CONFIG environment variable to the full path to pkg-config. Alternatively, you may set the environment variables zlib_CFLAGS and zlib_LIBS to avoid the need to call pkg-config.`'

`--with-zlib` enables support for modules compressed with zlib.

By default, installation uses `INSTALL=install-with-care` which checks if old utilities have not been destroyed. To avoid this check, we use `INSTALL=install`.

6.38 Less

Less is a file pager: it is used to view the content of a text file.

```
su - less
# 1 minute
tar xf /gllfsc/download/less-458.tar.gz -C /gllfsc/build
cd /gllfsc/build/less-458
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make prefix=/gllfsc install
cd ..
rm -rf less-458
cd
exit 0
```

6.39 Libpipeline

GNU Libpipeline is a C library for manipulating pipelines of subprocesses in a flexible and convenient way.

```
su - libpipeline
# 1 minute
tar xf /gllfsc/download/libpipeline-1.3.0.tar.gz -C /gllfsc/build
cd /gllfsc/build/libpipeline-1.3.0
```

```
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make prefix=/gllfsc install
cd ..
rm -rf libpipeline-1.3.0
cd
# fix man-db's /lib/libpipeline.so: error adding symbols: File in
# wrong format
rm /gllfsc/lib/libpipeline.la
exit 0
```

6.40 Make

GNU `make` utility determines automatically which pieces of a large program need to be recompiled, and issues the commands to recompile them.

```
su - make
# 1 minute
tar xf /gllfsc/download/make-4.0.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/make-4.0
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -rf make-4.0
cd
exit 0
```

6.41 Man-db

Man-db is an implementation of the standard Unix documentation system accessed using the man command. It uses a Berkeley DB database in place of the traditional flat-text whatis databases.

```
su - man-db
# 1 minute
tar xf /gllfsc/download/man-db-2.6.7.1.tar.xz -C /gllfsc/build
cd /gllfsc/build/man-db-2.6.7.1
libpipeline_CFLAGS="-I/gllfsc/include" \
    libpipeline_LIBS="-L/gllfsc/lib -lpipeline" \
    ./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --disable-nls
make
make DESTDIR=/gllfsc install
```

```
cd ..
rm -rf man-db-2.6.7.1
cd

sed -i 's/#\(DEFINE.*pager.*\)less -s/\1 less -isRc/' \
    /gllfsc/etc/man_db.conf
exit 0
```

'`libpipeline_CFLAGS`' and '`libpipeline_LIBS`' are defined to avoid the error message: '`The pkg-config script could not be found or is too old. Make sure it is in your PATH or set the PKG_CONFIG environment variable to the full path to pkg-config. Alternatively, you may set the environment variables libpipeline_CFLAGS and libpipeline_LIBS to avoid the need to call pkg-config.`'

The `sed` command is used to replace default pager with `less`. Option `-c` will cause `less` to display man pages faster as this option disables scrolling. Option `-R` will cause `less` to render colors in the man pages.

6.42 Nano

GNU nano is a lightweight text editor.

```
su - nano
# 1 minute
tar xf /gllfsc/download/nano-2.3.2.tar.gz -C /gllfsc/build
cd /gllfsc/build/nano-2.3.2
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --disable-nls
sed -i.orig \
    '/CPPFLAGS/s@/usr/include/ncursesw@/gllfsc/include@' \
    `find . -iname 'Makefile'`
make
make DESTDIR=/gllfsc install
cd ..
rm -rf nano-2.3.2
cd
exit 0
```

The sed expression is used to replace `/usr/include/ncursesw` with `/gllfsc/include` in every file named `Makefile` in order to overcome the error '`/usr/include/ncursesw/ncurses.h:60:34: fatal error: ncursesw/ncurses_dll.h: No such file or directory`'.

> **Note:** commands in nano are displayed as in '^X'. The '^' character means `CTRL` key, so '^X' means *`CTRL-X`*: press *`CTRL`* and *`X`* keys simultaneously on the keyboard.

6.43 Patch

GNU patch takes a patch file containing a difference listing produced by the `diff` program and applies those differences to one or more original files, producing patched versions.

```
su - patch
# 1 minute
tar xf /gllfsc/download/patch-2.7.1.tar.bz2 -C /gllfsc/build
```

```
cd /gllfsc/build/patch-2.7.1
cat > config.cache << EOF
ac_cv_path_ed_PROGRAM=ed
ac_cv_func_strnlen_working=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --cache-file=config.cache
make
make prefix=/gllfsc install
cd ..
rm -rf patch-2.7.1
cd
exit 0
```

6.44 Psmisc

This package contains utilities that use the proc filesystem.

```
su - psmisc
# 1 minute
tar xf /gllfsc/download/psmisc-22.20.tar.gz -C /gllfsc/build
cd /gllfsc/build/psmisc-22.20
cat > config.cache << EOF
ac_cv_func_malloc_0_nonnull=yes
ac_cv_func_realloc_0_nonnull=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --cache-file=config.cache \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -rf psmisc-22.20
cd
exit 0
```

6.45 Shadow

```
su - shadow
# 1 minute
tar xf /gllfsc/download/shadow-4.6.tar.xz -C /gllfsc/build
cd /gllfsc/build/shadow-4.6
#automake
echo "ac_cv_func_setpgrp_void=yes" > config.cache
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
```

```
    --libdir=/lib \
    --sysconfdir=/etc \
    --enable-shared \
    --without-audit \
    --without-libpam \
    --without-selinux \
    --cache-file=config.cache \
    --disable-nls
sed -i.orig '/man_MANS/s/$(man_nopam) //' man/ru/Makefile
#sed -i.orig 's/groups$(EXEEXT) //' src/Makefile
#for mkf in $(find man -name Makefile)
#    do
#    sed -i.orig -e '/groups.1.xml/d' -e 's/groups.1 //' ${mkf}
#    done
make
make DESTDIR=/gllfsc install
sed -i.orig -e 's@#MD5_CRYPT_ENAB.no@MD5_CRYPT_ENAB yes@' \
    -e 's@/var/spool/mail@/var/mail@' \
    /gllfsc/etc/login.defs
#${CROSS_TARGET}-pwconv
#${CROSS_TARGET}-grpconv
cd ..
rm -rf shadow-4.6
cd
# util-linux installs its own version of nologin:
mv -v /gllfsc/bin/nologin{,.shadow}
mv -v /gllfsc/usr/share/man/man8/nologin.8{,.shadow}
# Adjusting PATH:
sed -i /PATH=/s,=.*$,=/local/bin:/bin, /gllfsc/etc/login.defs
exit 0
```

The option `--enable-man` is used to generate man pages.

The first call of `sed` removes *$(man_nopam)* on the line with man_MANS in `man/ru/Makefile.am` in order for '`make install`' to complete.

The second call of `sed` disables the build of command `groups`, as coreutils already installed it.

The last call of `sed` enables support for MD5 encrypted passwords and changes the mail default directory from `/var/spool/mail` to `/var/mail`.

6.46 Sysvinit

Sysvinit is the system-V style init process. Init is the first process started during booting. It is started by the kernel. Init continues running as a daemon until the system is shut down. It is the direct or indirect ancestor of all other processes and automatically adopts all orphaned processes.

```
su - sysvinit
# 1 minute
tar xf /gllfsc/download/sysvinit-2.88dsf.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/sysvinit-2.88dsf
sed -i.orig -e 's@/dev/initctl@$(ROOT)&@g' \
    -e 's@\(mknod \)-m \([0-9]* \)\(.* \)p@\1\3p; chmod \2\3@g' \
    -e '/^ifeq/s/$(ROOT)//' \
```

```
    -e 's@/usr/lib@$(ROOT)/lib@' \
    src/Makefile
make -C src clobber
make -C src ROOT=/gllfsc CC="${CC}"
make -C src ROOT=/gllfsc INSTALL="install" install
cd ..
rm -rf sysvinit-2.88dsf
cd

cat > /gllfsc/etc/inittab << EOF
# Begin /etc/inittab

id:3:initdefault:

si::sysinit:/etc/rc.d/init.d/rc sysinit

l0:0:wait:/etc/rc.d/init.d/rc 0
l1:S1:wait:/etc/rc.d/init.d/rc 1
l2:2:wait:/etc/rc.d/init.d/rc 2
l3:3:wait:/etc/rc.d/init.d/rc 3
l4:4:wait:/etc/rc.d/init.d/rc 4
l5:5:wait:/etc/rc.d/init.d/rc 5
l6:6:wait:/etc/rc.d/init.d/rc 6

ca:12345:ctrlaltdel:/sbin/shutdown -t1 -a -r now

su:S016:once:/sbin/sulogin

1:2345:respawn:/sbin/agetty --noclear tty1 9600
2:2345:respawn:/sbin/agetty tty2 9600
#3:2345:respawn:/sbin/agetty tty3 9600
#4:2345:respawn:/sbin/agetty tty4 9600
#5:2345:respawn:/sbin/agetty tty5 9600
#6:2345:respawn:/sbin/agetty tty6 9600

#c0:12345:respawn:/sbin/agetty 115200 ttyS0 vt100

# End /etc/inittab
EOF
# util-linux installs its own versions:
mv -v /gllfsc/bin/mountpoint{,.sysvinit}
mv -v /gllfsc/bin/sulogin{,.sysvinit}
mv -v /gllfsc/bin/mesg{,.sysvinit}
mv -v /gllfsc/bin/last{,.sysvinit}
mv -v /gllfsc/bin/utmpdump{,.sysvinit}
mv -v /gllfsc/bin/lastb{,.sysvinit}
mv -v /gllfsc/usr/share/man/man1/mesg.1{,.sysvinit}
mv -v /gllfsc/usr/share/man/man1/last.1{,.sysvinit}
mv -v /gllfsc/usr/share/man/man1/lastb.1{,.sysvinit}
mv -v /gllfsc/usr/share/man/man1/utmpdump.1{,.sysvinit}
mv -v /gllfsc/usr/share/man/man1/mountpoint.1{,.sysvinit}
mv -v /gllfsc/usr/share/man/man8/sulogin.8{,.sysvinit}
```

```
exit 0
```

The first call of `sed` replaces `/dev/initctl` with `$(ROOT)/dev/initctl`, and `/usr/lib` with `$(ROOT)/lib` among other things in order to install sysvinit on the target system.

'`make -C src clobber`' is used to clean up the `src` directory.

Then, we create the `inittab` file that describes which processes are started at bootup and during normal operation.

The line '`#c0:12345:respawn:/sbin/agetty 115200 ttyS0 vt100`' is commented out (with `#`) in order to avoid the message: '`INIT: Id "c0" respawning too fast: disabled for 5 minutes`' on the target system.

6.47 Tar

GNU tar is an archiving utility: it stores and extracts files from a tape or disk archive.

```
su - tar
# 1 minute
tar xf /gllfsc/download/tar-1.27.1.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/tar-1.27.1
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -rf tar-1.27.1
cd
exit 0
```

6.48 Texinfo

GNU Texinfo is a documentation system that can produce both online information and a printed manual from a single source.

You need Ncurses headers on your system to compile this program from source.

```
su - texinfo
# 1 minute
tar xf /gllfsc/download/texinfo-4.13a.tar.gz -C /gllfsc/build
cd /gllfsc/build/texinfo-4.13
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --disable-nls
make -C tools/gnulib/lib
make -C tools
make
make DESTDIR=/gllfsc install
cd ..
rm -rf texinfo-4.13
cd
```

```
cd /gllfsc/share/info
#rm dir
for f in *
    do install-info $f dir 2>/dev/null
done
cd
exit 0
```

The first three calls of `make` make it possible to build Texinfo by cross-compilation.

For Info to work, the `info` directory must contain a file that serves as a top level directory for the Info system. By convention, this file is called `dir`. We update this file for the target system.

6.49 Udev

Udev is the dynamic device management of the kernel Linux.

You need Gperf on your system to compile this program from source. Under GLLFSC, do, as root:

```
tar xf /gllfsc/download/gperf-3.0.4.tar.gz
cd gperf-3.0.4
./configure --prefix=
make install
cd ..
rm -rf gperf-3.0.4
```

Then:

```
su - udev
# 1 minute
tar xf /gllfsc/download/udev-175.tar.gz -C /gllfsc/build
cd /gllfsc/build/udev-175
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --with-rootlibdir=/lib \
    --libexecdir=/lib/udev \
    --docdir=/share/doc/udev-175 \
    --disable-introspection \
    --with-pci-ids-path=no \
    --with-usb-ids-path=no \
    --disable-gudev
make
make DESTDIR=/gllfsc install
install -dv /gllfsc/lib/firmware
ln -sv ../lib/udev/udevd /gllfsc/sbin/udevd
cd ..
rm -rf udev-175
cd

# fix /lib/libudev.so: error adding symbols: File in wrong format
rm /gllfsc/lib/libudev.la

# Fix /bin/install: cannot change permissions of
```

```
# '/gllfsc/lib/udev/devices/pts': No such file or directory
chmod g+w,o+t /gllfsc/lib/udev/devices

# Fix permissions for Package Users:
chmod g+w,o+t /gllfsc/lib/udev/rules.d
chmod g+w,o+t /gllfsc/share/gtk-doc
chmod g+w,o+t /gllfsc/share/gtk-doc/html
chmod g+w,o+t /gllfsc/share/pkgconfig

exit 0
```

6.50 Util-Linux

util-linux is a random collection of utilities for use with the kernel Linux.

> **Warning:** If you have trouble building util-linux from a distribution using .deb packages, try to uninstall the package named '`libtinfo-dev`'. Then remove `/gllfsc/build/util-linux-2.24` and build it again.

```
su - util-linux
# 3 minutes
tar xf /gllfsc/download/util-linux-2.24.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/util-linux-2.24
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --enable-partx \
    --disable-wall \
    --enable-write \
    --disable-makeinstall-chown \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -r util-linux-2.24
cd
# procps-ng installs its own version of kill:
mv -v /gllfsc/bin/kill{,.util-linux}
mv -v /gllfsc/usr/share/man/man1/kill.1{,.util-linux}
exit 0
```

Option `--enable-partx` enables the build and installation of the `addpart`, `delpart` and `partx` commands.

Option `--disable-wall` disables the build of the `wall` command which is already provided by sysvinit.

Option `--enable-write` enables the build and installation of the `write` command.

Option `--disable-makeinstall-chown` disables the change of owner to root for installed programs.

6.51 XZ-Utils

XZ Utils is a general-purpose data compression software with high compression ratio.

```
su - xz-utils
# 1 minute
```

```
tar xf /gllfsc/download/xz-5.0.8.tar.bz2 -C /gllfsc/build
cd /gllfsc/build/xz-5.0.8
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --disable-nls
make
make DESTDIR=/gllfsc install
cd ..
rm -rf xz-5.0.8
cd
exit 0
```

6.52 Bootscripts

The bootscript archive contains scripts that manage services during system's bootup and shutdown.

```
su - bootscripts
# 1 minute
tar xf /gllfsc/download/bootscripts-cross-lfs-2.0.0.tar.xz \
    -C /gllfsc/build
cd /gllfsc/build/bootscripts-cross-lfs-2.0-pre2
make DESTDIR=/gllfsc install-bootscripts
make DESTDIR=/gllfsc install-network
cd ..
rm -rf bootscripts-cross-lfs-2.0-pre2
cd

# We do not use a system log daemon:
rm /gllfsc/etc/rc.d/rc3.d/S10rsyslog

# Bringing up network interfaces fails:
rm /gllfsc/etc/rc.d/rc3.d/S20network

# Fix permissions for Package Users:
chmod g+w,o+t /gllfsc/etc/sysconfig

exit 0
```

This installs basic bootscripts required for bootup and shutdown, and network-related bootscripts.

> **Note:** To modify the keyboard layout at boot, for instance fr' azerty:
>
> ```
> sed -i.orig '/^KEYMAP/s/us/fr/' /gllfsc/etc/sysconfig/i18n
> ```

6.53 The Kernel

Linux is a kernel aimed towards POSIX and Single UNIX Specification compliance.

You need Bc and Lzma on your system to compile this program from source. Under GLLFSC, install ed, which is a bc dependency then bc:

```
tar xf /gllfsc/download/ed-1.1.tar.bz2
cd ed-1.1
```

```
./configure --prefix=
make install
cd ..
rm -rf ed-1.1

tar xf /gllfsc/download/bc-1.07.1.tar.gz
cd bc-1.07.1
./configure --prefix=
make install
cd ..
rm -rf bc-1.07.1
su - linux-libre
# 25 minutes
tar xf /gllfsc/download/linux-libre-3.10.108-gnu.tar.xz \
    -C /gllfsc/build
cd /gllfsc/build/linux-3.10.108
make mrproper
```

Then:

```
cp arch/x86/configs/i386_defconfig .config
#patch -Np1 -i /gllfsc/download/100gnu+freedo.patch
```

Then, if you want to change the configuration:

```
make ARCH=i386 CROSS_COMPILE=${CROSS_TARGET}- menuconfig
```

Note: If you have more than 3GB of RAM installed on a 32 bit CPU, you can use all of it by selecting the following option:

```
Processor type and features
> High Memory Support
  (X) 64GB
```

In order to avoid the error message "cannot create directory '/dev/pts': read only filesystem" at boot, you have to activate the two options below:

```
Device Drivers
> Generic Driver Options
  > [*] Maintain a devtmpfs fs to mount on /dev
  > [*] Automount devtmpfs at /dev, after the kernel mounted the rootfs
```

Also ensure you have CONFIG_DRM_I915_KMS=y in your .config after the configuration step, working under tty is more pleasant with a nice resolution:

```
Device Drivers
> Graphics support
  > <*> Direct Rendering Manager (XFree86 4.1.0 and higher DRI support)
  > <*> Intel 8xx/9xx/G3x/G4x/HD Graphics
  > [*] Enable modesetting on intel by default
```

Disable the Tux/Freedo logo with:

```
Device Drivers
> Graphics support
  > [ ] Bootup logo
```

Then:

```
make \
    ARCH=i386 \
    CROSS_COMPILE=${CROSS_TARGET}-
```

```
make \
    ARCH=i386 \
    CROSS_COMPILE=${CROSS_TARGET}- \
    INSTALL_MOD_PATH=/gllfsc \
    modules_install
cp arch/x86/boot/bzImage /gllfsc/boot/vmlinuz-3.10.108-gnu
cp System.map /gllfsc/boot/System.map-3.10.108-gnu
cp .config /gllfsc/boot/config-3.10.108-gnu
cd ..
cd
exit 0
```

Tip: because future compilation may need kernel sources, the compilation directory of the kernel should be preserved.

6.54 GRUB

GNU GRUB is a Multiboot boot loader.

A bootloader is the first software program that runs when a computer starts. It is responsible for loading and transferring control to the operating system kernel software (such as Linux). The kernel, in turn, initializes the rest of the system (e.g. GNU).

```
su - grub
# 3 minutes
tar xf /gllfsc/download/grub-2.00.tar.gz \
    -C /gllfsc/build
cd /gllfsc/build/grub-2.00
sed -i '/gets is a security hole/d' grub-core/gnulib/stdio.in.h
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --disable-nls
cd grub-core/script
EXP1='\n#pragma GCC diagnostic ignored \"-Wunused-function\"'
sed -i.1 '/Wunsafe-loop-optimizations\"/s,$,'"$EXP1"',' yylex.l
EXP2='\n#pragma GCC diagnostic ignored \"-Wsign-compare\"'
sed -i.2 '/Wunused-function\"/s,$,'"$EXP2"',' yylex.l
cd ../..
make
make DESTDIR=/gllfsc install
cd ..
rm -rf grub-2.00
cd

mkdir /gllfsc/boot/grub

# Fix permissions for Package Users:
chmod g+w,o+t /etc/bash_completion.d

exit 0
```

'`sed -i '/gets is a security hole/d' grub-core/gnulib/stdio.in.h`' is used to fix the following error when issuing '`make`':

```
./stdio.h:456:1: error: 'gets' undeclared here (not in a function)
make[4]: Leaving directory '/gllfsc/build/grub-2.00/grub-core/gnulib'
```

The sed expressions applied to yylex.l fixes:

```
grub_script.yy.c:2296:17: error: comparison between signed and
unsigned integer expressions [-Werror=sign-compare]
./grub-core/script/yylex.l
```

7 Creating Required Configuration Files for the New System

7.1 File for Time Setup

```
su - bootscripts
echo UTC=1 > /gllfsc/etc/sysconfig/clock

# If you have trouble with the clock behaviour, do:
mv -v /gllfsc/etc/rc.d/rcsysinit.d/{S15setclock,K15setclock}
exit 0
```

7.2 Setting up Keyboard Function keys for the Shell

Note: You can automate this section by splitting the file `gllfsc-pentium4-1.9.1.texi` into instructions:

```
csplit gllfsc-pentium4-1.9.1.texi '/su - readline/' '{*}'
mv xx03 7.2
chmod o+x 7.2
```

Then, with '`nano`', you can remove the line beginning with '`su -`', and add the line '`set -e`' and the line '`set -v`' at the beginning of the script so that it will exit on error and print each instruction before executing it:

```
nano 7.2
```

Then, once inside the readline User personal directory:

```
/root/7.2
```

Readline default configuration file is set:

```
su - readline
cat > /gllfsc/etc/inputrc << EOF
set bell-style none
set convert-meta Off
set horizontal-scroll-mode Off
set input-meta On
set output-meta On
"\eOd": backward-word
"\eOc": forward-word
"\e[1~": beginning-of-line
"\e[4~": end-of-line
"\e[5~": beginning-of-history
"\e[6~": end-of-history
"\e[3~": delete-char
"\e[2~": quoted-insert
"\eOH": beginning-of-line
"\eOF": end-of-line
"\e[H": beginning-of-line
"\e[F": end-of-line
EOF
exit 0
```

If `convert-meta` is set to '`On`', Readline will convert characters with the eighth bit set to an ASCII key sequence by stripping the eighth bit and prefixing an `ESC` character, converting them to a meta-prefixed key sequence.

`horizontal-scroll-mode` set to '`Off`' means that the text of the lines being edited will be wrapped onto a new screen line when they are longer than the width of the screen, instead of being scrolled horizontally on a single screen line.

If `input-meta` is set to '`On`', Readline will enable eight-bit input (it will not clear the eighth bit in the characters it reads), regardless of what the terminal claims it can support.

If `output-meta` is set to '`On`', Readline will display characters with the eighth bit set directly rather than as a meta-prefixed escape sequence.

7.3 Setting up Bash Shell Startup Files

```
su - bash
cat > /gllfsc/etc/profile << 'EOF'
export LANG=en_US.UTF-8
export INPUTRC=/etc/inputrc
export PS1='\[\e[31m\]\A-\W\[\e[00m\]# '
EOF
exit 0
```

The environment variable `LANG` defines the default language that should be used on the system. '`en_US.UTF-8`' means "english" language, country "US" and UTF-8 (UCS Transformation Format—8-bit) encoding (Unicode).

For explanations on `PS1`, see Section 3.5 [Environment Variables Setup], page 9.

7.4 Localhost Setup

```
su - bootscripts
echo HOSTNAME=gllfsc > /gllfsc/etc/sysconfig/network
exit 0
```

7.5 Setting up `hosts` File

```
echo "127.0.0.1 gllfsc localhost" > /gllfsc/etc/hosts
```

7.6 Setting up Network Address

You can choose to have a network static or dynamic address.

7.6.1 Setting up Network Static Address

```
su - bootscripts
cd /gllfsc/etc/sysconfig/network-devices
mkdir -v ifconfig.eth0
cat > ifconfig.eth0/ipv4 << EOF
ONBOOT=yes
SERVICE=ipv4-static
IP=192.168.1.1
GATEWAY=192.168.1.2
PREFIX=24
BROADCAST=192.168.1.255
EOF
cd
exit 0
```

Warning: `IP`, `GATEWAY`, `BROADCAST` addresses are set up according to one's situation.

7.6.2 Setting up Network Dynamic Address

```
su - bootscripts
cd /gllfsc/etc/sysconfig/network-devices
mkdir -v ifconfig.eth0
cat > ifconfig.eth0/dhcpcd << EOF
ONBOOT=yes
SERVICE=dhcpcd
DHCP_START="-q"
DHCP_STOP="-k"
EOF
cd
exit 0
```

7.7 Setting up DNS

```
cat > /gllfsc/etc/resolv.conf << EOF
nameserver your-main-DNS-address
nameserver your-secondary-DNS-address
EOF
```

7.8 `fstab` File Creation

The file `/etc/fstab` is used at boot to mount partitions under the requested directories.

```
su - util-linux
cat > /gllfsc/etc/fstab << EOF
# file system    mount-point  type     options         dump  fsck order

/dev/sda3        /            ext3     defaults         0    0
#/dev/sda7        /home        ext3     defaults         0    0
/dev/sda5        swap         swap     pri=1            0    0
devtmpfs         /dev         dev      defaults         0    0
proc             /proc        proc     defaults         0    0
tmpfs            /run         run      defaults         0    0
sysfs            /sys         sysfs    defaults         0    0
devpts           /dev/pts     devpts   gid=4,mode=620   0    0
shm              /dev/shm     tmpfs    defaults         0    0
EOF
exit 0
```

Warning: the name of the hard drive and the filesystems used here have to be modified to reflect *your* real situation.

8 Before Booting GLLFSC

8.1 Enabling Package Users on the target GLLFSC

Note: You can automate parts of this chapter by splitting the file `gllfsc-pentium4-1.9.1.texi` into instructions for each section:

```
csplit gllfsc-pentium4-1.9.1.texi '/chown shadow/' '{*}'
rm xx0[0-5]
mv xx06 8.1
csplit 8.1 '/Archiving the System/'
mv xx00 8.1
mv xx01 8.2
csplit 8.2 '/Some Recommendations/'
mv xx00 8.2
rm xx01
```

Then, with '`nano`', you can add the line '`set -e`' and the line '`set -v`' at the beginning of each script so that it will exit on error and print each instruction before executing it. Then, edit its content. Then, make files executable and execute them:

```
chmod u+x 8.1 8.2
./8.1
./8.2
```

In order to enable Package Users under GLLFSC, we need to copy the package users and groups to the new system:

```
chown shadow:install /gllfsc/etc/{passwd,group}
su - shadow
grep ':100' /etc/passwd >> /gllfsc/etc/passwd
grep ':100' /etc/group >> /gllfsc/etc/group
exit 0
```

Then, as root, download Package Users archive at `https://www.linuxfromscratch.org/hints/downloads/files/ATTACHMENTS/more_control_and_pkg_man/more_control_helpers.tar.bz2` inside `/gllfsc/download`. :

```
cp -av /usr/src/* /gllfsc/usr/src

cd /tmp
tar xf /gllfsc/download/more_control_helpers.tar.bz2
cd more_control_helpers
rm sbin/{groupadd,useradd}

mkdir -v /gllfsc/etc/pkgusr
rm -v etc/{build,skel-package/{build,build.conf,.project}}
cp -Rv etc/* /gllfsc/etc/pkgusr

mkdir -v /gllfsc/usr/lib/pkgusr
cp -Rv lib/* /gllfsc/usr/lib/pkgusr

cp -v bin/* /gllfsc/usr/bin

sed -i.orig 's/"\$1"$/"install"/' sbin/install_package

cp -v sbin/{add_package_user,install_package} /gllfsc/usr/sbin
```

```
sed -i '/GROUP=1000/s/^/#/' /gllfsc/etc/default/useradd
sed -i '/CREATE_MAIL_SPOOL/s/yes/no/' /gllfsc/etc/default/useradd
```

Then:

```
cat > /gllfsc/etc/pkgusr/bash_profile << 'EOF'
export PATH=/usr/lib/pkgusr:/bin:/local/bin

# Make prompt reflect that we are a package user.
export PROMPT_COMMAND='PS1="\[\e[35m\]\A-package \u:\W\[\e[00m\]> "'

# Go to the home directory whenever we su to a package user.
cd

alias less='less -ic'
EOF
```

Finally:

```
cat > /gllfsc/root/.bash_profile << EOF
# Tab-complete package users when using su, finger or pinky
complete -o default -o nospace -A user su finger pinky
EOF
```

8.2 Archiving the System

Create required files:

```
cd /gllfsc
mknod -m 600 dev/console c 5 1
mknod -m 666 dev/null c 1 3
cp -av dev/{console,null} lib/udev/devices/
```

We archive the entire system by using the following command:

```
mkdir build.orig
mv build/linux-3.10.108 build.orig

# 7 minutes
tar -cjf gllfsc-pentium4-1.9.1.tar.bz2 \
    bin boot build dev download etc home include lib* local man mnt \
    opt proc root run sbin service share src static sys tmp usr var

cd
```

It is then simple to copy `gllfsc-pentium4-1.9.1.tar.bz2` to the target machine and extract it.

> **Warning:** If you use another GLLFSC system when you extract `gllfsc-pentium4-1.9.1.tar.bz2` to its dedicated partition, you should use option '`--numeric-owner`' to avoid conflicts with Package User names.

8.3 Some Recommendations

We recommend extracting the system to an empty partition. Moreover, the filesystem of the chosen partition has to be a filesystem supported by the kernel you compiled. Finally, this partition has to be consistent with the system description in the file `/etc/fstab` you created during setup (see Section 7.8 [fstab File Creation], page 67).

Then, you will have to edit the GRUB configuration file of the target machine: `/boot/grub/grub.cfg`. You can do it with '`nano`'.

A minimal `/boot/grub/grub.cfg` for classical hard disk could be:

```
insmod ext2
set default=0
set timeout=5

menuentry 'GLLFSC 1.9.1' {
    echo 'Loading linux-libre-3.10.108-gnu...'
    linux (hd0,3)/boot/vmlinuz-3.10.108-gnu root=/dev/sda3 quiet
}
```

A minimal `/boot/grub/grub.cfg` for hard disk supporting AHCI (Advanced Host Controller Interface) could be:

```
insmod part_msdos
insmod ext2
set default=0
set timeout=5

menuentry 'GLLFSC 1.9.1' {
    echo 'Loading linux-libre-3.10.108-gnu...'
    linux (ahci0,msdos3)/boot/vmlinuz-3.10.108-gnu root=/dev/sda3 quiet
}
```

8.4 Halting the Computer

In order to halt the computer, type:

```
init 0
```

If you prefer to reboot instead type:

```
init 6
```

9 After Booting GLLFSC

Some system configuration and package installation can only be made after booting onto the new system. The build process of this chapter takes about 25 minutes on my Lenovo ThinkPad X200.

9.1 Boot Process

Once the computer starts, the BIOS makes GRUB responsible for loading and transferring control to the operating system kernel (Linux-libre here). The kernel, in turn, initializes the rest of the operating system, beginning with init (runit at the end of this chapter).

If, for some reason, GRUB fails to launch linux-libre, you may be presented the following prompt:

```
grub rescue >
```

In this case, you may launch GRUB by issuing the following commands:

```
set
ls
# If you want to boot the kernel on partition 1 of a classical drive:
set prefix=(hd0,1)/grub
set root=(hd0,1)
insmod normal
normal
```

9.2 Login

To login as *root*, just type '`root`' when the system asks for your '`login:`'. There is no password.

Then, if you want to use the french keyboard layout, type '`loadkeys -q fr`'.

Note: To modify the keyboard layout at boot, for instance fr' azerty:

```
sed -i.orig '/^KEYMAP/s/us/fr/' /etc/sysconfig/i18n
```

9.3 Locales

You may want to have your new system display messages in your native language. If you desire to have a system supporting US english (german, french and China mainland's chinese are commented):

```
su - glibc
mkdir /lib/locale

#localedef -i de_DE -f UTF-8 de_DE
localedef -i en_US -f UTF-8 en_US
#localedef -i fr_FR -f UTF-8 fr_FR
#localedef -i zh_CN -f UTF-8 zh_CN
exit 0
```

Other locales are available:

- For available charmaps, see the content of `/share/i18n/charmaps`.
- For available locales, see the content of `/share/i18n/locales`.

9.4 Libevent

Note: You can automate parts of this chapter by splitting the script `3-build-post-boot.sh` (see Chapter 4 [Building the Cross-Compilation Toolchain], page 17) into instructions for each Package User:

```
csplit 3-build-post-boot.sh '/su -/' '{*}'
rm xx00 xx01 xx02 xx03
mv xx04 9.4-libevent
mv xx05 9.5-tmux
mv xx06 9.6-tz
mv xx07 9.7-runit
mv xx08 9.8-perl
mv xx09 9.9-openssl
mv xx10 9.10-wpa-supplicant
mv xx11 9.11-wireless-tools
mv xx12 9.12-wget
mv xx13 9.13-libtasn1
mv xx14 9.14-lynx
mv xx15 9.15-ca-certificates

csplit xx16 '/inetutils/'
mv xx00 9.16-procps-ng
rm xx16
mv xx01 xx99
csplit xx99 '/cat/'
rm xx99

mv xx01 xx99
csplit xx99 '/Clean up/'
mv xx00 9.17-pkgusr
mv xx01 9.18-archiving
rm xx99

chmod o+x 9.*
chmod u+x 9.17-pkgusr
```

Then, with '`nano`', you can remove lines beginning with '`su -`' and add the line '`set -e`' and the line '`set -v`' at the beginning of each script so that it will exit on error and print each instruction before executing it. To automate this step:

```
sed -i 's,su -.*,set -e\nset -v\n,' 9.*
```

You still have to add '`set -e`' and '`set -v`' at the begining of `9.16-pkgusr` and `9.17-archiving`, and '`exit 0`' at their end. Then, once inside the, for instance, tz User personal directory:

```
/root/9.4-libevent
```

Libevent is a dependency of Tmux.

```
su - libevent
# 1 minute
tar xf /download/libevent-2.0.22-stable.tar.gz -C /build
cd /build/libevent-2.0.22-stable
./configure \
    --prefix= \
    --disable-openssl
```

```
make
make DESTDIR= install
cd ..
rm -rf libevent-2.0.22-stable
cd
exit 0
```

9.5 Tmux

Tmux is a terminal multiplexer: it allows multiple terminal sessions to be accessed simultaneously in a single window.

```
su - tmux
# 1 minute
tar xf /download/tmux-1.8.tar.gz -C /build
cd /build/tmux-1.8
./configure --prefix=
make
make DESTDIR= install
cd ..
rm -rf tmux-1.8
cd
exit 0
```

9.6 Timezone

In order to have the time and date corresponding to the area where you live, you should build tzcode, tzdata and define your timezone.

```
su - tz
# 1 minute
mkdir /build/tz
tar xf /download/tzcode2013h.tar.gz -C /build/tz
tar xf /download/tzdata2013h.tar.gz -C /build/tz
cd /build/tz

make \
    TOPDIR=/ \
    TZDIR=/share/zoneinfo \
    ETCDIR=/bin

for TZ in africa antarctica asia australasia europe northamerica \
          southamerica pacificnew etcetera backward systemv factory \
          solar87 solar88 solar89; do
    zic -y "sh yearistype.sh" \
        -d /share/zoneinfo \
        -L /dev/null $TZ
done

zic -y "bash yearistype.sh" \
    -d /share/zoneinfo \
    -l GMT \
    -p America/New_York
```

```
cp iso3166.tab zone.tab /share/zoneinfo
cd ..
rm -rf tz
cd
```

Then, we define our timezone, in my case `Europe/Paris`:

```
cp -v --remove-destination \
    /share/zoneinfo/Europe/Paris \
    /etc/localtime
exit 0
```

9.7 Runit

runit is a cross-platform Unix init scheme with service supervision, a replacement for sysvinit, and other init schemes.

```
su - runit
# 1 minute
tar xf /download/runit-2.1.2.tar.gz -C /build
cd /build/admin/runit-2.1.2
cd src
make
make check

install -s -m0755 \
    chpst runit runit-init runsv runsvchdir runsvdir sv svlogd utmpset \
    /sbin

install -m0644 ../man/* \
    /share/man/man8

cd ..

mkdir /etc/runit

cp etc/debian/ctrlaltdel /etc/runit/

cd ../..
rm -rf admin
cd
```

The init-related programs have been installed. We need to create the boot scripts too: `/etc/runit/1` to boot the system, `/etc/runit/2` to launch 2 ttys and the service logging daemon and `/etc/runit/3` to halt or reboot the system.

```
cat > /etc/runit/1 << 'EOF'
#!/bin/sh
# system one time tasks

# Exit on error:
set -e

PATH=/bin

echo -n '16. Mounting kernel-based file systems:'
```

```
echo -n ' /proc'
mount -n -o nosuid,noexec,nodev -t proc proc /proc
echo -n ' /sys'
mount -n -o nosuid,noexec,nodev -t sysfs sys /sys
echo ' /run'
mount -n -o mode=0755,nosuid,nodev -t tmpfs run /run

echo -n '15. Creating directories:'
echo -n ' /run/lock'
mkdir -m 1777 /run/lock
echo -n ' /dev/pts'
mkdir -p /dev/pts
echo ' /dev/shm'
mkdir -p /dev/shm

echo '14. Mounting root file system in read-write mode.'
mount -n -o remount,rw / >/dev/null

# Remove fsck-related system watermarks.
rm -f /fastboot /forcefsck

echo '13. Recording existing mounts in /etc/mtab.'
> /etc/mtab
mount -f /
mount -f /proc
mount -f /sys
mount -f /run
mount -f /dev

echo '12. Mounting remaining file systems.'
mount -a -r >/dev/null

echo '11. Cleaning file system /tmp.'
cd /tmp && find . -xdev -mindepth 1 ! -name lost+found -delete

echo '10. Creating /var/run/utmp.'
if grep -q '^utmp:' /etc/group; then
    chmod 664 /var/run/utmp
    chgrp utmp /var/run/utmp
fi

echo '9. Starting udevd...'
echo '' > /sys/kernel/uevent_helper

/lib/udev/udevd --daemon

echo '8. Performing Coldplugging...'
/sbin/udevadm trigger --action=add --type=subsystems
/sbin/udevadm trigger --action=add --type=devices

/sbin/udevadm settle
```

```
# Uncomment the following lines if you use a swap partition:
#echo '7. Activating all swap files/partitions...'
#swapon -a

echo '6. Setting Font...'
setfont LatArCyrHeb-16 -C /dev/tty1
setfont LatArCyrHeb-16 -C /dev/tty2

echo '5. Setting keymap to UTF-8...'
dumpkeys | loadkeys --unicode

echo '4. Enabling Multibyte input...'
kbd_mode -u

echo '3. Setting up US Keymap...'
loadkeys -q us

echo '2. Setting encoding to UTF-8...'
echo -ne $'\033%G' > /dev/tty1
echo -ne $'\033%G' > /dev/tty2

echo '1. Bringing up the loopback interface...'
ip addr add 127.0.0.1/8 label lo dev lo
ip link set lo up

echo '0. Setting hostname to gllfsc...'
hostname gllfsc

echo
echo To login, remember:
echo your login is root
echo with no password
echo
echo You can now login here.
echo
echo If needed, you can use tty2 by pressing simultaneously Ctrl, Alt
echo and F2 keys. You can then come back to this screen \(tty1\) by
echo pressing simultaneously Ctrl, Alt and F1 keys.
echo
echo You can also use tmux to have multiple frames in a single window
echo Hotkeys:
echo CTRL-B then %
echo CTRL-B then \"
echo CTRL-B then LEFT, RIGHT, UP or DOWN ARROW
echo
echo Edit /etc/runit/1 if you want to remove this message.
echo

touch /etc/runit/stopit
chmod 0 /etc/runit/stopit

exit 0
```

```
EOF

chmod +x /etc/runit/1
cat > /etc/runit/2 << EOF
#!/bin/sh

PATH=/bin

exec env -i PATH=/bin \
runsvdir -P /service 'log: ........................................'
EOF

chmod +x /etc/runit/2
cat > /etc/runit/3 << EOF
#!/bin/sh

# Exit on error:
set -e

exec 2>&1

PATH=/bin

echo '4. Waiting for services to stop...'
sv down /service/*

echo '3. Exiting services...'
sv exit /service/*

echo '2. Deactivating all swap files/partitions...'
swapoff -a

# Unmount everything but /:
echo -n '1. Unmounting filesystems: /home'
umount -r /home
echo -n ' /proc'
umount -r /proc
echo -n ' /sys'
umount -r /sys
echo -n ' /dev/pts'
umount -r /dev/pts
echo ' /dev/shm'
umount -r /dev/shm

echo '0. Shutdown...'

exit 0
EOF

chmod +x /etc/runit/3
```

We now create useful services:

```
mkdir /etc/sv
mkdir /etc/sv/getty-1

cat > /etc/sv/getty-1/run << EOF
#!/bin/sh
exec /sbin/agetty --noclear tty1 9600
EOF
chmod +x /etc/sv/getty-1/run

cat > /etc/sv/getty-1/finish << EOF
#!/bin/sh
exec utmpset -w tty1
EOF
chmod +x /etc/sv/getty-1/finish

ln -sv /etc/sv/getty-1 /service/getty-1


mkdir -p /etc/sv/getty-2

cat > /etc/sv/getty-2/run << EOF
#!/bin/sh
exec /sbin/agetty tty2 9600
EOF
chmod +x /etc/sv/getty-2/run

cat > /etc/sv/getty-2/finish << EOF
#!/bin/sh
exec utmpset -w tty2
EOF
chmod +x /etc/sv/getty-2/finish

ln -sv /etc/sv/getty-2 /service/getty-2


mkdir /etc/sv/svlogd

cat > /etc/sv/svlogd/run << EOF
#!/bin/sh
exec svlogd
EOF
chmod +x /etc/sv/svlogd/run

ln -sv /etc/sv/svlogd /service/svlogd
exit 0
```

Finally, as root, make runit the default init:

```
mv /sbin/init /sbin/init.sysv
ln -sv runit-init /sbin/init
```

9.8 Perl

Perl is a high-level programming language.

Note: You may have to type 'exit' twice during the configure phase of the Perl installation.

```
su - perl
# 10 minutes
tar xf /download/perl-5.18.1.tar.gz -C /build
cd /build/perl-5.18.1
sh Configure -ds -e -Dprefix=
make
make install
cd ..
rm -rf perl-5.18.1
cd

# Fix permissions for Package Users:
chmod g+w,o+t /local/lib/perl5/site_perl/5.18.1
chmod g+w,o+t /local/lib/perl5/site_perl/5.18.1/i686-linux
chmod g+w,o+t /local/lib/perl5/5.18.1/i686-linux

exit 0
```

9.9 OpenSSL

OpenSSL is a toolkit implementing the Transport Layer Security (TLS) and Secure Sockets Layer (SSL) protocols as well as a cryptography library.

```
su - openssl
# 5 minutes
tar xf /download/openssl-1.1.1.tar.gz -C /build
cd /build/openssl-1.1.1
./config \
    --prefix=/usr \
    --openssldir=/etc/ssl \
    shared
make -j1
# Install without the documentation:
make install_sw
cd ..
rm -rf openssl-1.1.1
cd
exit 0
```

9.10 Wpa_supplicant

Wpa_supplicant is a user space IEEE 802.1X/WPA supplicant (wireless client) for many wireless drivers.

```
su - wpa-supplicant
# 1 minute
tar xf /download/wpa_supplicant-2.7.tar.gz -C /build
cd /build/wpa_supplicant-2.7/wpa_supplicant

cat > .config << EOF
CONFIG_DRIVER_HOSTAP=y
CONFIG_DRIVER_WEXT=y
```

```
#CONFIG_DRIVER_NL80211=y
#CONFIG_DRIVER_WIRED=y

#CONFIG_PKCS12=y
#CONFIG_SMARTCARD=y

CONFIG_CTRL_IFACE=y

CONFIG_BACKEND=file
CONFIG_PEERKEY=y
#CONFIG_IEEE80211W=y

CONFIG_TLS=openssl

#CONFIG_IEEE80211N=y
EOF

sed -i.orig 's@local/@@g' Makefile
make
make install
cd ../..
rm -rf wpa_supplicant-2.7
cd

cat > /etc/wpa_supplicant.conf << EOF
network={
    ssid="MYESSID"
    key_mgmt=WPA-PSK
    pairwise=TKIP
    group=TKIP
    psk="MYPASSWORD"
}
EOF
chmod 600 /etc/wpa_supplicant.conf
exit 0
```

9.11 Wireless_tools

The Wireless Tools is a set of tools allowing to manipulate the Wireless Extensions.

```
su - wireless-tools
# 1 minute
tar xf /download/wireless_tools.29.tar.gz -C /build
cd /build/wireless_tools.29
make
make PREFIX= install
cd ..
rm -rf wireless_tools.29
cd
exit 0
```

9.12 Wget

GNU wget is an utility for downloading network data.

```
su - wget
# 1 minute
tar xf /download/wget-1.19.5.tar.gz -C /build
cd /build/wget-1.19.5
#sed -i.orig 's/item $thing/item C<$thing>/' doc/texi2pod.pl
OPENSSL_CFLAGS='-I/include/openssl' \
    OPENSSL_LIBS='-L/lib -lssl -lcrypto' \
    ./configure \
    --prefix= \
    --with-ssl=openssl \
    --disable-nls
make
make install
cd ..
rm -rf wget-1.19.5
cd
exit 0
```

'OPENSSL_CFLAGS' and 'OPENSSL_LIBS' are defined to avoid the error message:

```
The pkg-config script could not be found or is too old. Make sure it
is in your PATH or set the PKG_CONFIG environment variable to the full
path to pkg-config. Alternatively, you may set the environment
variables OPENSSL_CFLAGS and OPENSSL_LIBS to avoid the need to call
pkg-config.
```

9.13 Libtasn1

GNU libtasn1 is a ASN.1 library.

```
su - libtasn1
# 1 minute
tar xf /download/libtasn1-3.4.tar.gz -C /build
cd /build/libtasn1-3.4
./configure --prefix=
make
make install
cd ..
rm -rf libtasn1-3.4
cd
exit 0
```

9.14 Lynx

Lynx is a text web browser.

```
su - lynx
# 2 minutes
tar xf /download/lynx2.8.9rel.1.tar.bz2 -C /build
cd /build/lynx2.8.9rel.1
./configure \
    --prefix= \
    --with-ssl=/lib \
```

```
    --enable-nls \
    --with-screen=ncursesw
make
make install
cd ..
rm -rf lynx2.8.9rel.1

# Stop asking questions about certificates:
sed -i s/#FORCE_SSL_PROMPT:PROMPT/FORCE_SSL_PROMPT:yes/ \
    /etc/lynx.cfg

# Display non-ascii characters:
sed -i s/#CHARACTER_SET:iso-8859-1/CHARACTER_SET:utf-8/  \
    /etc/lynx.cfg

# I don't want cookies:
sed -i 's/#SET_COOKIES:TRUE/SET_COOKIES:FALSE/'  \
    /etc/lynx.cfg
sed -i 's/#ACCEPT_ALL_COOKIES:FALSE/ACCEPT_ALL_COOKIES:FALSE/'  \
    /etc/lynx.cfg
sed -i 's/#PERSISTENT_COOKIES:FALSE/PERSISTENT_COOKIES:FALSE/'  \
    /etc/lynx.cfg
cd
exit 0
```

9.15 CA-Certificates

CA-Certificates are used for https web pages.

```
su - ca-certificates
# 1 minute
# Inspired from
# http://linuxfromscratch.org/blfs/view/stable/postlfs/cacerts.html

cp /download/certdata.txt /build
cd /build

cat > /bin/make-cert.pl << 'EOF'
#!/bin/perl -w

# Used to generate PEM encoded files from Mozilla certdata.txt.
# Run as ./make-cert.pl > certificate.crt
#
# Parts of this script courtesy of RedHat (mkcabundle.pl)
#
# This script modified for use with single file data (tempfile.cer)
# extracted from certdata.txt, taken from the latest version in the
# Mozilla NSS source.
# mozilla/security/nss/lib/ckfw/builtins/certdata.txt
#
# Authors: DJ Lucas
#          Bruce Dubbs
#
```

```
# Version 20120211

my $certdata = './tempfile.cer';

open( IN, "cat $certdata|" )
    || die "could not open $certdata";

my $incert = 0;

while ( <IN> )
{
    if ( /^CKA_VALUE MULTILINE_OCTAL/ )
    {
        $incert = 1;
        open( OUT, "|openssl x509 -text -inform DER -fingerprint" )
            || die "could not pipe to openssl x509";
    }

    elsif ( /^END/ && $incert )
    {
        close( OUT );
        $incert = 0;
        print "\n\n";
    }

    elsif ($incert)
    {
        my @bs = split( /\\/ );
        foreach my $b (@bs)
        {
            chomp $b;
            printf( OUT "%c", oct($b) ) unless $b eq '';
        }
    }
}
EOF

chmod +x /bin/make-cert.pl



cat > /bin/make-ca.sh << 'EOF'
#!/bin/sh
# Begin make-ca.sh
# Script to populate OpenSSL's CApath from a bundle of PEM formatted
# CAs
#
# The file certdata.txt must exist in the local directory
# Version number is obtained from the version of the data.
#
# Authors: DJ Lucas
#          Bruce Dubbs
```

```
#
# Version 20120211

certdata="certdata.txt"

if [ ! -r $certdata ]; then
  echo "$certdata must be in the local directory"
  exit 1
fi

REVISION=$(grep CVS_ID $certdata | cut -f4 -d'$')

if [ -z "${REVISION}" ]; then
  echo "$certfile has no 'Revision' in CVS_ID"
  exit 1
fi

VERSION=$(echo $REVISION | cut -f2 -d" ")

TEMPDIR=$(mktemp -d)
TRUSTATTRIBUTES="CKA_TRUST_SERVER_AUTH"
BUNDLE="BLFS-ca-bundle-${VERSION}.crt"
CONVERTSCRIPT="/bin/make-cert.pl"
SSLDIR="/etc/ssl"

mkdir "${TEMPDIR}/certs"

# Get a list of starting lines for each cert
CERTBEGINLIST=$(grep -n "^# Certificate" "${certdata}" | cut -d ":" -f1)

# Get a list of ending lines for each cert
CERTENDLIST=$(grep -n "^CKA_TRUST_STEP_UP_APPROVED" "${certdata}" \
    | cut -d ":" -f 1)

# Start a loop
for certbegin in ${CERTBEGINLIST}; do
  for certend in ${CERTENDLIST}; do
    if test "${certend}" -gt "${certbegin}"; then
      break
    fi
  done

  # Dump to a temp file with the name of the file as the beginning
  # line number
  sed -n "${certbegin},${certend}p" "${certdata}" \
      > "${TEMPDIR}/certs/${certbegin}.tmp"
done

unset CERTBEGINLIST CERTDATA CERTENDLIST certbegin certend

mkdir -p certs
rm -f certs/*      # Make sure the directory is clean
```

```
for tempfile in ${TEMPDIR}/certs/*.tmp; do
  # Make sure that the cert is trusted...
  grep "CKA_TRUST_SERVER_AUTH" "${tempfile}" | \
    egrep "TRUST_UNKNOWN|NOT_TRUSTED" > /dev/null

  if test "${?}" = "0"; then
    # Throw a meaningful error and remove the file
    cp "${tempfile}" tempfile.cer
    perl ${CONVERTSCRIPT} > tempfile.crt
    keyhash=$(openssl x509 -noout -in tempfile.crt -hash)
    echo "Certificate ${keyhash} is not trusted!  Removing..."
    rm -f tempfile.cer tempfile.crt "${tempfile}"
    continue
  fi

  # If execution made it to here in the loop, the temp cert is trusted
  # Find the cert data and generate a cert file for it

  cp "${tempfile}" tempfile.cer
  perl ${CONVERTSCRIPT} > tempfile.crt
  keyhash=$(openssl x509 -noout -in tempfile.crt -hash)
  mv tempfile.crt "certs/${keyhash}.pem"
  rm -f tempfile.cer "${tempfile}"
  echo "Created ${keyhash}.pem"
done

# Remove blacklisted files
# MD5 Collision Proof of Concept CA
if test -f certs/8f111d69.pem; then
  echo "Certificate 8f111d69 is not trusted!  Removing..."
  rm -f certs/8f111d69.pem
fi

# Finally, generate the bundle and clean up.
cat certs/*.pem >  ${BUNDLE}
rm -r "${TEMPDIR}"
EOF

chmod +x /bin/make-ca.sh



cat > /bin/remove-expired-certs.sh << 'EOF'
#!/bin/sh
# Begin /bin/remove-expired-certs.sh
#
# Version 20120211

# Make sure the date is parsed correctly on all systems
mydate()
{
```

```
  local y=$( echo $1 | cut -d" " -f4 )
  local M=$( echo $1 | cut -d" " -f1 )
  local d=$( echo $1 | cut -d" " -f2 )
  local m

  if [ ${d} -lt 10 ]; then d="0${d}"; fi

  case $M in
    Jan) m="01";;
    Feb) m="02";;
    Mar) m="03";;
    Apr) m="04";;
    May) m="05";;
    Jun) m="06";;
    Jul) m="07";;
    Aug) m="08";;
    Sep) m="09";;
    Oct) m="10";;
    Nov) m="11";;
    Dec) m="12";;
  esac

  certdate="${y}${m}${d}"
}

OPENSSL=/bin/openssl
DIR=/etc/ssl/certs

if [ $# -gt 0 ]; then
  DIR="$1"
fi

certs=$( find ${DIR} -type f -name "*.pem" -o -name "*.crt" )
today=$( date +%Y%m%d )

for cert in $certs; do
  notafter=$( $OPENSSL x509 -enddate -in "${cert}" -noout )
  date=$( echo ${notafter} |  sed 's/^notAfter=//' )
  mydate "$date"

  if [ ${certdate} -lt ${today} ]; then
     echo "${cert} expired on ${certdate}! Removing..."
     rm -f "${cert}"
  fi
done
EOF

chmod +x /bin/remove-expired-certs.sh


make-ca.sh
remove-expired-certs.sh certs
```

```
install -d /etc/ssl/certs
cp -v certs/*.pem /etc/ssl/certs
c_rehash
install BLFS-ca-bundle*.crt /etc/ssl/ca-bundle.crt
ln -sfv ../ca-bundle.crt /etc/ssl/certs/ca-certificates.crt

rm BLFS-ca-bundle*.crt
rm certdata.txt
rm -rf certs

cd
exit 0
```

9.16 Procps-ng

The procps-ng package contains utilities that give information about processes using the `/proc` filesystem. The package includes the commands `ps`, `top`, `vmstat`, `w`, `kill`, `free`, `slabtop`, and `skill`.

```
su - procps-ng
# 1 minute
tar xf /download/procps-ng-3.3.0.tar.gz -C /build
cd /build/procps-ng-3.3.0

# From http://lists.gnu.org/archive/html/bug-make/2010-07/msg00153.html
# ps/proc.mk makefile uses LIBPROC, which is set in proc/module.mk:
#sed '177s,\*/module.mk,proc/module.mk ps/proc.mk,' -i.orig Makefile

./configure --prefix=
make
make install
cd ..
rm -rf procps-ng-3.3.0
cd
exit 0
```

Option `lib64=lib` makes the directory `/lib` the one where to put 64 bit libraries, default would be `/lib64`.

Option `ldconfig=` is used in order not to use current host's `ldconfig`.

Option `install="install -D"` is used so that all the files installed are owned by the current user. By default, all installed files are owned by root.

9.17 Package Users Final Tweaks

In order to simplify the build of future packages, create the following file:

```
cat > /etc/pkgusr/skel-package/build-me.sh << EOF
# Exit on error:
set -e

wget
tar xf
```

```
cd
./configure --prefix=
make install
cd ..
rm -rf
rm

exit 0
EOF

chmod u+x /etc/pkgusr/skel-package/build-me.sh
```

Then:

```
cat >> /etc/pkgusr/bash_profile << 'EOF'
if [[ -f build-me.sh ]]
    then mv build-me.sh build-`whoami`.sh
    if [[ -f /src/recipes-1.9.x/`whoami` ]]
        then cp /src/recipes-1.9.x/`whoami` build-`whoami`.sh
    elif [[ -f /src/recipes-1.8/`whoami` ]]
        then cp /src/recipes-1.8/`whoami` build-`whoami`.sh
    elif [[ -f /src/recipes-1.7/`whoami` ]]
        then cp /src/recipes-1.7/`whoami` build-`whoami`.sh
    elif [[ -f /src/recipes-1.6/`whoami` ]]
        then cp /src/recipes-1.6/`whoami` build-`whoami`.sh
    elif [[ -f /src/recipes-1.5/`whoami` ]]
        then cp /src/recipes-1.5/`whoami` build-`whoami`.sh
    fi
fi
EOF
```

Because i wrote many recipes in the past, you can use them when possible in order to extend your OS. Connect to the wired internet first:

```
ifconfig eth0 up
dhcpcd eth0
```

Now download my recipes:

```
#mkdir -v /src/recipes-1.{5,6,7,8,9.x}
mv /src/recipes-1.9.{0,x}

cd /src/recipes-1.5
wget -N http://cjarry.org/gnu-linux/gllfsc/recipes/gllfsc-1.0-to-1.5/0-recipes-1.5
sed -i 's/wget h/wget -N h/' 0-recipes-1.5
chmod u+x 0-recipes-1.5
./0-recipes-1.5

cd /src/recipes-1.6
wget -N http://cjarry.org/gnu-linux/gllfsc/recipes/gllfsc-1.6/0-recipes-1.6
sed -i 's/wget h/wget -N h/' 0-recipes-1.6
chmod u+x 0-recipes-1.6
./0-recipes-1.6

cd /src/recipes-1.7
wget -N http://cjarry.org/gnu-linux/gllfsc/recipes/gllfsc-1.7/0-recipes-1.7
```

```
sed -i 's/wget h/wget -N h/' 0-recipes-1.7
chmod u+x 0-recipes-1.7
./0-recipes-1.7

cd /src/recipes-1.8
wget -N http://cjarry.org/gnu-linux/gllfsc/recipes/gllfsc-1.8/0-recipes-1.8
sed -i 's/wget h/wget -N h/' 0-recipes-1.8
chmod u+x 0-recipes-1.8
./0-recipes-1.8

cd /src/recipes-1.9.x
wget -N http://cjarry.org/gnu-linux/gllfsc/recipes/gllfsc-1.9.x/0-recipes-1.9.x
sed -i 's/wget h/wget -N h/' 0-recipes-1.9.x
chmod u+x 0-recipes-1.9.x
./0-recipes-1.9.x
cd
```

9.18 Archiving the Complete System

```
# Clean up:
#rm /src/*
rm /root/*
rm /root/.bash_history
rm -rf /share/doc
#mv /share/man/man* /share
#rm -rf /share/man/*
#mv /share/man[1-8] /share/man

# Strip binaries
# 116 MB before, 41 MB after
strip --strip-all /bin/*
```

Switch to another operating system on the same machine, for instance GLLFSC 1.9.0. Then issue the following command:

```
# To be done outside GLLFSC:
# 4 minutes
tar -cjf gllfsc-pentium4-1.9.1-completed.tar.bz2 \
    bin boot dev etc home include lib* local man mnt opt proc root run \
    sbin service share src static sys tmp usr var
```

9.19 Add User

To create a new user, without root rights:

```
useradd -m USER
```

This will create a new user named '`USER`' with group '`USER`' and user's home at `/home/USER`.

To give a password to this user:

```
passwd USER
```

You may want to change the color of this user's prompt:

```
cat > /home/USER/.bash_profile << EOF
export PS1='\[\e[32m\]\A-\W\[\e[00m\]$ '
EOF
chown USER:USER /home/USER/.bash_profile
```

9.20 Halting the Computer

In order to halt the computer after this build process, type:

```
init.sysv 0
```

If you prefer to reboot instead type:

```
init.sysv 6
```

The next time you use GLLFSC, runit will be the default init system and you will have to type '`init 0`' to halt the operating system and '`init 6`' to reboot.

10 Further Readings

On my personal website at `http://cjarry.org/gnu-linux/gllfsc/gllfsc.en.html`, there is some information on how to connect to the internet with wifi, and how to extend GLLFSC, for instance instructions on how to build Xorg, chose a font and a web browser, text-based or graphical.

Haiyong Sun's website (in Chinese): `http://blog.chinaunix.net/uid/436750.html`. It includes documents on building a GNU/Linux system for Loongson and a GNU/Hurd system for x86. He also owns repositories on `https://github.com/sunhaiyong1978/`, some of which concern the LoongArch architecture.

The suckless team[1] is a group of programmers that share the following philosophy[2]:

> Focus on simplicity, clarity and frugality. Our philosophy is about keeping things simple, minimal and usable. We believe this should become the mainstream philosophy in the IT sector. Unfortunately, the tendency for complex, error-prone and slow software seems to be prevalent in the present-day software industry. We intend to prove the opposite with our software projects.

The simple and lightweight programs released by this team are interesting for everyone who like small, reactive and reliable programs.

Musl[3] is a free software C library for the kernel Linux. It is simple and suitable for both static and dynamic linking of binaries.

[1] `http://suckless.org`

[2] `http://suckless.org/philosophy/`

[3] `https://musl.libc.org/`

11 Thanks

I am particularily grateful to Haiyong Sun for having shared his knowledge on building a free operating system for Loongson 2F machines, this document was heavily based on his work.

Appendix A GNU Free Documentation License

Version 1.3, 3 November 2008

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