

GNU/Linux-libre from source code

for Loongson 3A

Christophe Jarry

This is edition 1.7 (last updated 3 June 2017) of *GNU/Linux-libre from source code for Loongson 3A*.

Copyright © 2013-2016 Christophe Jarry.

This document is based on the Chinese page <http://zdbr.net.cn/download/Loongson64-2.0.htm>, which is copyright © 2009 Haiyong Sun. His blog is on <http://blog.chinaunix.net/uid/436750.html>.

Various formats of this manual as well as its texinfo source are available on <http://cjarry.org/gnu-linux/gllfsc/loongson3a/>.

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.3 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled “GNU Free Documentation License”.

Computer instructions in this manual are free software: you can redistribute them and/or modify them under the terms of the GNU General Public License as published by the Free Software Foundation, either version 3 of the License, or (at your option) any later version.

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

You should have received a copy of the GNU General Public License along with this manual. If not, see <http://www.gnu.org/licenses/>.

Short Contents

1	Introduction	1
2	Prerequisites	5
3	Preliminary Work	7
4	Building the Cross-Compilation Toolchain	15
5	Building the Cross-Compilation Tools	23
6	Building the Target System	27
7	Creating Required Configuration Files for the New System	55
8	Before Booting GLLFSC	59
9	After Booting GLLFSC	61
10	Further Readings	77
11	Thanks	79
A	GNU Free Documentation License	81
B	GNU General Public License	89

Table of Contents

1	Introduction	1
1.1	GNU/Linux History	1
1.1.1	GNU	1
1.1.2	HURD	1
1.1.3	Linux	2
1.1.4	Linux-libre	2
1.1.5	References	2
1.2	Purpose of this Document	3
2	Prerequisites	5
2.1	Definitions	5
2.1.1	sysroot	5
2.1.2	Toolchain	5
2.1.3	build, host and target	5
2.1.4	FHS	6
2.2	Commands	6
3	Preliminary Work	7
3.1	Build User Creation	7
3.2	Work Directory Creation	7
3.3	Creating Compilation and Download Directories	7
3.4	Switching to the Build User	7
3.5	Setting up Required Environment Variables	7
3.6	Downloads	9
3.6.1	Downloading Packages	9
3.6.2	Downloading Patches	11
3.7	Final Preparations	11
3.7.1	Target Filesystem Hierarchy Creation	11
3.7.2	Creating needed user, groups and log files	12
4	Building the Cross-Compilation Toolchain	15
4.1	Target Linux-Header	15
4.2	Cross Binutils	16
4.3	Cross GCC (C support only)	16
4.4	Target glibc	18
4.5	Cross GCC (C and C++ support)	20
5	Building the Cross-Compilation Tools	23
5.1	File	23
5.2	Groff	23
5.3	Shadow	23
5.4	M4	24
5.5	Ncurses	24
5.6	Cleaning up Cross-Compilation Toolchain	25

6	Building the Target System	27
6.1	Setting up the Environment	27
6.2	Man Pages	27
6.3	Zlib	27
6.4	Binutils	28
6.5	GMP	28
6.6	MPFR	29
6.7	MPC	29
6.8	GCC	29
6.9	Sed	30
6.10	E2fsprogs	30
6.11	Coreutils	31
6.12	iana-etc	32
6.13	M4	32
6.14	Bison	32
6.15	Ncurses	33
6.16	Procps	33
6.17	Libtool	34
6.18	Readline	34
6.19	Autoconf	34
6.20	Automake	35
6.21	Bash	35
6.22	Bzip2	36
6.23	DHCPD	37
6.24	Diffutils	37
6.25	File	38
6.26	Findutils	38
6.27	Flex	38
6.28	Gawk	39
6.29	Gdbm	39
6.30	Gettext	40
6.31	Grep	40
6.32	Groff	41
6.33	Gzip	41
6.34	Inetutils	42
6.35	Iproute2	42
6.36	Kbd	43
6.37	Kmod	43
6.38	Less	44
6.39	Libpipeline	44
6.40	Make	45
6.41	Man-db	45
6.42	Nano	46
6.43	Patch	46
6.44	Psmisc	46
6.45	Shadow	47
6.46	Sysvinit	48
6.47	Tar	49
6.48	Texinfo	49
6.49	Udev	50
6.50	Util-Linux	50
6.51	XZ-Utils	51
6.52	Bootscripts	51
6.53	The Kernel	52

7	Creating Required Configuration Files for the New System	55
7.1	File for Time Setup	55
7.2	Setting up Keyboard Function keys for the Shell	55
7.3	Setting up Bash Shell Startup Files	56
7.4	Localhost Setup	56
7.5	Setting up <code>hosts</code> File	56
7.6	Setting up Network Address	56
7.6.1	Setting up Network Static Address	56
7.6.2	Setting up Network Dynamic Address	56
7.7	Setting up DNS	57
7.8	<code>fstab</code> File Creation	57
8	Before Booting GLLFSC	59
8.1	Archiving the System	59
8.2	Some Recommendations	59
9	After Booting GLLFSC	61
9.1	Login	61
9.2	Locales	61
9.3	Timezone	61
9.4	Runit	62
9.5	Perl	67
9.6	OpenSSL	67
9.7	<code>Wpa_supplicant</code>	67
9.8	<code>Wireless_tools</code>	68
9.9	<code>Wget</code>	68
9.10	<code>Libtasn1</code>	69
9.11	<code>Lynx</code>	69
9.12	CA-Certificates	69
9.13	Archiving the Complete System	74
9.14	Add User	75
9.15	Halting the Computer	75
10	Further Readings	77
11	Thanks	79
Appendix A	GNU Free Documentation License	81
Appendix B	GNU General Public License	89

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 Unix¹. “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 Manifesto²:

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 her computing as she wishes (freedom 1). Access to the source code is a precondition for this.
- The freedom to redistribute copies so she can help her neighbor (freedom 2).
- The freedom to distribute copies of her modified versions to others (freedom 3). By doing this she can give the whole community a chance to benefit from her 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 GPL³).

The free software movement is supported by the Free Software Foundation (FSF⁴).

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 the user's freedom on her operating system by allowing her 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 <http://en.wikipedia.org/wiki/Unix>

² <http://www.gnu.org/gnu/manifesto.html>

³ <http://www.gnu.org/licenses/gpl.html>

⁴ <http://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 volunteers around the world.

1.1.4 Linux-libre

Linux, the kernel developed and distributed by Linus Torvalds et al, contains non-Free Software⁵, 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-libre⁶ is a project to maintain and publish 100% Free distributions of Linux, suitable for use in Free System Distributions⁷, 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.

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://www.h-online.com/open/features/GNU-HURD-Altered-visions-and-lost-promise-1030942.html>.

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

Lemote offered me a Yeeloong 8133 in late 2012. I wanted to adapt some parts of gNewSense⁸ for MIPS to this particular laptop. I also wanted to port the document I wrote for Loongson 2F to Loongson 3A: GNU/Linux⁹ Libre from Source Code for Loongson 3A was born.

⁸ <http://www.gnewsense.org>

⁹ 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>.

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 system¹. 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 Wikipedia²:

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:

¹ see Chapter 10 [Further Readings], page 77 for more details

² <http://en.wikipedia.org/wiki/Toolchain>

```
./configure --build=build-platform --host=host-platform --target=target-  
platform [various compilation parameters]
```

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 *Loongson*, but there is currently no way we can specify `'Loongson'` directly; because of this we specify `'mips64el-unknown-linux-gnu'`.

`--host` can also be left unspecified, 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. During the build process, some commands are used to comply with FHS.

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 <http://flossmanuals.net/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 Build User Creation

To create the builder group, user and password:

```
groupadd gllfsc
useradd -s /bin/bash -g gllfsc -m -k /dev/null gllfsc
passwd gllfsc
```

- Option `-s` (or `--shell`) is used to define the created user's default shell, here `/bin/bash`.
- Option `-g` (or `--gid`) is used to define the group name or number of the created user's initial login group, here `'gllfsc'`.
- Option `-m` (or `--create-home`) does create the user's home directory if it does not exist (`/home/username`).
- Option `-k` (or `--skel`) is used to define the skeleton directory to be copied in the user's home directory, here `/dev/null`. `/dev/null` is a special file which, in this case, will give no skeleton at all to `useradd`.

3.2 Work Directory Creation

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

```
export TARGET_DIR="/gllfsc"
mkdir -pv ${TARGET_DIR}
```

'`export TARGET_DIR="/gllfsc"`' sets the value of the variable `TARGET_DIR` to `/gllfsc`, the directory in which the system will be built.

3.3 Creating Compilation and Download Directories

```
mkdir -pv ${TARGET_DIR}/{build,download}
chown -Rv gllfsc ${TARGET_DIR}
```

3.4 Switching to the Build User

To login as the user that will build the system:

```
su - gllfsc
```

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.

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 file `~/.bash_profile`:

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

The first line creates the file `~/.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`:

```
export TARGET_DIR=/gllfsc
cat > ~/.bashrc << EOF
set +h
umask 022
alias make='make -j5'
export PS1='\[\e[35m\]\A-\W\[\e[00m\]$ '
export LC_ALL=POSIX
export TARGET_DIR=/gllfsc
export BUILD_DIR="${TARGET_DIR}/build"
export DOWNLOAD_DIR="${TARGET_DIR}/download"
export CROSS_HOST="$(echo $MACHTYPE | \
    sed "s/$(echo $MACHTYPE | cut -d- -f2)/cross/")"
export CROSS_TARGET="mips64el-unknown-linux-gnu"
export MABI="n32"
#export MABI="64"
export MARCH="loongson3a"
export PATH=${TARGET_DIR}/cross-tools/bin:/bin:/usr/bin
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.

`'alias make='make -j5''` tells Bash to replace every call of `'make'` by `'make -j5'`. This makes full use of the four cores available in the Loongson 3A to build packages by parallelizing tasks.

`'export PS1='\[\e[35m\]\A-\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-\W'` means that the time, in 24-hour HH:MM format and the basename of `$PWD` will be displayed separated by a `'-'`, as in `'19:33-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 http://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.

`'export BUILD_DIR="${TARGET_DIR}/build''` sets the environment variable `BUILD_DIR` to the value of `'${TARGET_DIR}/build'` which is `'/gllfsc/build'` in this document.

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. `'mips64el-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.

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 `${TARGET_DIR}/cross-tools/bin`, then, if the command was not found, in `/bin` and finally in `/usr/bin`.

`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.

Finally `'source ~/.bash_profile'` reads and executes the content of the file `~/.bash_profile`.

3.6 Downloads

3.6.1 Downloading Packages

The packages listed below are those used in this document. You can try other versions but you will need a recent version of Binutils, GCC and the kernel Linux in order to build GLLFSC for Loongson 3A.

Download those files under `${DOWNLOAD_DIR}` (which is `/gllfsc/download` in this document).

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>.
- 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: <http://www.bzip.org/1.0.6/bzip2-1.0.6.tar.gz>.
- CA-Certificates: <http://anduin.linuxfromscratch.org/sources/other/certdata.txt>.
- Coreutils: <http://ftpmirror.gnu.org/coreutils/coreutils-8.19.tar.xz>.
- DHCPD: <http://roy.marples.name/downloads/dhcpd/dhcpd-6.1.0.tar.bz2>.
- Diffutils: <http://ftpmirror.gnu.org/diffutils/diffutils-3.3.tar.xz>.
- E2fsprogs: <http://downloads.sourceforge.net/e2fsprogs/e2fsprogs-1.42.8.tar.gz>.
- 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://ftp.gnu.org/gnu/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>.

- Grep: <http://ftpmirror.gnu.org/grep/grep-2.15.tar.xz>.
- Groff: <http://ftpmirror.gnu.org/groff/groff-1.22.2.tar.gz>.
- Gzip: <http://ftpmirror.gnu.org/gzip/gzip-1.6.tar.gz>.
- Iana-Etc: <http://sethklein.net/iana-etc-2.30.tar.bz2>.
- Inetutils: <http://ftpmirror.gnu.org/inetutils/inetutils-1.9.1.tar.gz>.
- Iproute2: <https://www.kernel.org/pub/linux/utils/net/iproute2/iproute2-3.10.0.tar.bz2>.
- Kbd: <http://ftp.altlinux.org/pub/people/legion/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>.
- 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-Libre¹: <https://kernel.googlesource.com/pub/scm/linux/kernel/git/vapier/lemote/+archive/2.6.36-21.lemote.tar.gz>, <http://linux-libre.fsfla.org/pub/linux-libre/releases/2.6.36-gnu1/deblob-2.6.36> and <http://linux-libre.fsfla.org/pub/linux-libre/releases/2.6.36-gnu1/deblob-check>.
- Lynx: <http://invisible-mirror.net/archives/lynx/tarballs/lynx2.8.8dev.16.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: <ftp://ftp.openssl.org/source/old/1.0.1/openssl-1.0.1i.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: <http://procps.sourceforge.net/procps-3.2.8.tar.gz>.
- Psmisc: <http://sourceforge.net/projects/psmisc/files/psmisc/psmisc-22.20.tar.gz>.
- Readline: <http://ftpmirror.gnu.org/readline/readline-6.2.tar.gz>.
- Runit: <http://smarden.org/runit/runit-2.1.2.tar.gz>.
- Sed: <http://ftpmirror.gnu.org/sed/sed-4.2.2.tar.bz2>.
- Shadow: <http://pkg-shadow.alioth.debian.org/releases/shadow-4.1.4.3.tar.bz2>.
- Sysvinit: <http://download.savannah.gnu.org/releases/sysvinit/sysvinit-2.88dsf.tar.bz2>.

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

- Tar: <http://ftpmirror.gnu.org/tar/tar-1.27.1.tar.bz2>.
- Texinfo: <http://ftpmirror.gnu.org/texinfo/texinfo-4.13a.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>.
- Util-Linux: <https://www.kernel.org/pub/linux/utils/util-linux/v2.24/util-linux-2.24.tar.bz2>.
- Wireless_tools: http://www.hpl.hp.com/personal/Jean_Tourrilhes/Linux/wireless_tools.29.tar.gz.
- Wpa_supplicant: http://w1.fi/releases/wpa_supplicant-2.0.tar.gz.
- Wget: <http://ftpmirror.gnu.org/wget/wget-1.14.tar.gz>.
- XZ-Utills: <http://tukaani.org/xz/xz-5.0.8.tar.bz2>.
- Zlib: <http://www.zlib.net/fossils/zlib-1.2.8.tar.gz>.

3.6.2 Downloading Patches

Patches and configuration files location:

- <http://cjarry.org/gnu-linux/gllfsc/loongson3a/gllfsc-loongson3a-1.7-patches.tar.gz>. After having downloaded this file under `${DOWNLOAD_DIR}`, execute the following commands to extract its content:


```
cd ${DOWNLOAD_DIR}
tar xvf gllfsc-loongson3a-1.7-patches.tar.gz
cd
```
- http://www.fsfla.org/svn/fsfla/software/linux-libre/lemote/gnewsense/tags/2.6.36-libre-lemote_0lxo/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>.

3.7 Final Preparations

3.7.1 Target Filesystem Hierarchy Creation

```
cd ${TARGET_DIR}
```

```
# /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 proc root run static sys var
```

```
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
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.

The command `'ln -svf lib lib64'` creates a symbolic link (option `-s`) with the name `lib64` which will point to `lib`.

3.7.2 Creating needed user, groups and log files

```

cat > ${TARGET_DIR}/etc/passwd << EOF
root::0:0:root:/root:/bin/bash
EOF

```

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.

```

cat > ${TARGET_DIR}/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 ${TARGET_DIR}/var/run/utmp \
    ${TARGET_DIR}/var/log/{btmp,lastlog,wtmp}
chmod -v 664 ${TARGET_DIR}/var/run/utmp \
    ${TARGET_DIR}/var/log/lastlog
```


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.

4.1 Target Linux-Header

In this document, the kernel used is the one modified by Lemote to support Loongson 3A. The changes made by Lemote have been merged into the official kernel maintained by Linus Torvalds as of 3.15. However, 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, making the Yeeloong 8133 unusable.¹ Branch 2.6.36 modified by Lemote is usable without the non-free firmware of the radeon driver.

```
# 1 hour mostly to deblob the kernel
cd ${BUILD_DIR}

mkdir linux-2.6.36-21.lemote
tar xf ${DOWNLOAD_DIR}/2.6.36-21.lemote.tar.gz -C linux-2.6.36-21.lemote
cd linux-2.6.36-21.lemote

cp ${DOWNLOAD_DIR}/deblob-2.6.36 .
cp ${DOWNLOAD_DIR}/deblob-check .

chmod u+x deblob*

# About 60 minutes for the following command
./deblob-2.6.36 --force

rm deblob*
cd ..
mv linux-2.6.36-21.lemote linux-2.6.36-21.lemote-gnu1

# About 2 minutes for the following command (404 MB)
tar -cf linux-2.6.36-21.lemote-gnu1.tar linux-2.6.36-21.lemote-gnu1

# About 35 minutes for the following command (56 MB)
# (requires ~1 GB of RAM)
#xz -9 linux-2.6.36-21.lemote-gnu1.tar

mv linux-2.6.36-21.lemote-gnu1.tar ${DOWNLOAD_DIR}
#mv linux-2.6.36-21.lemote-gnu1.tar.xz ${DOWNLOAD_DIR}

cd linux-2.6.36-21.lemote-gnu1

make mrproper
make ARCH=mips headers_check
make ARCH=mips INSTALL_HDR_PATH=dest headers_install
cp -rv dest/include/* ${TARGET_DIR}/include
cd ..
rm -rf linux-2.6.36-21.lemote-gnu1
```

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

cd

‘1 hour’ is the time it takes to build the package on Lemote Yeeloong with a Loongson 3A processor.

The command ‘make mrproper’ cleans the sources.

We need to specify ‘ARCH=mips’ as we are cross-compiling.

4.2 Cross Binutils

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

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

‘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=${TARGET_DIR}/cross-tools` tells the `configure` script to install architecture-independent files in `${TARGET_DIR}/cross-tools`.

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

`--with-sysroot=${TARGET_DIR}` tells Binutils to consider `${TARGET_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.

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 system²:

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.

I recommend installing ‘gcc-4.4’ on gNewSense 3.0 to avoid this issue.

```
# 1 hour 35 minutes
tar xf ${DOWNLOAD_DIR}/gcc-4.7.3.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/gcc-4.7.3
tar xf ${DOWNLOAD_DIR}/gmp-5.1.3.tar.bz2
mv gmp-5.1.3 gmp
tar xf ${DOWNLOAD_DIR}/mpc-1.0.1.tar.gz
mv mpc-1.0.1 mpc
tar xf ${DOWNLOAD_DIR}/mpfr-3.1.2.tar.bz2
mv mpfr-3.1.2 mpfr
mkdir -pv ../gcc-build
cd ../gcc-build
../gcc-4.7.3/configure \
  --prefix=${TARGET_DIR}/cross-tools \
  --build=${CROSS_HOST} \
  --host=${CROSS_HOST} \
  --target=${CROSS_TARGET} \
  --with-sysroot=${TARGET_DIR} \
  --disable-multilib \
  --with-newlib \
  --disable-nls \
  --disable-shared \
  --disable-threads \
  --enable-languages=c \
  --with-abi=${MABI} \
  --with-mpfr-include="${BUILD_DIR}/gcc-4.7.3/mpfr/src" \
  --with-mpfr-lib="${BUILD_DIR}/gcc-build/mpfr/src/.libs"
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
cd
```

`--disable-multilib` specifies that multiple target libraries to support different target variants³, 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.

² <https://gmplib.org/#STATUS>

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

`--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.

```
# 1 hour 40 minutes
tar xf ${DOWNLOAD_DIR}/glibc-2.18.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/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=${TARGET_DIR}
libdir=/lib
EOF

BUILD_CC="gcc" \
    CC="${CROSS_TARGET}-gcc -march=${MARCH} -mabi=${MABI}" \
    AR="${CROSS_TARGET}-ar" \
    RANLIB="${CROSS_TARGET}-ranlib" \
    ../glibc-2.18/configure \
    --prefix= \
    --libexecdir=/lib/glibc \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --disable-profile \
    --enable-add-ons \
    --with-tls \
    --enable-kernel=2.6.36 \
    --with-__thread \
    --with-binutils=${TARGET_DIR}/cross-tools/bin \
    --with-headers=${TARGET_DIR}/include \
    --enable-obsolete-rpc \
```

```

    --cache-file=config.cache

make

make install

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

cat > ${TARGET_DIR}/etc/nsswitch.conf << EOF
# Begin /etc/nsswitch.conf

passwd: files
group: files
shadow: files

hosts: files dns
networks: files

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

# End /etc/nsswitch.conf
EOF

cat > ${TARGET_DIR}/etc/ld.so.conf << EOF
# Begin /etc/ld.so.conf

/local/lib

# End /etc/ld.so.conf
EOF

```

Glibc uses ‘n32’ ABI by default with MIPS. To use MABI instead, we do the following:

```

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

```

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 somewhere other 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`.

```
BUILD_CC="gcc" \
  CC="${CROSS_TARGET}-gcc -march=${MARCH} -mabi=${MABI}" \
  AR="${CROSS_TARGET}-ar" \
  RANLIB="${CROSS_TARGET}-ranlib"
```

`'CC="${CROSS_TARGET}-gcc -march=${MARCH} -mabi=${MABI}"'` 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 `'2.6.36'` parameter given to option `--enable-kernel` describes the smallest 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=${TARGET_DIR}/cross-tools/bin` tells the `configure` script to use the binutils (assembler and linker) built in the cross-compilation toolchain process.

`--with-headers=${TARGET_DIR}/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 `${TARGET_DIR}/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.

```
# 2 hours 10 minutes
```

```
tar xf ${DOWNLOAD_DIR}/gcc-4.7.3.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/gcc-4.7.3
```

```

tar xf ${DOWNLOAD_DIR}/gmp-5.1.3.tar.bz2
mv gmp-5.1.3 gmp
tar xf ${DOWNLOAD_DIR}/mpc-1.0.1.tar.gz
mv mpc-1.0.1 mpc
tar xf ${DOWNLOAD_DIR}/mpfr-3.1.2.tar.bz2
mv mpfr-3.1.2 mpfr
mkdir -v ../gcc-build
cd ../gcc-build
../gcc-4.7.3/configure \
  --prefix=${TARGET_DIR}/cross-tools \
  --build=${CROSS_HOST} \
  --host=${CROSS_HOST} \
  --target=${CROSS_TARGET} \
  --with-sysroot=${TARGET_DIR} \
  --disable-nls \
  --enable-shared \
  --enable-__cxa_atexit \
  --disable-multilib \
  --with-abi=${MABI} \
  --enable-c99 \
  --enable-long-long \
  --enable-threads=posix \
  --enable-languages=c,c++ \
  --with-mpfr-include="${BUILD_DIR}/gcc-4.7.3/mpfr/src" \
  --with-mpfr-lib="${BUILD_DIR}/gcc-build/mpfr/src/.libs"
make
make install
cd ..
rm -rf gcc-build
rm -rf gcc-4.7.3
cd

```

`--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

5.1 File

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

```
# 1 minute
tar xf ${DOWNLOAD_DIR}/file-5.16.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/file-5.16
./configure \
    --prefix=${TARGET_DIR}/cross-tools
make
make install
cd ..
rm -rf file-5.16
cd
```

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. Under gNewSense 3.0, try `'sudo apt-get install g++-4.4'`.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/groff-1.22.2.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/groff-1.22.2
PAGE=A4 \
    ./configure \
    --prefix=${TARGET_DIR}/cross-tools \
    --without-x
make
make install
cd ..
rm -rf groff-1.22.2
cd
```

`'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.

```
# 3 minutes
tar xf ${DOWNLOAD_DIR}/shadow-4.1.4.3.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/shadow-4.1.4.3
patch -Np1 -i ${DOWNLOAD_DIR}/shadow-4.1.4.3-sysroot_hacks-1.patch
#sed -i.orig \
#    's/bindir)\|\${$i/bindir})\|/mips64el-unknown-linux-gnu-\${$i/' \
#    src/Makefile.am
#automake-1.11
echo "shadow_cv_passwd_dir=${TARGET_DIR}/bin" > config.cache
echo "ac_cv_func_lckpddf=no" >> config.cache
```

```
./configure \
  --prefix=${TARGET_DIR}/cross-tools \
  --sbindir=${TARGET_DIR}/cross-tools/bin \
  --sysconfdir=${TARGET_DIR}/etc \
  --disable-shared \
  --without-audit \
  --without-libpam \
  --without-selinux \
  --program-prefix=${CROSS_TARGET}- \
  --cache-file=config.cache
sed -i.orig "/PASSWD_PROGRAM/s/passwd/${CROSS_TARGET}-&/" config.h
make
make install
cd ..
rm -rf shadow-4.1.4.3
cd
```

The patch `shadow-4.1.4.3-sysroot_hacks-1.patch` is used so that shadow can be built with the `sysroot` method. Because we use this patch, `'shadow_cv_passwd_dir=${TARGET_DIR}/bin'` and `'ac_cv_func_lckpwn=no'` have to be added in `config.cache` in order for the `configure` script not to test the functionalities associated.

`--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 `'mips64el-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's `configure` files.

```
# 3 minutes
tar xf ${DOWNLOAD_DIR}/m4-1.4.17.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/m4-1.4.17
./configure \
  --prefix=${TARGET_DIR}/cross-tools
make
make install
cd ..
rm -rf m4-1.4.17
cd
```

5.5 Ncurses

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

```
# 3 minutes
tar xf ${DOWNLOAD_DIR}/ncurses-5.9.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/ncurses-5.9
```



```
./configure \  
  --prefix=${TARGET_DIR}/cross-tools \  
  --without-shared  
make -C include  
make -C progs tic  
install -m755 progs/tic ${TARGET_DIR}/cross-tools/bin  
cd ..  
rm -rf ncurses-5.9  
cd
```

`--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 ${TARGET_DIR}/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 29 MB to 12 MB.

`--strip-debug` removes debugging symbols only. This command reduces the size of the `lib` directory's content from 15 MB to 14 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.

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 the `~/.bashrc` file, so that this setup is preserved when logging in:

```
cat >> ~/.bashrc << EOF
export CC="${CROSS_TARGET}-gcc -march=${MARCH} -mabi=${MABI}"
export CXX="${CROSS_TARGET}-g++ -march=${MARCH} -mabi=${MABI}"
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 ~/.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 Man Pages

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

```
# 1 minute
tar xf ${DOWNLOAD_DIR}/man-pages-3.54.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/man-pages-3.54
make prefix=${TARGET_DIR} install
cd ..
rm -rf man-pages-3.54
cd
```

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

6.3 Zlib

Zlib is a compression/decompression library.

```
# 1 minute
tar xf ${DOWNLOAD_DIR}/zlib-1.2.8.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/zlib-1.2.8
./configure \
    --prefix=
make AR="${AR}"
make prefix=${TARGET_DIR} install
```

```
cd ..
rm -rf zlib-1.2.8
cd
```

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

6.4 Binutils

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

```
# 30 minutes
tar xf ${DOWNLOAD_DIR}/binutils-2.24.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/binutils-2.24
mkdir -pv ../binutils-build
cd ../binutils-build
../binutils-2.24/configure \
  --prefix= \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --target=${CROSS_TARGET} \
  --enable-64-bit-bfd \
  --enable-shared
make configure-host
make tooldir=
make DESTDIR=${TARGET_DIR} tooldir= install
cp -v ../binutils-2.24/include/libiberty.h ${TARGET_DIR}/include
cd ..
rm -rf binutils-build
rm -rf binutils-2.24
cd
```

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

6.5 GMP

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

```
# 10 minutes
tar xf ${DOWNLOAD_DIR}/gmp-5.1.3.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/gmp-5.1.3
./configure \
  --host=${CROSS_TARGET} \
  --prefix= \
  --enable-cxx
make
make DESTDIR=${TARGET_DIR} install
rm -v ${TARGET_DIR}/lib/lib{gmp,gmpxx}.la
cd ..
rm -rf gmp-5.1.3
cd
```

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

The files `${TARGET_DIR}/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'`.

6.6 MPFR

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

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/mpfr-3.1.2.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/mpfr-3.1.2
./configure \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=${TARGET_DIR} install
rm -v ${TARGET_DIR}/lib/libmpfr.la
cd ..
rm -rf mpfr-3.1.2
cd
```

The file `${TARGET_DIR}/lib/libmpfr.la` is removed to avoid the following error when building MPC: `‘/lib/libmpfr.so: could not read symbols: File in wrong format’`.

6.7 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.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/mpc-1.0.1.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/mpc-1.0.1
./configure \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf mpc-1.0.1
cd
```

6.8 GCC

GCC is the GNU Compiler Collection.

```
# 2 hours 10 minutes
tar xf ${DOWNLOAD_DIR}/gcc-4.7.3.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/gcc-4.7.3
sed -i.orig 's/install_to_${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 \
--with-abi=${MABI} \
--enable-clocale=gnu \
--enable-languages=c,c++ \
--disable-libstdcxx-pch
make
make DESTDIR=${TARGET_DIR} install
ln -sv gcc ${TARGET_DIR}/bin/cc
cd ..
rm -rf gcc-build
rm -rf gcc-4.7.3
cd

```

‘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 \${TARGET_DIR}/bin/cc’ creates a symbolic link cc that points on gcc.

6.9 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).

```

# 5 minutes
tar xf ${DOWNLOAD_DIR}/sed-4.2.2.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/sed-4.2.2
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix= \
  --bindir=/bin
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf sed-4.2.2
cd

```

6.10 E2fsprogs

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

```

# 5 minutes
tar xf ${DOWNLOAD_DIR}/e2fsprogs-1.42.8.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/e2fsprogs-1.42.8
mkdir -v build
cd build
./configure \
  --build=${CROSS_HOST} \

```

```

    --host=${CROSS_TARGET} \
    --prefix= \
    --with-root-prefix="" \
    --enable-elf-shlibs
make
make DESTDIR=${TARGET_DIR} install
make DESTDIR=${TARGET_DIR} install-libs
rm -v ${TARGET_DIR}/lib/lib{blkid,com_err,e2p,ext2fs,ss,uuid}.so
cd ../../
rm -rf e2fsprogs-1.42.8
cd

```

`--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=${TARGET_DIR} install-libs`’ is used to install libraries, those are not installed with ‘`make DESTDIR=${TARGET_DIR} install`’.

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

6.11 Coreutils

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

On gNewSense Parkes, you need to install `xz-utils` to extract the package.

```

# 30 minutes
tar xf ${DOWNLOAD_DIR}/coreutils-8.19.tar.xz -C ${BUILD_DIR}
cd ${BUILD_DIR}/coreutils-8.19
cat > config.cache << EOF
fu_cv_sys_stat_statfs2_bsize=yes
gl_cv_func_mbrtowc_incomplete_state=yes
gl_cv_func_mbrtowc_nul_retval=yes
gl_cv_func_mbrtowc_null_arg=yes
gl_cv_func_mbrtowc_retval=yes
gl_cv_func_btowc_eof=yes
gl_cv_func_wcrtomb_retval=yes
gl_cv_func_wctob_works=yes
gl_cv_func_fstatat_zero_flag=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --enable-install-program=hostname \
    --enable-no-install-program=kill,uptime \
    --cache-file=config.cache
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf coreutils-8.19

```

cd

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-install-program=hostname` to install the command `hostname` which is not built by default.

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

6.12 iana-etc

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

```
# 1 minute
tar xf ${DOWNLOAD_DIR}/iana-etc-2.30.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/iana-etc-2.30
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf iana-etc-2.30
cd
```

6.13 M4

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

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/m4-1.4.17.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/m4-1.4.17
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf m4-1.4.17
cd
```

6.14 Bison

GNU bison parser generator.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/bison-2.7.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/bison-2.7
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix=
echo '#define YYENABLE_NLS 1' >> config.h
make
make DESTDIR=${TARGET_DIR} install
cd ..
```



```
rm -rf bison-2.7
cd
```

'echo '#define YYENABLE_NLS 1' >> config.h' is used to build NLS (native language support) inside bison.

6.15 Ncurses

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

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

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

6.16 Procps

The procps 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`.

```
# 2 minutes
ln -sv ncursesw/curses.h ${TARGET_DIR}/include/curses.h
ln -sv ncursesw/ncurses.h ${TARGET_DIR}/include/ncurses.h
ln -sv ncursesw/term.h ${TARGET_DIR}/include/term.h
ln -sv libncursesw.so ${TARGET_DIR}/lib/libncurses.so
tar xf ${DOWNLOAD_DIR}/procps-3.2.8.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/procps-3.2.8
```

```
# From http://lists.gnu.org/archive/html/bug-make/2010-07/msg00153.html
sed '177s,\*/module.mk,proc/module.mk ps/proc.mk,' -i.orig Makefile
```

```
make \
  CPPFLAGS= \
  lib64=lib
make \
  DESTDIR=${TARGET_DIR} \
  lib64=lib \
  ldconfig= \
  install="install -D" \
```

```

    install
cd ..
rm -rf procps-3.2.8
cd

```

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.

6.17 Libtool

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

```

# 2 minutes
tar xf ${DOWNLOAD_DIR}/libtool-2.4.2.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/libtool-2.4.2
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf libtool-2.4.2
cd

```

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.

```

# 5 minutes
tar xf ${DOWNLOAD_DIR}/readline-6.2.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/readline-6.2
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --libdir=/lib
make
make DESTDIR=${TARGET_DIR} install
make DESTDIR=${TARGET_DIR} install-doc
cd ..
rm -rf readline-6.2
cd

```

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.

```
# 1 minute
tar xf ${DOWNLOAD_DIR}/autoconf-2.69.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/autoconf-2.69
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf autoconf-2.69
cd
```

6.20 Automake

GNU automake is a tool for automatically generating `Makefile.in` files compliant with the GNU Coding Standards¹.

```
# 1 minute
tar xf ${DOWNLOAD_DIR}/automake-1.14.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/automake-1.14
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf automake-1.14
cd
```

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).

```
# 7 minutes
tar xf ${DOWNLOAD_DIR}/bash-4.2.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/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
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
```

¹ <http://www.gnu.org/prep/standards/>

```

EOF
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix= \
  --bindir=/bin \
  --cache-file=config.cache \
  --without-bash-malloc \
  --with-installed-readline
make
make \
  DESTDIR=${TARGET_DIR} \
  htmdir=/share/doc/bash-4.2 \
  install
ln -sv bash ${TARGET_DIR}/bin/sh
cd ..
rm -rf bash-4.2
cd

```

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 ${TARGET_DIR}/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`.

```

# 2 minutes
tar xf ${DOWNLOAD_DIR}/bzip2-1.0.6.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/bzip2-1.0.6
sed -i -e "/^all:/s/ test//" Makefile
sed -i -e '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="${RANLIB}"
make \
  PREFIX=${TARGET_DIR} \
  install
cp -av libbz2.so* ${TARGET_DIR}/lib
ln -sv ../../lib/libbz2.so.1.0 ${TARGET_DIR}/lib/libbz2.so
rm -v ${TARGET_DIR}/bin/{bunzip2,bzcat,bzip2}

```

```

cp -v bzip2-shared ${TARGET_DIR}/bin/bzip2
ln -sv bzip2 ${TARGET_DIR}/bin/bunzip2
ln -sv bzip2 ${TARGET_DIR}/bin/bzcat
cd ..
rm -rf bzip2-1.0.6
cd

```

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

‘sed -i -e '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 DHCPD

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

```

# 1 minute
tar xf ${DOWNLOAD_DIR}/dhcpcd-6.1.0.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/dhcpcd-6.1.0
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --bindir=/sbin \
    --sysconfdir=/etc \
    --dbdir=/var/lib/dhcpcd \
    --libexecdir=/lib/dhcpcd
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf dhcpcd-6.1.0
cd

```

6.24 Diffutils

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

```

# 5 minutes
tar xf ${DOWNLOAD_DIR}/diffutils-3.3.tar.xz -C ${BUILD_DIR}
cd ${BUILD_DIR}/diffutils-3.3
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf diffutils-3.3
cd

```

6.25 File

```
# 1 minute
tar xf ${DOWNLOAD_DIR}/file-5.16.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/file-5.16
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf file-5.16
cd
```

6.26 Findutils

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

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/findutils-4.4.2.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/findutils-4.4.2
cat > config.cache << EOF
gl_cv_func_wcwidth_works=yes
gl_cv_header_working_fcntl_h=yes
ac_cv_func_fnmatch_gnu=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --libexecdir=/lib/locate \
    --localstatedir=/var/lib/locate \
    --cache-file=config.cache
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf findutils-4.4.2
cd
```

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.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/flex-2.5.37.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/flex-2.5.37
# From http://sourceforge.net/p/flex/bugs/151/
sed '1s/${\n#undef malloc\n#undef realloc/' \
    -i.orig 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
make
make DESTDIR=${TARGET_DIR} install
ln -sv libfl.a ${TARGET_DIR}/lib/libl.a
cd ..
rm -r flex-2.5.37
cd
```

```
cat > ${TARGET_DIR}/bin/lex << EOF
#!/bin/sh
exec /bin/flex -l \${@}
EOF
chmod -v 755 ${TARGET_DIR}/bin/lex
```

`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.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/gawk-4.1.0.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/gawk-4.1.0
sed -i.orig \
  '/check-recursive all-recursive/s/ check-for-shared-lib-support//' \
  extension/Makefile.in
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix= \
  --libexecdir=/lib
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -r gawk-4.1.0
cd
```

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.

```
tar xf ${DOWNLOAD_DIR}/gdbm-1.11.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/gdbm-1.11
```

```
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -r gdbm-1.11
cd
```

6.30 Gettext

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

```
# 20 minutes
tar xf ${DOWNLOAD_DIR}/gettext-0.18.3.1.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/gettext-0.18.3.1
cat > config.cache << EOF
am_cv_func_iconv_works=yes
gl_cv_func_wcwidth_works=yes
gt_cv_func_printf_posix=yes
gt_cv_int_divbyzero_sigfpe=yes
EOF
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix= \
  --cache-file=config.cache
make
#cp gettext-tools/gnulib-lib/.libs/libgettextlib.la{i}
#cp gettext-tools/src/.libs/libgettextsrc.la{i}
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf gettext-0.18.3.1
cd
```

6.31 Grep

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

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/grep-2.15.tar.xz -C ${BUILD_DIR}
cd ${BUILD_DIR}/grep-2.15
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix= \
  --bindir=/bin \
  --disable-perl-regexp
make
make DESTDIR=${TARGET_DIR} install
cd ..
```



```
rm -rf grep-2.15
cd
```

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.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/groff-1.22.2.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/groff-1.22.2
PAGE=A4 \
  ./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix=
make \
  TROFFBIN=troff \
  GROFFBIN=groff \
  GROFF_BIN_PATH=
make prefix=${TARGET_DIR} install
ln -sv soelim ${TARGET_DIR}/bin/zsoelim
ln -sv eqn ${TARGET_DIR}/bin/geqn
ln -sv tbl ${TARGET_DIR}/bin/gtbl
cd ..
rm -rf groff-1.22.2
cd
```

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 23 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.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/gzip-1.6.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/gzip-1.6
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf gzip-1.6
cd
```

6.34 Inetutils

Inetutils is a collection of common network programs.

```
# 6 minutes
tar xf ${DOWNLOAD_DIR}/inetutils-1.9.1.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/inetutils-1.9.1
sed -i '/gets is a security hole/d' lib/stdio.in.h
sed -i -e '/PATH_PROCNET_DEV/s/\ no//' paths
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf inetutils-1.9.1
cd
```

'sed -i.orig '/gets is a security hole/d' lib/stdio.in.h' is used to fix the following error when issuing 'make': './stdio.h:1030:1: error: 'gets' undeclared here (not in a function)'.

'sed -i.orig -e '/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 to build this package.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/iproute2-3.10.0.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/iproute2-3.10.0
sed -i.orig '/^TARGETS/s@arpd@g' misc/Makefile
make \
    DESTDIR=${TARGET_DIR} \
    CC="${CC}" \
    DOCDIR=/share/doc/iproute2 \
    MANDIR=/share/man
make \
    DESTDIR=${TARGET_DIR} \
    DOCDIR=/share/doc/iproute2 \
    MANDIR=/share/man \
    install
cd ..
rm -rf iproute2-3.10.0
cd
```

'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 the build OS to build this package.

```
# 3 minutes
tar xf ${DOWNLOAD_DIR}/kbd-2.0.1.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/kbd-2.0.1

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

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

'sed -i.orig '/SUBDIRS/s/ tests//' Makefile.in' 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`) provide userspace-side assistance in loading kernel modules and their dependencies.

You need `xsftproc` on the build OS to build this package.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/kmod-15.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/kmod-15
zlib_CFLAGS="-I${TARGET_DIR}/include" \
    zlib_LIBS="-L${TARGET_DIR}/lib -lz" \
    ./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --with-zlib
make
make \
    DESTDIR=${TARGET_DIR} \
    INSTALL=install \
    install
cd ..
rm -rf kmod-15
cd
```

```
# For bootscripts:
ln -sv kmod ${TARGET_DIR}/bin/lsmmod
ln -sv kmod ${TARGET_DIR}/bin/depmod
ln -sv kmod ${TARGET_DIR}/bin/insmod
ln -sv kmod ${TARGET_DIR}/bin/modprobe
ln -sv kmod ${TARGET_DIR}/bin/modinfo
ln -sv kmod ${TARGET_DIR}/bin/rmmod
```

‘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.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/less-458.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/less-458
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make prefix=${TARGET_DIR} install
cd ..
rm -rf less-458
cd
```

6.39 Libpipeline

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

```
tar xf ${DOWNLOAD_DIR}/libpipeline-1.3.0.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/libpipeline-1.3.0
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make prefix=${TARGET_DIR} install
cd ..
rm -rf libpipeline-1.3.0
cd
```

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.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/make-4.0.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/make-4.0
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf make-4.0
cd
```

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.

```
# fix /lib/libpipeline.so: error adding symbols: File in wrong format
rm ${TARGET_DIR}/lib/libgdbm.la
rm ${TARGET_DIR}/lib/libpipeline.la

tar xf ${DOWNLOAD_DIR}/man-db-2.6.7.1.tar.xz -C ${BUILD_DIR}
cd ${BUILD_DIR}/man-db-2.6.7.1
libpipeline_CFLAGS="-I${TARGET_DIR}/include" \
    libpipeline_LIBS="-L${TARGET_DIR}/lib -lpipeline" \
    ./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf man-db-2.6.7.1
cd

sed -i 's/#\(\DEFINE.*pager.*\)\less -s/\1 less -isRc/' \
    ${TARGET_DIR}/etc/man_db.conf
```

‘`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.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/nano-2.3.2.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/nano-2.3.2
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=
sed -i.orig -e \
    '/CPPFLAGS/s@/usr/include/ncursesw@${TARGET_DIR}/include@' \
    'find . -iname 'Makefile''
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf nano-2.3.2
cd
```

The sed expression is used to replace `/usr/include/ncursesw` with `${TARGET_DIR}/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*.

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.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/patch-2.7.1.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/patch-2.7.1
cat > config.cache << EOF
ac_cv_path_ed_PROGRAM=ed
ac_cv_func_strnlen_working=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --cache-file=config.cache
make
make prefix=${TARGET_DIR} install
cd ..
rm -rf patch-2.7.1
cd
```

6.44 Psmisc

This package contains utilities that use the `proc` filesystem.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/psmisc-22.20.tar.gz -C ${BUILD_DIR}
```

```

cd ${BUILD_DIR}/psmisc-22.20
cat > config.cache << EOF
ac_cv_func_malloc_0_nonnull=yes
ac_cv_func_realloc_0_nonnull=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix= \
    --cache-file=config.cache
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf psmisc-22.20
cd

```

6.45 Shadow

```

# 4 minutes
tar xf ${DOWNLOAD_DIR}/shadow-4.1.4.3.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/shadow-4.1.4.3
#automake
echo "ac_cv_func_setpgrp_void=yes" > config.cache
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --libdir=/lib \
    --sysconfdir=/etc \
    --enable-shared \
    --without-audit \
    --without-libpam \
    --without-selinux \
    --cache-file=config.cache \
    --enable-man
sed -i.orig '/man_MANS/s/${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 //' ${mkf}
done
make
make DESTDIR=${TARGET_DIR} install
sed -i.orig -e 's@#MD5_CRYPT_ENAB.no@MD5_CRYPT_ENAB yes@' \
    -e 's@/var/spool/mail@/var/mail@' \
    ${TARGET_DIR}/etc/login.defs
${CROSS_TARGET}-pwconv
${CROSS_TARGET}-grpconv
cd ..
rm -rf shadow-4.1.4.3
cd

```

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`.

The `pwconv` command creates `shadow` file from file `passwd` and an optionally existing `shadow` file.

The `grpconv` command creates `gshadow` file from file `group` and an optionally existing `gshadow` file.

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.

```
# 1 minute
tar xf ${DOWNLOAD_DIR}/sysvinit-2.88dsf.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/sysvinit-2.88dsf
sed -i.orig -e 's@/dev/initctl@$(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=${TARGET_DIR} CC="${CC}"
make -C src ROOT=${TARGET_DIR} INSTALL="install" install
cd ..
rm -rf sysvinit-2.88dsf
cd

cat > ${TARGET_DIR}/etc/inittab << EOF
# Begin /etc/inittab

id:3:initdefault:

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

10:0:wait:/etc/rc.d/init.d/rc 0
11:S1:wait:/etc/rc.d/init.d/rc 1
12:2:wait:/etc/rc.d/init.d/rc 2
13:3:wait:/etc/rc.d/init.d/rc 3
14:4:wait:/etc/rc.d/init.d/rc 4
15:5:wait:/etc/rc.d/init.d/rc 5
16:6: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

```

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.

```

# 5 minutes
tar xf ${DOWNLOAD_DIR}/tar-1.27.1.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/tar-1.27.1
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf tar-1.27.1
cd

```

6.48 Texinfo

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

```

# 10 minutes
tar xf ${DOWNLOAD_DIR}/texinfo-4.13a.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/texinfo-4.13
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix=
make -C tools/gnulib/lib
make -C tools
make
make DESTDIR=${TARGET_DIR} install

```

```

cd ..
rm -rf texinfo-4.13
cd

cd ${TARGET_DIR}/share/info
rm dir
for f in *
do install-info $f dir 2>/dev/null
done
cd

```

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 the build OS to build this package.

```

# 2 minutes
tar xf ${DOWNLOAD_DIR}/udev-175.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/udev-175
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix= \
  --with-rootlibdir=/lib \
  --libexecdir=/lib/udev \
  --docdir=/share/doc/udev-175 \
  --disable-introspection \
  --with-pci-ids-path=no \
  --with-usb-ids-path=no \
  --disable-gudev
make
make DESTDIR=${TARGET_DIR} install
install -dv ${TARGET_DIR}/lib/firmware
ln -sv ../lib/udev/udevvd ${TARGET_DIR}/sbin/udevvd
cd ..
rm -rf udev-175
cd

```

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, try to uninstall the package named `libtinfo-dev`. Then remove `${BUILD_DIR}/util-linux-2.24` and build it again.

```

# 5 minutes
# fix /lib/libudev.so: error adding symbols: File in wrong format
rm ${TARGET_DIR}/lib/libudev.la

tar xf ${DOWNLOAD_DIR}/util-linux-2.24.tar.bz2 -C ${BUILD_DIR}

```

```

cd ${BUILD_DIR}/util-linux-2.24
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --enable-partx \
  --disable-wall \
  --enable-write \
  --disable-makeinstall-chown
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -r util-linux-2.24
cd

```

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.

```

# 2 minutes
tar xf ${DOWNLOAD_DIR}/xz-5.0.8.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/xz-5.0.8
./configure \
  --build=${CROSS_HOST} \
  --host=${CROSS_TARGET} \
  --prefix=
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf xz-5.0.8
cd

```

6.52 Bootscripts

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

```

# 1 minute
tar xf ${DOWNLOAD_DIR}/bootscripts-cross-lfs-2.0.0.tar.xz \
  -C ${BUILD_DIR}
cd ${BUILD_DIR}/bootscripts-cross-lfs-2.0-pre2
make DESTDIR=${TARGET_DIR} install-bootscripts
make DESTDIR=${TARGET_DIR} install-network
cd ..
rm -rf bootscripts-cross-lfs-2.0-pre2
cd

```

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

6.53 The Kernel

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

You need `bc` and `lzma` on the build OS to build this package.

Warning: You may need to install the package `libncurses5-dev` to build the Kernel.

2 hours

```
tar xf ${DOWNLOAD_DIR}/linux-2.6.36-21.lemote-gnu1.tar \
  -C ${BUILD_DIR}
```

```
cd ${BUILD_DIR}/linux-2.6.36-21.lemote-gnu1
```

Don't wait 60s for the firmware loading machinery to fail:

```
sed -i.orig '/static int loading_timeout/s/60/1/' \
  drivers/base/firmware_class.c
```

Fix kernel freeze if firmware is missing:

```
sed '1961s/$/\n return -EINVAL;/' \
  -i.orig drivers/gpu/drm/radeon/r600.c
```

```
sed -e '502s/(?)/?), or has been deblobbed/' \
```

```
-e '524s/^/\tif (!dev->num.crtcs)\n\t\treturn;\n\n/' \
  -i.orig drivers/gpu/drm/drm_irq.c
```

```
make mrproper
```

The `sed` expression is used to avoid waiting 60 seconds for the binary-blob firmware to load at boot time, as those have been removed by the `deblob` script.

Then:

```
cp arch/mips/configs/loongson3_config .config
#Skip the following as, with 4 CPUs, the result is ugly:
#patch -Np1 -i ${DOWNLOAD_DIR}/100gnu+freedo.patch
```

Then, if you want to change the configuration:

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

Note: To speed up the build, you may disable support for some file systems: Reiserfs support, JFS filesystem support, XFS filesystem support, GFS2 file system support, OCFS2 file system support, Btrfs filesystem (EXPERIMENTAL) and NILFS2 file system support (EXPERIMENTAL).

You can also disable bootup logos in Device drivers > Graphics support > Bootup logo.

Then:

```
make \
  ARCH=mips \
  CROSS_COMPILE=${CROSS_TARGET}-
make \
  ARCH=mips \
  CROSS_COMPILE=${CROSS_TARGET}- \
  INSTALL_MOD_PATH=${TARGET_DIR} \
  modules_install
cp vmlinuz ${TARGET_DIR}/boot/vmlinuz-2.6.36-21-gnu1
cp System.map ${TARGET_DIR}/boot/System.map
cp .config ${TARGET_DIR}/boot/config
```

```
cd ..  
cd
```

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

7 Creating Required Configuration Files for the New System

7.1 File for Time Setup

```
#mkdir ${TARGET_DIR}/etc/sysconfig
cat > ${TARGET_DIR}/etc/sysconfig/clock << EOF
# Begin /etc/sysconfig/clock

UTC=1

# End /etc/sysconfig/clock
EOF
```

If you have trouble with the clock behaviour, do:

```
mv ${TARGET_DIR}/etc/rc.d/rcsysinit.d/S15setclock \
    ${TARGET_DIR}/etc/rc.d/rcsysinit.d/K15setclock
```

7.2 Setting up Keyboard Function keys for the Shell

Readline default configuration file is set:

```
cat > ${TARGET_DIR}/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
```

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.

`input-meta` If 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

```
cat > ${TARGET_DIR}/etc/profile << 'EOF'
# Begin /etc/profile

export LANG=en_US.UTF-8
export INPUTRC=/etc/inputrc
export PS1='\[\e[31m\]\A-\W\[\e[00m\]# '

# End /etc/profile
EOF
```

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 7.

7.4 Localhost Setup

```
echo "HOSTNAME=gllfsc" > ${TARGET_DIR}/etc/sysconfig/network
```

7.5 Setting up hosts File

```
cat > ${TARGET_DIR}/etc/hosts << EOF
# Begin /etc/hosts

127.0.0.1 gllfsc localhost

# End /etc/hosts
EOF
```

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

```
cd ${TARGET_DIR}/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
```

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

7.6.2 Setting up Network Dynamic Address

```
cd ${TARGET_DIR}/etc/sysconfig/network-devices
mkdir -v ifconfig.eth0
cat > ifconfig.eth0/dhcpd << EOF
ONBOOT=yes
```



```
SERVICE=dhcpd
DHCP_START="-q"
DHCP_STOP="-k"
EOF
cd
```

7.7 Setting up DNS

```
cat > ${TARGET_DIR}/etc/resolv.conf << EOF
# Begin /etc/resolv.conf

nameserver your-main-DNS-address
nameserver your-secondary-DNS-address

# End /etc/resolv.conf
EOF
```

7.8 fstab File Creation

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

```
cat > ${TARGET_DIR}/etc/fstab << EOF
# Begin /etc/fstab
```

# file system	mount-point	type	options	dump	fsck	order
/dev/sda6	/	ext3	defaults	0	0	
/dev/sda7	/home	ext3	defaults	0	0	
/dev/sda3	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	

```
# End /etc/fstab
EOF
```

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

8 Before Booting GLLFSC

8.1 Archiving the System

After the system has been completed, we use the command `exit` to logout as the *gllfsc* user.

Now, login as the *root* user.

Then fix the permissions on the new system:

```
export TARGET_DIR=/gllfsc
cd ${TARGET_DIR}
mknod -m 600 dev/console c 5 1
mknod -m 666 dev/null c 1 3
cp -a dev/{console,null} lib/udev/devices/
#chown -R root:root *
chown -R root:root \
    bin boot dev etc home include lib* local man mnt proc root run \
    sbin share src static sys tmp usr var
```

Also copy packages to be built after reboot:

```
export DOWNLOAD_DIR="${TARGET_DIR}/download"
for FILE in \
    tzcode2013h.tar.gz \
    tzdata2013h.tar.gz \
    runit-2.1.2.tar.gz \
    openssl-1.0.1i.tar.gz \
    wpa_supplicant-2.0.tar.gz \
    wireless_tools.29.tar.gz \
    wget-1.14.tar.gz \
    perl-5.18.1.tar.gz \
    libtasn1-3.4.tar.gz \
    lynx2.8.8dev.16.tar.bz2 \
    certdata.txt; do
cp -v ${DOWNLOAD_DIR}/${FILE} ${TARGET_DIR}/src
done
```

We archive the entire system by using the following command:

```
# 8 minutes
tar -cjf gllfsc-loongson3a-1.7.tar.bz2 \
    bin boot dev etc home include lib* local man mnt proc root run \
    sbin share src static sys tmp usr var
```

It is then easy to copy the archive to the target machine and extract it.

8.2 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 57).

Then, you will have to edit the PMON BIOS configuration file of the target machine: `/boot.cfg`. This file has to be put on the first partition of the hard drive¹.

¹ http://gnewsense.org/Projects/Lemote#Updating_of_the_PMON_configuration

Note: On the Yeeloong 8133, `vmlinuz` *must* be on the first primary partition to be able to boot.

A minimal `/boot.cfg` could be:

```
default 0
timeout 2
showmenu 1

title GLLFSC 1.7 (2.6.36-21 gnu1)
kernel /dev/fs/ext2@wd0/vmlinuz-2.6.36-21-gnu1
args console=tty1 quiet root=/dev/sda6
```

9 After Booting GLLFSC

Some system configuration and package installation can only be made after booting onto the new system.

9.1 Login

To login as *root*, just type 'root' when the system asks for your 'login:'. Then, update your bash profile:

```
cat > ~/.bash_profile << EOF
export BUILD_DIR="/tmp"
export DOWNLOAD_DIR="/src"
EOF
```

```
source ~/.bash_profile
```

9.2 Locales

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

```
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
```

Other locales are available:

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

9.3 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.

```
mkdir ${BUILD_DIR}/tz
tar xf ${DOWNLOAD_DIR}/tzcode2013h.tar.gz -C ${BUILD_DIR}/tz
tar xf ${DOWNLOAD_DIR}/tzdata2013h.tar.gz -C ${BUILD_DIR}/tz
cd ${BUILD_DIR}/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 this case Europe/Paris:

```

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

```

9.4 Runit

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

```

tar xf ${DOWNLOAD_DIR}/runit-2.1.2.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/admin/runit-2.1.2

# On GLLFSC, sleep is not under /bin:
sed -i 's,/bin/sleep,sleep,' etc/debian/ctrlaltdel

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

mkdir /service

cp etc/debian/ctrlaltdel /etc/runit/

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

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/udev --daemon

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

/sbin/udevadm settle

echo '7. Activating all swap files/partitions...'
swapon -a

echo '6. Setting Font...'
setfont LatArCyrHeb-16 -C /dev/tty2
setfont LatArCyrHeb-16 -C /dev/tty3

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/tty2
echo -ne $'\033%G' > /dev/tty3

echo '1. Bringing up the loopback interface...'
ip addr add 127.0.0.1/8 labello 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 through tty2 by pressing simultaneously
echo Ctrl, Alt and F2 keys
echo
echo You can then come back to this screen \(\tty1\) by pressing
echo simultaneously Ctrl, Alt and F1 keys
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-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 -p /etc/sv/getty-3
```

```
cat > /etc/sv/getty-3/run << EOF
#!/bin/sh
exec /sbin/agetty tty3 9600
EOF
chmod +x /etc/sv/getty-3/run
```

```
cat > /etc/sv/getty-3/finish << EOF
#!/bin/sh
exec utmpset -w tty3
EOF
chmod +x /etc/sv/getty-3/finish
```

```
ln -sv /etc/sv/getty-3 /service/getty-3
```

```
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
```

9.5 Perl

Perl is a high-level programming language.

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

```
tar xf ${DOWNLOAD_DIR}/perl-5.18.1.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/perl-5.18.1
sh Configure -ds -e -Dprefix=
make
make install
cd ..
rm -rf perl-5.18.1
cd
```

9.6 OpenSSL

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

```
tar xf ${DOWNLOAD_DIR}/openssl-1.0.1i.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/openssl-1.0.1i
./config \
    --prefix=/usr \
    --openssldir=/etc/ssl \
    shared
make -j1
# Install without the documentation:
make install_sw
cd ..
rm -rf openssl-1.0.1i
cd
```

9.7 Wpa_supplicant

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

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/wpa_supplicant-2.0.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/wpa_supplicant-2.0/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-2.0
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
```

9.8 Wireless_tools

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

```
# 1 minute
tar xf ${DOWNLOAD_DIR}/wireless_tools.29.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/wireless_tools.29
make
make PREFIX= install
cd ..
rm -rf wireless_tools.29
cd
```

9.9 Wget

GNU wget is an utility for downloading network data.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/wget-1.14.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/wget-1.14
sed -i.orig 's/item $thing/item C<$thing>/' doc/texi2pod.pl
./configure \
    --prefix= \
    --with-ssl=openssl
make
make install
cd ..
rm -rf wget-1.14
cd
```

9.10 Libtasn1

GNU libtasn1 is a ASN.1 library.

```
tar xf ${DOWNLOAD_DIR}/libtasn1-3.4.tar.gz -C ${BUILD_DIR}
cd ${BUILD_DIR}/libtasn1-3.4
./configure \
    --prefix=
make
make install
cd ..
rm -rf libtasn1-3.4
cd
```

9.11 Lynx

Lynx is a text web browser.

```
tar xf ${DOWNLOAD_DIR}/lynx2.8.8dev.16.tar.bz2 -C ${BUILD_DIR}
cd ${BUILD_DIR}/lynx2-8-8
./configure \
    --prefix= \
    --with-ssl=/lib \
    --enable-nls \
    --with-screen=ncursesw
make
make install
cd ..
rm -rf lynx2-8-8

# 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
```

9.12 CA-Certificates

CA-Certificates are used for https web pages.

```
# Inspired from
# http://linuxfromscratch.org/blfs/view/stable/postlfs/cacerts.html

cp ${DOWNLOAD_DIR}/certdata.txt ${BUILD_DIR}
cd ${BUILD_DIR}
```

```
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" ")

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

mkdir "${TMPDIR}/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" "${certdata}" \
    > "${TMPDIR}/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 ${TMPDIR}/certs/*.tmp; do
  # Make sure that the cert is trusted...
  grep "CKA_TRUST_SERVER_AUTH" "${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*.cert /etc/ssl/ca-bundle.cert
ln -sfv ../ca-bundle.cert /etc/ssl/certs/ca-certificates.cert

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

cd

```

9.13 Archiving the Complete System

```

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

# Strip binaries
# n32: 114 MB before, 41 MB after
# 64: 139 MB before, 45 MB after
strip --strip-all /bin/*

# To be done outside gllfsc 1.7:
tar -cjf gllfsc-loongson3a-1.7-completed-n32.tar.bz2 \
  bin boot dev etc home include lib* local man mnt proc root run \
  sbin service share src sys tmp usr var

```

9.14 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
```

9.15 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 extend GLLFSC, for instance instructions on how to build Xorg and programs on top of it.

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.

Cross [GNU/]Linux from scratch: <http://www.clfs.org> (PDF files may be downloaded from <http://clfs.org/files/BOOK/>). Includes a lot of documentation to build a GNU/Linux system by cross-compilation on a variety of hardware, no information (yet) for cross-compiling with sysroot on MIPS though. There is also a Community-driven Beyond [GNU/]Linux From Scratch on http://cblfs.clfs.org/index.php/Main_Page. It documents the building of Xorg and TeXLive among other things.

http://www.linuxfromscratch.org/hints/downloads/files/more_control_and_pkg_man.txt documents an interesting way of managing packages. Quotation from the file:

DESCRIPTION:

- 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 suckless team¹ is a group of programmers that share the following philosophy²:

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 machines based on Loongson 3A processor as performance is limited compared to current x86 processors.

¹ <http://suckless.org>

² <http://suckless.org/philosophy>

11 Thanks

I thank Lemote and particularly the CEO, Fuxin Zhang, for offering me a Yeeloong 8133, Huacai Chen and Haiyong Sun for their help in fixing the bugs I found in the deblobbed kernel.

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

Appendix A GNU Free Documentation License

Version 1.3, 3 November 2008

Copyright © 2000, 2001, 2002, 2007, 2008 Free Software Foundation, Inc.

<http://fsf.org/>

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

0. PREAMBLE

The purpose of this License is to make a manual, textbook, or other functional and useful document *free* in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or noncommercially. Secondly, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of “copyleft”, which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

1. APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The “Document”, below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as “you”. You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A “Modified Version” of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A “Secondary Section” is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document’s overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The “Invariant Sections” are certain Secondary Sections whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released under this License. If a section does not fit the above definition of Secondary then it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none.

The “Cover Texts” are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words.

A “Transparent” copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not “Transparent” is called “Opaque”.

Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only.

The “Title Page” means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, “Title Page” means the text near the most prominent appearance of the work’s title, preceding the beginning of the body of the text.

The “publisher” means any person or entity that distributes copies of the Document to the public.

A section “Entitled XYZ” means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as “Acknowledgements”, “Dedications”, “Endorsements”, or “History”.) To “Preserve the Title” of such a section when you modify the Document means that it remains a section “Entitled XYZ” according to this definition.

The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License.

2. VERBATIM COPYING

You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

3. COPYING IN QUANTITY

If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document’s license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both

covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

4. MODIFICATIONS

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

- A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any, be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.
- B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.
- C. State on the Title page the name of the publisher of the Modified Version, as the publisher.
- D. Preserve all the copyright notices of the Document.
- E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.
- F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.
- G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice.
- H. Include an unaltered copy of this License.
- I. Preserve the section Entitled "History", Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled "History" in the Document, create one stating the title, year, authors, and publisher of the Document as given on its

Title Page, then add an item describing the Modified Version as stated in the previous sentence.

- J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the “History” section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.
- K. For any section Entitled “Acknowledgements” or “Dedications”, Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.
- L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.
- M. Delete any section Entitled “Endorsements”. Such a section may not be included in the Modified Version.
- N. Do not retitle any existing section to be Entitled “Endorsements” or to conflict in title with any Invariant Section.
- O. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their titles to the list of Invariant Sections in the Modified Version’s license notice. These titles must be distinct from any other section titles.

You may add a section Entitled “Endorsements”, provided it contains nothing but endorsements of your Modified Version by various parties—for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

5. COMBINING DOCUMENTS

You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections Entitled “History” in the various original documents, forming one section Entitled “History”; likewise combine any sections Entitled “Acknowledgements”, and any sections Entitled “Dedications”. You must delete all sections Entitled “Endorsements.”

6. COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

7. AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an “aggregate” if the copyright resulting from the compilation is not used to limit the legal rights of the compilation’s users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document’s Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

8. TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled “Acknowledgements”, “Dedications”, or “History”, the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

9. TERMINATION

You may not copy, modify, sublicense, or distribute the Document except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense, or distribute it is void, and will automatically terminate your rights under this License.

However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, receipt of a copy of some or all of the same material does not give you any rights to use it.

10. FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See <http://www.gnu.org/copyleft/>.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License “or any later version” applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation. If the Document specifies that a proxy can decide which future versions of this License can be used, that proxy’s public statement of acceptance of a version permanently authorizes you to choose that version for the Document.

11. RELICENSING

“Massive Multiauthor Collaboration Site” (or “MMC Site”) means any World Wide Web server that publishes copyrightable works and also provides prominent facilities for anybody to edit those works. A public wiki that anybody can edit is an example of such a server. A “Massive Multiauthor Collaboration” (or “MMC”) contained in the site means any set of copyrightable works thus published on the MMC site.

“CC-BY-SA” means the Creative Commons Attribution-Share Alike 3.0 license published by Creative Commons Corporation, a not-for-profit corporation with a principal place of business in San Francisco, California, as well as future copyleft versions of that license published by that same organization.

“Incorporate” means to publish or republish a Document, in whole or in part, as part of another Document.

An MMC is “eligible for relicensing” if it is licensed under this License, and if all works that were first published under this License somewhere other than this MMC, and subsequently incorporated in whole or in part into the MMC, (1) had no cover texts or invariant sections, and (2) were thus incorporated prior to November 1, 2008.

The operator of an MMC Site may republish an MMC contained in the site under CC-BY-SA on the same site at any time before August 1, 2009, provided the MMC is eligible for relicensing.

ADDENDUM: How to use this License for your documents

To use this License in a document you have written, include a copy of the License in the document and put the following copyright and license notices just after the title page:

```
Copyright (C) year your name.  
Permission is granted to copy, distribute and/or modify this document  
under the terms of the GNU Free Documentation License, Version 1.3  
or any later version published by the Free Software Foundation;  
with no Invariant Sections, no Front-Cover Texts, and no Back-Cover  
Texts. A copy of the license is included in the section entitled ‘‘GNU  
Free Documentation License’’.
```

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the “with...Texts.” line with this:

```
with the Invariant Sections being list their titles, with  
the Front-Cover Texts being list, and with the Back-Cover Texts  
being list.
```

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.

Appendix B GNU General Public License

Version 3, 29 June 2007

Copyright © 2007 Free Software Foundation, Inc. <http://fsf.org/>

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Preamble

The GNU General Public License is a free, copyleft license for software and other kinds of works.

The licenses for most software and other practical works are designed to take away your freedom to share and change the works. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change all versions of a program—to make sure it remains free software for all its users. We, the Free Software Foundation, use the GNU General Public License for most of our software; it applies also to any other work released this way by its authors. You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for them if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs, and that you know you can do these things.

To protect your rights, we need to prevent others from denying you these rights or asking you to surrender the rights. Therefore, you have certain responsibilities if you distribute copies of the software, or if you modify it: responsibilities to respect the freedom of others.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must pass on to the recipients the same freedoms that you received. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

Developers that use the GNU GPL protect your rights with two steps: (1) assert copyright on the software, and (2) offer you this License giving you legal permission to copy, distribute and/or modify it.

For the developers' and authors' protection, the GPL clearly explains that there is no warranty for this free software. For both users' and authors' sake, the GPL requires that modified versions be marked as changed, so that their problems will not be attributed erroneously to authors of previous versions.

Some devices are designed to deny users access to install or run modified versions of the software inside them, although the manufacturer can do so. This is fundamentally incompatible with the aim of protecting users' freedom to change the software. The systematic pattern of such abuse occurs in the area of products for individuals to use, which is precisely where it is most unacceptable. Therefore, we have designed this version of the GPL to prohibit the practice for those products. If such problems arise substantially in other domains, we stand ready to extend this provision to those domains in future versions of the GPL, as needed to protect the freedom of users.

Finally, every program is threatened constantly by software patents. States should not allow patents to restrict development and use of software on general-purpose computers, but in those that do, we wish to avoid the special danger that patents applied to a free program could make it effectively proprietary. To prevent this, the GPL assures that patents cannot be used to render the program non-free.

The precise terms and conditions for copying, distribution and modification follow.

TERMS AND CONDITIONS

0. Definitions.

“This License” refers to version 3 of the GNU General Public License.

“Copyright” also means copyright-like laws that apply to other kinds of works, such as semiconductor masks.

“The Program” refers to any copyrightable work licensed under this License. Each licensee is addressed as “you”. “Licensees” and “recipients” may be individuals or organizations.

To “modify” a work means to copy from or adapt all or part of the work in a fashion requiring copyright permission, other than the making of an exact copy. The resulting work is called a “modified version” of the earlier work or a work “based on” the earlier work.

A “covered work” means either the unmodified Program or a work based on the Program.

To “propagate” a work means to do anything with it that, without permission, would make you directly or secondarily liable for infringement under applicable copyright law, except executing it on a computer or modifying a private copy. Propagation includes copying, distribution (with or without modification), making available to the public, and in some countries other activities as well.

To “convey” a work means any kind of propagation that enables other parties to make or receive copies. Mere interaction with a user through a computer network, with no transfer of a copy, is not conveying.

An interactive user interface displays “Appropriate Legal Notices” to the extent that it includes a convenient and prominently visible feature that (1) displays an appropriate copyright notice, and (2) tells the user that there is no warranty for the work (except to the extent that warranties are provided), that licensees may convey the work under this License, and how to view a copy of this License. If the interface presents a list of user commands or options, such as a menu, a prominent item in the list meets this criterion.

1. Source Code.

The “source code” for a work means the preferred form of the work for making modifications to it. “Object code” means any non-source form of a work.

A “Standard Interface” means an interface that either is an official standard defined by a recognized standards body, or, in the case of interfaces specified for a particular programming language, one that is widely used among developers working in that language.

The “System Libraries” of an executable work include anything, other than the work as a whole, that (a) is included in the normal form of packaging a Major Component, but which is not part of that Major Component, and (b) serves only to enable use of the work with that Major Component, or to implement a Standard Interface for which an implementation is available to the public in source code form. A “Major Component”, in this context, means a major essential component (kernel, window system, and so on) of the specific operating system (if any) on which the executable work runs, or a compiler used to produce the work, or an object code interpreter used to run it.

The “Corresponding Source” for a work in object code form means all the source code needed to generate, install, and (for an executable work) run the object code and to modify the work, including scripts to control those activities. However, it does not include the work’s System Libraries, or general-purpose tools or generally available free programs which are used unmodified in performing those activities but which are not part of the work. For example, Corresponding Source includes interface definition files associated with source files for the work, and the source code for shared libraries and dynamically linked subprograms that the work is specifically designed to require, such as by intimate data communication or control flow between those subprograms and other parts of the work.

The Corresponding Source need not include anything that users can regenerate automatically from other parts of the Corresponding Source.

The Corresponding Source for a work in source code form is that same work.

2. Basic Permissions.

All rights granted under this License are granted for the term of copyright on the Program, and are irrevocable provided the stated conditions are met. This License explicitly affirms your unlimited permission to run the unmodified Program. The output from running a covered work is covered by this License only if the output, given its content, constitutes a covered work. This License acknowledges your rights of fair use or other equivalent, as provided by copyright law.

You may make, run and propagate covered works that you do not convey, without conditions so long as your license otherwise remains in force. You may convey covered works to others for the sole purpose of having them make modifications exclusively for you, or provide you with facilities for running those works, provided that you comply with the terms of this License in conveying all material for which you do not control copyright. Those thus making or running the covered works for you must do so exclusively on your behalf, under your direction and control, on terms that prohibit them from making any copies of your copyrighted material outside their relationship with you.

Conveying under any other circumstances is permitted solely under the conditions stated below. Sublicensing is not allowed; section 10 makes it unnecessary.

3. Protecting Users' Legal Rights From Anti-Circumvention Law.

No covered work shall be deemed part of an effective technological measure under any applicable law fulfilling obligations under article 11 of the WIPO copyright treaty adopted on 20 December 1996, or similar laws prohibiting or restricting circumvention of such measures.

When you convey a covered work, you waive any legal power to forbid circumvention of technological measures to the extent such circumvention is effected by exercising rights under this License with respect to the covered work, and you disclaim any intention to limit operation or modification of the work as a means of enforcing, against the work's users, your or third parties' legal rights to forbid circumvention of technological measures.

4. Conveying Verbatim Copies.

You may convey verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice; keep intact all notices stating that this License and any non-permissive terms added in accord with section 7 apply to the code; keep intact all notices of the absence of any warranty; and give all recipients a copy of this License along with the Program.

You may charge any price or no price for each copy that you convey, and you may offer support or warranty protection for a fee.

5. Conveying Modified Source Versions.

You may convey a work based on the Program, or the modifications to produce it from the Program, in the form of source code under the terms of section 4, provided that you also meet all of these conditions:

- a. The work must carry prominent notices stating that you modified it, and giving a relevant date.
- b. The work must carry prominent notices stating that it is released under this License and any conditions added under section 7. This requirement modifies the requirement in section 4 to "keep intact all notices".
- c. You must license the entire work, as a whole, under this License to anyone who comes into possession of a copy. This License will therefore apply, along with any applicable

section 7 additional terms, to the whole of the work, and all its parts, regardless of how they are packaged. This License gives no permission to license the work in any other way, but it does not invalidate such permission if you have separately received it.

- d. If the work has interactive user interfaces, each must display Appropriate Legal Notices; however, if the Program has interactive interfaces that do not display Appropriate Legal Notices, your work need not make them do so.

A compilation of a covered work with other separate and independent works, which are not by their nature extensions of the covered work, and which are not combined with it such as to form a larger program, in or on a volume of a storage or distribution medium, is called an “aggregate” if the compilation and its resulting copyright are not used to limit the access or legal rights of the compilation’s users beyond what the individual works permit. Inclusion of a covered work in an aggregate does not cause this License to apply to the other parts of the aggregate.

6. Conveying Non-Source Forms.

You may convey a covered work in object code form under the terms of sections 4 and 5, provided that you also convey the machine-readable Corresponding Source under the terms of this License, in one of these ways:

- a. Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by the Corresponding Source fixed on a durable physical medium customarily used for software interchange.
- b. Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by a written offer, valid for at least three years and valid for as long as you offer spare parts or customer support for that product model, to give anyone who possesses the object code either (1) a copy of the Corresponding Source for all the software in the product that is covered by this License, on a durable physical medium customarily used for software interchange, for a price no more than your reasonable cost of physically performing this conveying of source, or (2) access to copy the Corresponding Source from a network server at no charge.
- c. Convey individual copies of the object code with a copy of the written offer to provide the Corresponding Source. This alternative is allowed only occasionally and noncommercially, and only if you received the object code with such an offer, in accord with subsection 6b.
- d. Convey the object code by offering access from a designated place (gratis or for a charge), and offer equivalent access to the Corresponding Source in the same way through the same place at no further charge. You need not require recipients to copy the Corresponding Source along with the object code. If the place to copy the object code is a network server, the Corresponding Source may be on a different server (operated by you or a third party) that supports equivalent copying facilities, provided you maintain clear directions next to the object code saying where to find the Corresponding Source. Regardless of what server hosts the Corresponding Source, you remain obligated to ensure that it is available for as long as needed to satisfy these requirements.
- e. Convey the object code using peer-to-peer transmission, provided you inform other peers where the object code and Corresponding Source of the work are being offered to the general public at no charge under subsection 6d.

A separable portion of the object code, whose source code is excluded from the Corresponding Source as a System Library, need not be included in conveying the object code work.

A “User Product” is either (1) a “consumer product”, which means any tangible personal property which is normally used for personal, family, or household purposes, or (2) anything

designed or sold for incorporation into a dwelling. In determining whether a product is a consumer product, doubtful cases shall be resolved in favor of coverage. For a particular product received by a particular user, “normally used” refers to a typical or common use of that class of product, regardless of the status of the particular user or of the way in which the particular user actually uses, or expects or is expected to use, the product. A product is a consumer product regardless of whether the product has substantial commercial, industrial or non-consumer uses, unless such uses represent the only significant mode of use of the product.

“Installation Information” for a User Product means any methods, procedures, authorization keys, or other information required to install and execute modified versions of a covered work in that User Product from a modified version of its Corresponding Source. The information must suffice to ensure that the continued functioning of the modified object code is in no case prevented or interfered with solely because modification has been made.

If you convey an object code work under this section in, or with, or specifically for use in, a User Product, and the conveying occurs as part of a transaction in which the right of possession and use of the User Product is transferred to the recipient in perpetuity or for a fixed term (regardless of how the transaction is characterized), the Corresponding Source conveyed under this section must be accompanied by the Installation Information. But this requirement does not apply if neither you nor any third party retains the ability to install modified object code on the User Product (for example, the work has been installed in ROM).

The requirement to provide Installation Information does not include a requirement to continue to provide support service, warranty, or updates for a work that has been modified or installed by the recipient, or for the User Product in which it has been modified or installed. Access to a network may be denied when the modification itself materially and adversely affects the operation of the network or violates the rules and protocols for communication across the network.

Corresponding Source conveyed, and Installation Information provided, in accord with this section must be in a format that is publicly documented (and with an implementation available to the public in source code form), and must require no special password or key for unpacking, reading or copying.

7. Additional Terms.

“Additional permissions” are terms that supplement the terms of this License by making exceptions from one or more of its conditions. Additional permissions that are applicable to the entire Program shall be treated as though they were included in this License, to the extent that they are valid under applicable law. If additional permissions apply only to part of the Program, that part may be used separately under those permissions, but the entire Program remains governed by this License without regard to the additional permissions.

When you convey a copy of a covered work, you may at your option remove any additional permissions from that copy, or from any part of it. (Additional permissions may be written to require their own removal in certain cases when you modify the work.) You may place additional permissions on material, added by you to a covered work, for which you have or can give appropriate copyright permission.

Notwithstanding any other provision of this License, for material you add to a covered work, you may (if authorized by the copyright holders of that material) supplement the terms of this License with terms:

- a. Disclaiming warranty or limiting liability differently from the terms of sections 15 and 16 of this License; or
- b. Requiring preservation of specified reasonable legal notices or author attributions in that material or in the Appropriate Legal Notices displayed by works containing it; or

- c. Prohibiting misrepresentation of the origin of that material, or requiring that modified versions of such material be marked in reasonable ways as different from the original version; or
- d. Limiting the use for publicity purposes of names of licensors or authors of the material; or
- e. Declining to grant rights under trademark law for use of some trade names, trademarks, or service marks; or
- f. Requiring indemnification of licensors and authors of that material by anyone who conveys the material (or modified versions of it) with contractual assumptions of liability to the recipient, for any liability that these contractual assumptions directly impose on those licensors and authors.

All other non-permissive additional terms are considered “further restrictions” within the meaning of section 10. If the Program as you received it, or any part of it, contains a notice stating that it is governed by this License along with a term that is a further restriction, you may remove that term. If a license document contains a further restriction but permits relicensing or conveying under this License, you may add to a covered work material governed by the terms of that license document, provided that the further restriction does not survive such relicensing or conveying.

If you add terms to a covered work in accord with this section, you must place, in the relevant source files, a statement of the additional terms that apply to those files, or a notice indicating where to find the applicable terms.

Additional terms, permissive or non-permissive, may be stated in the form of a separately written license, or stated as exceptions; the above requirements apply either way.

8. Termination.

You may not propagate or modify a covered work except as expressly provided under this License. Any attempt otherwise to propagate or modify it is void, and will automatically terminate your rights under this License (including any patent licenses granted under the third paragraph of section 11).

However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, you do not qualify to receive new licenses for the same material under section 10.

9. Acceptance Not Required for Having Copies.

You are not required to accept this License in order to receive or run a copy of the Program. Ancillary propagation of a covered work occurring solely as a consequence of using peer-to-peer transmission to receive a copy likewise does not require acceptance. However, nothing other than this License grants you permission to propagate or modify any covered work. These actions infringe copyright if you do not accept this License. Therefore, by modifying or propagating a covered work, you indicate your acceptance of this License to do so.

10. Automatic Licensing of Downstream Recipients.

Each time you convey a covered work, the recipient automatically receives a license from the original licensors, to run, modify and propagate that work, subject to this License. You are not responsible for enforcing compliance by third parties with this License.

An “entity transaction” is a transaction transferring control of an organization, or substantially all assets of one, or subdividing an organization, or merging organizations. If propagation of a covered work results from an entity transaction, each party to that transaction who receives a copy of the work also receives whatever licenses to the work the party’s predecessor in interest had or could give under the previous paragraph, plus a right to possession of the Corresponding Source of the work from the predecessor in interest, if the predecessor has it or can get it with reasonable efforts.

You may not impose any further restrictions on the exercise of the rights granted or affirmed under this License. For example, you may not impose a license fee, royalty, or other charge for exercise of rights granted under this License, and you may not initiate litigation (including a cross-claim or counterclaim in a lawsuit) alleging that any patent claim is infringed by making, using, selling, offering for sale, or importing the Program or any portion of it.

11. Patents.

A “contributor” is a copyright holder who authorizes use under this License of the Program or a work on which the Program is based. The work thus licensed is called the contributor’s “contributor version”.

A contributor’s “essential patent claims” are all patent claims owned or controlled by the contributor, whether already acquired or hereafter acquired, that would be infringed by some manner, permitted by this License, of making, using, or selling its contributor version, but do not include claims that would be infringed only as a consequence of further modification of the contributor version. For purposes of this definition, “control” includes the right to grant patent sublicenses in a manner consistent with the requirements of this License.

Each contributor grants you a non-exclusive, worldwide, royalty-free patent license under the contributor’s essential patent claims, to make, use, sell, offer for sale, import and otherwise run, modify and propagate the contents of its contributor version.

In the following three paragraphs, a “patent license” is any express agreement or commitment, however denominated, not to enforce a patent (such as an express permission to practice a patent or covenant not to sue for patent infringement). To “grant” such a patent license to a party means to make such an agreement or commitment not to enforce a patent against the party.

If you convey a covered work, knowingly relying on a patent license, and the Corresponding Source of the work is not available for anyone to copy, free of charge and under the terms of this License, through a publicly available network server or other readily accessible means, then you must either (1) cause the Corresponding Source to be so available, or (2) arrange to deprive yourself of the benefit of the patent license for this particular work, or (3) arrange, in a manner consistent with the requirements of this License, to extend the patent license to downstream recipients. “Knowingly relying” means you have actual knowledge that, but for the patent license, your conveying the covered work in a country, or your recipient’s use of the covered work in a country, would infringe one or more identifiable patents in that country that you have reason to believe are valid.

If, pursuant to or in connection with a single transaction or arrangement, you convey, or propagate by procuring conveyance of, a covered work, and grant a patent license to some of the parties receiving the covered work authorizing them to use, propagate, modify or convey a specific copy of the covered work, then the patent license you grant is automatically extended to all recipients of the covered work and works based on it.

A patent license is “discriminatory” if it does not include within the scope of its coverage, prohibits the exercise of, or is conditioned on the non-exercise of one or more of the rights that are specifically granted under this License. You may not convey a covered work if you are a party to an arrangement with a third party that is in the business of distributing software, under which you make payment to the third party based on the extent of your activity of conveying the work, and under which the third party grants, to any of the parties who would receive the covered work from you, a discriminatory patent license (a) in connection with copies of the covered work conveyed by you (or copies made from those copies), or (b) primarily for and in connection with specific products or compilations that contain the covered work, unless you entered into that arrangement, or that patent license was granted, prior to 28 March 2007.

Nothing in this License shall be construed as excluding or limiting any implied license or other defenses to infringement that may otherwise be available to you under applicable patent law.

12. No Surrender of Others’ Freedom.

If conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot convey a covered work so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not convey it at all. For example, if you agree to terms that obligate you to collect a royalty for further conveying from those to whom you convey the Program, the only way you could satisfy both those terms and this License would be to refrain entirely from conveying the Program.

13. Use with the GNU Affero General Public License.

Notwithstanding any other provision of this License, you have permission to link or combine any covered work with a work licensed under version 3 of the GNU Affero General Public License into a single combined work, and to convey the resulting work. The terms of this License will continue to apply to the part which is the covered work, but the special requirements of the GNU Affero General Public License, section 13, concerning interaction through a network will apply to the combination as such.

14. Revised Versions of this License.

The Free Software Foundation may publish revised and/or new versions of the GNU General Public License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.

Each version is given a distinguishing version number. If the Program specifies that a certain numbered version of the GNU General Public License “or any later version” applies to it, you have the option of following the terms and conditions either of that numbered version or of any later version published by the Free Software Foundation. If the Program does not specify a version number of the GNU General Public License, you may choose any version ever published by the Free Software Foundation.

If the Program specifies that a proxy can decide which future versions of the GNU General Public License can be used, that proxy’s public statement of acceptance of a version permanently authorizes you to choose that version for the Program.

Later license versions may give you additional or different permissions. However, no additional obligations are imposed on any author or copyright holder as a result of your choosing to follow a later version.

15. Disclaimer of Warranty.

THERE IS NO WARRANTY FOR THE PROGRAM, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRIT-

ING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE PROGRAM “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PROGRAM IS WITH YOU. SHOULD THE PROGRAM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

16. Limitation of Liability.

IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MODIFIES AND/OR CONVEYS THE PROGRAM AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PROGRAM (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE PROGRAM TO OPERATE WITH ANY OTHER PROGRAMS), EVEN IF SUCH HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

17. Interpretation of Sections 15 and 16.

If the disclaimer of warranty and limitation of liability provided above cannot be given local legal effect according to their terms, reviewing courts shall apply local law that most closely approximates an absolute waiver of all civil liability in connection with the Program, unless a warranty or assumption of liability accompanies a copy of the Program in return for a fee.

END OF TERMS AND CONDITIONS

How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to the public, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.

To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively state the exclusion of warranty; and each file should have at least the “copyright” line and a pointer to where the full notice is found.

one line to give the program’s name and a brief idea of what it does.
Copyright (C) year name of author

This program is free software: you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation, either version 3 of the License, or (at your option) any later version.

This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details.

You should have received a copy of the GNU General Public License along with this program. If not, see <http://www.gnu.org/licenses/>.

Also add information on how to contact you by electronic and paper mail.

If the program does terminal interaction, make it output a short notice like this when it starts in an interactive mode:

program Copyright (C) year name of author

```
This program comes with ABSOLUTELY NO WARRANTY; for details type 'show w'.  
This is free software, and you are welcome to redistribute it  
under certain conditions; type 'show c' for details.
```

The hypothetical commands `'show w'` and `'show c'` should show the appropriate parts of the General Public License. Of course, your program's commands might be different; for a GUI interface, you would use an "about box".

You should also get your employer (if you work as a programmer) or school, if any, to sign a "copyright disclaimer" for the program, if necessary. For more information on this, and how to apply and follow the GNU GPL, see <http://www.gnu.org/licenses/>.

The GNU General Public License does not permit incorporating your program into proprietary programs. If your program is a subroutine library, you may consider it more useful to permit linking proprietary applications with the library. If this is what you want to do, use the GNU Lesser General Public License instead of this License. But first, please read <http://www.gnu.org/philosophy/why-not-lgpl.html>.