GNU/Linux-libre from source code

for Loongson 2F

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This is edition 1.0 (last updated 14 October 2012) of *GNU/Linux-libre from source code for Loongson 2F*.

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://youbest.cublog.cn.

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

Short Contents

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1 Introduction

1.1 GNU/Linux History

1.1.1 GNU

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

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

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

- The freedom to run the program, for any purpose (freedom 0).
- The freedom to study how the program works, and change it so it does 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 GPL[3]).

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

1.1.2 HURD

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

The purpose of the GNU HURD is to improve 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.

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[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 volonteers around the world.

1.1.4 Linux-libre

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

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

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.

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[5] For more information about the presence of proprietary firmware in the kernel Linux, read http://www.fsfla.org/svnwiki/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/svnwiki/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

I bought a Lemote Yeeloong 8101 in 2010 and used gNewSense[8] on it. After a while, I wanted to use a faster and simpler operating system, but the number of available GNU/Linux[9] distributions that supported the mipsel architecture (Loongson 2F) were limited: only a handful, from which only gNewSense committed to give its users full freedom. Since then, another distribution called Parabola[10] has been developed: it is free as in freedom and supports the mips64el architecture.

I decided to build a GNU/Linux system from source code by myself. Hopefully, I found a document in Chinese describing the process of building a GNU/Linux system for Loongson processor: http://zdbr.net.cn/download/Loongson64-2.0.htm[11]. The document was old (2009) but I updated succesfully most packages from it, replaced Linux with Linux-libre and added some information I felt was useful and it gave the document you are reading.

[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.

[10] https://parabolagnulinux.org

[11] At the time of writing (september 2012), the site http://zdbr.net.cn/ does not exist anymore. The author of this document was Haiyong Sun, and his (interesting) blog is on http://youbest.cublog.cn.

2 Prerequisites

2.1 Definitions

2.1.1 `sysroot`

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

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

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

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

2.1.2 Toolchain

According to Wikipedia[2]:

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

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

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

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

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

During GCC compilation, we use:

[1] See Chapter 9 [Further Readings], page 63 section for more details

[2] `http://www.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

In this document, 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.

3 Preliminary Work

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

3.1 Build Partition Creation

To dedicate the partition `/dev/sda4` to the system build, and to define the filesystem to be used for it as '`ext3`':

```
mke2fs -t ext3 /dev/sda4
```

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

3.2 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`.

3.3 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.

3.4 Mounting Partition

To mount the hard drive partition, for instance `/dev/sda4`, used to build the system:

```
mount /dev/sda4 ${TARGET_DIR}
```

3.5 Creating Compilation and Download Directories

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

3.6 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.

3.7 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`:

```
cat > ~/.bashrc << "EOF"
set +h
umask 022
export PS1='\[\e[32m\]\A-\W\[\e[00m\]\$ '
export TARGET_DIR=/gllfsc
export LC_ALL=POSIX
export BUILD_DIR="${TARGET_DIR}/build"
export DOWNLOAD_DIR="${TARGET_DIR}/download"
export CROSS_HOST="$(echo $MACHTYPE |\
    sed "s/$(echo $MACHTYPE | cut -d- -f2)/cross/")"
export CROSS_TARGET="mips64el-unknown-linux-gnu"
#export MABI="n32"
export MABI="64"
#export MARCH="loongson2e"
export MARCH="loongson2f"
export PATH=${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.

'`export PS1='\[\e[32m\]\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, '`\[\e[32m\]`' colors the strings in green 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`.

3.8 Downloads

3.8.1 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 and the kernel Linux in order to use the two options `-mfix-loongson2f-nop` and `-mfix-loongson2f-jump`. Those work around a problem related to the Loongson2F architecture[1].

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

- Autoconf: http://ftpmirror.gnu.org/autoconf/autoconf-2.69.tar.gz.
- Automake: http://ftpmirror.gnu.org/automake/automake-1.12.4.tar.gz.
- Bash: http://ftpmirror.gnu.org/bash/bash-4.2.tar.gz.
- Binutils: http://ftpmirror.gnu.org/binutils/binutils-2.22.tar.bz2.
- Bison: http://ftpmirror.gnu.org/bison/bison-2.5.tar.bz2.
- Bootscripts: http://ftp.cross-lfs.org/pub/clfs/conglomeration/bootscripts-cross-lfs/bootscripts-cross-lfs-1.2-pre11.tar.bz2.
- Bzip2: http://www.bzip.org/1.0.6/bzip2-1.0.6.tar.gz.
- Coreutils: http://ftpmirror.gnu.org/coreutils/coreutils-8.19.tar.xz.
- DHCPCD: http://roy.marples.name/downloads/dhcpcd/dhcpcd-5.6.2.tar.bz2.
- Diffutils: http://ftpmirror.gnu.org/diffutils/diffutils-3.2.tar.gz.
- E2fsprogs: http://downloads.sourceforge.net/e2fsprogs/e2fsprogs-1.42.6.tar.gz.
- File: ftp://ftp.astron.com/pub/file/file-5.11.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.

[1] For more information about the issue, see http://groups.google.com/group/loongson-dev/browse_thread/thread/d9103283141c00fb/e9a8830b01cc1913?hide_quotes=no#msg_d44adf83639fb0bd and http://sourceware.org/ml/binutils/2009-11/msg00387.html.

- Gawk: http://ftpmirror.gnu.org/gawk/gawk-4.0.1.tar.gz.
- GCC: http://ftpmirror.gnu.org/gcc/gcc-4.7.2/gcc-4.7.2.tar.bz2.
- Gettext: http://ftpmirror.gnu.org/gettext/gettext-0.18.1.1.tar.gz.
- Glibc: http://ftpmirror.gnu.org/glibc/glibc-2.13.tar.bz2.
- Glibc-Ports: http://ftpmirror.gnu.org/glibc/glibc-ports-2.13.tar.bz2.
- Gmp: http://ftpmirror.gnu.org/gmp/gmp-5.0.5.tar.bz2.
- Grep: http://ftpmirror.gnu.org/grep/grep-2.14.tar.xz.
- Groff: http://ftpmirror.gnu.org/groff/groff-1.21.tar.gz.
- Gzip: http://ftpmirror.gnu.org/gzip/gzip-1.5.tar.gz.
- Iana-Etc: http://sethwklein.net/iana-etc-2.30.tar.bz2.
- Iputils: http://www.skbuff.net/iputils/iputils-s20071127.tar.bz2.
- Iproute2: http://www.kernel.org/pub/linux/utils/net/iproute2/iproute2-3.5.1.tar.bz2
- Kbd: http://ftp.altlinux.org/pub/people/legion/kbd/kbd-1.15.3.tar.gz.
- Kmod: http://www.kernel.org/pub/linux/utils/kernel/kmod/kmod-10.tar.gz.
- Less: http://www.greenwoodsoftware.com/less/less-451.tar.gz.
- Libtool: http://ftpmirror.gnu.org/libtool/libtool-2.4.tar.gz.
- Linux-Libre[2]: http://linux-libre.fsfla.org/pub/linux-libre/releases/3.5.4-gnu/linux-libre-3.5.4-gnu.tar.bz2.
- M4: http://ftpmirror.gnu.org/m4/m4-1.4.16.tar.bz2.
- Make: http://ftpmirror.gnu.org/make/make-3.82.tar.bz2.
- Man-Pages: http://www.kernel.org/pub/linux/docs/man-pages/Archive/man-pages-3.32.tar.bz2.
- Man: http://primates.ximian.com/~flucifredi/man/man-1.6g.tar.gz.
- Mpc: http://www.multiprecision.org/mpc/download/mpc-1.0.1.tar.gz.
- Mpfr: http://www.mpfr.org/mpfr-3.1.1/mpfr-3.1.1.tar.bz2.
- Nano: http://ftpmirror.gnu.org/nano/nano-2.3.1.tar.gz
- Ncurses: ftp://ftp.gnu.org/gnu/ncurses/ncurses-5.9.tar.gz.
- Patch: http://ftpmirror.gnu.org/patch/patch-2.7.1.tar.bz2.
- Procps: http://procps.sourceforge.net/procps-3.2.8.tar.gz.
- Psmisc: http://sourceforge.net/projects/psmisc/files/psmisc/psmisc-22.20.tar.gz/download.
- Readline: http://ftpmirror.gnu.org/readline/readline-6.2.tar.gz.
- Rsyslog: http://rsyslog.com/files/download/rsyslog/rsyslog-5.8.6.tar.gz.
- Sed: http://ftpmirror.gnu.org/sed/sed-4.2.1.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.
- Tar: http://ftpmirror.gnu.org/tar/tar-1.26.tar.bz2.
- Texinfo: http://ftpmirror.gnu.org/texinfo/texinfo-4.13a.tar.gz.
- Udev: ftp://ftp.kernel.org/pub/linux/utils/kernel/hotplug/udev-175.tar.gz.

[2] 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/svnwiki/selibre/linux-libre/.

- Util-Linux: http://www.kernel.org/pub/linux/utils/util-linux/v2.19/util-linux-2.19.1.tar.bz2.
- XZ-Utils: http://tukaani.org/xz/xz-5.0.4.tar.bz2.
- Zlib: http://sourceforge.net/projects/libpng/files/zlib/1.2.7/zlib-1.2.7.tar.bz2/download.

3.8.2 Downloading Patches

Patches and configuration files location:

- http://cjarry.org/gnu-linux/gllfsc/gllfsc-loongson2f-1.0-patches.tar.gz. After having downloaded this file under `${DOWNLOAD_DIR}`, execute the following commands to extract its content:

  ```
  pushd ${DOWNLOAD_DIR}
  tar xvf gllfsc-loongson2f-1.0-patches.tar.gz
  popd
  ```

- The page http://microcai.gsalex.net/old/archives/2011/01/fbcon_UNICODE_font_support.html is useful for users who want support for CJK (Chinese Japanese Korean) characters under the (non-graphical) terminal. It gives access to a git[3] repository with kernel patches[4] that permit direct rendering of UTF-8 characters under the framebuffer environment. Be aware though that applying those CJK patches to the kernel may make characters that are both non-CJK and non-ASCII unreadable (accented letters, cyrillic, etc.).
- http://www.fsfla.org/svn/fsfla/software/linux-libre/lemote/gnewsense/tags/3.5.4-gnu_0loongsonlibre/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/svnwiki/selibre/linux-libre/100gnu+freedo.

3.9 Final Preparations

3.9.1 Target Filesystem Hierarchy Creation

```
pushd ${TARGET_DIR}
mkdir -pv bin boot dev {etc/,}opt home lib mnt
mkdir -pv proc media/{floppy,cdrom} sbin srv sys
mkdir -pv var/{lock,log,mail,run,spool}
mkdir -pv var/{opt,cache,lib/{misc,locate},local}
install -dv -m 0750 root
install -dv -m 1777 {var/,}tmp
mkdir -pv usr/{,local/}{bin,include,lib,sbin,src}
mkdir -pv usr/{,local/}share/{doc,info,locale,man}
mkdir -pv usr/{,local/}share/{misc,terminfo,zoneinfo}
mkdir -pv usr/{,local/}share/man/man{1..8}
for dir in usr{,/local}; do
    ln -sv share/{man,doc,info} $dir
done
ln -svf lib lib64
ln -svf lib lib32
ln -svf lib usr/lib64
```

[3] http://git-scm.com/

[4] The patches to use with version 3.5 of the kernel are the first four on http://repo.or.cz/w/linux-2.6/cjktty.git/shortlog/refs/heads/3.5-utf8.

```
ln -svf lib usr/lib32
cd boot
ln -svf . boot
popd
```

The command '`install -dv -m 1777 {var/,}tmp`' creates the directories `var/tmp` and `tmp` 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`.

3.9.2 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

To build a GNU/Linux distribution for Loongson 2F without patch, you need at least version 2.6.33 of the kernel Linux (-libre) as it includes: basic CS5536 VSM support, CS5536 MFGPT timer support, CPU frequency scaling support, suspend support framework, basic Loongson 2F support, support for GZIP / BZIP2 / LZMA compressed kernel images[1]. Moreover, version 2.6.35 and above include fixes for Loongson2F processor[2].

I chose version stable 3.5.4-gnu because it is from the stable branch, it has been deblobed with the latest version of the deblob script[3] and because it is recent and as such it should include the most complete support for Loongson 2F.

```
# 6 minutes
tar xf ${DOWNLOAD_DIR}/linux-libre-3.5.4-gnu.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/linux-3.5.4
make mrproper
make ARCH=mips headers_check
make ARCH=mips INSTALL_HDR_PATH=dest headers_install
cp -rv dest/include/* ${TARGET_DIR}/usr/include
cd ..
rm -rf linux-3.5.4
popd
```

'`6 minutes`' is the time it takes to build the package on Lemote Yeeloong with a Loongson 2F 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.

```
# 35 minutes
tar xf ${DOWNLOAD_DIR}/binutils-2.22.tar.bz2 -C ${BUILD_DIR}
pushd $BUILD_DIR/binutils-2.22
mkdir -pv ../binutils-build
cd ../binutils-build
CC="gcc" AR="ar" \
    ../binutils-2.22/configure \
    --prefix=${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
```

[1] See http://kernelnewbies.org/Linux_2_6_33 for more information.

[2] See http://lwn.net/Articles/386986/ for more information.

[3] http://linux-libre.fsfla.org/pub/linux-libre/releases/3.5.4-gnu/deblob-main

```
make configure-host
make
make install
cp -v ../binutils-2.22/include/libiberty.h \
    ${TARGET_DIR}/usr/include
cd ..
rm -rf binutils-build
rm -rf binutils-2.22
popd
```

'`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=${TARGET_DIR}/cross-tools` tells the configure script to install architecture-independant files in `${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 you system[4]:
>
> 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 Parkes to avoid this issue.

```
# 2 hours
tar xf ${DOWNLOAD_DIR}/gcc-4.7.2.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/gcc-4.7.2
tar xf ${DOWNLOAD_DIR}/gmp-5.0.5.tar.bz2
mv gmp-5.0.5 gmp
tar xf ${DOWNLOAD_DIR}/mpc-1.0.1.tar.gz
mv mpc-1.0.1 mpc
tar xf ${DOWNLOAD_DIR}/mpfr-3.1.1.tar.bz2
mv mpfr-3.1.1 mpfr
mkdir -pv ../gcc-build
cd ../gcc-build
../gcc-4.7.2/configure \
    --prefix=${TARGET_DIR}/cross-tools \
```

[4] http://gmplib.org/#STATUS

```
    --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}
make all-gcc
make all-target-libgcc
make install-gcc
make install-target-libgcc
cd ..
rm -r gcc-build
rm -r gcc-4.7.2
popd
```

`--disable-multilib` specifies that multiple target libraries to support different target variants[5], calling conventions, etc. should not be built. The default is to build a predefined set of them.

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

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

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

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

4.4 Target glibc

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

```
# 4 hours
tar xf ${DOWNLOAD_DIR}/glibc-2.13.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/glibc-2.13
tar xf ${DOWNLOAD_DIR}/glibc-ports-2.13.tar.bz2
mv -v glibc-ports-2.13 ports
#sed -i.orig "s/\ -lgcc_eh\|\ -lgcc_s//g" Makeconfig
patch -Np1 -i ${DOWNLOAD_DIR}/glibc-2.13-libgcc_eh.patch
patch -Np1 -i ${DOWNLOAD_DIR}/glibc-2.13-ldd-rewrite-script.patch
patch -Np1 -i ${DOWNLOAD_DIR}/glibc-2.13-localedef_segfault-1.patch
patch -Np1 -i ${DOWNLOAD_DIR}/glibc-2.13-cross_hacks-2.patch
echo "" > ports/sysdeps/mips/mips64/n64/Makefile
echo "" > ports/sysdeps/mips/mips64/n32/Makefile
echo "" > ports/sysdeps/mips/mips32/Makefile
```

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

```
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=/usr/lib
EOF

BUILD_CC="gcc" \
    CC="${CROSS_TARGET}-gcc -march=${MARCH} -mabi=${MABI}" \
    AR="${CROSS_TARGET}-ar" \
    RANLIB="${CROSS_TARGET}-ranlib" \
    ../glibc-2.13/configure \
    --prefix=/usr \
    --libexecdir=/usr/lib/glibc \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --disable-profile \
    --enable-add-ons \
    --with-tls \
    --enable-kernel=3.5.4 \
    --with-__thread \
    --with-binutils=${TARGET_DIR}/cross-tools/bin \
    --with-headers=${TARGET_DIR}/usr/include \
    --cache-file=config.cache
make
make install
make localedata/install-locales
cd ..
rm -rf glibc-build
rm -rf glibc-2.13
popd

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

cp -v --remove-destination \
    ${TARGET_DIR}/usr/share/zoneinfo/Europe/Paris \
    ${TARGET_DIR}/etc/localtime

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

/usr/local/lib
/opt/lib

# End /etc/ld.so.conf
EOF
```

The patch `glibc-2.13-libgcc_eh.patch` is used in order not to use library '`gcc_eh`' to build '`libgcc_eh`' and '`static-gnulib`' if current compiler does not have '`libgcc_eh`'.

The patch `glibc-2.13-ldd-rewrite-script.patch` is used to fix a bug in glibc when the configure script is called from a relative path.

The patch `glibc-2.13-localedef_segfault-1.patch` is used to overcome a segfault you may have when generating locales if you use PaX. PaX is a patch for the kernel Linux that implements least privilege protections for memory pages.

The patch `glibc-2.13-cross_hacks-2.patch` is used specially to build locales by cross-compilation.

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=/usr` tells the `configure` script to install glibc in the `/usr` directory of the target system.

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

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

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

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

The '`3.5.4`' 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}/usr/include` indicates the location of the kernel Linux' headers.

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

'`make localedata/install-locales`' configures all locales that are supported by glibc.

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.

The timezone is defined for 'Paris'.

4.5 Cross GCC (C and C++ support)

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

```
# 3 hours and 30 minutes
tar xf ${DOWNLOAD_DIR}/gcc-4.7.2.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/gcc-4.7.2
tar xf ${DOWNLOAD_DIR}/gmp-5.0.5.tar.bz2
mv gmp-5.0.5 gmp
tar xf ${DOWNLOAD_DIR}/mpc-1.0.1.tar.gz
mv mpc-1.0.1 mpc
tar xf ${DOWNLOAD_DIR}/mpfr-3.1.1.tar.bz2
mv mpfr-3.1.1 mpfr
mkdir -v ../gcc-build
cd ../gcc-build
../gcc-4.7.2/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++
make
make install
cd ..
rm -rf gcc-build
rm -rf gcc-4.7.2
popd
```

`--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.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/file-5.11.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/file-5.11
./configure \
    --prefix=${TARGET_DIR}/cross-tools
make
make install
cd ..
rm -rf file-5.11
popd
```

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 Parkes, try '`sudo apt-get install g++-4.4`'.

```
# 15 minutes
tar xf ${DOWNLOAD_DIR}/groff-1.21.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/groff-1.21
PAGE=A4 \
    ./configure \
    --prefix=${TARGET_DIR}/cross-tools \
    --without-x
make
make install
cd ..
rm -rf groff-1.21
popd
```

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

`--without-x` disables the dependancy 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.

```
# 10 minutes
tar xf ${DOWNLOAD_DIR}/shadow-4.1.4.3.tar.bz2 -C ${BUILD_DIR}
pushd ${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_lckpwdf=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
popd
```

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_lckpwdf=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 Cross M4

Bison 2.5 requires M4 to be built.

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

```
# 10 minutes
tar xf ${DOWNLOAD_DIR}/m4-1.4.16.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/m4-1.4.16
./configure \
    --prefix=${TARGET_DIR}/cross-tools
make
make install
cd ..
rm -rf m4-1.4.16
popd
```

5.5 Ncurses

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

```
# 15 minutes
tar xf ${DOWNLOAD_DIR}/ncurses-5.9.tar.gz -C ${BUILD_DIR}
pushd ${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
popd
```

`--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.

```
pushd ${TARGET_DIR}/cross-tools
strip --strip-all bin/*
strip --strip-debug lib/*
popd
```

`--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 21 MB to 20 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 CFLAGS="-Wa,-mfix-loongson2f-nop"
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
```

The variable `CFLAGS` is set to `-Wa,-mfix-loongson2f-nop` in which `-Wa` is a GCC option used to pass `-mfix-loongson2f-nop` to the assembler. This option replaces `NOP`[1] by `or at,at,zero` to work around the Loongson2F `NOP` errata. Without it, under extreme cases, CPU might deadlock[2].

`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-3.32.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/man-pages-3.32
make prefix=${TARGET_DIR}/usr install
cd ..
rm -rf man-pages-3.32
popd
```

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

[1] See http://en.wikipedia.org/wiki/NOP for more information

[2] For more information about the issue, see http://groups.google.com/group/loongson-dev/browse_thread/thread/d9103283141c00fb/e9a8830b01cc1913?hide_quotes=no#msg_d44adf83639fb0bd and http://sourceware.org/ml/binutils/2009-11/msg00387.html.

6.3 Zlib

Zlib is a compression/decompression library.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/zlib-1.2.7.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/zlib-1.2.7
./configure \
    --prefix=/usr
make AR="${AR}"
make prefix=${TARGET_DIR}/usr install
# For FHS compatibility:
#mv -v ${TARGET_DIR}/usr/lib/libz.so.* ${TARGET_DIR}/lib
#ln -svf ../../lib/libz.so.1 ${TARGET_DIR}/usr/lib/libz.so
cd ..
rm -rf zlib-1.2.7
popd
```

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

6.4 Binutils

```
# 30 minutes
tar xf ${DOWNLOAD_DIR}/binutils-2.22.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/binutils-2.22
mkdir -pv ../binutils-build
cd ../binutils-build
../binutils-2.22/configure \
    --prefix=/usr \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --target=${CROSS_TARGET} \
    --enable-64-bit-bfd \
    --enable-shared
make configure-host
make tooldir=/usr
make DESTDIR=${TARGET_DIR} tooldir=/usr install
cp -v ../binutils-2.22/include/libiberty.h ${TARGET_DIR}/usr/include
cd ..
rm -rf binutils-build
rm -rf binutils-2.22
popd
```

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.

```
# 20 minutes
tar xf ${DOWNLOAD_DIR}/gmp-5.0.5.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/gmp-5.0.5
./configure \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
```

```
    --enable-cxx \
    --enable-mpbsd
make
make DESTDIR=${TARGET_DIR} install
rm -v ${TARGET_DIR}/usr/lib/lib{gmp,gmpxx,mp}.la
cd ..
rm -rf gmp-5.0.5
popd
```

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

The Berkeley MP compatibility library (libmp) and header file (`mp.h`) are built and installed if the option `--enable-mpbsd` is used.

The files `${TARGET_DIR}/usr/lib/lib{gmp,gmpxx,mp}.la` are removed to avoid the following error when building MPFR: '`/usr/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.

```
# 7 minutes
tar xf ${DOWNLOAD_DIR}/mpfr-3.1.1.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/mpfr-3.1.1
./configure \
    --host=${CROSS_TARGET} \
    --prefix=/usr
make
make DESTDIR=${TARGET_DIR} install
rm -v ${TARGET_DIR}/usr/lib/libmpfr.la
cd ..
rm -rf mpfr-3.1.1
popd
```

The file `${TARGET_DIR}/usr/lib/libmpfr.la` is removed to avoid the following error when building MPC: '`/usr/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}
pushd ${BUILD_DIR}/mpc-1.0.1
./configure \
    --host=${CROSS_TARGET} \
    --prefix=/usr
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf mpc-1.0.1
popd
```

6.8 GCC

```
# 3 hours and 30 minutes
tar xf ${DOWNLOAD_DIR}/gcc-4.7.2.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/gcc-4.7.2
sed -i.orig 's/install_to_$(INSTALL_DEST) //' libiberty/Makefile.in
sed -i.orig 's@\./fixinc\.sh@-c true@' gcc/Makefile.in
mkdir -v ../gcc-build
cd ../gcc-build
../gcc-4.7.2/configure \
    --prefix=/usr \
    --libexecdir=/usr/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
# For FHS compatibility:
#ln -sv ../usr/bin/cpp ${TARGET_DIR}/lib
ln -sv gcc ${TARGET_DIR}/usr/bin/cc
cd ..
rm -rf gcc-build
rm -rf gcc-4.7.2
popd
```

'`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}/usr/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-4.2.1.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/sed-4.2.1
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
```

```
    --prefix=/usr \
    --bindir=/bin
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf sed-4.2.1
popd
```

6.10 E2fsprogs

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

```
# 10 minutes
tar xf ${DOWNLOAD_DIR}/e2fsprogs-1.42.6.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/e2fsprogs-1.42.6
mkdir -v build
cd build
../configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --with-root-prefix="" \
    --enable-elf-shlibs
make
make DESTDIR=${TARGET_DIR} install
make DESTDIR=${TARGET_DIR} install-libs
rm -v ${TARGET_DIR}/usr/lib/lib{blkid,com_err,e2p,ext2fs,ss,uuid}.so
ln -sv ../../lib/libblkid.so.1 ${TARGET_DIR}/usr/lib/libblkid.so
ln -sv ../../lib/libcom_err.so.2 ${TARGET_DIR}/usr/lib/libcom_err.so
ln -sv ../../lib/libe2p.so.2 ${TARGET_DIR}/usr/lib/libe2p.so
ln -sv ../../lib/libext2fs.so.2 ${TARGET_DIR}/usr/lib/libext2fs.so
ln -sv ../../lib/libss.so.2 ${TARGET_DIR}/usr/lib/libss.so
ln -sv ../../lib/libuuid.so.1 ${TARGET_DIR}/usr/lib/libuuid.so
cd ../..
rm -rf e2fsprogs-1.42.6
popd
```

`--with-root-prefix=""` is used to put e2fsprogs binaries inside `/sbin` instead of *`PREFIX`*`/sbin` which would be `/usr/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 `${TARGET_DIR}/usr/lib/lib{blkid,com_err,e2p,ext2fs,ss,uuid}.so` which point on abolute paths `/lib/lib{blkid,com_err,e2p,ext2fs,ss,uuid}.so`. In order to use the libraries of the target operating system, we need to symlink `${TARGET_DIR}/usr/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}
pushd ${BUILD_DIR}/coreutils-8.19
sed -i.orig '/strftime/s/\ LC_ALL//' man/help2man
cat > config.cache << EOF
fu_cv_sys_stat_statfs2_bsize=yes
gl_cv_func_mbrtowc_incomplete_state=yes
gl_cv_func_mbrtowc_nul_retval=yes
gl_cv_func_mbrtowc_null_arg=yes
gl_cv_func_mbrtowc_retval=yes
gl_cv_func_btowc_eof=yes
gl_cv_func_wcrtomb_retval=yes
gl_cv_func_wctob_works=yes
gl_cv_func_fstatat_zero_flag=yes
# From C[G]LFS:
#fu_cv_sys_stat_statfs2_bsize=yes
#gl_cv_func_working_mkstemp=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --enable-install-program=hostname \
    --enable-no-install-program=kill,uptime \
    --cache-file=config.cache
make
make DESTDIR=${TARGET_DIR} install
# For FHS compatibility:
#mv -v ${TARGET_DIR}/usr/bin/{cat,chgrp,chmod,chown,cp,date} \
#    ${TARGET_DIR}/bin
#mv -v ${TARGET_DIR}/usr/bin/{dd,df,echo,false,hostname,ls,mkdir} \
#    ${TARGET_DIR}/bin
#mv -v ${TARGET_DIR}/usr/bin/{mv,pwd,rm,rmdir,stty,true,ln,uname} \
#    ${TARGET_DIR}/bin
#mv -v ${TARGET_DIR}/usr/bin/chroot ${TARGET_DIR}/usr/sbin
#mv -v ${TARGET_DIR}/usr/bin/{[,basename,head,install,nice} \
#    ${TARGET_DIR}/bin
#mv -v ${TARGET_DIR}/usr/bin/{readlink,sleep,sync,test,touch} \
#    ${TARGET_DIR}/bin
#ln -svf ../../bin/install ${TARGET_DIR}/usr/bin
cd ..
rm -rf coreutils-8.19
popd
```

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}
pushd ${BUILD_DIR}/iana-etc-2.30
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf iana-etc-2.30
popd
```

6.13 M4

```
# 10 minutes
tar xf ${DOWNLOAD_DIR}/m4-1.4.16.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/m4-1.4.16
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf m4-1.4.16
popd
```

6.14 Bison

GNU bison parser generator.

```
# 7 minutes
tar xf ${DOWNLOAD_DIR}/bison-2.5.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/bison-2.5
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr
echo '#define YYENABLE_NLS 1' >> config.h
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf bison-2.5
popd
```

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

6.15 Ncurses

```
# 15 minutes
tar xf ${DOWNLOAD_DIR}/ncurses-5.9.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/ncurses-5.9
./configure \
```

```
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --with-shared \
    --enable-widec \
    --without-debug \
    --without-ada \
    --with-build-cc="gcc -D_GNU_SOURCE" \
    --libdir=/lib
make
make DESTDIR=${TARGET_DIR} install
# For FHS compatibility:
#mv -v ${TARGET_DIR}/lib/lib{panel,menu,form,ncurses,ncurses++}w.a \
#    ${TARGET_DIR}/usr/lib
#rm -v ${TARGET_DIR}/lib/lib{ncurses,menu,panel,form}w.so
#ln -svf ../../lib/libncursesw.so.5 \
#    ${TARGET_DIR}/usr/lib/libncursesw.so
#ln -svf ../../lib/libmenuw.so.5 ${TARGET_DIR}/usr/lib/libmenuw.so
#ln -svf ../../lib/libpanelw.so.5 ${TARGET_DIR}/usr/lib/libpanelw.so
#ln -svf ../../lib/libformw.so.5 ${TARGET_DIR}/usr/lib/libformw.so
#for lib in curses ncurses form panel menu ; do
#    echo "INPUT(-l${lib}w)" > ${TARGET_DIR}/usr/lib/lib${lib}.so
#    ln -sfv lib${lib}w.a ${TARGET_DIR}/usr/lib/lib${lib}.a
#    done
ln -sfv libncursesw.so ${TARGET_DIR}/lib/libncurses.so
#ln -sfv libncursesw.so ${TARGET_DIR}/usr/lib/libcursesw.so
#ln -sfv libncursesw.a ${TARGET_DIR}/usr/lib/libcursesw.a
#ln -sfv libncurses++w.a ${TARGET_DIR}/usr/lib/libncurses++.a
#ln -sfv ncursesw5-config ${TARGET_DIR}/usr/bin/ncurses5-config
#ln -sfv ../../usr/share/terminfo ${TARGET_DIR}/usr/lib/terminfo
cd ..
rm -rf ncurses-5.9
popd
```

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

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

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

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`.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/procps-3.2.8.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/procps-3.2.8
make \
    CPPFLAGS= \
    lib64=lib
make \
```

```
    DESTDIR=${TARGET_DIR} \
    lib64=lib \
    ldconfig= \
    install="install -D" \
    install
cd ..
rm -rf procps-3.2.8
popd
```

Option `CPPFLAGS=` is used so that the target system's ncurses library will be used, default value would have been `-I/usr/include/ncurses`.

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.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/libtool-2.4.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/libtool-2.4
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf libtool-2.4
popd
```

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}
pushd ${BUILD_DIR}/readline-6.2
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --libdir=/lib
make
make DESTDIR=${TARGET_DIR} install
make DESTDIR=${TARGET_DIR} install-doc
# For FHS compatibility:
#mv -v ${TARGET_DIR}/lib/lib{readline,history}.a ${TARGET_DIR}/usr/lib
#rm -v ${TARGET_DIR}/lib/lib{readline,history}.so
```

```
#ln -svf ../../lib/libreadline.so.6 \
#    ${TARGET_DIR}/usr/lib/libreadline.so
#ln -svf ../../lib/libhistory.so.6 ${TARGET_DIR}/usr/lib/libhistory.so
cd ..
rm -rf readline-6.2
popd
```

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.

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

6.20 Automake

GNU automake is a tool for automatically generating `Makefile.in` files compliant with the GNU Coding Standards[3].

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/automake-1.12.4.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/automake-1.12.4
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf automake-1.12.4
popd
```

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).

```
# 15 minutes
tar xf ${DOWNLOAD_DIR}/bash-4.2.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/bash-4.2
cat > config.cache << "EOF"
ac_cv_func_mmap_fixed_mapped=yes
```

[3] http://www.gnu.org/prep/standards/

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

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.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/bzip2-1.0.6.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/bzip2-1.0.6
sed -i.orig -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}/usr \
    install
cp -v bzip2-shared ${TARGET_DIR}/bin/bzip2
cp -av libbz2.so* ${TARGET_DIR}/lib
ln -sv ../../lib/libbz2.so.1.0 ${TARGET_DIR}/usr/lib/libbz2.so
rm -v ${TARGET_DIR}/usr/bin/{bunzip2,bzcat,bzip2}
ln -sv bzip2 ${TARGET_DIR}/bin/bunzip2
ln -sv bzip2 ${TARGET_DIR}/bin/bzcat
cd ..
rm -rf bzip2-1.0.6
popd
```

'`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 DHCPCD

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

```
# 3 minutes
tar xf ${DOWNLOAD_DIR}/dhcpcd-5.6.2.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/dhcpcd-5.6.2
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --bindir=/sbin \
    --sysconfdir=/etc \
    --dbdir=/var/lib/dhcpcd \
    --libexecdir=/usr/lib/dhcpcd
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf dhcpcd-5.6.2
popd
```

6.24 Diffutils

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

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/diffutils-3.2.tar.gz -C ${BUILD_DIR}
```

```
pushd ${BUILD_DIR}/diffutils-3.2
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf diffutils-3.2
popd
```

6.25 File

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/file-5.11.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/file-5.11
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf file-5.11
popd
```

6.26 Findutils

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

```
# 7 minutes
tar xf ${DOWNLOAD_DIR}/findutils-4.4.2.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/findutils-4.4.2
cat > config.cache << EOF
gl_cv_func_wcwidth_works=yes
gl_cv_header_working_fcntl_h=yes
ac_cv_func_fnmatch_gnu=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --libexecdir=/usr/lib/locate \
    --localstatedir=/var/lib/locate \
    --cache-file=config.cache
make
make DESTDIR=${TARGET_DIR} install
#mv -v ${TARGET_DIR}/usr/bin/find ${TARGET_DIR}/bin
#sed -i.orig 's@find:=${BINDIR}@find:=/bin@' \
#    ${TARGET_DIR}/usr/bin/updatedb
cd ..
rm -rf findutils-4.4.2
popd
```

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.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/flex-2.5.37.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/flex-2.5.37
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --cache-file=config.cache
make
make DESTDIR=${TARGET_DIR} install
ln -sv libfl.a ${TARGET_DIR}/usr/lib/libl.a
cd ..
rm -r flex-2.5.37
popd

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

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

We then create target system's `/usr/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-4.0.1.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/gawk-4.0.1
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --libexecdir=/usr/lib
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -r gawk-4.0.1
popd
```

6.29 Gettext

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

```
# 1 hour
tar xf ${DOWNLOAD_DIR}/gettext-0.18.1.1.tar.gz -C ${BUILD_DIR}
```

```
pushd ${BUILD_DIR}/gettext-0.18.1.1
cat > config.cache << EOF
am_cv_func_iconv_works=yes
gl_cv_func_wcwidth_works=yes
gt_cv_func_printf_posix=yes
gt_cv_int_divbyzero_sigfpe=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --cache-file=config.cache
make
#cp gettext-tools/gnulib-lib/.libs/libgettextlib.la{,i}
#cp gettext-tools/src/.libs/libgettextsrc.la{,i}
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf gettext-0.18.1.1
popd
```

6.30 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-2.14.tar.xz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/grep-2.14
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --bindir=/bin \
    --disable-perl-regexp
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf grep-2.14
popd
```

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

6.31 Groff

```
# 15 minutes
tar xf ${DOWNLOAD_DIR}/groff-1.21.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/groff-1.21
patch -Np1 -i ${DOWNLOAD_DIR}/groff-1.21-cross-compilation.patch
PAGE=A4 \
    ./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr
make \
```

```
    TROFFBIN=troff \
    GROFFBIN=groff \
    GROFF_BIN_PATH=
make prefix=${TARGET_DIR}/usr install
ln -sv soelim ${TARGET_DIR}/usr/bin/zsoelim
ln -sv eqn ${TARGET_DIR}/usr/bin/geqn
ln -sv tbl ${TARGET_DIR}/usr/bin/gtbl
cd ..
rm -rf groff-1.21
popd
```

The patch `groff-1.21-cross-compilation.patch` fixes a bug in groff' `Makefile.in` that prevents the cross-compilation build.

The variables `TROFFBIN=troff` and `GROFFBIN=groff` tell `make` to use `troff` and `groff` commands installed in the Chapter 5 [Building Cross-Compilation Tools], page 21 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.

6.32 Gzip

GNU Gzip is a data compression program.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/gzip-1.5.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/gzip-1.5
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --bindir=/bin
make
make DESTDIR=${TARGET_DIR} install
# For FHS compatibility:
#mv -v ${TARGET_DIR}/bin/z{egrep,cmp,diff,fgrep,force,grep,less,more} \
#    ${TARGET_DIR}/usr/bin
#mv -v ${TARGET_DIR}/bin/znew \
#    ${TARGET_DIR}/usr/bin
cd ..
rm -rf gzip-1.5
popd
```

6.33 IPutils

The iputils package is a set of small utilities for networking.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/iputils-s20071127.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/iputils-s20071127
patch -Np1 -i ${DOWNLOAD_DIR}/iputils-s20071127-fixes-2.patch
make CC="${CC}"
install -v -m755 ping{,6} ${TARGET_DIR}/bin
```

```
install -v -m755 arping ${TARGET_DIR}/usr/bin
install -v -m755 clockdiff ${TARGET_DIR}/usr/bin
install -v -m755 rdisc ${TARGET_DIR}/usr/bin
install -v -m755 tracepath ${TARGET_DIR}/usr/bin
install -v -m755 trace{path,route}6 ${TARGET_DIR}/usr/bin
cd ..
rm -rf iputils-s20071127
popd
```

6.34 Iproute2

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

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/iproute2-3.5.1.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/iproute2-3.5.1
sed -i.orig '/^TARGETS/s@arpd@@g' misc/Makefile
make \
    DESTDIR=${TARGET_DIR} \
    CC="${CC}" \
    DOCDIR=/usr/share/doc/iproute2 \
    MANDIR=/usr/share/man
make \
    DESTDIR=${TARGET_DIR} \
    DOCDIR=/usr/share/doc/iproute2 \
    MANDIR=/usr/share/man \
    install
cd ..
rm -rf iproute2-3.5.1
popd
```

'`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.

6.35 Kbd

Kbd contains keytable files and keyboard utilities.

```
# 3 minutes
tar xf ${DOWNLOAD_DIR}/kbd-1.15.3.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/kbd-1.15.3
patch -Np1 -i ${DOWNLOAD_DIR}/kbd-1.15.3-es.po-fix-1.patch
cat > config.cache << EOF
ac_cv_func_setpgrp_void=yes
ac_cv_func_malloc_0_nonnull=yes
ac_cv_func_realloc_0_nonnull=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --cache-file=config.cache
```

```
make
make DESTDIR=${TARGET_DIR} install
# For FHS compatibility
#mv -v ${TARGET_DIR}/usr/bin/{kbd_mode,dumpkeys,loadkeys,openvt} \
#    ${TARGET_DIR}/bin
#mv -v ${TARGET_DIR}/usr/bin/setfont \
#    ${TARGET_DIR}/bin
cd ..
rm -rf kbd-1.15.3
popd
```

The patch `kbd-1.15.3-es.po-fix-1.patch` fixes a bug in `po/es.po`.

6.36 Kmod

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

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/kmod-10.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/kmod-10
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --bindir=/bin \
    --sbindir=/sbin \
    --with-zlib
make
make \
    DESTDIR=${TARGET_DIR} \
    INSTALL=install \
    install
cd ..
rm -rf kmod-10
popd
```

`--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`.

6.37 Less

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

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/less-451.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/less-451
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --sysconfdir=/etc
make
make prefix=${TARGET_DIR}/usr install
# For FHS compatibility:
```

```
#mv -v ${TARGET_DIR}/usr/bin/less ${TARGET_DIR}/bin
cd ..
rm -rf less-451
popd
```

6.38 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-3.82.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/make-3.82
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf make-3.82
popd
```

6.39 Man

Man is an interface to the on-line reference manuals.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/man-1.6g.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/man-1.6g
sed -i.orig -e "/PREPATH=/s@=.*@=\"$(eval echo \
    ${TARGET_DIR}/{,usr/}{sbin,bin})\"@g" -e 's@-is@&Rc@g' configure
sed -i.orig -e 's@MANPATH./usr/man@#&@g' \
    -e 's@MANPATH./usr/local/man@#&@g' src/man.conf.in
./configure \
    -confdir=/etc
sed -i.orig "s@${TARGET_DIR}@@" conf_script
gcc src/makemsg.c -o src/makemsg
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf man-1.6g
popd
```

In the first use of `sed`, the first part replaces `PREPATH` default value '`/bin:/usr/bin:/usr/ucb:/usr/local/bin:$PATH`' with '`${TARGET_DIR}/{,usr/}{sbin,bin}`'. The variable `TARGET_DIR` is used to avoid errors when running the `configure` script.

The second part is used to replace default options of the man pager `-is` with `-isRc`. Option `-c` will cause `less` to display man pages faster as this option disables scrolling.

The second call of `sed` tells `man` where the cat pages corresponding to given man pages should not be stored: `/usr/man` and `/usr/local/man`.

Option `-confdir` is used to define configuration files location to target system's `/etc`.

The third call of `sed` is used in order to remove the presence of `TARGET_DIR` on the target system's programs.

`makemsg` will be used during the build, but because using the cross-compiler may make its build fail, we use the host's compiler.

6.40 Nano

GNU nano is a lightweight text editor.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/nano-2.3.1.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/nano-2.3.1
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf nano-2.3.1
popd
```

> **Note:** commands in nano are displayed as in '^X'. The '^' character means `CTRL` key, so '^X' means *`CTRL-X`*.

6.41 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}
pushd ${BUILD_DIR}/patch-2.7.1
cat > config.cache << EOF
ac_cv_path_ed_PROGRAM=ed
ac_cv_func_strnlen_working=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --cache-file=config.cache
make
make prefix=${TARGET_DIR}/usr install
cd ..
rm -rf patch-2.7.1
popd
```

6.42 Psmisc

This package contains utilities that use the proc filesystem.

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/psmisc-22.20.tar.gz -C ${BUILD_DIR}
pushd ${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=/usr \
    --exec-prefix="" \
    --cache-file=config.cache
make
make DESTDIR=${TARGET_DIR} install
# For FHS compatibility:
#mv -v ${TARGET_DIR}/bin/pstree* ${TARGET_DIR}/usr/bin
#ln -sv killall ${TARGET_DIR}/bin/pidof
cd ..
rm -rf psmisc-22.20
popd
```

6.43 Rsyslog

Rsyslog is an utility creating log messages.

```
# 10 minutes
tar xf ${DOWNLOAD_DIR}/rsyslog-5.8.6.tar.gz -C ${BUILD_DIR}
pushd ${BUILD_DIR}/rsyslog-5.8.6
cat > config.cache << EOF
ac_cv_func_malloc_0_nonnull=yes
ac_cv_func_realloc_0_nonnull=yes
EOF
PKG_CONFIG_PATH="${TARGET_DIR}/usr/lib/pkgconfig" \
    ./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --sbindir=/sbin \
    --cache-file=config.cache
make
make DESTDIR=${TARGET_DIR} install
install -dv ${TARGET_DIR}/etc/rsyslog.d
cd ..
rm -rf rsyslog-5.8.6
popd

cat > ${TARGET_DIR}/etc/rsyslog.conf << "EOF"
$ModLoad imuxsock.so
$ModLoad imklog.so

$ActionFileDefaultTemplate RSYSLOG_TraditionalFileFormat

$FileOwner root
$FileGroup root
$FileCreateMode 0640
$DirCreateMode 0755

$ModLoad imudp
```

```
$UDPServerRun 514

$RepeatedMsgReduction on

$IncludeConfig /etc/rsyslog.d/*.conf

auth,authpriv.*                         /var/log/auth.log
*.*;auth,authpriv.none                 -/var/log/syslog
daemon.*                               -/var/log/daemon.log
kern.*                                 -/var/log/kern.log
lpr.*                                  -/var/log/lpr.log
mail.*                                 -/var/log/mail.log
user.*                                 -/var/log/user.log

# Catch All Logs
*.=debug;\
        auth,authpriv.none;\
        news.none;mail.none            -/var/log/debug
*.=info;*.=notice;*.=warn;\
        auth,authpriv.none;\
        cron,daemon.none;\
        mail,news.none                 -/var/log/messages

# Emergency are shown to everyone
*.emerg                                 *
EOF
```

'`install -dv ${TARGET_DIR}/etc/rsyslog.d`' is used to create target system's `/etc/rsyslog.d` directory. Rsyslog looks for user-defined configuration files in this directory. The line '`$IncludeConfig /etc/rsyslog.d/*.conf`' in the target system's configuration file `/etc/rsyslog.conf` has this purpose.

We then create the target system's configuration file `/etc/rsyslog.conf`.

6.44 Shadow

```
# 7 minutes
tar xf ${DOWNLOAD_DIR}/shadow-4.1.4.3.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/shadow-4.1.4.3
patch -Np1 -i ${DOWNLOAD_DIR}/shadow-4.1.4.3-man-ru.patch
automake-1.11
echo "ac_cv_func_setpgrp_void=yes" > config.cache
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --libdir=/lib \
    --sysconfdir=/etc \
    --enable-shared \
    --without-audit \
    --without-libpam \
    --without-selinux \
    --cache-file=config.cache \
    --enable-man
sed -i.orig 's/groups$(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
# For FHS compatibility:
#mv -v ${TARGET_DIR}/usr/bin/passwd ${TARGET_DIR}/bin
${CROSS_TARGET}-pwconv
${CROSS_TARGET}-grpconv
${CROSS_TARGET}-passwd root
cd ..
rm -rf shadow-4.1.4.3
popd
```

The patch `shadow-4.1.4.3-man-ru.patch` contains a fix to `man/ru/Makefile.am` preventing '`make install`' to complete. `automake-1.11` is then run to update the makefile prototype `Makefile.in`.

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

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

The second 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.

The command '`passwd root`' will create the password for the root user, you will need it when logging in as root on your new system.

6.45 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.

```
# 2 minutes
tar xf ${DOWNLOAD_DIR}/sysvinit-2.88dsf.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/sysvinit-2.88dsf
sed -i.orig -e 's@/dev/initctl@$(ROOT)&@g' \
    -e 's@\(mknod \)-m \([0-9]* \)\(.* \)p@\1\3p; chmod \2\3@g' \
    -e '/^ifeq/s/$(ROOT)//' \
    -e 's@/usr/lib@$(ROOT)&@' \
    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
```

```
popd

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

id:3:initdefault:

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

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

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

su:S016:once:/sbin/sulogin

1:2345:respawn:/sbin/agetty 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)/usr/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.

6.46 Tar

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

```
# 8 minutes
tar xf ${DOWNLOAD_DIR}/tar-1.26.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/tar-1.26
cat > config.cache << EOF
gl_cv_func_btowc_eof=yes
ac_cv_func_malloc_0_nonnull=yes
ac_cv_func_realloc_0_nonnull=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_wcrtomb_retval=yes
EOF
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr \
    --bindir=/bin \
    --libexecdir=/usr/sbin \
    --cache-file=config.cache
make
make DESTDIR=${TARGET_DIR} install
cd ..
rm -rf tar-1.26
popd
```

6.47 Texinfo

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

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

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

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.

6.48 Udev

Udev is the dynamic device management of the kernel Linux.

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

6.49 Util-Linux

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

```
# 10 minutes
tar xf ${DOWNLOAD_DIR}/util-linux-2.19.1.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/util-linux-2.19.1
sed -i.orig 's@etc/adjtime@var/lib/hwclock/adjtime@g' \
    hwclock/hwclock.c
mkdir -pv ${TARGET_DIR}/var/lib/hwclock
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --enable-arch \
    --enable-partx \
    --disable-wall \
    --enable-write \
    --disable-makeinstall-chown
make
make DESTDIR=${TARGET_DIR} install
mv -v ${TARGET_DIR}/usr/bin/logger ${TARGET_DIR}/bin
cd ..
rm -r util-linux-2.19.1
popd
```

The `sed` command modifies the location of `adjtime` from the target system's `/etc` directory to its `/lib/hwclock/adjtime` to comply with FHS.

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

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.

6.50 XZ-Utils

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

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/xz-5.0.4.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/xz-5.0.4
./configure \
    --build=${CROSS_HOST} \
    --host=${CROSS_TARGET} \
    --prefix=/usr
make
make DESTDIR=${TARGET_DIR} install
# For FHS compatibility:
#mv -v ${TARGET_DIR}/usr/bin/{xz,lzma,lzcat,unlzma,unxz,xzcat} \
#    ${TARGET_DIR}/bin
cd ..
rm -rf xz-5.0.4
popd
```

6.51 Bootscripts

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

```
# 5 minutes
tar xf ${DOWNLOAD_DIR}/bootscripts-cross-lfs-1.2-pre11.tar.bz2 \
    -C ${BUILD_DIR}
pushd ${BUILD_DIR}/bootscripts-cross-lfs-1.2-pre11
make DESTDIR=${TARGET_DIR} install-bootscripts
make DESTDIR=${TARGET_DIR} install-network
cd ..
rm -rf bootscripts-cross-lfs-1.2-pre11
popd
```

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

6.52 The Kernel

To avoid potential kernel lockup on Loongson 2F machines, we need to add the option `-mfix-loongson2f-jump` to the environment variable `CFLAGS`[4]:

[4] For more information about the issue, see http://groups.google.com/group/loongson-dev/browse_thread/thread/d9103283141c00fb/e9a8830b01cc1913?hide_quotes=no#msg_d44adf83639fb0bd and http://sourceware.org/ml/binutils/2009-11/msg00387.html.

```
sed -i.orig \
    "/CFLAGS/s/-mfix-loongson2f-nop/& -Wa,-mfix-loongson2f-jump/" \
    ~/.bashrc
source ~/.bash_profile
```

Then:

```
tar xf ${DOWNLOAD_DIR}/linux-libre-3.5.4-gnu.tar.bz2 -C ${BUILD_DIR}
pushd ${BUILD_DIR}/linux-3.5.4
make mrproper
```

Then, if you are compiling the kernel for an Yeeloong '2f' netbook:

```
cp arch/mips/configs/lemote2f_defconfig .config
patch -Np1 -i ${DOWNLOAD_DIR}/100gnu+freedo.patch
```

Then, if you want to change the configuration:

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

6.52.1 CPU selection

To know the CPU model you have on a given computer, type '`cat /proc/cpuinfo`' inside a terminal.

```
Machine selection
    System type
        (X) Loongson family of machines
    Machine type
        (X) Lemote Loongson 2F family machines
```

As you will discover when you type '`lspci | grep CS5536`' in a terminal, AMD CS5536 is used for a variety of things on the Yeeloong: ISA bridge, IDE interface, Multimedia audio controller and two USB Controllers. In order to get the correct time, we need to enable the following option:

```
    [*] CS5536 MFGPT Timer
```

Note: MFGPT stands for Multi-Function General Purpose Timer.

MIPS architecture exists in two flavours: big endian and little endian. The difference resides in the order in which the Bytes are stored in the hardware: little endian's first Byte is the least significant one while big endian's first Byte is the most significant one. In our case, we have a little endian architecture, so:

```
Endianess selection
    (X) Little endian

CPU selection
    CPU type
        (X) Loongson 2F
```

If your version of Binutils is 2.20.2 or later, select the following option:

```
CPU selection
    [*] Loongson 2F Workarounds
```

It fixes some issues with the Loongson 2F processors[5].

Then, whatever your version of Binutils is:

[5] For more information about the issue, see http://groups.google.com/group/loongson-dev/browse_thread/thread/d9103283141c00fb/e9a8830b01cc1913?hide_quotes=no#msg_d44adf83639fb0bd and http://sourceware.org/ml/binutils/2009-11/msg00387.html.

```
Kernel type
    Kernel code model
        (X) 64-bit kernel
```

6.52.2 Optimizations

If you want higher performance but with increased memory consumption, select a `Kernel page size` of 16kB:

```
Kernel type
    Kernel page size
        (X) 16kB
```

Then, if you want to reduce the size of your kernel (this may increase decompression time at bootup though):

```
General setup
    Kernel compression mode
        (X) Bzip2
```

Then, whatever your choice:

```
General setup
    [*] Support for paging of anonymous memory (swap)
```

To be able to copy your kernel configuration through kernel versions, you may want to select the following options:

```
General setup
    <*> Kernel .config support
    [*]   Enable access to .config through /proc/config.gz
```

If you want to optimize your kernel for size (but not necessarily for speed), select the following option:

```
General setup
    [*] Optimize for size
```

Selecting this option will use option `-Os` of GCC instead of the default `-O2`.

6.52.3 Compatibility of executables

ELF (Executable and Linkable Format) is a common standard file format for executables, object code, shared libraries, and core dumps.

```
Executable file formats
    [*] Kernel support for ELF binaries
    [*] Kernel support for Linux/MIPS 32-bit binary compatibility
    [*]   Kernel support for o32 binaries
    [*]   Kernel support for n32 binaries
```

6.52.4 Power Management

Power management is a feature that turns off the power or switches the system to a low-power state when inactive.

```
Power management options
    [*] Power Management support
    [*]   Power Management Debug Support
    [*]     Verbose Power Management debugging
    [*] Suspend to RAM and standby
    [*] Hibernation (aka 'suspend to disk')
```

To be able to get information on your battery status, select the following option:

```
Device Drivers
    <*> Power supply class support
        [*]   Power supply debug
```

6.52.5 Network card configuration

The network card is the component of your computer that lets you browse the internet and receive emails, among other things. This section covers both wired and wireless network cards.

6.52.5.1 Ethernet card configuration

To know which ethernet controller you have, type in a terminal:

```
lspci | grep Ethernet
```

In order to build the driver for the RTL-8139 ethernet controller:

```
Device Drivers
    [*] Network device support
        [*] Ethernet (10 or 100Mbit)
            <*>   Realtek RTL-8129/8130/8139 PCI Fast Ethernet Adapter
                  support
```

6.52.5.2 Wireless card configuration

To know which wireless card is connected to your USB port, in a terminal, type:

```
lsusb | grep Wireless
```

To be able to build the option `cfg80211`, which is the current wireless configuration API, *not as a module* inside the kernel, you will have to select the following option first:

```
[*] Networking support
    <*>   RF Switch subsystem support
```

Then:

```
[*] Networking support
    -*- Wireless
        <*> cfg80211 -wireless configuration API
        [*]   cfg80211 wireless extensions compatibility
        <*> Wireless extensions sysfs files
        <*> Common routines for IEEE802.11 drivers
        [*] lib80211 debugging messages
```

mac80211 is a framework which driver developers can use to write drivers for SoftMAC wireless devices[6].

The following option needs to be built *not as a module* in order for the option `Realtek 8187 and 8187B USB support` to be built inside the kernel *not as a module*:

```
[*] Networking support
    -*- Wireless
         <*> Generic IEEE 802.11 Networking stack (mac80211)
```

Enabling EEPROM 93CX6 is required in order to build option `Realtek 8187 and 8187B USB support` inside the kernel:

```
Device Drivers
    [*] Misc devices
        EEPROM support
            -*- EEPROM 93CX6 support
```

If you want built-in support for Realtek 8187 and 8187B:

[6] See http://www.linuxwireless.org/en/developers/Documentation/mac80211/ for more information.

```
Device Drivers
    Network device support
        [*] Wireless LAN
            <*>   Realtek 8187 and 8187B USB support
```

Then:

```
Device Drivers
    [*] USB support
        {*}   Enable Wireless USB extensions (EXPERIMENTAL)
```

6.52.6 Flash media

To know which driver to enable in the kernel, type '`lsusb | grep multicard`' in a terminal.

If you want to enable support for USB keys and SDcard:

```
Device Drivers
    SCSI device support
        <*> SCSI device support
        <*> SCSI disk support

    [*] USB support
        <M>   USB Mass Storage support

    <*> MMC/SD/SDIO card support
        <*>   USB SD Host Controller (USHC) support
```

6.52.7 File Systems

By default, we recommend using Ext3 filesystem:

```
File systems
    <*> Ext3 journalling file system support
```

If you don't need support for RAID or LVM:

```
Device Drivers
    [ ] Multiple devices driver support (RAID and LVM)
```

6.52.8 Input devices

To configure Keyboard:

```
Device Drivers
    Input device support
        [*]   Keyboards
            <*>   AT keyboard
        [*]   Mice
            <*>   PS/2 mouse
            <*>     Synaptics PS/2 mouse protocol extension
```

6.52.9 Display

To know your VGA (Video Graphics Array) controller model (VGA refers to display hardware), type '`lspci | grep VGA`' in a terminal. A *framebuffer* is a video output device that drives a video display from a memory buffer containing a complete frame of data[7].

```
Device Drivers
    Graphics support
```

[7] For more information, see http://en.wikipedia.org/wiki/Framebuffer.

```
        <*> Support for frame buffer devices
            <M>   Userspace VESA VGA graphics support
        Console display driver support
            <*> Framebuffer Console support
            -*-   VGA 8x16 font

    [*] Staging drivers
        <*>      Silicon Motion SM7XX Frame Buffer Support
```

6.52.10 Unicode support

Unicode is a computing industry standard for the consistent encoding, representation and handling of text expressed in most of the world's writing systems[8].

```
File systems
    -*- Native language support
        <*>   NLS UTF-8
```

6.52.11 Kernel Compilation

```
# 2 hours and 40 minutes
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
cp System.map ${TARGET_DIR}/boot/System.map
cp .config ${TARGET_DIR}/boot/config
cd ..
popd
```

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

[8] For more information, read http://en.wikipedia.org/wiki/Unicode.

7 Creating Required Configuration Files for the New System

7.1 File for Time Setup

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

UTC=1

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

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 environement 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 3.7 [Environment Variables Setup], page 8.

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

```
pushd ${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
popd
```

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

7.6.2 Setting up Network Dynamic Address

```
pushd ${TARGET_DIR}/etc/sysconfig/network-devices
mkdir -v ifconfig.eth0
cat > ifconfig.eth0/ip << "EOF"
ONBOOT=yes
SERVICE=dhcpcd
DHCP_START="-t10"
DHCP_STOP="-k"
EOF
popd
```

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/hda4        /            ext3     defaults         1    1
/dev/hda3        swap         swap     pri=1            0    0
proc             /proc        proc     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 The End

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
pushd ${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 *
```

We archive the entire system by using the following command:

```
# 20 minutes without kernel sources nor cross-tools
tar -cjf gllfsc-20121006.tar.bz2 bin boot dev etc home lib* media \
    mnt opt proc root sbin srv sys tmp usr var
# 60 minutes with kernel sources + cross-tools
#tar -cjf gllfsc-20121006.tar.bz2 *
```

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

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 59).

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 drive[1]. A minimal `/boot.cfg` could be:

```
default 0
timeout 2
showmenu 1

title  GLLFSC
kernel (wd0,3)/boot/vmlinuz
args   console=tty no_auto_cmd root=/dev/hda4 rootdelay=8 machtype=8.9
```

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

9 Further Readings

Haiyong Sun's website (in Chinese): http://youbest.cublog.cn. 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.cross-lfs.org. 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.cross-lfs.org. 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 team[1] is a group of programmers that share the following philosophy[2]:

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

The simple and lightweight programs released by this team are interesting for machines based on Loongson 2F processor as performance is limited compared to current x86 processors.

[1] http://suckless.org

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

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Version 3, 29 June 2007

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```

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
```

```
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```

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