Linux From Scratch

Version 20160304-systemd

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Preface

My journey to learn and better understand Linux began over a decade ago, back in 1998. I had just installed my first Linux distribution and had quickly become intrigued with the whole concept and philosophy behind Linux.

There are always many ways to accomplish a single task. The same can be said about Linux distributions. A great many have existed over the years. Some still exist, some have morphed into something else, yet others have been relegated to our memories. They all do things differently to suit the needs of their target audience. Because so many different ways to accomplish the same end goal exist, I began to realize I no longer had to be limited by any one implementation. Prior to discovering Linux, we simply put up with issues in other Operating Systems as you had no choice. It was what it was, whether you liked it or not. With Linux, the concept of choice began to emerge. If you didn't like something, you were free, even encouraged, to change it.

I tried a number of distributions and could not decide on any one. They were great systems in their own right. It wasn't a matter of right and wrong anymore. It had become a matter of personal taste. With all that choice available, it became apparent that there would not be a single system that would be perfect for me. So I set out to create my own Linux system that would fully conform to my personal preferences.

To truly make it my own system, I resolved to compile everything from source code instead of using pre-compiled binary packages. This “perfect” Linux system would have the strengths of various systems without their perceived weaknesses. At first, the idea was rather daunting. I remained committed to the idea that such a system could be built.

After sorting through issues such as circular dependencies and compile-time errors, I finally built a custom-built Linux system. It was fully operational and perfectly usable like any of the other Linux systems out there at the time. But it was my own creation. It was very satisfying to have put together such a system myself. The only thing better would have been to create each piece of software myself. This was the next best thing.

As I shared my goals and experiences with other members of the Linux community, it became apparent that there was a sustained interest in these ideas. It quickly became plain that such custom-built Linux systems serve not only to meet user specific requirements, but also serve as an ideal learning opportunity for programmers and system administrators to enhance their (existing) Linux skills. Out of this broadened interest, the Linux From Scratch Project was born.

This Linux From Scratch book is the central core around that project. It provides the background and instructions necessary for you to design and build your own system. While this book provides a template that will result in a correctly working system, you are free to alter the instructions to suit yourself, which is, in part, an important part of this project. You remain in control; we just lend a helping hand to get you started on your own journey.

I sincerely hope you will have a great time working on your own Linux From Scratch system and enjoy the numerous benefits of having a system that is truly your own.

--
Gerard Beekmans
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Audience

There are many reasons why you would want to read this book. One of the questions many people raise is, “why go through all the hassle of manually building a Linux system from scratch when you can just download and install an existing one?”
One important reason for this project’s existence is to help you learn how a Linux system works from the inside out. Building an LFS system helps demonstrate what makes Linux tick, and how things work together and depend on each other. One of the best things that this learning experience can provide is the ability to customize a Linux system to suit your own unique needs.

Another key benefit of LFS is that it allows you to have more control over the system without relying on someone else’s Linux implementation. With LFS, you are in the driver's seat and dictate every aspect of the system.

LFS allows you to create very compact Linux systems. When installing regular distributions, you are often forced to install a great many programs which are probably never used or understood. These programs waste resources. You may argue that with today's hard drive and CPUs, such resources are no longer a consideration. Sometimes, however, you are still constrained by size considerations if nothing else. Think about bootable CDs, USB sticks, and embedded systems. Those are areas where LFS can be beneficial.

Another advantage of a custom built Linux system is security. By compiling the entire system from source code, you are empowered to audit everything and apply all the security patches desired. It is no longer necessary to wait for somebody else to compile binary packages that fix a security hole. Unless you examine the patch and implement it yourself, you have no guarantee that the new binary package was built correctly and adequately fixes the problem.

The goal of Linux From Scratch is to build a complete and usable foundation-level system. If you do not wish to build your own Linux system from scratch, you may not entirely benefit from the information in this book.

There are too many other good reasons to build your own LFS system to list them all here. In the end, education is by far the most powerful of reasons. As you continue in your LFS experience, you will discover the power that information and knowledge truly bring.

**LFS Target Architectures**

The primary target architectures of LFS are the AMD/Intel x86 (32-bit) and x86_64 (64-bit) CPUs. On the other hand, the instructions in this book are also known to work, with some modifications, with the Power PC and ARM CPUs. To build a system that utilizes one of these CPUs, the main prerequisite, in addition to those on the next few pages, is an existing Linux system such as an earlier LFS installation, Ubuntu, Red Hat/Fedora, SuSE, or other distribution that targets the architecture that you have. Also note that a 32-bit distribution can be installed and used as a host system on a 64-bit AMD/Intel computer.

Some other facts about 64-bit systems need to be added here. When compared to a 32-bit system, the sizes of executable programs are slightly larger and the execution speeds are only slightly faster. For example, in a test build of LFS-6.5 on a Core2Duo CPU based system, the following statistics were measured:

<table>
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<th>Architecture</th>
<th>Build Time</th>
<th>Build Size</th>
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<tr>
<td>32-bit</td>
<td>198.5 minutes</td>
<td>648 MB</td>
</tr>
<tr>
<td>64-bit</td>
<td>190.6 minutes</td>
<td>709 MB</td>
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As you can see, the 64-bit build is only 4% faster and is 9% larger than the 32-bit build. The gain from going to a 64-bit system is relatively minimal. Of course, if you have more than 4GB of RAM or want to manipulate data that exceeds 4GB, the advantages of a 64-bit system are substantial.

The default 64-bit build that results from LFS is considered a "pure" 64-bit system. That is, it supports 64-bit executables only. Building a "multi-lib" system requires compiling many applications twice, once for a 32-bit system and once for a 64-bit system. This is not directly supported in LFS because it would interfere with the educational objective of providing the instructions needed for a straightforward base Linux system. You can refer to the *Cross Linux From Scratch* project for this advanced topic.
LFS and Standards

The structure of LFS follows Linux standards as closely as possible. The primary standards are:

- **POSIX.1-2008.**
- **Filesystem Hierarchy Standard (FHS) Version 3.0**
- **Linux Standard Base (LSB) Version 5.0**

The LSB has four separate standards: Core, Desktop, Runtime Languages, and Imaging. In addition to generic requirements there are also architecture specific requirements. There are also two areas for trial use: Gtk3 and Graphics. LFS attempts to conform to the architectures discussed in the previous section.

### Note

Many people do not agree with the requirements of the LSB. The main purpose of defining it is to ensure that proprietary software will be able to be installed and run properly on a compliant system. Since LFS is source based, the user has complete control over what packages are desired and many choose not to install some packages that are specified by the LSB.

Creating a complete LFS system capable of passing the LSB certifications tests is possible, but not without many additional packages that are beyond the scope of LFS. These additional packages have installation instructions in BLFS.

#### Packages supplied by LFS needed to satisfy the LSB Requirements

- **LSB Core:** Bash, Bc, Binutils, Coreutils, Diffutils, File, Findutils, Gawk, Grep, GTK+2, Gzip, M4, Man-DB, Ncurses, Procps, Psmisc, Sed, Shadow, Tar, Util-linux, Zlib

- **LSB Desktop:** None

- **LSB Runtime Languages:** Perl

- **LSB Imaging:** None

- **LSB Gtk3 and LSB Graphics (Trial Use):** None

#### Packages supplied by BLFS needed to satisfy the LSB Requirements

- **LSB Core:** At, Batch (a part of At), Cpio, Ed, Fcrontab, Initd-tools, Lsb_release, NSPR, NSS, PAM, Pax, Sendmail (or Postfix or Exim), time

- **LSB Desktop:** Alsa, ATK, Cairo, Desktop-file-utils, Freetype, Fontconfig, Gdk-pixbuf, Glib2, Icon-naming-utils, Libjpeg-turbo, Libpng, Libtiff, Libxml2, MesaLib, Pango, Qt4, Xdg-utils, Xorg

- **LSB Runtime Languages:** Python, Libxml2, Libxslt

- **LSB Imaging:** CUPS, Cups-filters, Ghostscript, SANE

- **LSB Gtk3 and LSB Graphics (Trial Use):** GTK+3

#### Packages not supplied by LFS or BLFS needed to satisfy the LSB Requirements

- **LSB Core:** None
- **LSB Desktop:** None
- **LSB Runtime Languages:** None
- **LSB Imaging:** None
Rationale for Packages in the Book

As stated earlier, the goal of LFS is to build a complete and usable foundation-level system. This includes all packages needed to replicate itself while providing a relatively minimal base from which to customize a more complete system based on the choices of the user. This does not mean that LFS is the smallest system possible. Several important packages are included that are not strictly required. The lists below document the rationale for each package in the book.

- **Acl**
  This package contains utilities to administer Access Control Lists, which are used to define more fine-grained discretionary access rights for files and directories.

- **Attr**
  This package contains programs for administering extended attributes on filesystem objects.

- **Autoconf**
  This package contains programs for producing shell scripts that can automatically configure source code from a developer's template. It is often needed to rebuild a package after updates to the build procedures.

- **Automake**
  This package contains programs for generating Make files from a template. It is often needed to rebuild a package after updates to the build procedures.

- **Bash**
  This package satisfies an LSB core requirement to provide a Bourne Shell interface to the system. It was chosen over other shell packages because of its common usage and extensive capabilities beyond basic shell functions.

- **Bc**
  This package provides an arbitrary precision numeric processing language. It satisfies a requirement needed when building the Linux kernel.

- **Binutils**
  This package contains a linker, an assembler, and other tools for handling object files. The programs in this package are needed to compile most of the packages in an LFS system and beyond.

- **Bison**
  This package contains the GNU version of yacc (Yet Another Compiler Compiler) needed to build several other LFS programs.

- **Bzip2**
  This package contains programs for compressing and decompressing files. It is required to decompress many LFS packages.

- **Check**
  This package contains a test harness for other programs. It is only installed in the temporary toolchain.

- **Coreutils**
  This package contains a number of essential programs for viewing and manipulating files and directories. These programs are needed for command line file management, and are necessary for the installation procedures of every package in LFS.
• D-Bus
  This package contains programs to implement a message bus system, which a simple way for applications to talk
to one another. It is required by systemd.

• DejaGNU
  This package contains a framework for testing other programs. It is only installed in the temporary toolchain.

• Diffutils
  This package contains programs that show the differences between files or directories. These programs can be used
to create patches, and are also used in many packages' build procedures.

• E2fsprogs
  This package contains the utilities for handling the ext2, ext3 and ext4 file systems. These are the most common
and thoroughly tested file systems that Linux supports.

• Expat
  This package contains a relatively small XML parsing library. It is required by the XML::Parser Perl module.

• Expect
  This package contains a program for carrying out scripted dialogues with other interactive programs. It is
commonly used for testing other packages. It is only installed in the temporary toolchain.

• File
  This package contains a utility for determining the type of a given file or files. A few packages need it to build.

• Findutils
  This package contains programs to find files in a file system. It is used in many packages' build scripts.

• Flex
  This package contains a utility for generating programs that recognize patterns in text. It is the GNU version of the
lex (lexical analyzer) program. It is required to build several LFS packages.

• Gawk
  This package contains programs for manipulating text files. It is the GNU version of awk (Aho-Weinberg-
Kernighan). It is used in many other packages' build scripts.

• Gcc
  This package is the Gnu Compiler Collection. It contains the C and C++ compilers as well as several others not
built by LFS.

• GDBM
  This package contains the GNU Database Manager library. It is used by one other LFS package, Man-DB.

• Gettext
  This package contains utilities and libraries for internationalization and localization of numerous packages.

• Glibc
  This package contains the main C library. Linux programs would not run without it.

• GMP
This package contains math libraries that provide useful functions for arbitrary precision arithmetic. It is required to build Gcc.

- **Gperf**
  This package contains a program that generates a perfect hash function from a key set. It is required for systemd.

- **Grep**
  This package contains programs for searching through files. These programs are used by most packages' build scripts.

- **Groff**
  This package contains programs for processing and formatting text. One important function of these programs is to format man pages.

- **GRUB**
  This package is the Grand Unified Boot Loader. It is one of several boot loaders available, but is the most flexible.

- **Gzip**
  This package contains programs for compressing and decompressing files. It is needed to decompress many packages in LFS and beyond.

- **Iana-etc**
  This package provides data for network services and protocols. It is needed to enable proper networking capabilities.

- **Inetutils**
  This package contains programs for basic network administration.

- **Intltool**
  This package contains tools for extracting translatable strings from source files.

- **IProute2**
  This package contains programs for basic and advanced IPv4 and IPv6 networking. It was chosen over the other common network tools package (net-tools) for its IPv6 capabilities.

- **Kbd**
  This package contains key-table files, keyboard utilities for non-US keyboards, and a number of console fonts.

- **Kmod**
  This package contains programs needed to administer Linux kernel modules.

- **Less**
  This package contains a very nice text file viewer that allows scrolling up or down when viewing a file. It is also used by Man-DB for viewing manpages.

- **Libcap**
  This package implements the user-space interfaces to the POSIX 1003.1e capabilities available in Linux kernels.

- **Libpipeline**
  The Libpipeline package contains a library for manipulating pipelines of subprocesses in a flexible and convenient way. It is required by the Man-DB package.
• Libtool
  This package contains the GNU generic library support script. It wraps the complexity of using shared libraries in a consistent, portable interface. It is needed by the test suites in other LFS packages.

• Linux Kernel
  This package is the Operating System. It is the Linux in the GNU/Linux environment.

• M4
  This package contains a general text macro processor useful as a build tool for other programs.

• Make
  This package contains a program for directing the building of packages. It is required by almost every package in LFS.

• Man-DB
  This package contains programs for finding and viewing man pages. It was chosen instead of the man package due to superior internationalization capabilities. It supplies the man program.

• Man-pages
  This package contains the actual contents of the basic Linux man pages.

• MPC
  This package contains functions for the arithmetic of complex numbers. It is required by Gcc.

• MPFR
  This package contains functions for multiple precision arithmetic. It is required by Gcc.

• Ncurses
  This package contains libraries for terminal-independent handling of character screens. It is often used to provide cursor control for a menuing system. It is needed by a number of packages in LFS.

• Patch
  This package contains a program for modifying or creating files by applying a patch file typically created by the diff program. It is needed by the build procedure for several LFS packages.

• Perl
  This package is an interpreter for the runtime language PERL. It is needed for the installation and test suites of several LFS packages.

• Pkg-config
  This package provides a program to return meta-data about an installed library or package.

• Procps-NG
  This package contains programs for monitoring processes. These programs are useful for system administration, and are also used by the LFS Bootscripts.

• Psmisc
  This package contains programs for displaying information about running processes. These programs are useful for system administration.

• Readline
This package is a set of libraries that offers command-line editing and history capabilities. It is used by Bash.

- **Sed**
  This package allows editing of text without opening it in a text editor. It is also needed by most LFS packages' configure scripts.

- **Shadow**
  This package contains programs for handling passwords in a secure way.

- **Systemd**
  This package provides an init program and several additional boot and system control capabilities as an alternative to Sysvinit. It is used by many Linux distributions.

- **Tar**
  This package provides archiving and extraction capabilities of virtually all packages used in LFS.

- **Tcl**
  This package contains the Tool Command Language used in many test suites in LFS packages. It is only installed in the temporary toolchain.

- **Texinfo**
  This package contains programs for reading, writing, and converting info pages. It is used in the installation procedures of many LFS packages.

- **Util-linux**
  This package contains miscellaneous utility programs. Among them are utilities for handling file systems, consoles, partitions, and messages.

- **Vim**
  This package contains an editor. It was chosen because of its compatibility with the classic vi editor and its huge number of powerful capabilities. An editor is a very personal choice for many users and any other editor could be substituted if desired.

- **XML::Parser**
  This package is a Perl module that interfaces with Expat.

- **XZ Utils**
  This package contains programs for compressing and decompressing files. It provides the highest compression generally available and is useful for decompressing packages in XZ or LZMA format.

- **Zlib**
  This package contains compression and decompression routines used by some programs.

**Prerequisites**

Building an LFS system is not a simple task. It requires a certain level of existing knowledge of Unix system administration in order to resolve problems and correctly execute the commands listed. In particular, as an absolute minimum, you should already have the ability to use the command line (shell) to copy or move files and directories, list directory and file contents, and change the current directory. It is also expected that you have a reasonable knowledge of using and installing Linux software.
Because the LFS book assumes at least this basic level of skill, the various LFS support forums are unlikely to be able to provide you with much assistance in these areas. You will find that your questions regarding such basic knowledge will likely go unanswered or you will simply be referred to the LFS essential pre-reading list.

Before building an LFS system, we recommend reading the following HOWTOs:

- Software-Building-HOWTO http://www.tldp.org/HOWTO/Software-Building-HOWTO.html
  This is a comprehensive guide to building and installing “generic” Unix software packages under Linux. Although it was written some time ago, it still provides a good summary of the basic techniques needed to build and install software.

- The Linux Users’ Guide http://tldp.org/pub/Linux/docs/ldp-archived/users-guide/
  This guide covers the usage of assorted Linux software. This reference is also fairly old, but still valid.

### Host System Requirements

Your host system should have the following software with the minimum versions indicated. This should not be an issue for most modern Linux distributions. Also note that many distributions will place software headers into separate packages, often in the form of “<package-name>-devel” or “<package-name>-dev”. Be sure to install those if your distribution provides them.

Earlier versions of the listed software packages may work, but has not been tested.

- Bash-3.2 (/bin/sh should be a symbolic or hard link to bash)
- Binutils-2.17 (Versions greater than 2.26 are not recommended as they have not been tested)
- Bison-2.3 (/usr/bin/yacc should be a link to bison or small script that executes bison)
- Bzip2-1.0.4
- Coreutils-6.9
- Diffutils-2.8.1
- Findutils-4.2.31
- Gawk-4.0.1 (/usr/bin/awk should be a link to gawk)
- GCC-4.7 including the C++ compiler, g++ (Versions greater than 5.3.0 are not recommended as they have not been tested)

#### Note

On some distributions, there have been reports that some libraries used by gcc can be in an inconsistent state and that this interferes with building some LFS packages. To check this, look in /usr/lib and possibly /usr/lib64 for libgmp.la, libmpfr.la, and libmpc.la. Either all three should be present or absent, but not only one or two. If the problem exists on your system, either rename or delete the .la files or install the appropriate missing package.

- Glibc-2.11 (Versions greater than 2.23 are not recommended as they have not been tested)
- Grep-2.5.1a
- Gzip-1.3.12
- Linux Kernel-2.6.32

The reason for the kernel version requirement is that we specify that version when building glibc in Chapter 6 at the recommendation of the developers. It is also required by udev.
If the host kernel is earlier than 2.6.32 you will need to replace the kernel with a more up to date version. There are two ways you can go about this. First, see if your Linux vendor provides a 2.6.32 or later kernel package. If so, you may wish to install it. If your vendor doesn't offer an acceptable kernel package, or you would prefer not to install it, you can compile a kernel yourself. Instructions for compiling the kernel and configuring the boot loader (assuming the host uses GRUB) are located in Chapter 8.

- M4-1.4.10
- Make-3.81
- Patch-2.5.4
- Perl-5.8.8
- Sed-4.1.5
- Tar-1.18
- Texinfo-4.7
- Xz-5.0.0

Note that the symlinks mentioned above are required to build an LFS system using the instructions contained within this book. Symlinks that point to other software (such as dash, mawk, etc.) may work, but are not tested or supported by the LFS development team, and may require either deviation from the instructions or additional patches to some packages.
To see whether your host system has all the appropriate versions, and the ability to compile programs, run the following:

```bash
cat > version-check.sh << "EOF"
#!/bin/bash
# Simple script to list version numbers of critical development tools
export LC_ALL=C
bash --version | head -n1 | cut -d" " -f2-4
MYSH=$(readlink -f /bin/sh)
echo "/bin/sh -> $MYSH"
echo $MYSH | grep -q bash || echo "ERROR: /bin/sh does not point to bash"
unset MYSH

echo -n "Binutils: "; ld --version | head -n1 | cut -d" " -f3-
bison --version | head -n1

if [ -h /usr/bin/yacc ]; then
    echo "/usr/bin/yacc -> `readlink -f /usr/bin/yacc`";
elif [ -x /usr/bin/yacc ]; then
    echo yacc is "/usr/bin/yacc --version | head -n1`
else
    echo "yacc not found"
fi

bzip2 --version 2>&1 < /dev/null | head -n1 | cut -d" " -f1,6-
echo -n "Coreutils: "; chown --version | head -n1 | cut -d")" -f2
diff --version | head -n1
find --version | head -n1
gawk --version | head -n1

if [ -h /usr/bin/awk ]; then
    echo "/usr/bin/awk -> `readlink -f /usr/bin/awk`";
elif [ -x /usr/bin/awk ]; then
    echo awk is "/usr/bin/awk --version | head -n1`
else
    echo "awk not found"
fi
```

<table>
<thead>
<tr>
<th>Command</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>gcc --version</td>
<td>head -n1</td>
</tr>
<tr>
<td>g++ --version</td>
<td>head -n1</td>
</tr>
<tr>
<td>ldd --version head -n1</td>
<td>cut -d&quot; &quot; -f2- glibc version</td>
</tr>
<tr>
<td>grep --version</td>
<td>head -n1</td>
</tr>
<tr>
<td>gzip --version</td>
<td>head -n1</td>
</tr>
<tr>
<td>cat /proc/version</td>
<td></td>
</tr>
<tr>
<td>m4 --version</td>
<td>head -n1</td>
</tr>
<tr>
<td>make --version</td>
<td>head -n1</td>
</tr>
<tr>
<td>patch --version</td>
<td>head -n1</td>
</tr>
<tr>
<td>echo Perl <code>perl -V:version</code></td>
<td></td>
</tr>
<tr>
<td>sed --version</td>
<td>head -n1</td>
</tr>
<tr>
<td>tar --version</td>
<td>head -n1</td>
</tr>
<tr>
<td>makeinfo --version</td>
<td>head -n1</td>
</tr>
<tr>
<td>xz --version</td>
<td>head -n1</td>
</tr>
</tbody>
</table>
echo 'int main(){}' > dummy.c && g++ -o dummy dummy.c
if [ -x dummy ]; then echo "g++ compilation OK"; else echo "g++ compilation failed"; fi
rm -f dummy.c dummy

bash version-check.sh

Also check for some library consistency:

cat > library-check.sh << "EOF"
#!/bin/bash
for lib in lib{gmp,mpfr,mpc}.la; do
  echo $lib: $(if find /usr/lib* -name $lib|grep -q $lib;then :;else echo not;fi) found
done
unset lib
EOF
bash library-check.sh

The files identified by this script should be all present or all absent, but not only one or two present.

**Typography**

To make things easier to follow, there are a few typographical conventions used throughout this book. This section contains some examples of the typographical format found throughout Linux From Scratch.

```
./configure --prefix=/usr
```

This form of text is designed to be typed exactly as seen unless otherwise noted in the surrounding text. It is also used in the explanation sections to identify which of the commands is being referenced.

In some cases, a logical line is extended to two or more physical lines with a backslash at the end of the line.

```
CC="gcc -B/usr/bin/" ../binutils-2.18/configure \ --prefix=/tools --disable-nls --disable-werror
```

Note that the backslash must be followed by an immediate return. Other whitespace characters like spaces or tab characters will create incorrect results.

```
install-info: unknown option '--dir-file=/mnt/lfs/usr/info/dir'
```

This form of text (fixed-width text) shows screen output, usually as the result of commands issued. This format is also used to show filenames, such as /etc/ld.so.conf.

**Emphasis**

This form of text is used for several purposes in the book. Its main purpose is to emphasize important points or items.
This format is used for hyperlinks both within the LFS community and to external pages. It includes HOWTOs, download locations, and websites.

```bash
cat > $LFS/etc/group << "EOF"
root:x:0:
bin:x:1:
......
EOF
```

This format is used when creating configuration files. The first command tells the system to create the file `$LFS/etc/group` from whatever is typed on the following lines until the sequence End Of File (EOF) is encountered. Therefore, this entire section is generally typed as seen.

<REPLACED TEXT>

This format is used to encapsulate text that is not to be typed as seen or for copy-and-paste operations.

[OPTIONAL TEXT]

This format is used to encapsulate text that is optional.

`passwd(5)`

This format is used to refer to a specific manual (man) page. The number inside parentheses indicates a specific section inside the manuals. For example, `passwd` has two man pages. Per LFS installation instructions, those two man pages will be located at `/usr/share/man/man1/passwd.1` and `/usr/share/man/man5/passwd.5`. When the book uses `passwd(5)` it is specifically referring to `/usr/share/man/man5/passwd.5`. `man passwd` will print the first man page it finds that matches “passwd”, which will be `/usr/share/man/man1/passwd.1`. For this example, you will need to run `man 5 passwd` in order to read the specific page being referred to. It should be noted that most man pages do not have duplicate page names in different sections. Therefore, `man <program name>` is generally sufficient.

**Structure**

This book is divided into the following parts.

**Part I - Introduction**

Part I explains a few important notes on how to proceed with the LFS installation. This section also provides meta-information about the book.

**Part II - Preparing for the Build**

Part II describes how to prepare for the building process—making a partition, downloading the packages, and compiling temporary tools.

**Part III - Building the LFS System**

Part III guides the reader through the building of the LFS system—compiling and installing all the packages one by one, setting up the boot scripts, and installing the kernel. The resulting Linux system is the foundation on which other software can be built to expand the system as desired. At the end of this book, there is an easy to use reference listing all of the programs, libraries, and important files that have been installed.
Errata

The software used to create an LFS system is constantly being updated and enhanced. Security warnings and bug fixes may become available after the LFS book has been released. To check whether the package versions or instructions in this release of LFS need any modifications to accommodate security vulnerabilities or other bug fixes, please visit http://www.linuxfromscratch.org/lfs/errata/systemd/ before proceeding with your build. You should note any changes shown and apply them to the relevant section of the book as you progress with building the LFS system.
Part I. Introduction
Chapter 1. Introduction

1.1. How to Build an LFS System

The LFS system will be built by using an already installed Linux distribution (such as Debian, OpenMandriva, Fedora, or openSUSE). This existing Linux system (the host) will be used as a starting point to provide necessary programs, including a compiler, linker, and shell, to build the new system. Select the “development” option during the distribution installation to be able to access these tools.

As an alternative to installing a separate distribution onto your machine, you may wish to use a LiveCD from a commercial distribution.

Chapter 2 of this book describes how to create a new Linux native partition and file system. This is the place where the new LFS system will be compiled and installed. Chapter 3 explains which packages and patches need to be downloaded to build an LFS system and how to store them on the new file system. Chapter 4 discusses the setup of an appropriate working environment. Please read Chapter 4 carefully as it explains several important issues you need be aware of before beginning to work your way through Chapter 5 and beyond.

Chapter 5 explains the installation of a number of packages that will form the basic development suite (or toolchain) which is used to build the actual system in Chapter 6. Some of these packages are needed to resolve circular dependencies—for example, to compile a compiler, you need a compiler.

Chapter 5 also shows you how to build a first pass of the toolchain, including Binutils and GCC (first pass basically means these two core packages will be reinstalled). The next step is to build Glibc, the C library. Glibc will be compiled by the toolchain programs built in the first pass. Then, a second pass of the toolchain will be built. This time, the toolchain will be dynamically linked against the newly built Glibc. The remaining Chapter 5 packages are built using this second pass toolchain. When this is done, the LFS installation process will no longer depend on the host distribution, with the exception of the running kernel.

This effort to isolate the new system from the host distribution may seem excessive. A full technical explanation as to why this is done is provided in Section 5.2, “Toolchain Technical Notes”.

In Chapter 6, the full LFS system is built. The chroot (change root) program is used to enter a virtual environment and start a new shell whose root directory will be set to the LFS partition. This is very similar to rebooting and instructing the kernel to mount the LFS partition as the root partition. The system does not actually reboot, but instead uses chroot because creating a bootable system requires additional work which is not necessary just yet. The major advantage is that “chrooting” allows you to continue using the host system while LFS is being built. While waiting for package compilations to complete, you can continue using your computer as normal.

To finish the installation, the basic system configuration is set up in Chapter 7, and the kernel and boot loader are set up in Chapter 8. Chapter 9 contains information on continuing the LFS experience beyond this book. After the steps in this book have been implemented, the computer will be ready to reboot into the new LFS system.

This is the process in a nutshell. Detailed information on each step is discussed in the following chapters and package descriptions. Items that may seem complicated will be clarified, and everything will fall into place as you embark on the LFS adventure.

1.2. What's new since the last release

Below is a list of package updates made since the previous release of the book.
Upgraded to:

- Binutils 2.26
- Coreutils 8.25
- D-Bus-1.10.6
- E2fsprogs 1.42.13
- File 5.25
- Findutils 4.6.0
- Flex 2.6.0
- GCC 5.3.0
- Gettext 0.19.7
- Glibc 2.23
- GMP 6.1.0
- Grep 2.23
- IPRoute2 4.4.0
- Kmod 22
- Less 481
- Libcap-2.25
- Linux 4.4.2
- Man-DB 2.7.5
- Man-pages 4.04
- Perl 5.22.1
- Pkg-config 0.29
- Systemd 229
- Texinfo 6.1
- Tzdata 2016a
- Util-Linux 2.27.1
- XZ-Utils 5.2.2

Added:

- bash-4.3.30-upstream_fixes-3.patch
- binutils-2.26-upstream_fix-2.patch
- mpfr-3.1.3-upstream_fixes-2.patch

Removed:
1.3. Changelog

This is version 20160304-systemd of the Linux From Scratch book, dated March 04, 2016. If this book is more than six months old, a newer and better version is probably already available. To find out, please check one of the mirrors via http://www.linuxfromscratch.org/mirrors.html.

Below is a list of changes made since the previous release of the book.

Changelog Entries:

- 2016-03-04
  - [dj] - Prevent attr and shadow from overwriting man pages installed by the man-pages package - Merged from trunk.
  - [dj] - Retain flex static library for automake regression tests. Remove at the end of Chapter 6 - Merged from trunk.

- 2016-02-19
  - [dj] - Update to glibc-2.23 - Merged from trunk.
  - [dj] - Update to linux-4.4.2 - Merged from trunk.

- 2016-02-16
  - [renodr] - Add patches for mpfr, binutils, gcc, glibc, and bash

- 2016-02-15
  - [dj] - Update package timings and statistics.

- 2016-02-13
  - [dj] - Add description for base32 in coreutils.
  - [dj] - Updated to systemd-229.
  - [Chris] - Removed obsolete --dbus* switches from systemd installation - current systemd sets reasonable defaults for D-Bus files.

- 2016-02-09
  - [dj] - Updated to texinfo-6.1.

- 2016-02-06
  - [dj] - Updated to grep-2.23 - Merged from trunk.
  - [dj] - Updated to linux-4.1.1 - Merged from trunk.
  - [dj] - Updated to binutils-2.26 - Merged from trunk.
  - [dj] - Updated to tzdata-2016a - Merged from trunk.

- 2016-02-01
  - [dj] - Updated to libcap-2.25.
- 2016-01-29
  - [dj] - Corrected installation of nscd configuration after move to in-tree build directory for glibc.
- 2016-01-28
  - [dj] - Move external build directories into dedicated build directories inside the source tree for binutils, gcc, and glibc - Merged from trunk.
- 2016-01-24
  - [dj] - Update to coreutils-8.25 - Merged from trunk.
  - [dj] - Simplify bash installation procedures - Merged from trunk.
- 2016-01-17
  - [dj] - Sync to LFS r10986.
  - [dj] - Update to linux-4.4 - Merged from trunk.
  - [dj] - Update to iproute2-4.4.0 - Merged from trunk.
- 2016-01-02
  - [dj] - Fix build of systemd with libblkid and libmount in /tools/lib and move util-linux to its previous build order to solve reciprocal dependency.
  - [dj] - Removed /etc/resolv.conf symlink in network configuration as it is created automatically if needed.
- 2016-01-17
  - [dj] - Fix broken build order - movexz, kmod, gettext, and util-linux before systemd.
  - [dj] - Update to man-pages-4.04 - Merged from trunk.
- 2015-12-31
  - [dj] - Use 'ipv4" instead of "yes" for DCHP configuration in systemd-networkd configuration.
  - [dj] - Modify text in network configuration page to more accurately reflect current version of systemd.
  - [dj] - Change build order for gperf before expat.
  - [dj] - Change build order for systemd before procps-ng.
  - [dj] - Add --with-systemd to procps-ng configuration.
  - [dj] - Update to systemd-228.
  - [dj] - Update to DBus-1.10.6.
  - [dj] - Sync to LFS r10981.
  - [dj] - Add OpenSSL as optional kernel dependency - Merged from trunk.
  - [dj] - Update to findutils-4.6.0 - Merged from trunk.
  - [dj] - Update to gettext-0.19.7 - Merged from trunk.
  - [dj] - Update to linux-4.3.3 - Merged from trunk.
  - [dj] - Reword FHS Compliance Note - Merged from trunk.
  - [dj] - Update to perl-5.22.1 - Merged from trunk.
  - [dj] - Update to perl-5.22.1 - Merged from trunk.
  - [dj] - Update to man-pages-4.03 - Merged from trunk.
• [dj] - Fix xz problem identified upstream - Merged from trunk.
• [dj] - Update to gcc-5.3.0 - Merged from trunk.
• [dj] - Update to gmp-6.1.0 - Merged from trunk.
• [dj] - Update host requirements to require GCC-4.7 or later - Merged from trunk.
• [dj] - Clarify that setting and using the LFS variable assumes the bash shell - Merged from trunk.
• [dj] - Update to flex-2.6.0 - Merged from trunk.
• [dj] - Update to man-db-2.7.5 - Merged from trunk.
• [dj] - Update to kmod-22 - Merged from trunk.
• [dj] - Add glibc-2.22-largefile-1.patch.
• [dj] - Update to linux-4.3 - Merged from trunk.
• [dj] - Update to iproute2-4.3.0 - Merged from trunk.
• [dj] - Update to grep-2.22 - Merged from trunk.
• [dj] - Update to util-linux-2.27.1 - Merged from trunk.
• [dj] - Revise version-check.sh to flag bad /bin/sh symlinks - Merged from trunk.
• [dj] - Update to less-481 - Merged from trunk.
• [dj] - Update to man-db-2.7.4 - Merged from trunk.
• [dj] - Update to tzdata2015g - Merged from trunk.
• [dj] - Many updates to installed files and directories. Huge thanks to Fernando - Merged from trunk.
• [dj] - Reset location of anduin hosted files - Merged from trunk.
• [dj] - Change references to ncursesw5 to ncursesw6. Thanks to Pierre Labastie for the patch - Merged from
trunk.
• [dj] - Update to gettext-0.19.6 - Merged from trunk.
• [dj] - Update to file-5.25 - Merged from trunk.
• [dj] - Update to pkg-config-0.29 - Merged from trunk.
• [dj] - Update to xz-5.2.2 - Merged from trunk.
• 2015-09-28
  • [renodr] - Fix a warning when doing the GCC compile tests.
  • [renodr] - Add additional discussion about copying LFS systems from one machine to another machine.
  • [renodr] - Provide ncurses non-wide-character libraries that are compliant with version 5 of ncurses.
  • [renodr] - Remove unnecessary sed in e2fsprogs.
  • [renodr] - Update to util-linux-2.27.
  • [renodr] - Update to linux-4.2.
  • [renodr] - Update to iproute2-4.2.0.
  • [renodr] - Refresh build sizes and SBU values.
• 2015-08-25
  • [renodr] - Add an upstream patch for MPFR.
• [renodr] - Update to libpipeline-1.4.1.
• [renodr] - Update to linux-4.1.6.
• [renodr] - Update to man-db-2.7.2.
• [renodr] - Add a patch to allow glibc to build properly on i386 systems.
• [renodr] - Remove obsolete r* programs from inetutils.

2015-08-19
• [bdubbs] - Add a workaround to ncurses in Chapter 5 for hosts that have mawk installed.
• [renodr] - Update to binutils-2.25.1.
• [renodr] - Update to check-0.10.0.
• [renodr] - Update to procps-ng-3.3.11.
• [renodr] - Update to man-pages-4.02.
• [renodr] - Update to glibc-2.22.
• [renodr] - Update to linux-4.1.5.
• [renodr] - Update to tzdata2015f.

2015-07-23
• [krejzi] - Fixed a warning in the intltool-update perl script caused by perl-5.22.
• [krejzi] - Updated to dbus-1.8.20.
• [krejzi] - Updated to systemd-222.

2015-07-16
• [bdubbs] - Update to gcc-5.2.0. Fixes *3819.
• [bdubbs] - Update to gettext-0.19.5.1. Fixes *3818.
• [bdubbs] - Update to kbd-2.0.3. Fixes #3815.

2015-07-12
• [bdubbs] - Update to iproute2-4.1.1. Fixes *3811.
• [bdubbs] - Update to file-5.24. Fixes *3812.
• [bdubbs] - Update to linux-4.1.2. Fixes #3814.
• [bdubbs] - Update to gettext-0.19.5. Fixes #3813.
• [bdubbs] - Fix a warning in the installed automake perl script. #3809.

2015-07-04
• [bdubbs] - Update to iproute2-4.1.0. Fixes *3802.
• [bdubbs] - Update to texinfo-6.0. Fixes *3803.
• [bdubbs] - Update to linux-4.1.1. Fixes #3805.
• [bdubbs] - Update perl installed files. Fixes #3804.

2015-06-28
• [krejzi] - Updated to systemd-221.
• 2015-06-23
  • [bdubbs] - Update to tzdata-2015e. Fixes #3798.
  • [bdubbs] - Update to mpfr-3.1.3. Fixes #3800.
  • [bdubbs] - Update to linux-4.1. Fixes #3801.
• 2015-06-13
  • [bdubbs] - Simplify gcc-pass1 instructions. Thanks to Pierre Labastie for the patch. Fixes #3797.
• 2015-06-10
  • [bdubbs] - Update standards discussion for FHS 3.0 and LSB-5.0.
  • [bdubbs] - Update to inetutils-1.9.4. Fixes #3796.
  • [bdubbs] - Update to file-5.23. Fixes #3795.
• 2015-06-07
  • [bdubbs] - Update to linux-4.0.5. Fixes #3793.
• 2015-06-05
  • [bdubbs] - Update to perl-5.22.0. Fixes #3791.
• 2015-05-25
  • [bdubbs] - Update to bash-4.3.30-upstream_fixes-2.patch. Fixes #3789.
• 2015-05-23
  • [bdubbs] - Update to linux-4.0.4. Fixes #3786.
  • [bdubbs] - Update to e2fsprogs-1.42.13. Fixes #3787.
  • [bdubbs] - Update to gawk-4.1.3. Fixes #3788.
  • [bdubbs] - Added a new patch for gcc to fix inline issues and some libgomp problems.
• 2015-05-15
  • [bdubbs] - Add a patch from upstream to fix some libgomp (gcc) problems.
• 2015-05-14
  • [bdubbs] - Update to gawk-4.1.2. Fixes #3781.
  • [bdubbs] - Update to linux-4.0.3. Fixes #3782.
  • [bdubbs] - Update to man-pages-4.00. Fixes #3784.
  • [bdubbs] - Update to inetutils-1.9.3. Fixes #3785.
  • [krejzi] - Updated to dbus-1.8.18.
• 2015-04-26
  • [bdubbs] - Updated to tzdata-2015d. Fixes #3780.
• 2015-04-24
• [krejzi] - Fixed Ncurses and Perl build with GCC 5. Thanks to Ken Moffat and Douglas R. Reno for providing the patches.
• [krejzi] - Updated to GCC-5.1.0. Fixes #3779.

2015-04-21
• [bdubbs] - Update to man-pages-3.8.3. Fixes #3778.

2015-04-16
• [bdubbs] - Update to linux-4.0. Fixes #3775.
• [bdubbs] - Update to tzdata-2015c. Fixes #3776.
• [bdubbs] - Update to iproute2-4.0.0. Fixes #3777.

2015-03-31
• [bdubbs] - Adjust discussion of LFS environment variable to be before first use.
• [bdubbs] - Update to dejagnu-1.5.3. Fixes #3773.

2015-03-28
• [bdubbs] - Update to linux-3.19.3. Fixes #3772.
• [bdubbs] - Update to tzdata2015b. Fixes #3770.

2015-03-20
• [bdubbs] - Update to linux-3.19.2. Fixes #3768.

2015-03-15
• [bdubbs] - Update to tcl-core-8.6.4. Fixes #3766.
• [bdubbs] - Remove non-essential static libraries from the installation. Added a new section in Chapter 6 Introduction, suppressed many static libraries in different packages, and removed the remaining in the Cleaning Up section. Fixes #3751.

2015-03-11
• [bdubbs] - Update to intltool-0.51.0. Fixes #3764.

2015-03-08
• [bdubbs] - Update to patch-2.7.5. Fixes #3762.
• [bdubbs] - Change tcl to minimal tcl-core package. Fixes #3752.

2015-03-07
• [bdubbs] - Update to mpc-1.0.3. Fixes #3753.
• [bdubbs] - Update to xz-5.2.1. Fixes #3757.
• [bdubbs] - Update to kmod-20. Fixes #3758.

2015-03-06
• [krejzi] - LFS-7.7-systemd released.

1.4. Resources

1.4.1. FAQ

If during the building of the LFS system you encounter any errors, have any questions, or think there is a typo in the book, please start by consulting the Frequently Asked Questions (FAQ) that is located at http://www.linuxfromscratch.org/faq/.

1.4.2. Mailing Lists

The linuxfromscratch.org server hosts a number of mailing lists used for the development of the LFS project. These lists include the main development and support lists, among others. If the FAQ does not solve the problem you are having, the next step would be to search the mailing lists at http://www.linuxfromscratch.org/search.html.

For information on the different lists, how to subscribe, archive locations, and additional information, visit http://www.linuxfromscratch.org/mail.html.

1.4.3. IRC

Several members of the LFS community offer assistance on Internet Relay Chat (IRC). Before using this support, please make sure that your question is not already answered in the LFS FAQ or the mailing list archives. You can find the IRC network at irc.freenode.net. The support channel is named #LFS-support.

1.4.4. Mirror Sites

The LFS project has a number of world-wide mirrors to make accessing the website and downloading the required packages more convenient. Please visit the LFS website at http://www.linuxfromscratch.org/mirrors.html for a list of current mirrors.

1.4.5. Contact Information

Please direct all your questions and comments to one of the LFS mailing lists (see above).

1.5. Help

If an issue or a question is encountered while working through this book, please check the FAQ page at http://www.linuxfromscratch.org/faq/#generalfaq. Questions are often already answered there. If your question is not answered on this page, try to find the source of the problem. The following hint will give you some guidance for troubleshooting: http://www.linuxfromscratch.org/hints/downloads/files/errors.txt.

If you cannot find your problem listed in the FAQ, search the mailing lists at http://www.linuxfromscratch.org/search.html.

We also have a wonderful LFS community that is willing to offer assistance through the mailing lists and IRC (see the Section 1.4, “Resources” section of this book). However, we get several support questions every day and many of them can be easily answered by going to the FAQ and by searching the mailing lists first. So, for us to offer the best assistance possible, you need to do some research on your own first. That allows us to focus on the more unusual support needs. If your searches do not produce a solution, please include all relevant information (mentioned below) in your request for help.
1.5.1. Things to Mention

Apart from a brief explanation of the problem being experienced, the essential things to include in any request for help are:

- The version of the book being used (in this case 20160304-systemd)
- The host distribution and version being used to create LFS
- The output from the Section vii, Host System Requirements script
- The package or section the problem was encountered in
- The exact error message or symptom being received
- Note whether you have deviated from the book at all

Note

Deviating from this book does not mean that we will not help you. After all, LFS is about personal preference. Being upfront about any changes to the established procedure helps us evaluate and determine possible causes of your problem.

1.5.2. Configure Script Problems

If something goes wrong while running the configure script, review the config.log file. This file may contain errors encountered during configure which were not printed to the screen. Include the relevant lines if you need to ask for help.

1.5.3. Compilation Problems

Both the screen output and the contents of various files are useful in determining the cause of compilation problems. The screen output from the configure script and the make run can be helpful. It is not necessary to include the entire output, but do include enough of the relevant information. Below is an example of the type of information to include from the screen output from make:

```bash
gcc -DALIASPATH="/mnt/lfs/usr/share/locale:" -DLOCALEDIR="/mnt/lfs/usr/share/locale" -DLIBDIR="/mnt/lfs/usr/lib" -DINCLUDEDIR="/mnt/lfs/usr/include" -DHAVE_CONFIG_H -I. -I. -g -O2 -c getopt1.c
gcc -g -O2 -static -o make ar.o arscan.o commands.o dir.o expand.o file.o function.o getopt.o implicit.o job.o main.o misc.o read.o remake.o rule.o signame.o variable.o vpath.o default.o remote-stub.o version.o opt1.o -lutil job.o: In function `load_too_high':
/lfs/tmp/make-3.79.1/job.c:1565: undefined reference to `getloadavg'
collect2: ld returned 1 exit status
make[2]: *** [make] Error 1
make[2]: Leaving directory `/lfs/tmp/make-3.79.1'
make[1]: *** [all-recursive] Error 1
make[1]: Leaving directory `/lfs/tmp/make-3.79.1'
make: *** [all-recursive-am] Error 2
```
In this case, many people would just include the bottom section:

```
make [2]: *** [make] Error 1
```

This is not enough information to properly diagnose the problem because it only notes that something went wrong, not what went wrong. The entire section, as in the example above, is what should be saved because it includes the command that was executed and the associated error message(s).

An excellent article about asking for help on the Internet is available online at http://catb.org/~esr/faqs/smart-questions.html. Read and follow the hints in this document to increase the likelihood of getting the help you need.
Part II. Preparing for the Build
Chapter 2. Preparing a New Partition

2.1. Introduction

In this chapter, the partition which will host the LFS system is prepared. We will create the partition itself, create a file system on it, and mount it.

2.2. Creating a New Partition

Like most other operating systems, LFS is usually installed on a dedicated partition. The recommended approach to building an LFS system is to use an available empty partition or, if you have enough unpartitioned space, to create one.

A minimal system requires a partition of around 4 gigabytes (GB). This is enough to store all the source tarballs and compile the packages. However, if the LFS system is intended to be the primary Linux system, additional software will probably be installed which will require additional space. A 10 GB partition is a reasonable size to provide for growth. The LFS system itself will not take up this much room. A large portion of this requirement is to provide sufficient free temporary storage. Compiling packages can require a lot of disk space which will be reclaimed after the package is installed.

Because there is not always enough Random Access Memory (RAM) available for compilation processes, it is a good idea to use a small disk partition as swap space. This is used by the kernel to store seldom-used data and leave more memory available for active processes. The swap partition for an LFS system can be the same as the one used by the host system, in which case it is not necessary to create another one.

Start a disk partitioning program such as cfdisk or fdisk with a command line option naming the hard disk on which the new partition will be created—for example /dev/sda for the primary Integrated Drive Electronics (IDE) disk. Create a Linux native partition and a swap partition, if needed. Please refer to cfdisk(8) or fdisk(8) if you do not yet know how to use the programs.

Note

For experienced users, other partitioning schemes are possible. The new LFS system can be on a software RAID array or an LVM logical volume. However, some of these options require an initramfs, which is an advanced topic. These partitioning methodologies are not recommended for first time LFS users.

Remember the designation of the new partition (e.g., sda5). This book will refer to this as the LFS partition. Also remember the designation of the swap partition. These names will be needed later for the /etc/fstab file.

2.2.1. Other Partition Issues

Requests for advice on system partitioning are often posted on the LFS mailing lists. This is a highly subjective topic. The default for most distributions is to use the entire drive with the exception of one small swap partition. This is not optimal for LFS for several reasons. It reduces flexibility, makes sharing of data across multiple distributions or LFS builds more difficult, makes backups more time consuming, and can waste disk space through inefficient allocation of file system structures.

2.2.1.1. The Root Partition

A root LFS partition (not to be confused with the /root directory) of ten gigabytes is a good compromise for most systems. It provides enough space to build LFS and most of BLFS, but is small enough so that multiple partitions can be easily created for experimentation.
2.2.1.2. The Swap Partition

Most distributions automatically create a swap partition. Generally the recommended size of the swap partition is about twice the amount of physical RAM, however this is rarely needed. If disk space is limited, hold the swap partition to two gigabytes and monitor the amount of disk swapping.

Swapping is never good. Generally you can tell if a system is swapping by just listening to disk activity and observing how the system reacts to commands. The first reaction to swapping should be to check for an unreasonable command such as trying to edit a five gigabyte file. If swapping becomes a normal occurrence, the best solution is to purchase more RAM for your system.

2.2.1.3. Convenience Partitions

There are several other partitions that are not required, but should be considered when designing a disk layout. The following list is not comprehensive, but is meant as a guide.

- /boot – Highly recommended. Use this partition to store kernels and other booting information. To minimize potential boot problems with larger disks, make this the first physical partition on your first disk drive. A partition size of 100 megabytes is quite adequate.
- /home – Highly recommended. Share your home directory and user customization across multiple distributions or LFS builds. The size is generally fairly large and depends on available disk space.
- /usr – A separate /usr partition is generally used if providing a server for a thin client or diskless workstation. It is normally not needed for LFS. A size of five gigabytes will handle most installations.
- /opt – This directory is most useful for BLFS where multiple installations of large packages like Gnome or KDE can be installed without embedding the files in the /usr hierarchy. If used, 5 to 10 gigabytes is generally adequate.
- /tmp – A separate /tmp directory is rare, but useful if configuring a thin client. This partition, if used, will usually not need to exceed a couple of gigabytes.
- /usr/src – This partition is very useful for providing a location to store BLFS source files and share them across LFS builds. It can also be used as a location for building BLFS packages. A reasonably large partition of 30-50 gigabytes allows plenty of room.

Any separate partition that you want automatically mounted upon boot needs to be specified in the /etc/fstab. Details about how to specify partitions will be discussed in Section 8.2, “Creating the /etc/fstab File”.

2.3. Creating a File System on the Partition

Now that a blank partition has been set up, the file system can be created. LFS can use any file system recognized by the Linux kernel, but the most common types are ext3 and ext4. The choice of file system can be complex and depends on the characteristics of the files and the size of the partition. For example:

- ext2
  is suitable for small partitions that are updated infrequently such as /boot.

- ext3
  is an upgrade to ext2 that includes a journal to help recover the partition’s status in the case of an unclean shutdown. It is commonly used as a general purpose file system.

- ext4
  is the latest version of the ext file system family of partition types. It provides several new capabilities including nano-second timestamps, creation and use of very large files (16 TB), and speed improvements.
Other file systems, including FAT32, NTFS, ReiserFS, JFS, and XFS are useful for specialized purposes. More information about these file systems can be found at http://en.wikipedia.org/wiki/Comparison_of_file_systems.

LFS assumes that the root file system (/) is of type ext4. To create an ext4 file system on the LFS partition, run the following:

```
mkfs -v -t ext4 /dev/<xxx>
```

If you are using an existing swap partition, there is no need to format it. If a new swap partition was created, it will need to be initialized with this command:

```
mkswap /dev/<yyy>
```

Replace <yyy> with the name of the swap partition.

### 2.4. Setting The $LFS Variable

Throughout this book, the environment variable LFS will be used several times. You should ensure that this variable is always defined throughout the LFS build process. It should be set to the name of the directory where you will be building your LFS system - we will use /mnt/lfs as an example, but the directory choice is up to you. If you are building LFS on a separate partition, this directory will be the mount point for the partition. Choose a directory location and set the variable with the following command:

```
export LFS=/mnt/lfs
```

Having this variable set is beneficial in that commands such as `mkdir -v $LFS/tools` can be typed literally. The shell will automatically replace “$LFS” with “/mnt/lfs” (or whatever the variable was set to) when it processes the command line.

---

**Caution**

Do not forget to check that LFS is set whenever you leave and reenter the current working environment (such as when doing a su to root or another user). Check that the LFS variable is set up properly with:

```
echo $LFS
```

Make sure the output shows the path to your LFS system's build location, which is /mnt/lfs if the provided example was followed. If the output is incorrect, use the command given earlier on this page to set $LFS to the correct directory name.

---

**Note**

One way to ensure that the LFS variable is always set is to edit the .bash_profile file in both your personal home directory and in /root/.bash_profile and enter the export command above. In addition, the shell specified in the /etc/passwd file for all users that need the LFS variable needs to be bash to ensure that the /root/.bash_profile file is incorporated as a part of the login process.

### 2.5. Mounting the New Partition

Now that a file system has been created, the partition needs to be made accessible. In order to do this, the partition needs to be mounted at a chosen mount point. For the purposes of this book, it is assumed that the file system is mounted under the directory specified by the LFS environment variable as described in the previous section.
Create the mount point and mount the LFS file system by running:

```bash
mkdir -pv $LFS
mount -v -t ext4 /dev/<xxx> $LFS
```

Replace `<xxx>` with the designation of the LFS partition.

If using multiple partitions for LFS (e.g., one for `/` and another for `/usr`), mount them using:

```bash
mkdir -pv $LFS
mount -v -t ext4 /dev/<xxx> $LFS
mkdir -v $LFS/usr
mount -v -t ext4 /dev/<yyy> $LFS/usr
```

Replace `<xxx>` and `<yyy>` with the appropriate partition names.

Ensure that this new partition is not mounted with permissions that are too restrictive (such as the `nosuid` or `nodev` options). Run the `mount` command without any parameters to see what options are set for the mounted LFS partition. If `nosuid` and/or `nodev` are set, the partition will need to be remounted.

If you are using a `swap` partition, ensure that it is enabled using the `swapon` command:

```bash
/sbin/swapon -v /dev/<zzz>
```

Replace `<zzz>` with the name of the `swap` partition.

Now that there is an established place to work, it is time to download the packages.
Chapter 3. Packages and Patches

3.1. Introduction

This chapter includes a list of packages that need to be downloaded in order to build a basic Linux system. The listed version numbers correspond to versions of the software that are known to work, and this book is based on their use. We highly recommend against using newer versions because the build commands for one version may not work with a newer version. The newest package versions may also have problems that require work-arounds. These work-arounds will be developed and stabilized in the development version of the book.

Download locations may not always be accessible. If a download location has changed since this book was published, Google (http://www.google.com/) provides a useful search engine for most packages. If this search is unsuccessful, try one of the alternative means of downloading discussed at http://www.linuxfromscratch.org/lfs/packages.html#packages.

Downloaded packages and patches will need to be stored somewhere that is conveniently available throughout the entire build. A working directory is also required to unpack the sources and build them. $LFS/sources can be used both as the place to store the tarballs and patches and as a working directory. By using this directory, the required elements will be located on the LFS partition and will be available during all stages of the building process.

To create this directory, execute the following command, as user root, before starting the download session:

```
mkdir -v $LFS/sources
```

Make this directory writable and sticky. “Sticky” means that even if multiple users have write permission on a directory, only the owner of a file can delete the file within a sticky directory. The following command will enable the write and sticky modes:

```
chmod -v a+wt $LFS/sources
```

An easy way to download all of the packages and patches is by using wget-list as an input to wget. For example:

```
wget --input-file=wget-list --continue --directory-prefix=$LFS/sources
```

Additionally, starting with LFS-7.0, there is a separate file, md5sums, which can be used to verify that all the correct packages are available before proceeding. Place that file in $LFS/sources and run:

```
pushd $LFS/sources
md5sum -c md5sums
popd
```

3.2. All Packages

Download or otherwise obtain the following packages:

- **Acl (2.2.52) - 380 KB:**
  Download: http://download.savannah.gnu.org/releases/acl/acl-2.2.52.src.tar.gz
  MD5 sum: a61415312426e9c2212bd7dc7929abda

- **Attr (2.4.47) - 336 KB:**
  Home page: http://www.gnu.org/software/attr/
  Download: http://download.savannah.gnu.org/releases/attr/attr-2.4.47.src.tar.gz
  MD5 sum: 84f58dec00b60f2dc8fd1c9709291cc7
• Autoconf (2.69) - 1,186 KB:
Home page: http://www.gnu.org/software/autoconf/
MD5 sum: 50f97f4159805e374639a73e2636f22e

• Automake (1.15) - 1,462 KB:
Home page: http://www.gnu.org/software/automake/
Download: http://ftp.gnu.org/gnu/automake/automake-1.15.tar.xz
MD5 sum: 9a1dddb0e053474d9d1105cfe39b0c48d

• Bash (4.3.30) - 7,7791 KB:
Home page: http://www.gnu.org/software/bash/
MD5 sum: a27b3ee9be83bd3ba448c0ff52b28447

• Bc (1.06.95) - 288 KB:
Home page: http://www.gnu.org/software/bc/
Download: http://alpha.gnu.org/gnu/bc/bc-1.06.95.tar.bz2
MD5 sum: 5126a721b73f97d715bb72c13c889035

• Binutils (2.26) - 24,945 KB:
Home page: http://www.gnu.org/software/binutils/
MD5 sum: 64146a0faa3b411ba774f47d41d239f

• Bison (3.0.4) - 1,928 KB:
Home page: http://www.gnu.org/software/bison/
Download: http://ftp.gnu.org/gnu/bison/bison-3.0.4.tar.xz
MD5 sum: c342201de104cc9ce0a21e0ad10d4021

• Bzip2 (1.0.6) - 764 KB:
Home page: http://www.bzip.org/
Download: http://www.bzip.org/1.0.6/bzip2-1.0.6.tar.gz
MD5 sum: 00b516f4704d4a7cb50a1d97e6e8e15b

• Check (0.10.0) - 752 KB:
Home page: http://check.sourceforge.net/
Download: http://sourceforge.net/projects/check/files/check/0.10.0/check-0.10.0.tar.gz
MD5 sum: 53c5e5c77d090e103a17f3ed7fd7b88

• Coreutils (8.25) - 5,591 KB:
Home page: http://www.gnu.org/software/coreutils/
MD5 sum: 07e43ba7f618d7474148f56ab248a48

• D-Bus (1.10.6) - 1,908 KB:
Home page: http://www.freedesktop.org/wiki/Software/dbus
Download: http://dbus.freedesktop.org/releases/dbus/dbus-1.10.6.tar.gz
MD5 sum: 26d0cf3a1c9782cb0e342101f04504400

• DejaGNU (1.5.3) - 584 KB:
Home page: http://www.gnu.org/software/dejagnu/
Download: http://ftp.gnu.org/gnu/dejagnu/dejagnu-1.5.3.tar.gz
MD5 sum: 5bda2cdblaf51a80aecc58d6e42bd2f
• Diffutils (3.3) - 1,170 KB:
  Home page: http://www.gnu.org/software/diffutils/
  Download: http://ftp.gnu.org/gnu/diffutils/diffutils-3.3.tar.xz
  MD5 sum: 99180208ec2a82ce71f55b0d7389f1b3

• E2fsprogs (1.42.13) - 6,360 KB:
  Home page: http://e2fsprogs.sourceforge.net/
  Download: http://downloads.sourceforge.net/project/e2fsprogs/e2fsprogs/v1.42.13/e2fsprogs-1.42.13.tar.gz
  MD5 sum: bc759fc62666786f5436e2075beb3265

• Expat (2.1.0) - 552 KB:
  Home page: http://expat.sourceforge.net/
  Download: http://prdownloads.sourceforge.net/expat/expat-2.1.0.tar.gz
  MD5 sum: dd7dab7a5f6ea97d2a6a43f511449b7cd

• Expect (5.45) - 614 KB:
  Home page: http://expect.sourceforge.net/
  Download: http://prdownloads.sourceforge.net/expect/expect5.45.tar.gz
  MD5 sum: 44e1a4f4c877e9dd5a542dafa7ecc92b

• File (5.25) - 723 KB:
  Home page: http://www.darwinsys.com/file/
  MD5 sum: e6a972d4e10d9e76407a432f4a63cd4c

  Note
  File (5.25) may no longer be available at the listed location. The site administrators of the master download location occasionally remove older versions when new ones are released. An alternative download location that may have the correct version available can also be found at: http://www.linuxfromscratch.org/lfs/download.html#ftp.

• Findutils (4.6.0) - 3,692 KB:
  Home page: http://www.gnu.org/software/findutils/
  MD5 sum: 9936aa8009438ce185bea2694a997fc1

• Flex (2.6.0) - 1,338 KB:
  Home page: http://flex.sourceforge.net
  Download: http://prdownloads.sourceforge.net/flex/flex-2.6.0.tar.xz
  MD5 sum: 3cbbfa1554d0b75fad9f8100732454de

• Gawk (4.1.3) - 2,258 KB:
  Home page: http://www.gnu.org/software/gawk/
  Download: http://ftp.gnu.org/gnu/gawk/gawk-4.1.3.tar.xz
  MD5 sum: 97f8f44149ea9b9e94be97f68988be87

• GCC (5.3.0) - 93,205 KB:
  Home page: http://gcc.gnu.org/
  Download: http://ftp.gnu.org/gnu/gcc/gcc-5.3.0/gcc-5.3.0.tar.bz2
  MD5 sum: c9616fd448f980259c31de613e575719
• GDBM (1.11) - 796 KB:
Home page: http://www.gnu.org/software/gdbm/
Download: http://ftp.gnu.org/gnu/gdbm/gdbm-1.11.tar.gz
MD5 sum: 72c832680cf0999caedbe5b265c8c1bd

• Gettext (0.19.7) - 7,019 KB:
Home page: http://www.gnu.org/software/gettext/
Download: http://ftp.gnu.org/gnu/gettext/gettext-0.19.7.tar.xz
MD5 sum: f81e50556da41b44c1d59ac93474dca5

• Glibc (2.23) - 13,140 KB:
Home page: http://www.gnu.org/software/libc/
MD5 sum: 456995968f3acadbed39f5eba31678df

• GMP (6.1.0) - 1,905 KB:
Home page: http://www.gnu.org/software/gmp/
MD5 sum: a9868ef2556ad6a2909babc9c1d583c7

• Gperf (3.0.4) - 960 KB:
Home page: http://www.gnu.org/software/gperf/
MD5 sum: c1f1db32fb6598d6a93e6e88796a8632

• Grep (2.23) - 1,287 KB:
Home page: http://www.gnu.org/software/grep/
MD5 sum: f46aa9d0d2577b9212a104348a286787

• Groff (1.22.3) - 4,091 KB:
Home page: http://www.gnu.org/software/groff/
Download: http://ftp.gnu.org/gnu/groff/groff-1.22.3.tar.gz
MD5 sum: cc825fa64bc7306a885f2fb2268d3ec5

• GRUB (2.02-beta2) - 5,663 KB:
Home page: http://www.gnu.org/software/grub/
Download: http://alpha.gnu.org/gnu/grub/grub-2.02-beta2.tar.xz
MD5 sum: be62932eade308a364ea4bb9c1295930

• Gzip (1.6) - 712 KB:
Home page: http://www.gnu.org/software/gzip/
MD5 sum: da981f86677d58a106496e68de6f8995

• Iana-Etc (2.30) - 201 KB:
Home page: http://freecode.com/projects/iana-etc
Download: http://anduin.linuxfromscratch.org/LFS/iana-etc-2.30.tar.bz2
MD5 sum: 3ba3afbd1b261383d247f46cb135ee8

• Inetutils (1.9.4) - 1,333 KB:
Home page: http://www.gnu.org/software/inetutils/
Download: http://ftp.gnu.org/gnu/inetutils/inetutils-1.9.4.tar.xz
MD5 sum: 87f3f1fa3f603aef11c41dcc097af75e
• Intltool (0.51.0) - 159 KB:
Home page: http://freedesktop.org/wiki/Software/intltool
Download: http://launchpad.net/intltool/trunk/0.51.0/+download/intltool-0.51.0.tar.gz
MD5 sum: 12e517cac2b57a0121cda351570f1e63

• IPRoute2 (4.4.0) - 517 KB:
Home page: https://www.kernel.org/pub/linux/utils/net/iproute2/
Download: https://www.kernel.org/pub/linux/utils/net/iproute2/iproute2-4.4.0.tar.xz
MD5 sum: d762653ec3elab0d4a9689e169ca184f

• Kbd (2.0.3) - 1,013 KB:
Home page: http://ftp.altlinux.org/pub/people/legion/kbd
Download: https://www.kernel.org/pub/linux/utils/kbd/kbd-2.0.3.tar.xz
MD5 sum: 231b46e7142eb41ea3ae06d2ded3c208

• Kmod (22) - 440 KB:
Download: https://www.kernel.org/pub/linux/utils/kernel/kmod/kmod-22.tar.xz
MD5 sum: 4371b847f3fbbaa4e9aa890ad616748f

• Less (481) - 310 KB:
Home page: http://www.greenwoodsoftware.com/less/
Download: http://www.greenwoodsoftware.com/less/less-481.tar.gz
MD5 sum: 50ef46065665257141a7340123527767

• Libcap (2.25) - 64 KB:
Home page: https://sites.google.com/site/fullycapable/
MD5 sum: 6666b839e5d46c2ad33fc8aa2ceb5f77

• Libpipeline (1.4.1) - 787 KB:
Home page: http://libpipeline.nongnu.org/
Download: http://download.savannah.gnu.org/releases/libpipeline/libpipeline-1.4.1.tar.gz
MD5 sum: e54590ec68d6c1239f67b5b44e92022c

• Libtool (2.4.6) - 951 KB:
Home page: http://www.gnu.org/software/libtool/
MD5 sum: 1bf9b923f2c1339b4d2ce1807064aa5

• Linux (4.4.2) - 85,249 KB:
Home page: http://www.kernel.org/
Download: https://www.kernel.org/pub/linux/kernel/v4.x/linux-4.4.2.tar.xz
MD5 sum: d1b8be99e6c12cbc52b2af0520d550bb

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**Note**

The Linux kernel is updated relatively often, many times due to discoveries of security vulnerabilities. The latest available 4.4.x kernel version should be used, unless the errata page says otherwise.

For users with limited speed or expensive bandwidth who wish to update the Linux kernel, a baseline version of the package and patches can be downloaded separately. This may save some time or cost for a subsequent patch level upgrade within a minor release.
• M4 (1.4.17) - 1,122 KB:
Home page: http://www.gnu.org/software/m4/
Download: http://ftp.gnu.org/gnu/m4/m4-1.4.17.tar.xz
MD5 sum: 12a3c829301a4fd6586a57d3fcf196dc

• Make (4.1) - 1,297 KB:
Home page: http://www.gnu.org/software/make/
MD5 sum: 57a7a224a822f94789a587ccbc6df967

• Man-DB (2.7.5) - 1,471 KB:
Home page: http://www.nongnu.org/man-db/
Download: http://download.savannah.gnu.org/releases/man-db/man-db-2.7.5.tar.xz
MD5 sum: 37da0bb0400cc7b640f33c26f6052202

• Man-pages (4.04) - 1,393 KB:
MD5 sum: c20326ff9687f3ded1c24aa319a3880d

• MPC (1.0.3) - 655 KB:
Home page: http://www.multiprecision.org/
Download: http://www.multiprecision.org/mpc/download/mpc-1.0.3.tar.gz
MD5 sum: d6a1d5f8ddea3abd2cc3e98f58352d26

• MPFR (3.1.3) - 1,087 KB:
Home page: http://www.mpfr.org/
Download: http://www.mpfr.org/mpfr-3.1.3/mpfr-3.1.3.tar.xz
MD5 sum: 6969398cd2fbc56a6af570b5273c56a9

• Ncurses (6.0) - 3,059 KB:
Home page: http://www.gnu.org/software/ncurses/
MD5 sum: ee13d052e1ead260d7c28071f46eefb1

• Patch (2.7.5) - 711 KB:
Home page: http://savannah.gnu.org/projects/patch/
Download: http://ftp.gnu.org/gnu/patch/patch-2.7.5.tar.xz
MD5 sum: e3da7940431633fb65a01b91d3b7a27a

• Perl (5.22.1) - 13,376 KB:
Home page: http://www.perl.org/
Download: http://www.cpan.org/src/5.0/perl-5.22.1.tar.gz
MD5 sum: 67242b9bd642b458bec884ed2a040910

• Pkg-config (0.29) - 1,928 KB:
Home page: http://www.freedesktop.org/wiki/Software/pkg-config
Download: http://pkgconfig.freedesktop.org/releases/pkg-config-0.29.tar.gz
MD5 sum: 77f27dce7ef88d0634d0d6f90e03a77f
• **Procps (3.3.11)** - 797 KB:
  Home page: [http://sourceforge.net/projects/procps-ng](http://sourceforge.net/projects/procps-ng)
  Download: [http://sourceforge.net/projects/procps-ng/files/Production/procps-ng-3.3.11.tar.xz](http://sourceforge.net/projects/procps-ng/files/Production/procps-ng-3.3.11.tar.xz)
  MD5 sum: 6cc5b94c1c5b8cbc89ad345a7b522f74

• **Psmisc (22.21)** - 447 KB:
  MD5 sum: 935c0fd6eb208288262b385fa656f1bf

• **Readline (6.3)** - 2,411 KB:
  MD5 sum: 33c8fb279e981274f485fd91da77e94a

• **Sed (4.2.2)** - 1,035 KB:
  Download: [http://ftp.gnu.org/gnu/sed/sed-4.2.2.tar.bz2](http://ftp.gnu.org/gnu/sed/sed-4.2.2.tar.bz2)
  MD5 sum: 7ffe1c7cdc3233e10c4b502df253974

• **Shadow (4.2.1)** - 1,558 KB:
  Download: [http://pkg-shadow.alioth.debian.org/releases/shadow-4.2.1.tar.xz](http://pkg-shadow.alioth.debian.org/releases/shadow-4.2.1.tar.xz)
  MD5 sum: 2bfafe7d4962682d31b5eba65dba4fc8

• **Systemd (229)** - 3,844 KB:
  MD5 sum: 5d5115ee08afffe005f821bc5ea3171e8

• **Tar (1.28)** - 1,921 KB:
  MD5 sum: 49b6306167724fe48f419a33a5beb857

• **Tcl (8.6.4)** - 5,677 KB:
  MD5 sum: 8b8c9d85469d8dbe32e51117b8ef11e3

• **Texinfo (6.1)** - 4,416 KB:
  MD5 sum: 1d7ec1888fae00730693597852b00cde

• **Time Zone Data (2016a)** - 296 KB:
  Home page: [http://www.iana.org/time-zones](http://www.iana.org/time-zones)
  MD5 sum: 0d3123eb1b453ec0620822bd65be4c42

• **Util-linux (2.27.1)** - 3,872 KB:
  Download: [https://www.kernel.org/pub/linux/utils/util-linux/v2.27/util-linux-2.27.1.tar.xz](https://www.kernel.org/pub/linux/utils/util-linux/v2.27/util-linux-2.27.1.tar.xz)
  MD5 sum: 3cd2698d1363a2c64091c2dadc974647
Linux From Scratch - Version 20160304-systemd

• Vim (7.4) - 9,632 KB:
Home page: http://www.vim.org
MD5 sum: 607e135c559be642f210094ad023dc65

• XML::Parser (2.44) - 232 KB:
Home page: https://github.com/chorny/XML-Parser
Download: http://cpan.metacpan.org/authors/id/T/TO/TODDR/XML-Parser-2.44.tar.gz
MD5 sum: af4813fe3952362451201ced6fbce379

• Xz Utils (5.2.2) - 993 KB:
Home page: http://tukaani.org/xz
Download: http://tukaani.org/xz/xz-5.2.2.tar.xz
MD5 sum: e26772b69940085c0632589ab1d52e64

• Zlib (1.2.8) - 441 KB:
Home page: http://www.zlib.net/
Download: http://www.zlib.net/zlib-1.2.8.tar.xz
MD5 sum: 28f1205d8dd2001f26flec1e8c2cbe37

Total size of these packages: about 408 MB

3.3. Needed Patches

In addition to the packages, several patches are also required. These patches correct any mistakes in the packages that should be fixed by the maintainer. The patches also make small modifications to make the packages easier to work with. The following patches will be needed to build an LFS system:

• Bash Upstream Fixes Patch - 15 KB:
Download: http://www.linuxfromscratch.org/patches/lfs/systemd/bash-4.3.30-upstream_fixes-3.patch
MD5 sum: e183ab08f0a51a7c5a2e974eb1ecbc46

• Bc Memory Leak Patch - 1.4 KB:
Download: http://www.linuxfromscratch.org/patches/lfs/systemd/bc-1.06.95-memory_leak-1.patch
MD5 sum: 877e81fba316fe487ec23501059d54b8

• Binutils Upstream Patch - 13 KB:
MD5 sum: 33662839ab819ac58796c4c2db20631

• Bzip2 Documentation Patch - 1.6 KB:
Download: http://www.linuxfromscratch.org/patches/lfs/systemd/bzip2-1.0.6-install_docs-1.patch
MD5 sum: 6a5ac7e89b791aae556de0f745916f7f

• Coreutils Internationalization Fixes Patch - 148 KB:
MD5 sum: c6334ed5b03062ef7e9649e8ceb2cfc1

• Glibc FHS Patch - 2.8 KB:
Download: http://www.linuxfromscratch.org/patches/lfs/systemd/glibc-2.23-fhs-1.patch
MD5 sum: 9a5997c3452909b1769918c759eff8a2
• **Kbd Backspace/Delete Fix Patch - 12 KB:**
  Download: [http://www.linuxfromscratch.org/patches/lfs/systemd/kbd-2.0.3-backspace-1.patch](http://www.linuxfromscratch.org/patches/lfs/systemd/kbd-2.0.3-backspace-1.patch)
  MD5 sum: f75cca16a38da6caaa7d52151f7136895

• **MPFR Upstream Fixes Patch - 128 KB:**
  MD5 sum: ef2f0b72f7e2dccc7775303bd3b850bca

• **Readline Upstream Fixes Patch - 8 KB:**
  MD5 sum: 6b0d9f4e79319d56a7fee9b35e5cfadb

• **Systemd Compat Patch - 12 KB:**
  MD5 sum: 8a9b70794ead5a87297d7cc7a753d78

**Total size of these patches: about 341.8 KB**

In addition to the above required patches, there exist a number of optional patches created by the LFS community. These optional patches solve minor problems or enable functionality that is not enabled by default. Feel free to peruse the patches database located at [http://www.linuxfromscratch.org/patches/downloads/](http://www.linuxfromscratch.org/patches/downloads/) and acquire any additional patches to suit your system needs.
**Chapter 4. Final Preparations**

**4.1. Introduction**

In this chapter, we will perform a few additional tasks to prepare for building the temporary system. We will create a directory in $LFS for the installation of the temporary tools, add an unprivileged user to reduce risk, and create an appropriate build environment for that user. We will also explain the unit of time we use to measure how long LFS packages take to build, or “SBUs”, and give some information about package test suites.

**4.2. Creating the $LFS/tools Directory**

All programs compiled in Chapter 5 will be installed under $LFS/tools to keep them separate from the programs compiled in Chapter 6. The programs compiled here are temporary tools and will not be a part of the final LFS system. By keeping these programs in a separate directory, they can easily be discarded later after their use. This also prevents these programs from ending up in the host production directories (easy to do by accident in Chapter 5).

Create the required directory by running the following as root:

```bash
mkdir -v $LFS/tools
```

The next step is to create a /tools symlink on the host system. This will point to the newly-created directory on the LFS partition. Run this command as root as well:

```bash
ln -sv $LFS/tools /
```

**Note**

The above command is correct. The ln command has a few syntactic variations, so be sure to check info coreutils ln and ln(1) before reporting what you may think is an error.

The created symlink enables the toolchain to be compiled so that it always refers to /tools, meaning that the compiler, assembler, and linker will work both in Chapter 5 (when we are still using some tools from the host) and in the next (when we are “chrooted” to the LFS partition).

**4.3. Adding the LFS User**

When logged in as user root, making a single mistake can damage or destroy a system. Therefore, we recommend building the packages in this chapter as an unprivileged user. You could use your own user name, but to make it easier to set up a clean working environment, create a new user called lfs as a member of a new group (also named lfs) and use this user during the installation process. As root, issue the following commands to add the new user:

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

The meaning of the command line options:

```bash
-s /bin/bash
```

This makes bash the default shell for user lfs.
-g lfs
This option adds user lfs to group lfs.

-m
This creates a home directory for lfs.

-k /dev/null
This parameter prevents possible copying of files from a skeleton directory (default is /etc/skel) by changing the input location to the special null device.

lfs
This is the actual name for the created group and user.

To log in as lfs (as opposed to switching to user lfs when logged in as root, which does not require the lfs user to have a password), give lfs a password:

```
passwd lfs
```

Grant lfs full access to $LFS/tools by making lfs the directory owner:

```
chown -v lfs $LFS/tools
```

If a separate working directory was created as suggested, give user lfs ownership of this directory:

```
chown -v lfs $LFS/sources
```

Next, login as user lfs. This can be done via a virtual console, through a display manager, or with the following substitute user command:

```
su - lfs
```

The “-” instructs su to start a login shell as opposed to a non-login shell. The difference between these two types of shells can be found in detail in bash(1) and info bash.

### 4.4. Setting Up the Environment

Set up a good working environment by creating two new startup files for the bash shell. While logged in as user lfs, issue the following command to create a new .bash_profile:

```
cat > ~/.bash_profile << "EOF"
exec env -i HOME=$HOME TERM=$TERM PS1='\u:\w\$ ' /bin/bash
EOF
```

When logged on as user lfs, the initial shell is usually a login shell which reads the /etc/profile of the host (probably containing some settings and environment variables) and then .bash_profile. The exec env -i../bin/bash command in the .bash_profile file replaces the running shell with a new one with a completely empty environment, except for the HOME, TERM, and PS1 variables. This ensures that no unwanted and potentially hazardous environment variables from the host system leak into the build environment. The technique used here achieves the goal of ensuring a clean environment.
The new instance of the shell is a non-login shell, which does not read the /etc/profile or .bash_profile files, but rather reads the .bashrc file instead. Create the .bashrc file now:

```
cat > ~/.bashrc << "EOF"
set +h
umask 022
LFS=/mnt/lfs
LC_ALL=POSIX
LFS_TGT=$(uname -m)-lfs-linux-gnu
PATH=/tools/bin:/bin:/usr/bin
export LFS LC_ALL LFS_TGT PATH
EOF
```

The set +h command turns off bash’s hash function. Hashing is ordinarily a useful feature—bash uses a hash table to remember the full path of executable files to avoid searching the PATH time and again to find the same executable. However, the new tools should be used as soon as they are installed. By switching off the hash function, the shell will always search the PATH when a program is to be run. As such, the shell will find the newly compiled tools in $LFS/tools as soon as they are available without remembering a previous version of the same program in a different location.

Setting the user file-creation mask (umask) to 022 ensures that newly created files and directories are only writable by their owner, but are readable and executable by anyone (assuming default modes are used by the open(2) system call, new files will end up with permission mode 644 and directories with mode 755).

The LFS variable should be set to the chosen mount point.

The LC_ALL variable controls the localization of certain programs, making their messages follow the conventions of a specified country. Setting LC_ALL to “POSIX” or “C” (the two are equivalent) ensures that everything will work as expected in the chroot environment.

The LFS_TGT variable sets a non-default, but compatible machine description for use when building our cross compiler and linker and when cross compiling our temporary toolchain. More information is contained in Section 5.2, “Toolchain Technical Notes”.

By putting /tools/bin ahead of the standard PATH, all the programs installed in Chapter 5 are picked up by the shell immediately after their installation. This, combined with turning off hashing, limits the risk that old programs are used from the host when the same programs are available in the chapter 5 environment.

Finally, to have the environment fully prepared for building the temporary tools, source the just-created user profile:

```
source ~/.bash_profile
```

### 4.5. About SBUs

Many people would like to know beforehand approximately how long it takes to compile and install each package. Because Linux From Scratch can be built on many different systems, it is impossible to provide accurate time estimates. The biggest package (Glibc) will take approximately 20 minutes on the fastest systems, but could take up to three days on slower systems! Instead of providing actual times, the Standard Build Unit (SBU) measure will be used instead.

The SBU measure works as follows. The first package to be compiled from this book is Binutils in Chapter 5. The time it takes to compile this package is what will be referred to as the Standard Build Unit or SBU. All other compile times will be expressed relative to this time.
For example, consider a package whose compilation time is 4.5 SBUs. This means that if a system took 10 minutes to compile and install the first pass of Binutils, it will take approximately 45 minutes to build this example package. Fortunately, most build times are shorter than the one for Binutils.

In general, SBUs are not entirely accurate because they depend on many factors, including the host system's version of GCC. They are provided here to give an estimate of how long it might take to install a package, but the numbers can vary by as much as dozens of minutes in some cases.

Note

For many modern systems with multiple processors (or cores) the compilation time for a package can be reduced by performing a "parallel make" by either setting an environment variable or telling the make program how many processors are available. For instance, a Core2Duo can support two simultaneous processes with:

```
export MAKEFLAGS='--jobs 2'
```

or just building with:

```
make -j2
```

When multiple processors are used in this way, the SBU units in the book will vary even more than they normally would. In some cases, the make step will simply fail. Analyzing the output of the build process will also be more difficult because the lines of different processes will be interleaved. If you run into a problem with a build step, revert back to a single processor build to properly analyze the error messages.

4.6. About the Test Suites

Most packages provide a test suite. Running the test suite for a newly built package is a good idea because it can provide a “sanity check” indicating that everything compiled correctly. A test suite that passes its set of checks usually proves that the package is functioning as the developer intended. It does not, however, guarantee that the package is totally bug free.

Some test suites are more important than others. For example, the test suites for the core toolchain packages—GCC, Binutils, and Glibc—are of the utmost importance due to their central role in a properly functioning system. The test suites for GCC and Glibc can take a very long time to complete, especially on slower hardware, but are strongly recommended.

Note

Experience has shown that there is little to be gained from running the test suites in Chapter 5. There can be no escaping the fact that the host system always exerts some influence on the tests in that chapter, often causing inexplicable failures. Because the tools built in Chapter 5 are temporary and eventually discarded, we do not recommend running the test suites in Chapter 5 for the average reader. The instructions for running those test suites are provided for the benefit of testers and developers, but they are strictly optional.

A common issue with running the test suites for Binutils and GCC is running out of pseudo terminals (PTYs). This can result in a high number of failing tests. This may happen for several reasons, but the most likely cause is that the host system does not have the `devpts` file system set up correctly. This issue is discussed in greater detail at [http://www.linuxfromscratch.org/lfs/faq.html#no-ptys](http://www.linuxfromscratch.org/lfs/faq.html#no-ptys).
Sometimes package test suites will fail, but for reasons which the developers are aware of and have deemed non-critical. Consult the logs located at http://www.linuxfromscratch.org/lfs/build-logs/systemd/ to verify whether or not these failures are expected. This site is valid for all tests throughout this book.
Chapter 5. Constructing a Temporary System

5.1. Introduction

This chapter shows how to build a minimal Linux system. This system will contain just enough tools to start constructing the final LFS system in Chapter 6 and allow a working environment with more user convenience than a minimum environment would.

There are two steps in building this minimal system. The first step is to build a new and host-independent toolchain (compiler, assembler, linker, libraries, and a few useful utilities). The second step uses this toolchain to build the other essential tools.

The files compiled in this chapter will be installed under the $LFS/tools directory to keep them separate from the files installed in the next chapter and the host production directories. Since the packages compiled here are temporary, we do not want them to pollute the soon-to-be LFS system.

5.2. Toolchain Technical Notes

This section explains some of the rationale and technical details behind the overall build method. It is not essential to immediately understand everything in this section. Most of this information will be clearer after performing an actual build. This section can be referred to at any time during the process.

The overall goal of Chapter 5 is to produce a temporary area that contains a known-good set of tools that can be isolated from the host system. By using chroot, the commands in the remaining chapters will be contained within that environment, ensuring a clean, trouble-free build of the target LFS system. The build process has been designed to minimize the risks for new readers and to provide the most educational value at the same time.

Note

Before continuing, be aware of the name of the working platform, often referred to as the target triplet. A simple way to determine the name of the target triplet is to run the config.guess script that comes with the source for many packages. Unpack the Binutils sources and run the script: ./config.guess and note the output. For example, for a 32-bit Intel processor the output will be i686-pc-linux-gnu. On a 64-bit system it will be x86_64-pc-linux-gnu.

Also be aware of the name of the platform's dynamic linker, often referred to as the dynamic loader (not to be confused with the standard linker ld that is part of Binutils). The dynamic linker provided by Glibc finds and loads the shared libraries needed by a program, prepares the program to run, and then runs it. The name of the dynamic linker for a 32-bit Intel machine will be ld-linux.so.2 (ld-linux-x86-64.so.2 for 64-bit systems). A sure-fire way to determine the name of the dynamic linker is to inspect a random binary from the host system by running: readelf -l <name of binary> | grep interpreter and noting the output. The authoritative reference covering all platforms is in the shlib-versions file in the root of the Glibc source tree.

Some key technical points of how the Chapter 5 build method works:

• Slightly adjusting the name of the working platform, by changing the "vendor" field target triplet by way of the LFS_TGT variable, ensures that the first build of Binutils and GCC produces a compatible cross-linker and cross-compiler. Instead of producing binaries for another architecture, the cross-linker and cross-compiler will produce binaries compatible with the current hardware.
The temporary libraries are cross-compiled. Because a cross-compiler by its nature cannot rely on anything from its host system, this method removes potential contamination of the target system by lessening the chance of headers or libraries from the host being incorporated into the new tools. Cross-compilation also allows for the possibility of building both 32-bit and 64-bit libraries on 64-bit capable hardware.

Careful manipulation of the GCC source tells the compiler which target dynamic linker will be used. Binutils is installed first because the `configure` runs of both GCC and Glibc perform various feature tests on the assembler and linker to determine which software features to enable or disable. This is more important than one might first realize. An incorrectly configured GCC or Glibc can result in a subtly broken toolchain, where the impact of such breakage might not show up until near the end of the build of an entire distribution. A test suite failure will usually highlight this error before too much additional work is performed.

Binutils installs its assembler and linker in two locations, `/tools/bin` and `/tools/$LFS_TGT/bin`. The tools in one location are hard linked to the other. An important facet of the linker is its library search order. Detailed information can be obtained from `ld` by passing it the `--verbose` flag. For example, an `ld --verbose | grep SEARCH` will illustrate the current search paths and their order. It shows which files are linked by `ld` by compiling a dummy program and passing the `--verbose` switch to the linker. For example, `gcc dummy.c -Wl,--verbose 2>&1 | grep succeeded` will show all the files successfully opened during the linking.

The next package installed is GCC. An example of what can be seen during its run of `configure` is:

```
checking what assembler to use... /tools/i686-lfs-linux-gnu/bin/as
checking what linker to use... /tools/i686-lfs-linux-gnu/bin/ld
```

This is important for the reasons mentioned above. It also demonstrates that GCC's configure script does not search the PATH directories to find which tools to use. However, during the actual operation of `gcc` itself, the same search paths are not necessarily used. To find out which standard linker `gcc` will use, run: `gcc -print-prog-name=ld`.

Detailed information can be obtained from `gcc` by passing it the `--v` command line option while compiling a dummy program. For example, `gcc -v dummy.c` will show detailed information about the preprocessor, compilation, and assembly stages, including `gcc`'s included search paths and their order.

Next installed are sanitized Linux API headers. These allow the standard C library (Glibc) to interface with features that the Linux kernel will provide.

The next package installed is Glibc. The most important considerations for building Glibc are the compiler, binary tools, and kernel headers. The compiler is generally not an issue since Glibc will always use the compiler relating to the `--host` parameter passed to its configure script, e.g. in our case, `i686-lfs-linux-gnu-gcc`. The binary tools and kernel headers can be a bit more complicated. Therefore, take no risks and use the available configure switches to enforce the correct selections. After the run of `configure`, check the contents of the `config.make` file in the glibc-build directory for all important details. Note the use of `CC="i686-lfs-gnu-gcc"` to control which binary tools are used and the use of the `--nostdinc` and `--isystem` flags to control the compiler's include search path. These items highlight an important aspect of the Glibc package—it is very self-sufficient in terms of its build machinery and generally does not rely on toolchain defaults.

During the second pass of Binutils, we are able to utilize the `--with-lib-path` configure switch to control `ld`'s library search path.

For the second pass of GCC, its sources also need to be modified to tell GCC to use the new dynamic linker. Failure to do so will result in the GCC programs themselves having the name of the dynamic linker from the host system's `/lib` directory embedded into them, which would defeat the goal of getting away from the host. From this point onwards, the core toolchain is self-contained and self-hosted. The remainder of the Chapter 5 packages all build against the new Glibc in `/tools`.

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Upon entering the chroot environment in Chapter 6, the first major package to be installed is Glibc, due to its self-sufficient nature mentioned above. Once this Glibc is installed into /usr, we will perform a quick changeover of the toolchain defaults, and then proceed in building the rest of the target LFS system.

5.3. General Compilation Instructions

When building packages there are several assumptions made within the instructions:

- Several of the packages are patched before compilation, but only when the patch is needed to circumvent a problem. A patch is often needed in both this and the next chapter, but sometimes in only one or the other. Therefore, do not be concerned if instructions for a downloaded patch seem to be missing. Warning messages about offset or fuzz may also be encountered when applying a patch. Do not worry about these warnings, as the patch was still successfully applied.

- During the compilation of most packages, there will be several warnings that scroll by on the screen. These are normal and can safely be ignored. These warnings are as they appear—warnings about deprecated, but not invalid, use of the C or C++ syntax. C standards change fairly often, and some packages still use the older standard. This is not a problem, but does prompt the warning.

- Check one last time that the LFS environment variable is set up properly:

  ```
  echo $LFS
  ```

  Make sure the output shows the path to the LFS partition's mount point, which is /mnt/lfs, using our example.

- Finally, two last important items must be emphasized:

  !important

  The build instructions assume that the Host System Requirements, including symbolic links, have been set properly:
  - bash is the shell in use.
  - sh is a symbolic link to bash.
  - /usr/bin/awk is a symbolic link to gawk.
  - /usr/bin/yacc is a symbolic link to bison or a small script that executes bison.

  !important

  To re-emphasize the build process:
  1. Place all the sources and patches in a directory that will be accessible from the chroot environment such as /mnt/lfs/sources/. Do not put sources in /mnt/lfs/tools/.
  2. Change to the sources directory.
  3. For each package:
     a. Using the tar program, extract the package to be built. In Chapter 5, ensure you are the lfs user when extracting the package.
     b. Change to the directory created when the package was extracted.
     c. Follow the book’s instructions for building the package.
     d. Change back to the sources directory.
     e. Delete the extracted source directory unless instructed otherwise.
5.4. Binutils-2.26 - Pass 1

The Binutils package contains a linker, an assembler, and other tools for handling object files.

Approximate build time: 1 SBU  
Required disk space: 522 MB

5.4.1. Installation of Cross Binutils

Note

Go back and re-read the notes in the previous section. Understanding the notes labeled important will save you a lot of problems later.

It is important that Binutils be the first package compiled because both Glibc and GCC perform various tests on the available linker and assembler to determine which of their own features to enable.

The Binutils documentation recommends building Binutils in a dedicated build directory:

```bash
mkdir -v build
cd build
```

Note

In order for the SBU values listed in the rest of the book to be of any use, measure the time it takes to build this package from the configuration, up to and including the first install. To achieve this easily, wrap the commands in a `time` command like this: `time { ./configure ... && ... && make install; }`. 

Note

The approximate build SBU values and required disk space in Chapter 5 does not include test suite data.

Now prepare Binutils for compilation:

```bash
./configure --prefix=/tools            
--with-sysroot=$LFS        
--with-lib-path=/tools/lib 
--target=$LFS_TGT          
--disable-nls              
--disable-werror
```

The meaning of the configure options:

```bash
--prefix=/tools
This tells the configure script to prepare to install the Binutils programs in the /tools directory.
```

```bash
--with-sysroot=$LFS
For cross compilation, this tells the build system to look in $LFS for the target system libraries as needed.
```

```bash
--with-lib-path=/tools/lib
This specifies which library path the linker should be configured to use.
```
--target=$LFS_TGT
Because the machine description in the LFS_TGT variable is slightly different than the value returned by the config.guess script, this switch will tell the configure script to adjust Binutil's build system for building a cross linker.

--disable-nls
This disables internationalization as i18n is not needed for the temporary tools.

--disable-werror
This prevents the build from stopping in the event that there are warnings from the host's compiler.

Continue with compiling the package:

```
make
```

Compilation is now complete. Ordinarily we would now run the test suite, but at this early stage the test suite framework (Tcl, Expect, and DejaGNU) is not yet in place. The benefits of running the tests at this point are minimal since the programs from this first pass will soon be replaced by those from the second.

If building on x86_64, create a symlink to ensure the sanity of the toolchain:

```
case $(uname -m) in
  x86_64) mkdir -v /tools/lib && ln -sv lib /tools/lib64 ;;
esac
```

Install the package:

```
make install
```

Details on this package are located in Section 6.13.2, “Contents of Binutils.”
5.5. GCC-5.3.0 - Pass 1

The GCC package contains the GNU compiler collection, which includes the C and C++ compilers.

- **Approximate build time:** 8.2 SBU
- **Required disk space:** 2.4 GB

5.5.1. Installation of Cross GCC

GCC now requires the GMP, MPFR and MPC packages. As these packages may not be included in your host distribution, they will be built with GCC. Unpack each package into the GCC source directory and rename the resulting directories so the GCC build procedures will automatically use them:

```bash
Note
There are frequent misunderstandings about this chapter. The procedures are the same as every other chapter as explained earlier (Package build instructions). First extract the gcc tarball from the sources directory and then change to the directory created. Only then should you proceed with the instructions below.

tar -xf ../mpfr-3.1.3.tar.xz
mv -v mpfr-3.1.3 mpfr

tar -xf ../gmp-6.1.0.tar.xz
mv -v gmp-6.1.0 gmp

tar -xf ../mpc-1.0.3.tar.gz
mv -v mpc-1.0.3 mpc
```

The following command will change the location of GCC's default dynamic linker to use the one installed in `/tools`. It also removes `/usr/include` from GCC's include search path. Issue:

```bash
for file in \ $(find gcc/config -name linux64.h -o -name linux.h -o -name sysv4.h) do
    cp -uv $file{,.orig}
    sed -e 's@/lib\(64\)\?/ld@/tools&@g' \ -e 's@/usr@/tools@g' $file.orig > $file
    echo '
    #undef STANDARD_STARTFILE_PREFIX_1
    #undef STANDARD_STARTFILE_PREFIX_2
    #define STANDARD_STARTFILE_PREFIX_1 "/tools/lib/"
    #define STANDARD_STARTFILE_PREFIX_2 "" >> $file
    touch $file.orig
done
```

In case the above seems hard to follow, let's break it down a bit. First we find all the files under the `gcc/config` directory that are named either `linux.h`, `linux64.h` or `sysv4.h`. For each file found, we copy it to a file of the same name but with an added suffix of “.orig”. Then the first sed expression prepends “/tools” to every instance of “/lib/ld”, “/lib64/ld” or “/lib32/ld”, while the second one replaces hard-coded instances of “/usr”. Next, we add our define statements which alter the default startfile prefix to the end of the file. Note that the trailing “/” in “/tools/lib/” is required. Finally, we use `touch` to update the timestamp on the copied files. When used in conjunction with `cp -u`, this prevents unexpected changes to the original files in case the commands are inadvertently run twice.
The GCC documentation recommends building GCC in a dedicated build directory:

```bash
mkdir -v build
cd build
```

Prepare GCC for compilation:

```
../configure
   --target=$LFS_TGT
   --prefix=/tools
   --with-glibc-version=2.11
   --with-sysroot=$LFS
   --with-newlib
   --without-headers
   --with-local-prefix=/tools
   --with-native-system-header-dir=/tools/include
   --disable-nls
   --disable-shared
   --disable-multilib
   --disable-decimal-float
   --disable-threads
   --disable-libatomic
   --disable-libgomp
   --disable-libquadmath
   --disable-libssp
   --disable-libvtv
   --disable-libstdcxx
   --enable-languages=c,c++
```

The meaning of the configure options:

`--with-newlib`
Since a working C library is not yet available, this ensures that the inhibit_libc constant is defined when building libgcc. This prevents the compiling of any code that requires libc support.

`--without-headers`
When creating a complete cross-compiler, GCC requires standard headers compatible with the target system. For our purposes these headers will not be needed. This switch prevents GCC from looking for them.

`--with-local-prefix=/tools`
The local prefix is the location in the system that GCC will search for locally installed include files. The default is `/usr/local`. Setting this to `/tools` helps keep the host location of `/usr/local` out of this GCC’s search path.

`--with-native-system-header-dir=/tools/include`
By default GCC searches `/usr/include` for system headers. In conjunction with the sysroot switch, this would translate normally to `$LFS/usr/include`. However the headers that will be installed in the next two sections will go to `$LFS/tools/include`. This switch ensures that gcc will find them correctly. In the second pass of GCC, this same switch will ensure that no headers from the host system are found.

`--disable-shared`
This switch forces GCC to link its internal libraries statically. We do this to avoid possible issues with the host system.

These switches disable support for the decimal floating point extension, threading, libatomic, libgomp, libquadmath, libssp, libvtv, and the C++ standard library respectively. These features will fail to compile when building a cross-compiler and are not necessary for the task of cross-compiling the temporary libc.

--disable-multilib

On x86_64, LFS does not yet support a multilib configuration. This switch is harmless for x86.

--enable-languages=c,c++

This option ensures that only the C and C++ compilers are built. These are the only languages needed now.

Compile GCC by running:

```
make
```

Compilation is now complete. At this point, the test suite would normally be run, but, as mentioned before, the test suite framework is not in place yet. The benefits of running the tests at this point are minimal since the programs from this first pass will soon be replaced.

Install the package:

```
make install
```

Details on this package are located in Section 6.17.2, “Contents of GCC.”
5.6. Linux-4.4.2 API Headers

The Linux API Headers (in linux-4.4.2.tar.xz) expose the kernel's API for use by Glibc.

**Approximate build time:** 0.1 SBU  
**Required disk space:** 727 MB

5.6.1. Installation of Linux API Headers

The Linux kernel needs to expose an Application Programming Interface (API) for the system's C library (Glibc in LFS) to use. This is done by way of sanitizing various C header files that are shipped in the Linux kernel source tarball.

Make sure there are no stale files embedded in the package:

```bash
make mrproper
```

Now extract the user-visible kernel headers from the source. They are placed in an intermediate local directory and copied to the needed location because the extraction process removes any existing files in the target directory.

```bash
make INSTALL_HDR_PATH=dest headers_install
cp -rv dest/include/* /tools/include
```

Details on this package are located in Section 6.7.2, “Contents of Linux API Headers.”
5.7. Glibc-2.23

The Glibc package contains the main C library. This library provides the basic routines for allocating memory, searching directories, opening and closing files, reading and writing files, string handling, pattern matching, arithmetic, and so on.

**Approximate build time:** 4.3 SBU  
**Required disk space:** 654 MB

5.7.1. Installation of Glibc

The Glibc documentation recommends building Glibc in a dedicated build directory:

```
mkdir -v build
cd build
```

Next, prepare Glibc for compilation:

```
..configure                             
   --prefix=/tools                    
   --host=$LFS_TGT                    
   --build=$(../scripts/config.guess) 
   --disable-profile                  
   --enable-kernel=2.6.32             
   --enable-obsolete-rpc              
   --with-headers=/tools/include      
       libc_cv_forced_unwind=yes      
       libc_cv_ctors_header=yes      
       libc_cv_c_cleanup=yes
```

The meaning of the configure options:

`--host=$LFS_TGT, --build=$(../scripts/config.guess)`

The combined effect of these switches is that Glibc's build system configures itself to cross-compile, using the cross-linker and cross-compiler in /tools.

`--disable-profile`

This builds the libraries without profiling information. Omit this option if profiling on the temporary tools is necessary.

`--enable-kernel=2.6.32`

This tells Glibc to compile the library with support for 2.6.32 and later Linux kernels. Workarounds for older kernels are not enabled.

`--enable-obsolete-rpc`

This installs NIS and RPC related headers that are not installed by default. They are required to build GCC and by several BLFS packages.

`--with-headers=/tools/include`

This tells Glibc to compile itself against the headers recently installed to the tools directory, so that it knows exactly what features the kernel has and can optimize itself accordingly.
**libc_cv_forced_unwind=yes**

The linker installed during Section 5.4, “Binutils-2.26 - Pass 1” was cross-compiled and as such cannot be used until Glibc has been installed. This means that the configure test for force-unwind support will fail, as it relies on a working linker. The `libc_cv_forced_unwind=yes` variable is passed in order to inform `configure` that force-unwind support is available without it having to run the test.

**libc_cv_c_cleanup=yes**

Similarly, we pass `libc_cv_c_cleanup=yes` through to the `configure` script so that the test is skipped and C cleanup handling support is configured.

**libc_cv_ctors_header=yes**

Similarly, we pass `libc_cv_ctors_header=yes` through to the `configure` script so that the test is skipped and gcc constructor support is configured.

During this stage the following warning might appear:

```bash
configure: WARNING:
*** These auxiliary programs are missing or
*** incompatible versions: msgfmt
*** some features will be disabled.
*** Check the INSTALL file for required versions.
```

The missing or incompatible `msgfmt` program is generally harmless. This `msgfmt` program is part of the Gettext package which the host distribution should provide.

**Note**

There have been reports that this package may fail when building as a "parallel make". If this occurs, rerun the make command with a "-j1" option.

Compile the package:

```make
make
```

Install the package:

```make
make install
```
Caution

At this point, it is imperative to stop and ensure that the basic functions (compiling and linking) of the new toolchain are working as expected. To perform a sanity check, run the following commands:

```
$ echo 'int main(){}' > dummy.c
$ $LFS_TGT-gcc dummy.c
$ readelf -l a.out | grep ': /tools'
```

If everything is working correctly, there should be no errors, and the output of the last command will be of the form:

```
[Requesting program interpreter: /tools/lib/ld-linux.so.2]
```

Note that for 64-bit machines, the interpreter name will be `/tools/lib64/ld-linux-x86-64.so.2`. If the output is not shown as above or there was no output at all, then something is wrong. Investigate and retrace the steps to find out where the problem is and correct it. This issue must be resolved before continuing on.

Once all is well, clean up the test files:

```
$ rm -v dummy.c a.out
```

Note

Building Binutils in the section after next will serve as an additional check that the toolchain has been built properly. If Binutils fails to build, it is an indication that something has gone wrong with the previous Binutils, GCC, or Glibc installations.

Details on this package are located in Section 6.9.3, “Contents of Glibc.”
5.8. Libstdc++-5.3.0

Libstdc++ is the standard C++ library. It is needed for the correct operation of the g++ compiler.

Approximate build time: 0.4 SBU
Required disk space: 860 MB

5.8.1. Installation of Target Libstdc++

Note

Libstdc++ is part of the GCC sources. You should first unpack the GCC tarball and change to the gcc-5.3.0 directory.

Create a separate build directory for Libstdc++ and enter it:

```
mkdir -v build
cd build
```

Prepare Libstdc++ for compilation:

```
./libstdc++-v3/configure
   --host=$LFS_TGT
   --prefix=/tools
   --disable-multilib
   --disable-nls
   --disable-libstdcxx-threads
   --disable-libstdcxx-pch
   --with-gxx-include-dir=/tools/$LFS_TGT/include/c++/5.3.0
```

The meaning of the configure options:

```
--host=...
Indicates to use the cross compiler we have just built instead of the one in /usr/bin.

--disable-libstdcxx-threads
Since we have not yet built the C threads library, the C++ one cannot be built either.

--disable-libstdcxx-pch
This switch prevents the installation of precompiled include files, which are not needed at this stage.

--with-gxx-include-dir=/tools/$LFS_TGT/include/c++/5.3.0
This is the location where the standard include files are searched by the C++ compiler. In a normal build, this information is automatically passed to the Libstdc++ configure options from the top level directory. In our case, this information must be explicitly given.
```

Compile libstdc++ by running:

```
make
```

Install the library:

```
make install
```
Details on this package are located in Section 6.17.2, “Contents of GCC.”
5.9. Binutils-2.26 - Pass 2

The Binutils package contains a linker, an assembler, and other tools for handling object files.

**Approximate build time:** 1.1 SBU  
**Required disk space:** 508 MB

### 5.9.1. Installation of Binutils

Create a separate build directory again:

```
mkdir -v build  
cd build
```

Prepare Binutils for compilation:

```
CC=$LFS_TGT-gcc  
AR=$LFS_TGT-ar  
RANLIB=$LFS_TGT-ranlib  
../configure  
   --prefix=/tools  
   --disable-nls  
   --disable-werror  
   --with-lib-path=/tools/lib  
   --with-sysroot
```

The meaning of the new configure options:

```
CC=$LFS_TGT-gcc AR=$LFS_TGT-ar RANLIB=$LFS_TGT-ranlib
```

Because this is really a native build of Binutils, setting these variables ensures that the build system uses the cross-compiler and associated tools instead of the ones on the host system.

```
--with-lib-path=/tools/lib
```

This tells the configure script to specify the library search path during the compilation of Binutils, resulting in `/tools/lib` being passed to the linker. This prevents the linker from searching through library directories on the host.

```
--with-sysroot
```

The sysroot feature enables the linker to find shared objects which are required by other shared objects explicitly included on the linker's command line. Without this, some packages may not build successfully on some hosts.

Compile the package:

```
make
```

Install the package:

```
make install
```

Now prepare the linker for the “Re-adjusting” phase in the next chapter:

```
make -C ld clean  
make -C ld LIB_PATH=/usr/lib:/lib  
cp -v ld/ld-new /tools/bin
```
The meaning of the make parameters:

- \texttt{C ld clean}
  This tells the make program to remove all compiled files in the ld subdirectory.

- \texttt{C ld LIB_PATH=/usr/lib:/lib}
  This option rebuilds everything in the ld subdirectory. Specifying the LIB_PATH Makefile variable on the command line allows us to override the default value of the temporary tools and point it to the proper final path. The value of this variable specifies the linker's default library search path. This preparation is used in the next chapter.

Details on this package are located in Section 6.13.2, “Contents of Binutils.”
5.10. GCC-5.3.0 - Pass 2

The GCC package contains the GNU compiler collection, which includes the C and C++ compilers.

Approximate build time: 10.5 SBU
Required disk space: 2.8 GB

5.10.1. Installation of GCC

Our first build of GCC has installed a couple of internal system headers. Normally one of them, limits.h, will in turn include the corresponding system limits.h header, in this case, /tools/include/limits.h. However, at the time of the first build of gcc /tools/include/limits.h did not exist, so the internal header that GCC installed is a partial, self-contained file and does not include the extended features of the system header. This was adequate for building the temporary libc, but this build of GCC now requires the full internal header. Create a full version of the internal header using a command that is identical to what the GCC build system does in normal circumstances:

```
cat gcc/limitx.h gcc/glimits.h gcc/limity.h > `dirname `$(LFS_TGT-gcc -print-libgcc-file-name)`/include-fixed/limits.h`
```

Once again, change the location of GCC's default dynamic linker to use the one installed in /tools.

```
for file in $(find gcc/config -name linux64.h -o -name linux.h -o -name sysv4.h)
do
cp -uv $file{,.orig}
sed -e 's@/lib\(64\)?@/tools&@g' -e 's@/usr@/tools@g' $file.orig > $file
echo '#undef STANDARD_STARTFILE_PREFIX_1
#undef STANDARD_STARTFILE_PREFIX_2
#define STANDARD_STARTFILE_PREFIX_1 "/tools/lib/"
#define STANDARD_STARTFILE_PREFIX_2 ""' >> $file
touch $file.orig
done
```

As in the first build of GCC it requires the GMP, MPFR and MPC packages. Unpack the tarballs and move them into the required directory names:

```
tar -xf ../mpfr-3.1.3.tar.xz
tar -xf ../gmp-6.1.0.tar.xz
tar -xf ../mpc-1.0.3.tar.gz
```

Create a separate build directory again:

```
mkdir -v build
cd build
```

Before starting to build GCC, remember to unset any environment variables that override the default optimization flags.
Now prepare GCC for compilation:

```
CC=$LFS_TGT-gcc                                    \`
CXX=$LFS_TGT-g++                                   \`
AR=$LFS_TGT-ar                                     \`
RANLIB=$LFS_TGT-ranlib                             \`
../configure                                       \`
   --prefix=/tools                                \`
   --with-local-prefix=/tools                     \`
   --with-native-system-header-dir=/tools/include  \`
   --enable-languages=c,c++                       \`
   --disable-libstdcxx-pch                        \`
   --disable-multilib                             \`
   --disable-bootstrap                            \`
   --disable-libgomp                               \`
```

The meaning of the new configure options:

`--enable-languages=c,c++`
This option ensures that both the C and C++ compilers are built.

`--disable-libstdcxx-pch`
Do not build the pre-compiled header (PCH) for `libstdc++`. It takes up a lot of space, and we have no use for it.

`--disable-bootstrap`
For native builds of GCC, the default is to do a "bootstrap" build. This does not just compile GCC, but compiles it several times. It uses the programs compiled in a first round to compile itself a second time, and then again a third time. The second and third iterations are compared to make sure it can reproduce itself flawlessly. This also implies that it was compiled correctly. However, the LFS build method should provide a solid compiler without the need to bootstrap each time.

Compile the package:

```
make
```

Install the package:

```
make install
```

As a finishing touch, create a symlink. Many programs and scripts run `cc` instead of `gcc`, which is used to keep programs generic and therefore usable on all kinds of UNIX systems where the GNU C compiler is not always installed. Running `cc` leaves the system administrator free to decide which C compiler to install:

```
ln -sv gcc /tools/bin/cc
```
**Caution**

At this point, it is imperative to stop and ensure that the basic functions (compiling and linking) of the new toolchain are working as expected. To perform a sanity check, run the following commands:

```
    echo 'int main(){}' > dummy.c
    cc dummy.c
    readelf -l a.out | grep ': /tools'
```

If everything is working correctly, there should be no errors, and the output of the last command will be of the form:

```
[Requesting program interpreter: /tools/lib/ld-linux.so.2]
```

Note that `/tools/lib`, or `/tools/lib64` for 64-bit machines appears as the prefix of the dynamic linker.

If the output is not shown as above or there was no output at all, then something is wrong. Investigate and retrace the steps to find out where the problem is and correct it. This issue must be resolved before continuing on. First, perform the sanity check again, using `gcc` instead of `cc`. If this works, then the `/tools/bin/cc` symlink is missing. Install the symlink as per above. Next, ensure that the `PATH` is correct. This can be checked by running `echo $PATH` and verifying that `/tools/bin` is at the head of the list. If the `PATH` is wrong it could mean that you are not logged in as user `lfs` or that something went wrong back in Section 4.4, “Setting Up the Environment.”

Once all is well, clean up the test files:

```
    rm -v dummy.c a.out
```

Details on this package are located in Section 6.17.2, “Contents of GCC.”
5.11. Tcl-core-8.6.4

The Tcl package contains the Tool Command Language.

**Approximate build time:** 0.4 SBU
**Required disk space:** 41 MB

5.11.1. Installation of Tcl-core

This package and the next three (Expect, DejaGNU, and Check) are installed to support running the test suites for GCC and Binutils and other packages. Installing four packages for testing purposes may seem excessive, but it is very reassuring, if not essential, to know that the most important tools are working properly. Even if the test suites are not run in this chapter (they are not mandatory), these packages are required to run the test suites in Chapter 6.

Note that the Tcl package used here is a minimal version needed to run the LFS tests. For the full package, see the BLFS Tcl procedures.

Prepare Tcl for compilation:

```bash
cd unix
./configure --prefix=/tools
```

Build the package:

```bash
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Tcl test suite anyway, issue the following command:

```bash
TZ=UTC make test
```

The Tcl test suite may experience failures under certain host conditions that are not fully understood. Therefore, test suite failures here are not surprising, and are not considered critical. The `TZ=UTC` parameter sets the time zone to Coordinated Universal Time (UTC), but only for the duration of the test suite run. This ensures that the clock tests are exercised correctly. Details on the `TZ` environment variable are provided in Chapter 7.

Install the package:

```bash
make install
```

Make the installed library writable so debugging symbols can be removed later:

```bash
chmod -v u+w /tools/lib/libtcl8.6.so
```

Install Tcl's headers. The next package, Expect, requires them to build.

```bash
make install-private-headers
```

Now make a necessary symbolic link:

```bash
ln -sv tclsh8.6 /tools/bin/tclsh
```

5.11.2. Contents of Tcl-core

**Installed programs:** tclsh (link to tclsh8.6) and tclsh8.6
**Installed library:** libtcl8.6.so, libtclstub8.6.a
### Short Descriptions

<table>
<thead>
<tr>
<th>tclsh8.6</th>
<th>The Tcl command shell</th>
</tr>
</thead>
<tbody>
<tr>
<td>tclsh</td>
<td>A link to tclsh8.6</td>
</tr>
<tr>
<td>libtcl8.6.so</td>
<td>The Tcl library</td>
</tr>
<tr>
<td>libtclstub8.6.a</td>
<td>The Tcl Stub library</td>
</tr>
</tbody>
</table>
5.12. Expect-5.45

The Expect package contains a program for carrying out scripted dialogues with other interactive programs.

**Approximate build time:** less than 0.1 SBU  
**Required disk space:** 4.4 MB

5.12.1. Installation of Expect

First, force Expect's configure script to use `/bin/stty` instead of a `/usr/local/bin/stty` it may find on the host system. This will ensure that our test suite tools remain sane for the final builds of our toolchain:

```bash
cp -v configure{,.orig}  
```

```bash
sed 's:/usr/local/bin:/bin:' configure.orig > configure
```

Now prepare Expect for compilation:

```bash
./configure --prefix=/tools     
   --with-tcl=/tools/lib       
   --with-tclinclude=/tools/include
```

The meaning of the configure options:

```bash
--with-tcl=/tools/lib
```

This ensures that the configure script finds the Tcl installation in the temporary tools location instead of possibly locating an existing one on the host system.

```bash
--with-tclinclude=/tools/include
```

This explicitly tells Expect where to find Tcl's internal headers. Using this option avoids conditions where `configure` fails because it cannot automatically discover the location of Tcl's headers.

Build the package:

```bash
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Expect test suite anyway, issue the following command:

```bash
make test
```

Note that the Expect test suite is known to experience failures under certain host conditions that are not within our control. Therefore, test suite failures here are not surprising and are not considered critical.

Install the package:

```bash
make SCRIPTS="" install
```

The meaning of the make parameter:

```bash
SCRIPTS=""
```

This prevents installation of the supplementary Expect scripts, which are not needed.

5.12.2. Contents of Expect

**Installed program:** expect  
**Installed library:** libexpect-5.45.so
<table>
<thead>
<tr>
<th><strong>Short Descriptions</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>expect</strong></td>
<td>Communicates with other interactive programs according to a script</td>
</tr>
<tr>
<td><strong>libexpect-5.45.so</strong></td>
<td>Contains functions that allow Expect to be used as a Tcl extension or to be used directly from C or C++ (without Tcl)</td>
</tr>
</tbody>
</table>
5.13. DejaGNU-1.5.3

The DejaGNU package contains a framework for testing other programs.

Approximate build time: less than 0.1 SBU
Required disk space: 4.2 MB

5.13.1. Installation of DejaGNU

Prepare DejaGNU for compilation:

```
./configure --prefix=/tools
```

Build and install the package:

```
make install
```

To test the results, issue:

```
make check
```

5.13.2. Contents of DejaGNU

Installed program: runtest

Short Descriptions

runtest A wrapper script that locates the proper expect shell and then runs DejaGNU
5.14. Check-0.10.0

Check is a unit testing framework for C.

Approximate build time: 0.1 SBU
Required disk space: 10 MB

5.14.1. Installation of Check

Prepare Check for compilation:

```
PKG_CONFIG= ./configure --prefix=/tools
```

The meaning of the configure parameter:

```
PKG_CONFIG=
```

This tells the configure script to ignore any pkg-config options that may cause the system to try to link with libraries not in the /tools directory.

Build the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Check test suite anyway, issue the following command:

```
make check
```

Note that the Check test suite may take a relatively long (up to 4 SBU) time.

Install the package:

```
make install
```

5.14.2. Contents of Check

Installed program: checkmk
Installed library: libcheck.{a,so}

Short Descriptions

checkmk  
Awk script for generating C unit tests for use with the Check unit testing framework

libcheck.{a,so}  
Contains functions that allow Check to be called from a test program
5.15. Ncurses-6.0

The Ncurses package contains libraries for terminal-independent handling of character screens.

**Approximate build time:** 0.5 SBU  
**Required disk space:** 38 MB

5.15.1. Installation of Ncurses

First, ensure that gawk is found first during configuration:

```
sed -i s/mawk// configure
```

Prepare Ncurses for compilation:

```
./configure --prefix=/tools \  
  --with-shared \  
  --without-debug \  
  --without-ada \  
  --enable-widec \  
  --enable-overwrite
```

The meaning of the configure options:

```
--without-ada
   This ensures that Ncurses does not build support for the Ada compiler which may be present on the host but will not be available once we enter the chroot environment.

--enable-overwrite
   This tells Ncurses to install its header files into /tools/include, instead of /tools/include/ncurses, to ensure that other packages can find the Ncurses headers successfully.

--enable-widec
   This switch causes wide-character libraries (e.g., libncursesw.so.6.0) to be built instead of normal ones (e.g., libncurses.so.6.0). These wide-character libraries are usable in both multibyte and traditional 8-bit locales, while normal libraries work properly only in 8-bit locales. Wide-character and normal libraries are source-compatible, but not binary-compatible.
```

Compile the package:

```
make
```

This package has a test suite, but it can only be run after the package has been installed. The tests reside in the test/ directory. See the README file in that directory for further details.

Install the package:

```
make install
```

Details on this package are located in Section 6.20.2, “Contents of Ncurses.”
5.16. Bash-4.3.30

The Bash package contains the Bourne-Again SHell.

Approximate build time: 0.4 SBU
Required disk space: 55 MB

5.16.1. Installation of Bash

Prepare Bash for compilation:

```
./configure --prefix=/tools --without-bash-malloc
```

The meaning of the configure options:

```
--without-bash-malloc
```

This option turns off the use of Bash's memory allocation (malloc) function which is known to cause segmentation faults. By turning this option off, Bash will use the malloc functions from Glibc which are more stable.

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Bash test suite anyway, issue the following command:

```
make tests
```

Install the package:

```
make install
```

Make a link for the programs that use sh for a shell:

```
ln -sv bash /tools/bin/sh
```

Details on this package are located in Section 6.33.2, “Contents of Bash.”
5.17. Bzip2-1.0.6

The Bzip2 package contains programs for compressing and decompressing files. Compressing text files with `bzip2` yields a much better compression percentage than with the traditional `gzip`.

Approximate build time: less than 0.1 SBU  
Required disk space: 5.7 MB

5.17.1. Installation of Bzip2

The Bzip2 package does not contain a `configure` script. Compile and test it with:

```
make
```

Install the package:

```
make PREFIX=/tools install
```

Details on this package are located in Section 6.18.2, “Contents of Bzip2.”
5.18. Coreutils-8.25

The Coreutils package contains utilities for showing and setting the basic system characteristics.

Approximate build time: 0.7 SBU
Required disk space: 136 MB

5.18.1. Installation of Coreutils

Prepare Coreutils for compilation:

```
./configure --prefix=/tools --enable-install-program=hostname
```

The meaning of the configure options:

--enable-install-program=hostname
This enables the hostname binary to be built and installed – it is disabled by default but is required by the Perl test suite.

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Coreutils test suite anyway, issue the following command:

```
make RUN_EXPENSIVE_TESTS=yes check
```

The RUN_EXPENSIVE_TESTS=yes parameter tells the test suite to run several additional tests that are considered relatively expensive (in terms of CPU power and memory usage) on some platforms, but generally are not a problem on Linux.

Install the package:

```
make install
```

Details on this package are located in Section 6.51.2, “Contents of Coreutils.”
5.19. Diffutils-3.3

The Diffutils package contains programs that show the differences between files or directories.

Approximate build time: 0.2 SBU
Required disk space: 20 MB

5.19.1. Installation of Diffutils

Prepare Diffutils for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Diffutils test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.52.2, “Contents of Diffutils.”
5.20. File-5.25

The File package contains a utility for determining the type of a given file or files.

**Approximate build time:** less than 0.1 SBU
**Required disk space:** 14 MB

5.20.1. Installation of File

Prepare File for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the File test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.12.2, “Contents of File.”
5.21. Findutils-4.6.0

The Findutils package contains programs to find files. These programs are provided to recursively search through a directory tree and to create, maintain, and search a database (often faster than the recursive find, but unreliable if the database has not been recently updated).

Approximate build time: 0.3 SBU
Required disk space: 36 MB

5.21.1. Installation of Findutils

Prepare Findutils for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Findutils test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.54.2, “Contents of Findutils.”
5.22. Gawk-4.1.3

The Gawk package contains programs for manipulating text files.

Approximate build time: 0.2 SBU
Required disk space: 36 MB

5.22.1. Installation of Gawk

Prepare Gawk for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Gawk test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.53.2, “Contents of Gawk.”
5.23. Gettext-0.19.7

The Gettext package contains utilities for internationalization and localization. These allow programs to be compiled with NLS (Native Language Support), enabling them to output messages in the user's native language.

Approximate build time: 0.9 SBU
Required disk space: 171 MB

5.23.1. Installation of Gettext

For our temporary set of tools, we only need to build and install three programs from Gettext.

Prepare Gettext for compilation:

```
cd gettext-tools
EMACS="no" ./configure --prefix=/tools --disable-shared
```

The meaning of the configure option:

`EMACS="no"`

This prevents the configure script from determining where to install Emacs Lisp files as the test is known to hang on some hosts.

`--disable-shared`

We do not need to install any of the shared Gettext libraries at this time, therefore there is no need to build them.

Compile the package:

```
make -C gnulib-lib
make -C intel pluralx.c
make -C src msgfmt
make -C src msgmerge
make -C src xgettext
```

As only three programs have been compiled, it is not possible to run the test suite without compiling additional support libraries from the Gettext package. It is therefore not recommended to attempt to run the test suite at this stage.

Install the `msgfmt`, `msgmerge` and `xgettext` programs:

```
cp -v src/{msgfmt,msgmerge,xgettext} /tools/bin
```

Details on this package are located in Section 6.47.2, “Contents of Gettext.”
5.24. Grep-2.23

The Grep package contains programs for searching through files.

**Approximate build time:** 0.2 SBU  
**Required disk space:** 19 MB

5.24.1. Installation of Grep

Prepare Grep for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Grep test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.31.2, “Contents of Grep.”
5.25. Gzip-1.6

The Gzip package contains programs for compressing and decompressing files.

Approximate build time: 0.1 SBU
Required disk space: 10 MB

5.25.1. Installation of Gzip

Prepare Gzip for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Gzip test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.58.2, “Contents of Gzip.”
5.26. M4-1.4.17

The M4 package contains a macro processor.

Approximate build time: 0.2 SBU
Required disk space: 19 MB

5.26.1. Installation of M4

Prepare M4 for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the M4 test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.28.2, “Contents of M4.”
5.27. Make-4.1

The Make package contains a program for compiling packages.

**Approximate build time:** 0.1 SBU  
**Required disk space:** 12.3 MB

5.27.1. Installation of Make

Prepare Make for compilation:

```
./configure --prefix=/tools --without-guile
```

The meaning of the configure option:

```
--without-guile
```

This ensures that Make-4.1 won’t link against Guile libraries, which may be present on the host system, but won’t be available within the `chroot` environment in the next chapter.

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Make test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.62.2, “Contents of Make.”
5.28. Patch-2.7.5

The Patch package contains a program for modifying or creating files by applying a “patch” file typically created by the `diff` program.

Approximate build time: 0.2 SBU
Required disk space: 11 MB

5.28.1. Installation of Patch

Prepare Patch for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Patch test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.63.2, “Contents of Patch.”
5.29. Perl-5.22.1

The Perl package contains the Practical Extraction and Report Language.

**Approximate build time:** 1.4 SBU  
**Required disk space:** 241 MB

5.29.1. Installation of Perl

Prepare Perl for compilation:

```
sh Configure -des -Dprefix=/tools -Dlibs=-lm
```

Build the package:

```
make
```

Although Perl comes with a test suite, it would be better to wait until it is installed in the next chapter.

Only a few of the utilities and libraries need to be installed at this time:

```
cp -v perl cpan/podlators/pod2man /tools/bin  
mkdir -pv /tools/lib/perl5/5.22.1  
cp -Rv lib/* /tools/lib/perl5/5.22.1
```

Details on this package are located in Section 6.40.2, “Contents of Perl.”
5.30. Sed-4.2.2

The Sed package contains a stream editor.

**Approximate build time:** 0.1 SBU  
**Required disk space:** 10 MB

5.30.1. Installation of Sed

Prepare Sed for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Sed test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.24.2, “Contents of Sed.”
5.31. Tar-1.28

The Tar package contains an archiving program.

Approximate build time: 0.3 SBU
Required disk space: 33 MB

5.31.1. Installation of Tar

Prepare Tar for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Tar test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.67.2, “Contents of Tar.”
5.32. Texinfo-6.1

The Texinfo package contains programs for reading, writing, and converting info pages.

- **Approximate build time:** 0.2 SBU
- **Required disk space:** 100 MB

### 5.32.1. Installation of Texinfo

Prepare Texinfo for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Texinfo test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.68.2, “Contents of Texinfo.”
5.33. Util-linux-2.27.1

The Util-linux package contains miscellaneous utility programs.

**Approximate build time:** 0.7 SBU

**Required disk space:** 120 MB

5.33.1. Installation of Util-linux

Prepare Util-linux for compilation:

```
./configure --prefix=/tools                \
    --without-python               \
    --disable-makeinstall-chown    \
    --without-systemdsystemunitdir \n    PKG_CONFIG=""
```

The meaning of the configure option:

```
--without-python
This switch disables using Python if it is installed on the host system. It avoids trying to build unneeded bindings.
```

```
--disable-makeinstall-chown
This switch disables using the `chown` command during installation. This is not needed when installing into the `/tools` directory and avoids the necessity of installing as root.
```

```
--without-systemdsystemunitdir
On systems that use systemd, the package tries to install a systemd specific file to a non-existent directory in `/tools`. This switch disables the unnecessary action.
```

```
PKG_CONFIG=""
Setting this environment variable prevents adding unneeded features that may be available on the host. Note that the location shown for setting this environment variable is different from other LFS sections where variables are set preceding the command. This location is shown to demonstrate an alternative way of setting an environment variable when using configure.
```

Compile the package:

```
made
```

Install the package:

```
made install
```
5.34. Xz-5.2.2

The Xz package contains programs for compressing and decompressing files. It provides capabilities for the lzma and the newer xz compression formats. Compressing text files with xz yields a better compression percentage than with the traditional gzip or bzip2 commands.

Approximate build time: 0.2 SBU
Required disk space: 18 MB

5.34.1. Installation of Xz

Prepare Xz for compilation:

```
./configure --prefix=/tools
```

Compile the package:

```
make
```

Compilation is now complete. As discussed earlier, running the test suite is not mandatory for the temporary tools here in this chapter. To run the Xz test suite anyway, issue the following command:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section 6.45.2, “Contents of Xz.”
5.35. Stripping

The steps in this section are optional, but if the LFS partition is rather small, it is beneficial to learn that unnecessary items can be removed. The executables and libraries built so far contain about 70 MB of unneeded debugging symbols. Remove those symbols with:

```
strip --strip-debug /tools/lib/*
/usr/bin/strip --strip-unneeded /tools/{,s}bin/*
```

These commands will skip a number of files, reporting that it does not recognize their file format. Most of these are scripts instead of binaries. Also use the system strip command to include the strip binary in /tools.

Take care not to use --strip-unneeded on the libraries. The static ones would be destroyed and the toolchain packages would need to be built all over again.

To save more, remove the documentation:

```
rm -rf /tools/{,share}/{info,man,doc}
```

At this point, you should have at least 3 GB of free space in $LFS that can be used to build and install Glibc and Gcc in the next phase. If you can build and install Glibc, you can build and install the rest too.

5.36. Changing Ownership

**Note**

The commands in the remainder of this book must be performed while logged in as user root and no longer as user lfs. Also, double check that $LFS is set in root's environment.

Currently, the $LFS/tools directory is owned by the user lfs, a user that exists only on the host system. If the $LFS/tools directory is kept as is, the files are owned by a user ID without a corresponding account. This is dangerous because a user account created later could get this same user ID and would own the $LFS/tools directory and all the files therein, thus exposing these files to possible malicious manipulation.

To avoid this issue, you could add the lfs user to the new LFS system later when creating the /etc/passwd file, taking care to assign it the same user and group IDs as on the host system. Better yet, change the ownership of the $LFS/tools directory to user root by running the following command:

```
chown -R root:root $LFS/tools
```

Although the $LFS/tools directory can be deleted once the LFS system has been finished, it can be retained to build additional LFS systems of the same book version. How best to backup $LFS/tools is a matter of personal preference.

**Caution**

If you intend to keep the temporary tools for use in building future LFS systems, now is the time to back them up. Subsequent commands in chapter 6 will alter the tools currently in place, rendering them useless for future builds.
Part III. Building the LFS System
Chapter 6. Installing Basic System Software

6.1. Introduction

In this chapter, we enter the building site and start constructing the LFS system in earnest. That is, we chroot into the temporary mini Linux system, make a few final preparations, and then begin installing the packages.

The installation of this software is straightforward. Although in many cases the installation instructions could be made shorter and more generic, we have opted to provide the full instructions for every package to minimize the possibilities for mistakes. The key to learning what makes a Linux system work is to know what each package is used for and why you (or the system) may need it.

We do not recommend using optimizations. They can make a program run slightly faster, but they may also cause compilation difficulties and problems when running the program. If a package refuses to compile when using optimization, try to compile it without optimization and see if that fixes the problem. Even if the package does compile when using optimization, there is the risk it may have been compiled incorrectly because of the complex interactions between the code and build tools. Also note that the \texttt{-march} and \texttt{-mtune} options using values not specified in the book have not been tested. This may cause problems with the toolchain packages (Binutils, GCC and Glibc). The small potential gains achieved in using compiler optimizations are often outweighed by the risks. First-time builders of LFS are encouraged to build without custom optimizations. The subsequent system will still run very fast and be stable at the same time.

The order that packages are installed in this chapter needs to be strictly followed to ensure that no program accidentally acquires a path referring to \texttt{/tools} hard-wired into it. For the same reason, do not compile separate packages in parallel. Compiling in parallel may save time (especially on dual-CPU machines), but it could result in a program containing a hard-wired path to \texttt{/tools}, which will cause the program to stop working when that directory is removed.

Before the installation instructions, each installation page provides information about the package, including a concise description of what it contains, approximately how long it will take to build, and how much disk space is required during this building process. Following the installation instructions, there is a list of programs and libraries (along with brief descriptions of these) that the package installs.

\begin{note}

The SBU values and required disk space includes test suite data for all applicable packages in Chapter 6.

\end{note}

6.1.1. About libraries

In general, the LFS editors discourage building and installing static libraries. The original purpose for most static libraries has been made obsolete in a modern Linux system. In addition linking a static library into a program can be detrimental. If an update to the library is needed to remove a security problem, all programs that use the static library will need to be relinked to the new library. Since the use of static libraries is not always obvious, the relevant programs (and the procedures needed to do the linking) may not even be known.

In the procedures in Chapter 6, we remove or disable installation of most static libraries. In a few cases, especially glibc and gcc, the use of static libraries remains essential to the general package building process. Usually this is done by passing a \texttt{--disable-static} option to \texttt{configure}. In other cases, alternate means are needed.

For a more complete discussion of libraries, see the discussion \textit{Libraries: Static or shared?} in the BLFS book.
6.2. Preparing Virtual Kernel File Systems

Various file systems exported by the kernel are used to communicate to and from the kernel itself. These file systems are virtual in that no disk space is used for them. The content of the file systems resides in memory.

Begin by creating directories onto which the file systems will be mounted:

```
mkdir -pv $LFS/{dev,proc,sys,run}
```

6.2.1. Creating Initial Device Nodes

When the kernel boots the system, it requires the presence of a few device nodes, in particular the `console` and `null` devices. The device nodes must be created on the hard disk so that they are available before `udevd` has been started, and additionally when Linux is started with `init=/bin/bash`. Create the devices by running the following commands:

```
mknod -m 600 $LFS/dev/console c 5 1
mknod -m 666 $LFS/dev/null c 1 3
```

6.2.2. Mounting and Populating /dev

The recommended method of populating the `/dev` directory with devices is to mount a virtual filesystem (such as `tmpfs`) on the `/dev` directory, and allow the devices to be created dynamically on that virtual filesystem as they are detected or accessed. Device creation is generally done during the boot process by Udev. Since this new system does not yet have Udev and has not yet been booted, it is necessary to mount and populate `/dev` manually. This is accomplished by bind mounting the host system's `/dev` directory. A bind mount is a special type of mount that allows you to create a mirror of a directory or mount point to some other location. Use the following command to achieve this:

```
mount -v --bind /dev $LFS/dev
```

6.2.3. Mounting Virtual Kernel File Systems

Now mount the remaining virtual kernel filesystems:

```
mount -vt devpts devpts $LFS/dev/pts -o gid=5,mode=620
mount -vt proc proc $LFS/proc
mount -vt sysfs sysfs $LFS/sys
mount -vt tmpfs tmpfs $LFS/run
```

The meaning of the mount options for devpts:

```
gid=5
```

This ensures that all devpts-created device nodes are owned by group ID 5. This is the ID we will use later on for the `tty` group. We use the group ID instead of a name, since the host system might use a different ID for its `tty` group.

```
mode=0620
```

This ensures that all devpts-created device nodes have mode 0620 (user readable and writable, group writable). Together with the option above, this ensures that devpts will create device nodes that meet the requirements of `grantpt()`, meaning the Glibc `pt_chown` helper binary (which is not installed by default) is not necessary.
In some host systems, `/dev/shm` is a symbolic link to `/run/shm`. The `/run` tmpfs was mounted above so in this case only a directory needs to be created.

```bash
if [ -h $LFS/dev/shm ]; then
  mkdir -pv $LFS/$(readlink $LFS/dev/shm)
fi
```

### 6.3. Package Management

Package Management is an often requested addition to the LFS Book. A Package Manager allows tracking the installation of files making it easy to remove and upgrade packages. As well as the binary and library files, a package manager will handle the installation of configuration files. Before you begin to wonder, NO—this section will not talk about nor recommend any particular package manager. What it provides is a roundup of the more popular techniques and how they work. The perfect package manager for you may be among these techniques or may be a combination of two or more of these techniques. This section briefly mentions issues that may arise when upgrading packages.

Some reasons why no package manager is mentioned in LFS or BLFS include:

- Dealing with package management takes the focus away from the goals of these books—teaching how a Linux system is built.
- There are multiple solutions for package management, each having its strengths and drawbacks. Including one that satisfies all audiences is difficult.

There are some hints written on the topic of package management. Visit the Hints Project and see if one of them fits your need.

#### 6.3.1. Upgrade Issues

A Package Manager makes it easy to upgrade to newer versions when they are released. Generally the instructions in the LFS and BLFS Book can be used to upgrade to the newer versions. Here are some points that you should be aware of when upgrading packages, especially on a running system.

- If Glibc needs to be upgraded to a newer version, (e.g. from glibc-2.19 to glibc-2.20, it is safer to rebuild LFS. Though you may be able to rebuild all the packages in their dependency order, we do not recommend it.
- If a package containing a shared library is updated, and if the name of the library changes, then all the packages dynamically linked to the library need to be recompiled to link against the newer library. (Note that there is no correlation between the package version and the name of the library.) For example, consider a package foo-1.2.3 that installs a shared library with name `libfoo.so.1`. Say you upgrade the package to a newer version foo-1.2.4 that installs a shared library with name `libfoo.so.2`. In this case, all packages that are dynamically linked to `libfoo.so.1` need to be recompiled to link against `libfoo.so.2`. Note that you should not remove the previous libraries until the dependent packages are recompiled.

#### 6.3.2. Package Management Techniques

The following are some common package management techniques. Before making a decision on a package manager, do some research on the various techniques, particularly the drawbacks of the particular scheme.

##### 6.3.2.1. It is All in My Head!

Yes, this is a package management technique. Some folks do not find the need for a package manager because they know the packages intimately and know what files are installed by each package. Some users also do not need any package management because they plan on rebuilding the entire system when a package is changed.
6.3.2.2. Install in Separate Directories

This is a simplistic package management that does not need any extra package to manage the installations. Each package is installed in a separate directory. For example, package foo-1.1 is installed in /usr/pkg/foo-1.1 and a symlink is made from /usr/pkg/foo to /usr/pkg/foo-1.1. When installing a new version foo-1.2, it is installed in /usr/pkg/foo-1.2 and the previous symlink is replaced by a symlink to the new version.

Environment variables such as PATH, LD_LIBRARY_PATH, MANPATH, INFOPATH and CPPFLAGS need to be expanded to include /usr/pkg/foo. For more than a few packages, this scheme becomes unmanageable.

6.3.2.3. Symlink Style Package Management

This is a variation of the previous package management technique. Each package is installed similar to the previous scheme. But instead of making the symlink, each file is symlinked into the /usr hierarchy. This removes the need to expand the environment variables. Though the symlinks can be created by the user to automate the creation, many package managers have been written using this approach. A few of the popular ones include Stow, Epkg, Graft, and Depot.

The installation needs to be faked, so that the package thinks that it is installed in /usr though in reality it is installed in the /usr/pkg hierarchy. Installing in this manner is not usually a trivial task. For example, consider that you are installing a package libfoo-1.1. The following instructions may not install the package properly:

```
./configure --prefix=/usr/pkg/libfoo/1.1
make
make install
```

The installation will work, but the dependent packages may not link to libfoo as you would expect. If you compile a package that links against libfoo, you may notice that it is linked to /usr/pkg/libfoo/1.1/lib/libfoo.so.1 instead of /usr/lib/libfoo.so.1 as you would expect. The correct approach is to use the DESTDIR strategy to fake installation of the package. This approach works as follows:

```
./configure --prefix=/usr
make
make DESTDIR=/usr/pkg/libfoo/1.1 install
```

Most packages support this approach, but there are some which do not. For the non-compliant packages, you may either need to manually install the package, or you may find that it is easier to install some problematic packages into /opt.

6.3.2.4. Timestamp Based

In this technique, a file is timestamped before the installation of the package. After the installation, a simple use of the find command with the appropriate options can generate a log of all the files installed after the timestamp file was created. A package manager written with this approach is install-log.

Though this scheme has the advantage of being simple, it has two drawbacks. If, during installation, the files are installed with any timestamp other than the current time, those files will not be tracked by the package manager. Also, this scheme can only be used when one package is installed at a time. The logs are not reliable if two packages are being installed on two different consoles.

6.3.2.5. Tracing Installation Scripts

In this approach, the commands that the installation scripts perform are recorded. There are two techniques that one can use:
The `LD_PRELOAD` environment variable can be set to point to a library to be preloaded before installation. During installation, this library tracks the packages that are being installed by attaching itself to various executables such as `cp`, `install`, `mv` and tracking the system calls that modify the filesystem. For this approach to work, all the executables need to be dynamically linked without the suid or sgid bit. Preloading the library may cause some unwanted side-effects during installation. Therefore, it is advised that one performs some tests to ensure that the package manager does not break anything and logs all the appropriate files.

The second technique is to use `strace`, which logs all system calls made during the execution of the installation scripts.

### 6.3.2.6. Creating Package Archives

In this scheme, the package installation is faked into a separate tree as described in the Symlink style package management. After the installation, a package archive is created using the installed files. This archive is then used to install the package either on the local machine or can even be used to install the package on other machines.

This approach is used by most of the package managers found in the commercial distributions. Examples of package managers that follow this approach are RPM (which, incidentally, is required by the *Linux Standard Base Specification*), pkg-utils, Debian's apt, and Gentoo's Portage system. A hint describing how to adopt this style of package management for LFS systems is located at [http://www.linuxfromscratch.org/hints/downloads/files/fakeroot.txt](http://www.linuxfromscratch.org/hints/downloads/files/fakeroot.txt).

Creation of package files that include dependency information is complex and is beyond the scope of LFS.

Slackware uses a `tar` based system for package archives. This system purposely does not handle package dependencies as more complex package managers do. For details of Slackware package management, see [http://www.slackbook.org/html/package-management.html](http://www.slackbook.org/html/package-management.html).

### 6.3.2.7. User Based Management

This scheme, unique to LFS, was devised by Matthias Benkmann, and is available from the *Hints Project*. In this scheme, each package is installed as a separate user into the standard locations. Files belonging to a package are easily identified by checking the user ID. The features and shortcomings of this approach are too complex to describe in this section. For the details please see the hint at [http://www.linuxfromscratch.org/hints/downloads/files/more_control_and_pkg_man.txt](http://www.linuxfromscratch.org/hints/downloads/files/more_control_and_pkg_man.txt).

### 6.3.3. Deploying LFS on Multiple Systems

One of the advantages of an LFS system is that there are no files that depend on the position of files on a disk system. Cloning an LFS build to another computer with the same architecture as the base system is as simple as using `tar` on the LFS partition that contains the root directory (about 250MB uncompressed for a base LFS build), copying that file via network transfer or CD-ROM to the new system and expanding it. From that point, a few configuration files will have to be changed. Configuration files that may need to be updated include: `/etc/hosts`, `/etc/fstab`, `/etc/passwd`, `/etc/group`, `/etc/shadow`, and `/etc/ld.so.conf`.

A custom kernel may need to be built for the new system depending on differences in system hardware and the original kernel configuration.

**Note**

There have been some reports of issues when copying between similar but not identical architectures. For instance, the instruction set for an Intel architecture is not identical with an AMD processor and later versions of some processors may have instructions that are unavailable in earlier versions.
Finally the new system has to be made bootable via Section 8.4, “Using GRUB to Set Up the Boot Process”.

### 6.4. Entering the Chroot Environment

It is time to enter the chroot environment to begin building and installing the final LFS system. As user root, run the following command to enter the realm that is, at the moment, populated with only the temporary tools:

```bash
chroot "$LFS" /tools/bin/env -i
  HOME=/root
  TERM="$TERM"
  PS1='\u: \w\$ '  
  PATH=/bin:/usr/bin:/sbin:/usr/sbin:/tools/bin
/ttools/bin/bash --login +h
```

The `-i` option given to the `env` command will clear all variables of the chroot environment. After that, only the `HOME`, `TERM`, `PS1`, and `PATH` variables are set again. The `TERM=$TERM` construct will set the `TERM` variable inside chroot to the same value as outside chroot. This variable is needed for programs like `vim` and `less` to operate properly. If other variables are needed, such as `CFLAGS` or `CXXFLAGS`, this is a good place to set them again.

From this point on, there is no need to use the `LFS` variable anymore, because all work will be restricted to the LFS file system. This is because the Bash shell is told that `$LFS` is now the root (`/`) directory.

Notice that `/tools/bin` comes last in the `PATH`. This means that a temporary tool will no longer be used once its final version is installed. This occurs when the shell does not “remember” the locations of executed binaries—for this reason, hashing is switched off by passing the `+h` option to `bash`.

Note that the `bash` prompt will say `I have no name!` This is normal because the `/etc/passwd` file has not been created yet.

---

**Note**

It is important that all the commands throughout the remainder of this chapter and the following chapters are run from within the chroot environment. If you leave this environment for any reason (rebooting for example), ensure that the virtual kernel filesystems are mounted as explained in Section 6.2.2, “Mounting and Populating `/dev`” and Section 6.2.3, “Mounting Virtual Kernel File Systems” and enter chroot again before continuing with the installation.
6.5. Creating Directories

It is time to create some structure in the LFS file system. Create a standard directory tree by issuing the following commands:

```bash
mkdir -pv /{bin,boot,etc/{opt,sysconfig},home,lib/firmware,mnt,opt}
mkdir -pv /{media/{floppy,cdrom},sbin,srv,var}
install -dv -m 0750 /root
install -dv -m 1777 /tmp /var/tmp
mkdir -pv /usr/{,local/}{bin,include,lib,sbin,src}
mkdir -pv /usr/{,local/}share/{color,dict,doc,info,locale,man}
mkdir -v /usr/{,local/}share/{misc,terminfo,zoneinfo}
mkdir -v /usr/libexec
mkdir -pv /usr/{,local/}share/man/man{1..8}
```

```bash
case $(uname -m) in
  x86_64) ln -sv lib /lib64
  ln -sv lib /usr/lib64
  ln -sv lib /usr/local/lib64 ;;
esac
```

```bash
mkdir -v /var/{log,mail,spool}
ln -sv /run /var/run
ln -sv /run/lock /var/lock
mkdir -pv /var/{opt,cache,lib/{color,misc,locate},local}
```

Directories are, by default, created with permission mode 755, but this is not desirable for all directories. In the commands above, two changes are made—one to the home directory of user root, and another to the directories for temporary files.

The first mode change ensures that not just anybody can enter the /root directory—the same as a normal user would do with his or her home directory. The second mode change makes sure that any user can write to the /tmp and /var/tmp directories, but cannot remove another user's files from them. The latter is prohibited by the so-called “sticky bit,” the highest bit (1) in the 1777 bit mask.

6.5.1. FHS Compliance Note

The directory tree is based on the Filesystem Hierarchy Standard (FHS) (available at https://wiki.linuxfoundation.org/en/FHS). The FHS also stipulates the optional existence some directories such as /usr/local/games and /usr/share/games. We create only the directories that are needed. However, feel free to create these directories.
6.6. Creating Essential Files and Symlinks

Some programs use hard-wired paths to programs which do not exist yet. In order to satisfy these programs, create a number of symbolic links which will be replaced by real files throughout the course of this chapter after the software has been installed:

```
ln -sv /tools/bin/{bash,cat,echo,pwd,stty} /bin
ln -sv /tools/bin/perl /usr/bin
ln -sv /tools/lib/libgcc_s.so{,.1} /usr/lib
ln -sv /tools/lib/libstdc++.so{,.6} /usr/lib
sed 's/tools/usr/' /tools/lib/libstdc++.la > /usr/lib/libstdc++.la
ln -sv bash /bin/sh
```

The purpose of each link:

```
/bin/bash
  Many bash scripts specify /bin/bash.
/bin/cat
  This pathname is hard-coded into Glibc's configure script.
/bin/echo
  This is to satisfy one of the tests in Glibc's test suite, which expects /bin/echo.
/bin/pwd
  Some configure scripts, particularly Glibc's, have this pathname hard-coded.
/bin/stty
  This pathname is hard-coded into Expect, therefore it is needed for Binutils and GCC test suites to pass.
/usr/bin/perl
  Many Perl scripts hard-code this path to the perl program.
/usr/lib/libgcc_s.so{,.1}
  Glibc needs this for the pthreads library to work.
/usr/lib/libstdc++{,.6}
  This is needed by several tests in Glibc's test suite, as well as for C++ support in GMP.
/usr/lib/libstdc++.la
  This prevents a /tools reference that would otherwise be in /usr/lib/libstdc++.la after GCC is installed.
/bin/sh
  Many shell scripts hard-code /bin/sh.
```

Historically, Linux maintains a list of the mounted file systems in the file /etc/mtab. Modern kernels maintain this list internally and exposes it to the user via the /proc filesystem. To satisfy utilities that expect the presence of /etc/mtab, create the following symbolic link:

```
ln -sv /proc/self/mounts /etc/mtab
```

In order for user root to be able to login and for the name “root” to be recognized, there must be relevant entries in the /etc/passwd and /etc/group files.
Create the `/etc/passwd` file by running the following command:

```
cat > /etc/passwd << "EOF"
root:x:0:0:root:/root:/bin/bash
bin:x:1:1:bin:/dev/null:/bin/false
daemon:x:6:6:Daemon User:/dev/null:/bin/false
messagebus:x:18:18:D-Bus Message Daemon User:/var/run/dbus:/bin/false
systemd-bus-proxy:x:72:72:systemd Bus Proxy:/bin/false
systemd-journal-gateway:x:73:73:systemd Journal Gateway:/bin/false
systemd-journal-upload:x:75:75:systemd Journal Upload:/bin/false
systemd-network:x:76:76:systemd Network Management:/bin/false
systemd-resolve:x:77:77:systemd Resolver:/bin/false
systemd-timesync:x:78:78:systemd Time Synchronization:/bin/false
systemd-coredump:x:79:79:systemd Core Dumper:/bin/false
nobody:x:99:99:Unprivileged User:/dev/null:/bin/false
EOF
```

The actual password for `root` (the “x” used here is just a placeholder) will be set later.
Create the `/etc/group` file by running the following command:

```bash

cat > /etc/group << "EOF"
root:x:0:
bin:x:1:daemon
sys:x:2:
kmem:x:3:
tape:x:4:
tty: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:
adm:x:16:
messagebus:x:18:
systemd-journal:x:23:
input:x:24:
mail:x:34:
systemd-bus-proxy:x:72:
systemd-journal-gateway:x:73:
systemd-journal-remote:x:74:
systemd-journal-upload:x:75:
systemd-network:x:76:
systemd-resolve:x:77:
systemd-timesync:x:78:
systemd-coredump:x:79:
nogroup:x:99:
users:x:999:
EOF
```

The created groups are not part of any standard—they are groups decided on in part by the requirements of the Udev configuration in this chapter, and in part by common convention employed by a number of existing Linux distributions. In addition, some test suites rely on specific users or groups. The Linux Standard Base (LSB, available at [http://www.linuxbase.org](http://www.linuxbase.org)) recommends only that, besides the group `root` with a Group ID (GID) of 0, a group `bin` with a GID of 1 be present. All other group names and GIDs can be chosen freely by the system administrator since well-written programs do not depend on GID numbers, but rather use the group's name.

To remove the “I have no name!” prompt, start a new shell. Since a full Glibc was installed in Chapter 5 and the `/etc/passwd` and `/etc/group` files have been created, user name and group name resolution will now work:

```bash
exec /tools/bin/bash --login +h
```
Note the use of the +h directive. This tells bash not to use its internal path hashing. Without this directive, bash would remember the paths to binaries it has executed. To ensure the use of the newly compiled binaries as soon as they are installed, the +h directive will be used for the duration of this chapter.

The login, agetty, and init programs (and others) use a number of log files to record information such as who was logged into the system and when. However, these programs will not write to the log files if they do not already exist. Initialize the log files and give them proper permissions:

```
touch /var/log/{btmp,lastlog,wtmp}
chgrp -v utmp /var/log/lastlog
chmod -v 664 /var/log/lastlog
chmod -v 600 /var/log/btmp
```

The /var/log/wtmp file records all logins and logouts. The /var/log/lastlog file records when each user last logged in. The /var/log/btmp file records the bad login attempts.

**Note**

The /run/utmp file records the users that are currently logged in. This file is created dynamically in the boot scripts.
6.7. Linux-4.4.2 API Headers

The Linux API Headers (in linux-4.4.2.tar.xz) expose the kernel's API for use by Glibc.

**Approximate build time:** 0.1 SBU

**Required disk space:** 732 MB

### 6.7.1. Installation of Linux API Headers

The Linux kernel needs to expose an Application Programming Interface (API) for the system's C library (Glibc in LFS) to use. This is done by way of sanitizing various C header files that are shipped in the Linux kernel source tarball.

Make sure there are no stale files and dependencies lying around from previous activity:

```
makermproper
```

Now extract the user-visible kernel headers from the source. They are placed in an intermediate local directory and copied to the needed location because the extraction process removes any existing files in the target directory. There are also some hidden files used by the kernel developers and not needed by LFS that are removed from the intermediate directory.

```
makerINSTALL_HDR_PATH=destheaders_install
finddest/include\( -name .install-o-name ..install.cmd\) -delete
cp -rv dest/include/* /usr/include
```

### 6.7.2. Contents of Linux API Headers

**Installed headers:**

- `/usr/include/asm/*.h`
- `/usr/include/asm-generic/*.h`
- `/usr/include/drm/*.h`
- `/usr/include/linux/*.h`
- `/usr/include/mtd/*.h`
- `/usr/include/rdma/*.h`
- `/usr/include/scsi/*.h`
- `/usr/include/sound/*.h`
- `/usr/include/video/*.h`
- `/usr/include/xen/*.h`

**Installed directories:**

- `/usr/include/asm`
- `/usr/include/asm-generic`
- `/usr/include/drm`
- `/usr/include/linux`
- `/usr/include/mtd`
- `/usr/include/rdma`
- `/usr/include/scsi`
- `/usr/include/sound`
- `/usr/include/video`
- `/usr/include/xen`

**Short Descriptions**

- `/usr/include/asm/*.h` The Linux API ASM Headers
- `/usr/include/asm-generic/*.h` The Linux API ASM Generic Headers
- `/usr/include/drm/*.h` The Linux API DRM Headers
- `/usr/include/linux/*.h` The Linux API Linux Headers
- `/usr/include/mtd/*.h` The Linux API MTD Headers
- `/usr/include/rdma/*.h` The Linux API RDMA Headers
- `/usr/include/scsi/*.h` The Linux API SCSI Headers
- `/usr/include/sound/*.h` The Linux API Sound Headers
- `/usr/include/video/*.h` The Linux API Video Headers
- `/usr/include/xen/*.h` The Linux API Xen Headers
6.8. Man-pages-4.04

The Man-pages package contains over 2,200 man pages.

Approximate build time: less than 0.1 SBU
Required disk space: 26 MB

6.8.1. Installation of Man-pages

Install Man-pages by running:

```
make install
```

6.8.2. Contents of Man-pages

Installed files: various man pages

Short Descriptions

man pages Describe C programming language functions, important device files, and significant configuration files
6.9. Glibc-2.23

The Glibc package contains the main C library. This library provides the basic routines for allocating memory, searching directories, opening and closing files, reading and writing files, string handling, pattern matching, arithmetic, and so on.

**Approximate build time:** 18.7 SBU

**Required disk space:** 1.2 GB

6.9.1. Installation of Glibc

**Note**

Some packages outside of LFS suggest installing GNU libiconv in order to translate data from one encoding to another. The project's home page ([http://www.gnu.org/software/libiconv/](http://www.gnu.org/software/libiconv/)) says “This library provides an iconv() implementation, for use on systems which don’t have one, or whose implementation cannot convert from/to Unicode.” Glibc provides an iconv() implementation and can convert from/to Unicode, therefore libiconv is not required on an LFS system.

Some of the Glibc programs use non-FHS compilant /var/db directory to store their runtime data. Apply the following patch to make such programs store their runtime data in the FHS-compliant locations:

```
patch -Np1 -i ../glibc-2.23-fhs-1.patch
```

The Glibc build system is self-contained and will install perfectly, even though the compiler specs file and linker are still pointing at /tools. The specs and linker cannot be adjusted before the Glibc install because the Glibc autoconf tests would give false results and defeat the goal of achieving a clean build.

The Glibc documentation recommends building Glibc in a dedicated build directory:

```
mkdir -v build
cd build
```

Prepare Glibc for compilation:

```
../configure --prefix=/usr          \
    --disable-profile      \
    --enable-kernel=2.6.32      \
    --enable-obsolete-rpc
```

Compile the package:

```
make
```

**Important**

In this section, the test suite for Glibc is considered critical. Do not skip it under any circumstance.

Generally a few tests do not pass, but you can generally ignore any of the test failures listed below. Now test the build results:

```
make check
```
You will probably see some test failures. The Glibc test suite is somewhat dependent on the host system. This is a list of the most common issues seen for this version of LFS:

- **posix/tst-getaddrinfo4** and **posix/tst-getaddrinfo5** will always fail due to not having the necessary networking applications when the tests are run.
- The **rt/tst-cputimer1** and **rt/tst-cpuclock2** tests have been known to fail. The reason is not completely understood, but indications are that minor timing issues can trigger these failures.
- The math tests sometimes fail when running on systems where the CPU is not a relatively new Intel or AMD processor.
- Other tests known to fail on some architectures are **malloc/tst-malloc-usable** and **nptl/tst-cleanupx4**.

Though it is a harmless message, the install stage of Glibc will complain about the absence of `/etc/ld.so.conf`. Prevent this warning with:

```
touch /etc/ld.so.conf
```

Install the package:

```
make install
```

Install the configuration file and runtime directory for **nscd**:

```
cp -v ..../nscd/nscd.conf /etc/nscd.conf
mkdir -pv /var/cache/nscd
```

Install the systemd support files for **nscd**:

```
install -v -Dm644 ..../nscd/nscd.tmpfiles /usr/lib/tmpfiles.d/nscd.conf
install -v -Dm644 ..../nscd/nscd.service /lib/systemd/system/nscd.service
```

The locales that can make the system respond in a different language were not installed by the above command. None of the locales are required, but if some of them are missing, test suites of the future packages would skip important test cases.
Individual locales can be installed using the **localedef** program. E.g., the first `localedef` command below combines the `/usr/share/i18n/locales/cs_CZ` charset-independent locale definition with the `/usr/share/i18n/charmaps/UTF-8.gz` charmap definition and appends the result to the `/usr/lib/locale/locale-archive` file. The following instructions will install the minimum set of locales necessary for the optimal coverage of tests:

```
mkdir -pv /usr/lib/locale
localedef -i cs_CZ -f UTF-8 cs_CZ.UTF-8
localedef -i de_DE -f ISO-8859-1 de_DE
localedef -i de_DE@euro -f ISO-8859-15 de_DE@euro
localedef -i de_DE -f UTF-8 de_DE.UTF-8
localedef -i en_GB -f UTF-8 en_GB.UTF-8
localedef -i en_HK -f ISO-8859-1 en_HK
localedef -i en_PH -f ISO-8859-1 en_PH
localedef -i en_US -f ISO-8859-1 en_US
localedef -i en_US -f UTF-8 en_US.UTF-8
localedef -i es_MX -f ISO-8859-1 es_MX
localedef -i fa_IR -f UTF-8 fa_IR
localedef -i fr_FR -f ISO-8859-1 fr_FR
localedef -i fr_FR@euro -f ISO-8859-15 fr_FR@euro
localedef -i fr_FR -f UTF-8 fr_FR.UTF-8
localedef -i it_IT -f ISO-8859-1 it_IT
localedef -i it_IT -f UTF-8 it_IT.UTF-8
localedef -i ru_RU -f KOI8-R ru_RU.KOI8-R
localedef -i ru_RU -f UTF-8 ru_RU.UTF-8
localedef -i tr_TR -f UTF-8 tr_TR.UTF-8
localedef -i zh_CN -f GB18030 zh_CN.GB18030
```

In addition, install the locale for your own country, language and character set.

Alternatively, install all locales listed in the `glibc-2.23/localedata/SUPPORTED` file (it includes every locale listed above and many more) at once with the following time-consuming command:

```
make localedata/install-locales
```

Then use the `localedef` command to create and install locales not listed in the `glibc-2.23/localedata/SUPPORTED` file in the unlikely case you need them.

### 6.9.2. Configuring Glibc

#### 6.9.2.1. Adding nsswitch.conf

The `/etc/nsswitch.conf` file needs to be created because the Glibc defaults do not work well in a networked environment.
Create a new file `/etc/nsswitch.conf` by running the following:

```bash
cat > /etc/nsswitch.conf << "EOF"
# Begin /etc/nsswitch.conf
passwd: files
group: files
shadow: files
hosts: files dns myhostname
networks: files
protocols: files
services: files
ethers: files
rpc: files

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

### 6.9.2.2. Adding time zone data

Install and set up the time zone data with the following:

```bash
tar -xf ../../*/tzdata2016a.tar.gz

ZONEINFO=/usr/share/zoneinfo
mkdir -pv $ZONEINFO/{posix,right}

for tz in etcetera southamerica northamerica europe africa antarctica \   asia australasia backward pacific new systemv; do
    zic -L /dev/null -d $ZONEINFO -y "sh yearistype.sh" ${tz}
    zic -L /dev/null -d $ZONEINFO/posix -y "sh yearistype.sh" ${tz}
    zic -L leapseconds -d $ZONEINFO/right -y "sh yearistype.sh" ${tz}
done

cp -v zone.tab zone1970.tab iso3166.tab $ZONEINFO
zic -d $ZONEINFO -p America/New_York
unset ZONEINFO
```

The meaning of the `zic` commands:

```
zic -L /dev/null ...
```

This creates posix time zones, without any leap seconds. It is conventional to put these in both `zoneinfo` and `zoneinfo/posix`. It is necessary to put the POSIX time zones in `zoneinfo`, otherwise various test-suites will report errors. On an embedded system, where space is tight and you do not intend to ever update the time zones, you could save 1.9MB by not using the `posix` directory, but some applications or test-suites might produce some failures.
This creates right time zones, including leap seconds. On an embedded system, where space is tight and you do not intend to ever update the time zones, or care about the correct time, you could save 1.9MB by omitting the right directory.

This creates the `posixrules` file. We use New York because POSIX requires the daylight savings time rules to be in accordance with US rules.

One way to determine the local time zone is to run the following script:

```
tzselect
```

After answering a few questions about the location, the script will output the name of the time zone (e.g., `America/Edmonton`). There are also some other possible time zones listed in `/usr/share/zoneinfo` such as `Canada/Eastern` or `EST5EDT` that are not identified by the script but can be used.

Then create the `/etc/localtime` file by running:

```
ln -sfv /usr/share/zoneinfo/<xxx> /etc/localtime
```

Replace `<xxx>` with the name of the time zone selected (e.g., Canada/Eastern).

### 6.9.2.3. Configuring the Dynamic Loader

By default, the dynamic loader (`/lib/ld-linux.so.2`) searches through `/lib` and `/usr/lib` for dynamic libraries that are needed by programs as they are run. However, if there are libraries in directories other than `/lib` and `/usr/lib`, these need to be added to the `/etc/ld.so.conf` file in order for the dynamic loader to find them. Two directories that are commonly known to contain additional libraries are `/usr/local/lib` and `/opt/lib`, so add those directories to the dynamic loader's search path.

Create a new file `/etc/ld.so.conf` by running the following:

```
cat > /etc/ld.so.conf << "EOF"
# Begin /etc/ld.so.conf
/usr/local/lib
/opt/lib
EOF
```

If desired, the dynamic loader can also search a directory and include the contents of files found there. Generally the files in this include directory are one line specifying the desired library path. To add this capability run the following commands:

```
cat >> /etc/ld.so.conf << "EOF"
# Add an include directory
include /etc/ld.so.conf.d/*.conf
EOF
mkdir -pv /etc/ld.so.conf.d
```
6.9.3. Contents of Glibc

**Installed programs:**
catchsegv, gencat, getconf, getent, iconv, iconvconfig, ldconfig, ldd, lddlibc4, locale, localedef, makedb, mtrace, nscd, pcprofiledump, pldd, rpcgen, sln, sotruss, sprof, tzselect, xtrace, zdump, and zic

**Installed libraries:**
ld-2.23.so, libBrokenLocale.{a,so}, libSegFault.so, libanl.{a,so}, libc.{a,so}, libc_nonshared.a, libcidn.so, libcrypt.{a,so}, libdl.{a,so}, libg.a, libieeef.a, libm. {a,so}, libmcheck.a, libmemusage.so, libnsl.{a,so}, libnss_compat.so, libnss_dns.so, libnss_files.so, libnss_hesiod.so, libnss_nis.so, libnss_nisplus.so, libpcprofile.so, libpthread.{a,so}, libpthread_nonshared.a, libresolv.{a,so}, librpcsvc.a, librt.{a,so}, libthread_db.so, and libutil.{a,so}

**Installed directories:**
/usr/include/arpa, /usr/include/bits, /usr/include/gnu, /usr/include/net, /usr/include/netash, /usr/include/netatalk, /usr/include/netax25, /usr/include/neteconet, /usr/include/network, /usr/include/netipx, /usr/include/neticmp, /usr/include/netinet, /usr/include/netipx, /usr/include/nfs, /usr/include/protocols, /usr/include/rpc, /usr/include/rpcsvc, /usr/include/sys, /usr/lib/audit, /usr/lib/gconv, /usr/lib/locale, /usr/libexec/getconf, /usr/share/i18n, /usr/share/zoneinfo, /var/cache/nscd, and /var/lib/nss_db

**Short Descriptions**

- **catchsegv**
  Can be used to create a stack trace when a program terminates with a segmentation fault

- **gencat**
  Generates message catalogues

- **getconf**
  Displays the system configuration values for file system specific variables

- **getent**
  Gets entries from an administrative database

- **iconv**
  Performs character set conversion

- **iconvconfig**
  Creates fastloading **iconv** module configuration files

- **ldconfig**
  Configures the dynamic linker runtime bindings

- **ldd**
  Reports which shared libraries are required by each given program or shared library

- **lddlibc4**
  Assists **ldd** with object files

- **locale**
  Prints various information about the current locale

- **localedef**
  Compiles locale specifications

- **makedb**
  Creates a simple database from textual input

- **mtrace**
  Reads and interprets a memory trace file and displays a summary in human-readable format

- **nscd**
  A daemon that provides a cache for the most common name service requests

- **pcprofiledump**
  Dumps information generated by PC profiling

- **pldd**
  Lists dynamic shared objects used by running processes

- **rpcgen**
  Generates C code to implement the Remote Procedure Call (RPC) protocol

- **sln**
  A statically linked **ln** program

- **sotruss**
  Traces shared library procedure calls of a specified command

- **sprof**
  Reads and displays shared object profiling data
tzselect Asks the user about the location of the system and reports the corresponding time zone description

xtrace Traces the execution of a program by printing the currently executed function

zdmp The time zone dumper

zic The time zone compiler

ld-2.23.so The helper program for shared library executables

libBrokenLocale Used internally by Glibc as a gross hack to get broken programs (e.g., some Motif applications) running. See comments in glibc-2.23/locale/broken_cur_max.c for more information

libSegFault The segmentation fault signal handler, used by catchsegv

libanl An asynchronous name lookup library

libc The main C library

libcidn Used internally by Glibc for handling internationalized domain names in the getaddrinfo() function

libcrypt The cryptography library

libdl The dynamic linking interface library

libg Dummy library containing no functions. Previously was a runtime library for g++

libieee Linking in this module forces error handling rules for math functions as defined by the Institute of Electrical and Electronic Engineers (IEEE). The default is POSIX.1 error handling

libm The mathematical library

libmcheck Turns on memory allocation checking when linked to

libmemusage Used by memusage to help collect information about the memory usage of a program

libnsl The network services library

libnss The Name Service Switch libraries, containing functions for resolving host names, user names, group names, aliases, services, protocols, etc.

libpcprofile Contains profiling functions used to track the amount of CPU time spent in specific source code lines

libpthread The POSIX threads library

libresolv Contains functions for creating, sending, and interpreting packets to the Internet domain name servers

librpcsvc Contains functions providing miscellaneous RPC services

librt Contains functions providing most of the interfaces specified by the POSIX.1b Realtime Extension

libthread_db Contains functions useful for building debuggers for multi-threaded programs

libutil Contains code for “standard” functions used in many different Unix utilities
6.10. Adjusting the Toolchain

Now that the final C libraries have been installed, it is time to adjust the toolchain so that it will link any newly compiled program against these new libraries.

First, backup the /tools linker, and replace it with the adjusted linker we made in chapter 5. We’ll also create a link to its counterpart in /tools/$(uname -m)-pc-linux-gnu/bin:

```bash
mv -v /tools/bin/{ld,ld-old}
mv -v /tools/$(uname -m)-pc-linux-gnu/bin/{ld,ld-old}
mv -v /tools/bin/{ld-new,ld}
ln -sv /tools/bin/ld /tools/$(uname -m)-pc-linux-gnu/bin/ld
```

Next, amend the GCC specs file so that it points to the new dynamic linker. Simply deleting all instances of “/tools” should leave us with the correct path to the dynamic linker. Also adjust the specs file so that GCC knows where to find the correct headers and Glibc start files. A `sed` command accomplishes this:

```bash
gcc -dumpspecs | sed -e 's@/tools@@g'                   \
    -e '/\*startfile_prefix_spec:/{n;s@.*@/usr/lib/ @}' \
    -e '/\*cpp:/{n;s@$@ -isystem /usr/include@}' >      \
    `dirname $(gcc --print-libgcc-file-name)`/specs
```

It is a good idea to visually inspect the specs file to verify the intended change was actually made.

It is imperative at this point to ensure that the basic functions (compiling and linking) of the adjusted toolchain are working as expected. To do this, perform the following sanity checks:

```bash
echo 'int main(){}' > dummy.c
cc dummy.c -v -Wl,--verbose &> dummy.log
readelf -l a.out | grep ': /lib'
```

There should be no errors, and the output of the last command will be (allowing for platform-specific differences in dynamic linker name):

```bash
[Requesting program interpreter: /lib/ld-linux.so.2]
```

Note that /lib is now the prefix of our dynamic linker.

Now make sure that we're setup to use the correct start files:

```bash
grep -o '/usr/lib.*/crt[1in]*succeeded' dummy.log
```

The output of the last command should be:

```bash
/usr/lib/crt1.o succeeded
/usr/lib/crti.o succeeded
/usr/lib/crti.o succeeded
```

Verify that the compiler is searching for the correct header files:

```bash
grep -Bl '^ /usr/include' dummy.log
```
This command should return the following output:

```
#include <...> search starts here:
/usr/include
```

Next, verify that the new linker is being used with the correct search paths:

```
grep 'SEARCH.*/usr/lib' dummy.log | sed 's|; |
|g'
```

References to paths that have components with '-linux-gnu' should be ignored, but otherwise the output of the last command should be:

```
SEARCH_DIR("/usr/lib")
SEARCH_DIR("/lib");
```

Next make sure that we're using the correct libc:

```
grep "/lib.*/libc.so.6 " dummy.log
```

The output of the last command (allowing for a lib64 directory on 64-bit hosts) should be:

```
attempt to open /lib/libc.so.6 succeeded
```

Lastly, make sure GCC is using the correct dynamic linker:

```
grep found dummy.log
```

The output of the last command should be (allowing for platform-specific differences in dynamic linker name and a lib64 directory on 64-bit hosts):

```
found ld-linux.so.2 at /lib/ld-linux.so.2
```

If the output does not appear as shown above or is not received at all, then something is seriously wrong. Investigate and retrace the steps to find out where the problem is and correct it. The most likely reason is that something went wrong with the specs file adjustment. Any issues will need to be resolved before continuing on with the process.

Once everything is working correctly, clean up the test files:

```
rm -v dummy.c a.out dummy.log
```
6.11. Zlib-1.2.8

The Zlib package contains compression and decompression routines used by some programs.

**Approximate build time:** 0.1 SBU  
**Required disk space:** 4.1 MB

6.11.1. Installation of Zlib

Prepare Zlib for compilation:

```
./configure --prefix=/usr
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

The shared library needs to be moved to `/lib`, and as a result the `.so` file in `/usr/lib` will need to be recreated:

```
mv -v /usr/lib/libz.so.* /lib  
ln -sfv ../../../lib/$(readlink /usr/lib/libz.so) /usr/lib/libz.so
```

6.11.2. Contents of Zlib

**Installed libraries:** `libz.{a,so}`

**Short Descriptions**

`libz` Contains compression and decompression functions used by some programs
6.12. File-5.25

The File package contains a utility for determining the type of a given file or files.

Approximate build time: less than 0.1 SBU
Required disk space: 14 MB

6.12.1. Installation of File

Prepare File for compilation:

```
./configure --prefix=/usr
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

6.12.2. Contents of File

Installed programs: file
Installed library: libmagic.so

Short Descriptions

file Tries to classify each given file; it does this by performing several tests—file system tests, magic number tests, and language tests
libmagic Contains routines for magic number recognition, used by the file program
6.13. Binutils-2.26

The Binutils package contains a linker, an assembler, and other tools for handling object files.

**Approximate build time:** 1.1 SBU

**Required disk space:** 540 MB

6.13.1. Installation of Binutils

Verify that the PTYs are working properly inside the chroot environment by performing a simple test:

```
expect -c "spawn ls"
```

This command should output the following:

```
spawn ls
```

If, instead, the output includes the message below, then the environment is not set up for proper PTY operation. This issue needs to be resolved before running the test suites for Binutils and GCC:

```
The system has no more ptys.
Ask your system administrator to create more.
```

Fix a problem identified upstream:

```
patch -Np1 -i ../binutils-2.26-upstream_fix-2.patch
```

The Binutils documentation recommends building Binutils in a dedicated build directory:

```
mkdir -v build
```

```
cd build
```

Prepare Binutils for compilation:

```
..configure --prefix=/usr \ 
    --enable-shared \ 
    --disable-werror
```

Compile the package:

```
make tooldir=/usr
```

**The meaning of the make parameter:**

```
tooldir=/usr
```

Normally, the tooldir (the directory where the executables will ultimately be located) is set to $(exec_prefix)/$(target_alias). For example, x86_64 machines would expand that to /usr/x86_64-unknown-linux-gnu. Because this is a custom system, this target-specific directory in /usr is not required. $(exec_prefix)/$(target_alias) would be used if the system was used to cross-compile (for example, compiling a package on an Intel machine that generates code that can be executed on PowerPC machines).

**Important**

The test suite for Binutils in this section is considered critical. Do not skip it under any circumstances.
Test the results:

```
make check
```

The test 'Link with zlib-gabi compressed debug output' is known to fail.

Install the package:

```
make tooldir=/usr install
```

### 6.13.2. Contents of Binutils

**Installed programs:**
- addr2line, ar, as, c++filt, elfedit, gprof, ld, ld.bfd, nm, objcopy, objdump, ranlib, readelf, size, strings, and strip

**Installed libraries:**
- libbfd.{a,so} and libopcodes.{a,so}

**Installed directory:**
- /usr/lib/ldscripts

**Short Descriptions**

- **addr2line**: Translates program addresses to file names and line numbers; given an address and the name of an executable, it uses the debugging information in the executable to determine which source file and line number are associated with the address.

- **ar**: Creates, modifies, and extracts from archives.

- **as**: An assembler that assembles the output of gcc into object files.

- **c++filt**: Used by the linker to de-mangle C++ and Java symbols and to keep overloaded functions from clashing.

- **elfedit**: Updates the ELF header of ELF files.

- **gprof**: Displays call graph profile data.

- **ld**: A linker that combines a number of object and archive files into a single file, relocating their data and tying up symbol references.

- **ld.bfd**: Hard link to ld.

- **nm**: Lists the symbols occurring in a given object file.

- **objcopy**: Translates one type of object file into another.

- **objdump**: Displays information about the given object file, with options controlling the particular information to display; the information shown is useful to programmers who are working on the compilation tools.

- **ranlib**: Generates an index of the contents of an archive and stores it in the archive; the index lists all of the symbols defined by archive members that are relocatable object files.

- **readelf**: Displays information about ELF type binaries.

- **size**: Lists the section sizes and the total size for the given object files.

- **strings**: Outputs, for each given file, the sequences of printable characters that are of at least the specified length (defaulting to four); for object files, it prints, by default, only the strings from the initializing and loading sections while for other types of files, it scans the entire file.

- **strip**: Discards symbols from object files.

- **libbfd**: The Binary File Descriptor library.
libopcodes  A library for dealing with opcodes—the “readable text” versions of instructions for the processor; it is used for building utilities like objdump
6.14. GMP-6.1.0

The GMP package contains math libraries. These have useful functions for arbitrary precision arithmetic.

Approximate build time: 1.4 SBU
Required disk space: 59 MB

6.14.1. Installation of GMP

Note

If you are building for 32-bit x86, but you have a CPU which is capable of running 64-bit code and you have specified $CFLAGS$ in the environment, the configure script will attempt to configure for 64-bits and fail. Avoid this by invoking the configure command below with

```
ABI=32 ./configure ...
```

Prepare GMP for compilation:

```
./configure --prefix=/usr    \
   --enable-cxx    \
   --disable-static \n   --docdir=/usr/share/doc/gmp-6.1.0
```

The meaning of the new configure options:

```
--enable-cxx
   This parameter enables C++ support
--docdir=/usr/share/doc/gmp-6.1.0
   This variable specifies the correct place for the documentation.
```

Compile the package and generate the HTML documentation:

```
make
make html
```

Important

The test suite for GMP in this section is considered critical. Do not skip it under any circumstances.

Test the results:

```
make check 2>&1 | tee gmp-check-log
```

Ensure that all 190 tests in the test suite passed. Check the results by issuing the following command:

```
awk '/# PASS:/{total+=$3} ; END{print total}' gmp-check-log
```

Install the package and its documentation:

```
make install
make install-html
```
6.14.2. Contents of GMP

**Installed Libraries:** libgmp.so and libgmpxx.so
**Installed directory:** /usr/share/doc/gmp-6.1.0

**Short Descriptions**

- **libgmp** Contains precision math functions
- **libgmpxx** Contains C++ precision math functions
6.15. MPFR-3.1.3

The MPFR package contains functions for multiple precision math.

**Approximate build time:** 0.8 SBU  
**Required disk space:** 47 MB

6.15.1. Installation of MPFR

First, apply the following patch to fix various bugs that have been addressed upstream:

```
patch -Np1 -i ../mpfr-3.1.3-upstream_fixes-2.patch
```

Prepare MPFR for compilation:

```
./configure --prefix=/usr  
   --disable-static  
   --enable-thread-safe  
   --docdir=/usr/share/doc/mpfr-3.1.3
```

Compile the package and generate the HTML documentation:

```
make  
make html
```

**Important**  
The test suite for MPFR in this section is considered critical. Do not skip it under any circumstances.

Test the results and ensure that all tests passed:

```
make check
```

Install the package and its documentation:

```
make install  
make install-html
```

6.15.2. Contents of MPFR

**Installed Libraries:** libmpfr.so  
**Installed directory:** /usr/share/doc/mpfr-3.1.3

**Short Descriptions**

- **libmpfr**  
  Contains multiple-precision math functions
6.16. MPC-1.0.3

The MPC package contains a library for the arithmetic of complex numbers with arbitrarily high precision and correct rounding of the result.

Approximate build time: 0.4 SBU
Required disk space: 18 MB

6.16.1. Installation of MPC

Prepare MPC for compilation:

```
./configure --prefix=/usr    
   --disable-static    
   --docdir=/usr/share/doc/mpc-1.0.3
```

Compile the package and generate the HTML documentation:

```
make
make html
```

To test the results, issue:

```
make check
```

Install the package and its documentation:

```
make install
make install-html
```

6.16.2. Contents of MPC

Installed Libraries: libmpc.so
Installed Directory: /usr/share/doc/mpc-1.0.3

Short Descriptions

libmpc Contains complex math functions
6.17. GCC-5.3.0

The GCC package contains the GNU compiler collection, which includes the C and C++ compilers.

**Approximate build time:** 91.2 SBU (with tests)
**Required disk space:** 3.2 GB

6.17.1. Installation of GCC

The GCC documentation recommends building GCC in a dedicated build directory:

```
mkdir -v build
cd build
```

Prepare GCC for compilation:

```
SED=sed
../configure --prefix=/usr \
  --enable-languages=c,c++ \n  --disable-multilib \n  --disable-bootstrap \n  --with-system-zlib
```

Note that for other languages, there are some prerequisites that are not yet available. See the *BLFS Book* for instructions on how to build all of GCC's supported languages.

**The meaning of the new configure option:**

- **SED=sed**
  
  Setting this environment variable prevents a hard-coded path to /tools/bin/sed.

- **--with-system-zlib**
  
  This switch tells GCC to link to the system installed copy of the Zlib library, rather than its own internal copy.

Compile the package:

```
make
```

**Important**

In this section, the test suite for GCC is considered critical. Do not skip it under any circumstance.

One set of tests in the GCC test suite is known to exhaust the stack, so increase the stack size prior to running the tests:

```
ulimit -s 32768
```

Test the results, but do not stop at errors:

```
make -k check
```

To receive a summary of the test suite results, run:

```
../contrib/test_summary
```
For only the summaries, pipe the output through `grep -A7 Summ`.

Results can be compared with those located at `http://www.linuxfromscratch.org/lfs/build-logs/systemd/` and `http://gcc.gnu.org/ml/gcc-testresults/`.

A few unexpected failures cannot always be avoided. The GCC developers are usually aware of these issues, but have not resolved them yet. In particular, two tests in the libstdc++ test suite are known to fail when running as the root user as we do here. Unless the test results are vastly different from those at the above URL, it is safe to continue.

Install the package:

```
make install
```

Some packages expect the C preprocessor to be installed in the `/lib` directory. To support those packages, create this symlink:

```
ln -sv ..../usr/bin/cpp /lib
```

Many packages use the name `cc` to call the C compiler. To satisfy those packages, create a symlink:

```
ln -sv gcc /usr/bin/cc
```

Add a compatibility symlink to enable building programs with Link Time Optimization (LTO):

```
install -v -dm755 /usr/lib/bfd-plugins
ln -sfv ../../libexec/gcc/$(gcc -dumpmachine)/5.3.0/liblto_plugin.so /usr/lib/bfd-plugins/
```

Now that our final toolchain is in place, it is important to again ensure that compiling and linking will work as expected. We do this by performing the same sanity checks as we did earlier in the chapter:

```
echo 'int main(){}' > dummy.c
c c dummy.c -v -Wl,--verbose &> dummy.log
readelf -l a.out | grep ': /lib'
```

There should be no errors, and the output of the last command will be (allowing for platform-specific differences in dynamic linker name):

```
[Requesting program interpreter: /lib/ld-linux.so.2]
```

Now make sure that we're setup to use the correct start files:

```
grep -o '/usr/lib.*crt[1in].*succeeded' dummy.log
```

The output of the last command should be:

```
/usr/lib/gcc/i686-pc-linux-gnu/5.3.0/..../..../crt1.o succeeded
/usr/lib/gcc/i686-pc-linux-gnu/5.3.0/..../..../crti.o succeeded
/usr/lib/gcc/i686-pc-linux-gnu/5.3.0/..../..../crtn.o succeeded
```

Depending on your machine architecture, the above may differ slightly, the difference usually being the name of the directory after `/usr/lib/gcc`. If your machine is a 64-bit system, you may also see a directory named `lib64` towards the end of the string. The important thing to look for here is that `gcc` has found all three `crt*.o` files under the `/usr/lib` directory.
Verify that the compiler is searching for the correct header files:

```
grep -B4 '^ /usr/include' dummy.log
```

This command should return the following output:

```
#include <...> search starts here:
/usr/lib/gcc/i686-pc-linux-gnu/5.3.0/include
/usr/local/include
/usr/lib/gcc/i686-pc-linux-gnu/5.3.0/include-fixed
/usr/include
```

Again, note that the directory named after your target triplet may be different than the above, depending on your architecture.

**Note**

As of version 4.3.0, GCC now unconditionally installs the `limits.h` file into the private `include-fixed` directory, and that directory is required to be in place.

Next, verify that the new linker is being used with the correct search paths:

```
grep 'SEARCH.*/usr/lib' dummy.log | sed 's| | \n |g'
```

References to paths that have components with `-linux-gnu' should be ignored, but otherwise the output of the last command should be:

```
SEARCH_DIR("/usr/i686-pc-linux-gnu/lib32")
SEARCH_DIR("/usr/local/lib32")
SEARCH_DIR("/lib32")
SEARCH_DIR("/usr/lib32")
SEARCH_DIR("/usr/i686-pc-linux-gnu/lib")
SEARCH_DIR("/usr/local/lib")
SEARCH_DIR("/lib")
SEARCH_DIR("/usr/lib");
```

A 64-bit system may see a few different directories. For example, here is the output from an x86_64 machine:

```
SEARCH_DIR("/usr/x86_64-unknown-linux-gnu/lib64")
SEARCH_DIR("/usr/local/lib64")
SEARCH_DIR("/lib64")
SEARCH_DIR("/usr/lib64")
SEARCH_DIR("/usr/x86_64-unknown-linux-gnu/lib")
SEARCH_DIR("/usr/local/lib")
SEARCH_DIR("/lib")
SEARCH_DIR("/usr/lib");
```

Next make sure that we're using the correct libc:

```
grep "/lib.*/libc.so.6 " dummy.log
```
The output of the last command (allowing for a lib64 directory on 64-bit hosts) should be:

```
attempt to open /lib/libc.so.6 succeeded
```

Lastly, make sure GCC is using the correct dynamic linker:

```
grep found dummy.log
```

The output of the last command should be (allowing for platform-specific differences in dynamic linker name and a lib64 directory on 64-bit hosts):

```
found ld-linux.so.2 at /lib/ld-linux.so.2
```

If the output does not appear as shown above or is not received at all, then something is seriously wrong. Investigate and retrace the steps to find out where the problem is and correct it. The most likely reason is that something went wrong with the specs file adjustment. Any issues will need to be resolved before continuing on with the process.

Once everything is working correctly, clean up the test files:

```
rm -v dummy.c a.out dummy.log
```

Finally, move a misplaced file:

```
mkdir -pv /usr/share/gdb/auto-load/usr/lib
mv -v /usr/lib/*gdb.py /usr/share/gdb/auto-load/usr/lib
```

6.17.2. Contents of GCC

**Installed programs:**
- c++, cc (link to gcc), cpp, g++, gcc, gcc-ar, gcc-nm, gcc-ranlib, and gcov

**Installed libraries:**
- libasan.{a,so}, libatomic.{a,so}, libgcc.a, libgcc_eh.a, libgcc_s.so, libgcov.a, libgomp.{a,so}, libiberty.a, libitm.{a,so}, liblto_plugin.so, libquadmath.{a,so}, libssp.{a,so}, libssp_nonshared.a, libstdc++.{a,so}, libsupc++.a, and libtsan.{a,so}

**Installed directories:**
- /usr/include/c++, /usr/lib/gcc, /usr/libexec/gcc, and /usr/share/gcc-5.3.0

---

**Short Descriptions**

- **c++**
  The C++ compiler

- **cc**
  The C compiler

- **cpp**
  The C preprocessor; it is used by the compiler to expand the #include, #define, and similar statements in the source files

- **g++**
  The C++ compiler

- **gcc**
  The C compiler

- **gcc-ar**
  A wrapper around ar that adds a plugin to the command line. This program is only used to add "link time optimization" and is not useful with the default build options

- **gcc-nm**
  A wrapper around nm that adds a plugin to the command line. This program is only used to add "link time optimization" and is not useful with the default build options

- **gcc-ranlib**
  A wrapper around ranlib that adds a plugin to the command line. This program is only used to add "link time optimization" and is not useful with the default build options

- **gcov**
  A coverage testing tool; it is used to analyze programs to determine where optimizations will have the most effect
<table>
<thead>
<tr>
<th>Library</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>libasan</td>
<td>The Address Sanitizer runtime library</td>
</tr>
<tr>
<td>libgcc</td>
<td>Contains run-time support for gcc</td>
</tr>
<tr>
<td>libgcov</td>
<td>This library is linked in to a program when GCC is instructed to enable profiling</td>
</tr>
<tr>
<td>libgomp</td>
<td>GNU implementation of the OpenMP API for multi-platform shared-memory parallel programming in C/C++ and Fortran</td>
</tr>
<tr>
<td>libiberty</td>
<td>Contains routines used by various GNU programs, including getopt, obstack, strerror, strtol, and strtoul</td>
</tr>
<tr>
<td>liblto_plugin</td>
<td>GCC's Link Time Optimization (LTO) plugin allows GCC to perform optimizations across compilation units</td>
</tr>
<tr>
<td>libquadmath</td>
<td>GCC Quad Precision Math Library API</td>
</tr>
<tr>
<td>libssp</td>
<td>Contains routines supporting GCC's stack-smashing protection functionality</td>
</tr>
<tr>
<td>libstdc++</td>
<td>The standard C++ library</td>
</tr>
<tr>
<td>libsupc++</td>
<td>Provides supporting routines for the C++ programming language</td>
</tr>
<tr>
<td>libtsan</td>
<td>The Thread Sanitizer runtime library</td>
</tr>
</tbody>
</table>
6.18. Bzip2-1.0.6

The Bzip2 package contains programs for compressing and decompressing files. Compressing text files with **bzip2** yields a much better compression percentage than with the traditional **gzip**.

**Approximate build time:** less than 0.1 SBU  
**Required disk space:** 1.7 MB

### 6.18.1. Installation of Bzip2

Apply a patch that will install the documentation for this package:

```bash
patch -Np1 -i ../bzip2-1.0.6-install_docs-1.patch
```

The following command ensures installation of symbolic links are relative:

```bash
sed -i 's@\(ln -s -f \)$(PREFIX)/bin/@\1@' Makefile
```

Ensure the man pages are installed into the correct location:

```bash
sed -i "s@(PREFIX)/man@(PREFIX)/share/man@g" Makefile
```

Prepare Bzip2 for compilation with:

```bash
make -f Makefile-libbz2.so  
make clean
```

The meaning of the make parameter:

`-f Makefile-libbz2.so`

This will cause Bzip2 to be built using a different Makefile file, in this case the `Makefile-libbz2_so` file, which creates a dynamic `libbz2.so` library and links the Bzip2 utilities against it.

Compile and test the package:

```bash
make
```

Install the programs:

```bash
make PREFIX=/usr install
```

Install the shared `bzip2` binary into the `/bin` directory, make some necessary symbolic links, and clean up:

```bash
cp -v bzip2-shared /bin/bzip2  
cp -av libbz2.so* /lib  
ln -sv ../../../lib/libbz2.so.1.0 /usr/lib/libbz2.so  
rm -v /usr/bin/{bunzip2,bzcat,bzip2}  
ln -sv bzip2 /bin/bunzip2  
ln -sv bzip2 /bin/bzcat
```

### 6.18.2. Contents of Bzip2

**Installed programs:** bunzip2 (link to bzip2), bzcat (link to bzip2), bzcmp (link to bzdif), bzdif, bzegrep (link to bzgrep), bzfgrep (link to bzgrep), bzgrep, bzip2, bzip2recover, bzless (link to bzmore), and bzmore

**Installed libraries:** `libbz2.{a,so}`

**Installed directory:** `/usr/share/doc/bzip2-1.0.6`
Short Descriptions

bunzip2  Decompresses bzipped files
bzcat    Decompresses to standard output
bzcmp    Runs cmp on bzipped files
bzdiff   Runs diff on bzipped files
bzegrep  Runs egrep on bzipped files
bzfgrep  Runs fgrep on bzipped files
bzigrep  Runs grep on bzipped files

bzip2    Compresses files using the Burrows-Wheeler block sorting text compression algorithm with Huffman coding; the compression rate is better than that achieved by more conventional compressors using “Lempel-Ziv” algorithms, like gzip

bzip2recover Tries to recover data from damaged bzipped files
bzless   Runs less on bzipped files
bzmore   Runs more on bzipped files
libbz2   The library implementing lossless, block-sorting data compression, using the Burrows-Wheeler algorithm
6.19. Pkg-config-0.29

The pkg-config package contains a tool for passing the include path and/or library paths to build tools during the configure and make file execution.

Approximate build time: 0.3 SBU
Required disk space: 31 MB

6.19.1. Installation of Pkg-config

Prepare Pkg-config for compilation:

```
./configure --prefix=/usr        \
   --with-internal-glib        \
   --disable-host-tool        \
   --docdir=/usr/share/doc/pkg-config-0.29
```

The meaning of the new configure options:

```
--with-internal-glib
This will allow pkg-config to use its internal version of Glib because an external version is not available in LFS.
```

```
--disable-host-tool
This option disables the creation of an undesired hard link to the pkg-config program.
```

Compile the package:

```
made
```

To test the results, issue:

```
made check
```

Install the package:

```
made install
```

6.19.2. Contents of Pkg-config

Installed program: pkg-config
Installed directory: /usr/share/doc/pkg-config-0.29

Short Descriptions

pkg-config returns meta information for the specified library or package
6.20. Ncurses-6.0

The Ncurses package contains libraries for terminal-independent handling of character screens.

Approximate build time: 0.4 SBU
Required disk space: 39 MB

6.20.1. Installation of Ncurses

Don't install a static library that is not handled by configure:

```
sed -i '/LIBTOOL_INSTALL/d' c++/Makefile.in
```

Prepare Ncurses for compilation:

```
./configure --prefix=/usr           \
--mandir=/usr/share/man            \
--with-shared                      \
--without-debug                    \
--without-normal                   \
--enable-pc-files                  \
--enable-widec
```

The meaning of the new configure options:

```
--enable-widec
This switch causes wide-character libraries (e.g., libncursesw.so.6.0) to be built instead of normal ones (e.g., libncurses.so.6.0). These wide-character libraries are usable in both multibyte and traditional 8-bit locales, while normal libraries work properly only in 8-bit locales. Wide-character and normal libraries are source-compatible, but not binary-compatible.

--enable-pc-files
This switch generates and installs .pc files for pkg-config.

--without-normal
This switch disables building and installing most static libraries.
```

Compile the package:

```
make
```

This package has a test suite, but it can only be run after the package has been installed. The tests reside in the test/ directory. See the README file in that directory for further details.

Install the package:

```
make install
```

Move the shared libraries to the /lib directory, where they are expected to reside:

```
mv -v /usr/lib/libncursesw.so.6* /lib
```

Because the libraries have been moved, one symlink points to a non-existent file. Recreate it:

```
lv -sfv ..../lib/$(readlink /usr/lib/libncursesw.so) /usr/lib/libncursesw.so
```
Many applications still expect the linker to be able to find non-wide-character Ncurses libraries. Trick such applications into linking with wide-character libraries by means of symlinks and linker scripts:

```bash
for lib in ncurses form panel menu ; do
  rm -vf /usr/lib/lib${lib}.so
  echo "INPUT(-l${lib}w)" > /usr/lib/lib${lib}.so
  ln -sfv ${lib}w.pc /usr/lib/pkgconfig/${lib}.pc
done
```

Finally, make sure that old applications that look for `-lcurses` at build time are still buildable:

```bash
rm -vf /usr/lib/libcursesw.so
echo "INPUT(-lcursesw)" > /usr/lib/libcursesw.so
ln -sfv libncurses.so /usr/lib/libcurses.so
```

If desired, install the Ncurses documentation:

```bash
mkdir -v /usr/share/doc/ncurses-6.0
cp -v -R doc/* /usr/share/doc/ncurses-6.0
```

### Note

The instructions above don't create non-wide-character Ncurses libraries since no package installed by compiling from sources would link against them at runtime. However, the only known binary-only applications that link against non-wide-character Ncurses libraries require version 5. If you must have such libraries because of some binary-only application or to be compliant with LSB, build the package again with the following commands:

```bash
make distclean
./configure --prefix=/usr    \
  --with-shared    \ 
  --without-normal \ 
  --without-debug  \ 
  --without-cxx-binding \ 
  --with-abi-version=5
make sources libs
cp -av lib/lib*.so.5* /usr/lib
```

### 6.20.2. Contents of Ncurses

**Installed programs:**
- captoinfo (link to tic), clear, infocmp, infotocap (link to tic), ncursesw6-config, reset (link to tset), tabs, tic, toe, tput, and tset

**Installed libraries:**
- libcursesw.so (symlink and linker script to libncursesw.so), libformw.so, libmenuw.so, libncursesw.so, libncurses++w.a, libpanelw.so, and their non-wide-character counterparts without "w" in the library names.

**Installed directories:**
- /usr/share/tabset, /usr/share/terminfo, and /usr/share/doc/ncurses-6.0

### Short Descriptions

**captoinfo**
- Converts a termcap description into a terminfo description
clear
  Clears the screen, if possible
infocmp
  Compares or prints out terminfo descriptions
infotocap
  Converts a terminfo description into a termcap description
ncursesw6-config
  Provides configuration information for ncurses
reset
  Reinitializes a terminal to its default values
tabs
  Clears and sets tab stops on a terminal
tic
  The terminfo entry-description compiler that translates a terminfo file from source format into the binary format needed for the ncurses library routines [A terminfo file contains information on the capabilities of a certain terminal.]
toe
  Lists all available terminal types, giving the primary name and description for each
tput
  Makes the values of terminal-dependent capabilities available to the shell; it can also be used to reset or initialize a terminal or report its long name
tset
  Can be used to initialize terminals
libcursesw
  A link to libncursesw
libncursesw
  Contains functions to display text in many complex ways on a terminal screen; a good example of the use of these functions is the menu displayed during the kernel's make menuconfig
libformw
  Contains functions to implement forms
libmenuw
  Contains functions to implement menus
libpanelw
  Contains functions to implement panels
6.21. Attr-2.4.47

The attr package contains utilities to administer the extended attributes on filesystem objects.

**Approximate build time:** less than 0.1 SBU  
**Required disk space:** 3.4 MB

### 6.21.1. Installation of Attr

Modify the documentation directory so that it is a versioned directory:

```
sed -i -e 's|/@pkg_name@|&-@pkg_version@|' include/builddefs.in
```

Prevent installation of manual pages that were already installed by the `man pages` package:

```
sed -i -e "/{SUBDIRS/s|man[25]||g" man/Makefile
```

Prepare Attr for compilation:

```
./configure --prefix=/usr --disable-static
```

Compile the package:

```
machine
```

The tests need to be run on a filesystem that supports extended attributes such as the ext2, ext3, or ext4 filesystems. The tests are also known to fail if running multiple simultaneous tests (-j option greater than 1). To test the results, issue:

```
machine -j1 tests root-tests
```

Install the package:

```
make install install-dev install-lib
```

```
chmod -v 755 /usr/lib/libattr.so
```

The shared library needs to be moved to `/lib`, and as a result the `.so` file in `/usr/lib` will need to be recreated:

```
mv -v /usr/lib/libattr.so.* /lib
```

```
ln -sfv ../../lib/$(readlink /usr/lib/libattr.so) /usr/lib/libattr.so
```

### 6.21.2. Contents of Attr

**Installed programs:** `attr`, `getfattr`, and `setattr`  
**Installed library:** `libattr.so`  
**Installed directories:** `/usr/include/attr` and `/usr/share/doc/attr-2.4.47`

#### Short Descriptions

- **attr** Extends attributes on filesystem objects  
- **getfattr** Gets the extended attributes of filesystem objects  
- **setattr** Sets the extended attributes of filesystem objects  
- **libattr** Contains the library functions for manipulating extended attributes
6.22. Acl-2.2.52

The Acl package contains utilities to administer Access Control Lists, which are used to define more fine-grained discretionary access rights for files and directories.

**Approximate build time:** less than 0.1 SBU  
**Required disk space:** 5.0 MB

6.22.1. Installation of Acl

Modify the documentation directory so that it is a versioned directory:

```
sed -i -e 's|/@pkg_name@|&-@pkg_version@|' include/builddefs.in
```

Fix some broken tests:

```
sed -i "s:\ sed.*::g" test/{sbits-restore,cp,misc}.test
```

Additionally, fix a bug that causes `getfacl -e` to segfault on overly long group name:

```
sed -i -e "/TABS-1;/a if (x > (TABS-1)) x = (TABS-1);" \ 
  libacl/__acl_to_any_text.c
```

Prepare Acl for compilation:

```
./configure --prefix=/usr \ 
  --disable-static \ 
  --libexecdir=/usr/lib
```

Compile the package:

```
make
```

The Acl tests need to be run on a filesystem that supports access controls after Coreutils has been built with the Acl libraries. If desired, return to this package and run `make -j1 tests` after Coreutils has been built later in this chapter.

Install the package:

```
make install install-dev install-lib
chmod -v 755 /usr/lib/libacl.so
```

The shared library needs to be moved to `/lib`, and as a result the `.so` file in `/usr/lib` will need to be recreated:

```
mv -v /usr/lib/libacl.so.* /lib
ln -sfv../../lib/$(readlink /usr/lib/libacl.so) /usr/lib/libacl.so
```

6.22.2. Contents of Acl

- **Installed programs:** chacl, getfacl, and setacl  
- **Installed library:** libacl.so  
- **Installed directories:** /usr/include/acl and /usr/share/doc/acl-2.2.52

**Short Descriptions**

- **chacl** Changes the access control list of a file or directory
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getfacl</td>
<td>Gets file access control lists</td>
</tr>
<tr>
<td>setacl</td>
<td>Sets file access control lists</td>
</tr>
<tr>
<td>libacl</td>
<td>Contains the library functions for manipulating Access Control Lists</td>
</tr>
</tbody>
</table>
6.23. Libcap-2.25

The Libcap package implements the user-space interfaces to the POSIX 1003.1e capabilities available in Linux kernels. These capabilities are a partitioning of the all powerful root privilege into a set of distinct privileges.

Approximate build time: less than 0.1 SBU
Required disk space: 1.4 MB

6.23.1. Installation of Libcap

Prevent a static library from being installed:

```
sed -i '/install.*STALIBNAME/d' libcap/Makefile
```

Compile the package:

```
make
```

This package does not come with a test suite.

Install the package:

```
make RAISE_SETFCAP=no prefix=/usr install
chmod -v 755 /usr/lib/libcap.so
```

The meaning of the make option:

```
RAISE_SETFCAP=no
```

This parameter skips trying to use `setcap` on itself. This avoids an installation error if the kernel or file system does not support extended capabilities.

The shared library needs to be moved to `/lib`, and as a result the `.so` file in `/usr/lib` will need to be recreated:

```
mv -v /usr/lib/libcap.so.* /lib
ln -sfv ../..lib/$(readlink /usr/lib/libcap.so) /usr/lib/libcap.so
```

6.23.2. Contents of Libcap

Installed programs: `capsh`, `getcap`, `getpcaps`, and `setcap`

Installed library: `libcap.so`

Short Descriptions

- **capsh**: A shell wrapper to explore and constrain capability support
- **getcap**: Examines file capabilities
- **getpcaps**: Displays the capabilities on the queried process(es)
- **libcap**: Contains the library functions for manipulating POSIX 1003.1e capabilities
6.24. Sed-4.2.2

The Sed package contains a stream editor.

Approximate build time: 0.2 SBU
Required disk space: 11 MB

6.24.1. Installation of Sed

Prepare Sed for compilation:

```
./configure --prefix=/usr --bindir=/bin --htmldir=/usr/share/doc/sed-4.2.2
```

The meaning of the new configure option:

```
--htmldir
```

This sets the installation directory for the HTML documentation.

Compile the package and generate the HTML documentation:

```
make
make html
```

To test the results, issue:

```
make check
```

Install the package and its documentation:

```
make install
make -C doc install-html
```

6.24.2. Contents of Sed

Installed program: sed
Installed directory: /usr/share/doc/sed-4.2.2

Short Descriptions

sed Filters and transforms text files in a single pass
6.25. Shadow-4.2.1

The Shadow package contains programs for handling passwords in a secure way.

Approximate build time: 0.2 SBU
Required disk space: 43 MB

6.25.1. Installation of Shadow

Note
If you would like to enforce the use of strong passwords, refer to http://www.linuxfromscratch.org/blfs/view/systemd/postlfs/cracklib.html for installing CrackLib prior to building Shadow. Then add --with-libcrack to the configure command below.

Disable the installation of the groups program and its man pages, as Coreutils provides a better version. Also Prevent the installation of manual pages that were already installed by the man pages package:

```
sed -i 's/groups$(EXEEXT) // src/Makefile.in
find man -name Makefile.in -exec sed -i 's/groups\.'1 // {} \;
find man -name Makefile.in -exec sed -i 's/getspnam\.'3 // {} \;
find man -name Makefile.in -exec sed -i 's/passwd\.'5 // {} \;
```

Instead of using the default crypt method, use the more secure SHA-512 method of password encryption, which also allows passwords longer than 8 characters. It is also necessary to change the obsolete /var/spool/mail location for user mailboxes that Shadow uses by default to the /var/mail location used currently:

```
sed -i -e 's@#ENCRYPT_METHOD DES@ENCRYPT_METHOD SHA512@' \\
-e 's@/var/spool/mail@/var/mail@' etc/login.defs
```

Note
If you chose to build Shadow with Cracklib support, run the following:

```
sed -i 's@DICTPATH.*@DICTPATH\t/lib/cracklib/pw_dict\' etc/login.defs
```

Make a minor change to make the default useradd consistent with the LFS groups file:

```
sed -i 's/1000/999/' etc/useradd
```

Prepare Shadow for compilation:

```
./configure --sysconfdir=/etc --with-group-name-max-length=32
```

The meaning of the configure option:

```
--with-group-name-max-length=32
```

The maximum user name is 32 characters. Make the maximum group name the same.

Compile the package:

```
magic
```
This package does not come with a test suite.

Install the package:

```
make install
```

Move a misplaced program to its proper location:

```
mv -v /usr/bin/passwd /bin
```

### 6.25.2. Configuring Shadow

This package contains utilities to add, modify, and delete users and groups; set and change their passwords; and perform other administrative tasks. For a full explanation of what *password shadowing* means, see the `doc/HOWTO` file within the unpacked source tree. If using Shadow support, keep in mind that programs which need to verify passwords (display managers, FTP programs, pop3 daemons, etc.) must be Shadow-compliant. That is, they need to be able to work with shadowed passwords.

To enable shadowed passwords, run the following command:

```
pwconv
```

To enable shadowed group passwords, run:

```
grpconv
```

Shadow's stock configuration for the `useradd` utility has a few caveats that need some explanation. First, the default action for the `useradd` utility is to create the user and a group of the same name as the user. By default the user ID (UID) and group ID (GID) numbers will begin with 1000. This means if you don't pass parameters to `useradd`, each user will be a member of a unique group on the system. If this behavior is undesirable, you'll need to pass the `-g` parameter to `useradd`. The default parameters are stored in the `/etc/default/useradd` file. You may need to modify two parameters in this file to suit your particular needs.

**/etc/default/useradd Parameter Explanations**

```
GROUP=1000
```

This parameter sets the beginning of the group numbers used in the `/etc/group` file. You can modify it to anything you desire. Note that `useradd` will never reuse a UID or GID. If the number identified in this parameter is used, it will use the next available number after this. Note also that if you don't have a group 1000 on your system the first time you use `useradd` without the `-g` parameter, you'll get a message displayed on the terminal that says: `useradd: unknown GID 1000`. You may disregard this message and group number 1000 will be used.

```
CREATE_MAIL_SPOOL=yes
```

This parameter causes `useradd` to create a mailbox file for the newly created user. `useradd` will make the group ownership of this file to the `mail` group with 0660 permissions. If you would prefer that these mailbox files are not created by `useradd`, issue the following command:

```
sed -i 's/yes/no/' /etc/default/useradd
```

### 6.25.3. Setting the root password

Choose a password for user `root` and set it by running:

```
passwd root
```
6.25.4. Contents of Shadow

**Installed programs:**
- chage, chfn, chgpasswd, chpsswd, chsh, expiry, faillog, gpasswd, groupadd, groupdel, groupmems, groupmod, grpck, grpconv, grpunconv, lastlog, login, logoutd, newgidmap, newgrp, newuidmap, newusers, nologin, passwd, pwck, pwconv, pwunconv, sg (link to newgrp), su, useradd, userdel, usermod, vigr (link to vipw), and vipw

**Installed directory:**
/etc/default

**Short Descriptions**

- **chage**
  Used to change the maximum number of days between obligatory password changes

- **chfn**
  Used to change a user's full name and other information

- **chgpasswd**
  Used to update group passwords in batch mode

- **chpasswd**
  Used to update user passwords in batch mode

- **chsh**
  Used to change a user's default login shell

- **expiry**
  Checks and enforces the current password expiration policy

- **faillog**
  Is used to examine the log of login failures, to set a maximum number of failures before an account is blocked, or to reset the failure count

- **gpasswd**
  Is used to add and delete members and administrators to groups

- **groupadd**
  Creates a group with the given name

- **groupdel**
  Deletes the group with the given name

- **groupmems**
  Allows a user to administer his/her own group membership list without the requirement of super user privileges.

- **groupmod**
  Is used to modify the given group's name or GID

- **grpck**
  Verifies the integrity of the group files /etc/group and /etc/gshadow

- **grpconv**
  Creates or updates the shadow group file from the normal group file

- **grpunconv**
  Updates /etc/group from /etc/gshadow and then deletes the latter

- **lastlog**
  Reports the most recent login of all users or of a given user

- **login**
  Is used by the system to let users sign on

- **logoutd**
  Is a daemon used to enforce restrictions on log-on time and ports

- **newgidmap**
  Is used to set the gid mapping of a user namespace

- **newgrp**
  Is used to change the current GID during a login session

- **newuidmap**
  Is used to set the uid mapping of a user namespace

- **newusers**
  Is used to create or update an entire series of user accounts

- **nologin**
  Displays a message that an account is not available; it is designed to be used as the default shell for accounts that have been disabled

- **passwd**
  Is used to change the password for a user or group account

- **pwck**
  Verifies the integrity of the password files /etc/passwd and /etc/shadow

- **pwconv**
  Creates or updates the shadow password file from the normal password file

- **pwunconv**
  Updates /etc/passwd from /etc/shadow and then deletes the latter
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sg</td>
<td>Executes a given command while the user's GID is set to that of the given group</td>
</tr>
<tr>
<td>su</td>
<td>Runs a shell with substitute user and group IDs</td>
</tr>
<tr>
<td>useradd</td>
<td>Creates a new user with the given name, or updates the default new-user information</td>
</tr>
<tr>
<td>userdel</td>
<td>Deletes the given user account</td>
</tr>
<tr>
<td>usermod</td>
<td>Is used to modify the given user's login name, User Identification (UID), shell, initial group, home directory, etc.</td>
</tr>
<tr>
<td>vigr</td>
<td>Edits the <code>/etc/group</code> or <code>/etc/gshadow</code> files</td>
</tr>
<tr>
<td>vipw</td>
<td>Edits the <code>/etc/passwd</code> or <code>/etc/shadow</code> files</td>
</tr>
</tbody>
</table>
6.26. Psmisc-22.21

The Psmisc package contains programs for displaying information about running processes.

Approximate build time: less than 0.1 SBU
Required disk space: 4.2 MB

6.26.1. Installation of Psmisc

Prepare Psmisc for compilation:

```
./configure --prefix=/usr
```

Compile the package:

```
make
```

This package does not come with a test suite.

Install the package:

```
make install
```

Finally, move the `killall` and `fuser` programs to the location specified by the FHS:

```
mv -v /usr/bin/fuser   /bin
mv -v /usr/bin/killall /bin
```

6.26.2. Contents of Psmisc

Installed programs: fuser, killall, peekfd, prtstat, pstree, and pstree.x11 (link to pstree)

Short Descriptions

- **fuser**: Reports the Process IDs (PIPs) of processes that use the given files or file systems
- **killall**: Kills processes by name; it sends a signal to all processes running any of the given commands
- **peekfd**: Peek at file descriptors of a running process, given its PID
- **prtstat**: Prints information about a process
- **pstree**: Displays running processes as a tree
- **pstree.x11**: Same as `pstree`, except that it waits for confirmation before exiting
6.27. Iana-Etc-2.30

The Iana-Etc package provides data for network services and protocols.

**Approximate build time:**  less than 0.1 SBU

**Required disk space:**   2.3 MB

6.27.1. Installation of Iana-Etc

The following command converts the raw data provided by IANA into the correct formats for the `/etc/protocols` and `/etc/services` data files:

```
make
```

This package does not come with a test suite.

Install the package:

```
make install
```

6.27.2. Contents of Iana-Etc

**Installed files:**  `/etc/protocols` and `/etc/services`

**Short Descriptions**

- `/etc/protocols`  Describes the various DARPA Internet protocols that are available from the TCP/IP subsystem
- `/etc/services`  Provides a mapping between friendly textual names for internet services, and their underlying assigned port numbers and protocol types
6.28. M4-1.4.17

The M4 package contains a macro processor.

Approximate build time: 0.4 SBU
Required disk space: 31 MB

6.28.1. Installation of M4

Prepare M4 for compilation:

```
./configure --prefix=/usr
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

The test-update-copyright.sh failure can safely be ignored.

Install the package:

```
make install
```

6.28.2. Contents of M4

Installed program: m4

Short Descriptions

m4  copies the given files while expanding the macros that they contain [These macros are either built-in or user-defined and can take any number of arguments. Besides performing macro expansion, m4 has built-in functions for including named files, running Unix commands, performing integer arithmetic, manipulating text, recursion, etc. The m4 program can be used either as a front-end to a compiler or as a macro processor in its own right.]
6.29. Bison-3.0.4

The Bison package contains a parser generator.

Approximate build time: 0.3 SBU
Required disk space: 34 MB

6.29.1. Installation of Bison

Prepare Bison for compilation:

```
./configure --prefix=/usr --docdir=/usr/share/doc/bison-3.0.4
```

Compile the package:

```
make
```

There is a circular dependency between bison and flex with regard to the checks. If desired, after installing flex in the next section, the bison checks can be run with `make check`.

Install the package:

```
make install
```

6.29.2. Contents of Bison

**Installed programs:** bison and yacc
**Installed library:** liby.a
**Installed directory:** /usr/share/bison

**Short Descriptions**

**bison**  Generates, from a series of rules, a program for analyzing the structure of text files; Bison is a replacement for Yacc (Yet Another Compiler Compiler)

**yacc**  A wrapper for **bison**, meant for programs that still call **yacc** instead of **bison**; it calls **bison** with the `–y` option

**liby**  The Yacc library containing implementations of Yacc-compatible `yyerror` and `main` functions; this library is normally not very useful, but POSIX requires it
6.30. Flex-2.6.0

The Flex package contains a utility for generating programs that recognize patterns in text.

Approximate build time: 0.4 SBU
Required disk space: 34 MB

6.30.1. Installation of Flex

Prepare Flex for compilation:

```
./configure --prefix=/usr --docdir=/usr/share/doc/flex-2.6.0
```

Compile the package:

```
make
```

To test the results (about 0.5 SBU), issue:

```
make check
```

Install the package:

```
make install
```

A few programs do not know about flex yet and try to run its predecessor, lex. To support those programs, create a symbolic link named lex that runs flex in lex emulation mode:

```
ln -sv flex /usr/bin/lex
```

6.30.2. Contents of Flex

- **Installed programs:** flex, flex++ (link to flex), and lex (link to flex)
- **Installed libraries:** libfl.so and libfl_pic.so
- **Installed directory:** /usr/share/doc/flex-2.6.0

Short Descriptions

- **flex** A tool for generating programs that recognize patterns in text; it allows for the versatility to specify the rules for pattern-finding, eradicating the need to develop a specialized program
- **flex++** An extension of flex, is used for generating C++ code and classes. It is a symbolic link to flex
- **lex** A script that runs flex in lex emulation mode
- **libfl** The flex library
6.31. Grep-2.23

The Grep package contains programs for searching through files.

**Approximate build time:** 0.4 SBU
**Required disk space:** 29 MB

### 6.31.1. Installation of Grep

Prepare Grep for compilation:

```
./configure --prefix=/usr --bindir=/bin
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

### 6.31.2. Contents of Grep

**Installed programs:** egrep, fgrep, and grep

**Short Descriptions**

- **egrep**
  
  Prints lines matching an extended regular expression

- **fgrep**
  
  Prints lines matching a list of fixed strings

- **grep**
  
  Prints lines matching a basic regular expression
6.32. Readline-6.3

The Readline package is a set of libraries that offers command-line editing and history capabilities.

- **Approximate build time:** 0.1 SBU
- **Required disk space:** 14 MB

6.32.1. Installation of Readline

First install some patches to fix various bugs that have been addressed upstream:

```
patch -Np1 -i ../readline-6.3-upstream_fixes-3.patch
```

Reinstalling Readline will cause the old libraries to be moved to `<libraryname>.old`. While this is normally not a problem, in some cases it can trigger a linking bug in `ldconfig`. This can be avoided by issuing the following two seds:

```
sed -i '/MV.*old/d' Makefile.in
sed -i '/{OLDSUFF}/c:' support/shlib-install
```

Prepare Readline for compilation:

```
./configure --prefix=/usr \
    --disable-static \
    --docdir=/usr/share/doc/readline-6.3
```

Compile the package:

```
make SHLIB_LIBS=-lncurses
```

The meaning of the make option:

```
SHLIB_LIBS=-lncurses
```

This option forces Readline to link against the `libncurses` (really, `libncursesw`) library.

This package does not come with a test suite.

Install the package:

```
make SHLIB_LIBS=-lncurses install
```

Now move the dynamic libraries to a more appropriate location and fix up some symbolic links:

```
mv -v /usr/lib/lib{readline,history}.so.* /lib
ln -sfv ..../lib/$(readlink /usr/lib/libreadline.so) /usr/lib/libreadline.so
ln -sfv ..../lib/$(readlink /usr/lib/libhistory.so ) /usr/lib/libhistory.so
```

If desired, install the documentation:

```
install -v -m644 doc/*.{ps,pdf,html,dvi} /usr/share/doc/readline-6.3
```

6.32.2. Contents of Readline

- **Installed libraries:** `libhistory.so` and `libreadline.so`
- **Installed directories:** `/usr/include/readline`, `/usr/share/readline`, and `/usr/share/doc/readline-6.3`
Short Descriptions

libhistory  Provides a consistent user interface for recalling lines of history
libreadline  Aids in the consistency of user interface across discrete programs that need to provide a command line interface
6.33. Bash-4.3.30

The Bash package contains the Bourne-Again SHell.

**Approximate build time:** 1.4 SBU  
**Required disk space:** 50 MB

6.33.1. Installation of Bash

First, apply the following patch to fix various bugs that have been addressed upstream:

```
patch -Np1 -i ../bash-4.3.30-upstream_fixes-3.patch
```

Prepare Bash for compilation:

```
./configure --prefix=/usr                       
   --docdir=/usr/share/doc/bash-4.3.30       
   --without-bash-malloc                     
   --with-installed-readline
```

**The meaning of the new configure option:**

```
--with-installed-readline
```

This option tells Bash to use the `readline` library that is already installed on the system rather than using its own readline version.

Compile the package:

```
make
```

Skip down to “Install the package” if not running the test suite.

To prepare the tests, ensure that the `nobody` user can write to the sources tree:

```
chown -Rv nobody .
```

Now, run the tests as the `nobody` user:

```
su nobody -s /bin/bash -c "PATH=$PATH make tests"
```

Install the package and move the main executable to `/bin`:

```
make install
mv -vf /usr/bin/bash /bin
```

Run the newly compiled `bash` program (replacing the one that is currently being executed):

```
exec /bin/bash --login +h
```

**Note**

The parameters used make the `bash` process an interactive login shell and continue to disable hashing so that new programs are found as they become available.
6.33.2. Contents of Bash

**Installed programs:** bash, bashbug, and sh (link to bash)

**Installed directory:** /usr/share/doc/bash-4.3.30

**Short Descriptions**

**bash**  A widely-used command interpreter; it performs many types of expansions and substitutions on a given command line before executing it, thus making this interpreter a powerful tool

**bashbug**  A shell script to help the user compose and mail standard formatted bug reports concerning **bash**

**sh**  A symlink to the **bash** program; when invoked as **sh**, **bash** tries to mimic the startup behavior of historical versions of **sh** as closely as possible, while conforming to the POSIX standard as well
6.34. Bc-1.06.95

The Bc package contains an arbitrary precision numeric processing language.

**Approximate build time:** 0.1 SBU  
**Required disk space:** 3.7 MB

6.34.1. Installation of Bc

First, fix some minor memory leaks in the code:

```
patch -Np1 -i ../bc-1.06.95-memory_leak-1.patch
```

Prepare Bc for compilation:

```
./configure --prefix=/usr           \
   --with-readline       \
   --mandir=/usr/share/man \
   --infodir=/usr/share/info
```

The meaning of the configure options:

`--with-readline`
This option tells Bc to use the `readline` library that is already installed on the system rather than using its own readline version.

Compile the package:

```
make
```

To test bc, run the commands below. There is quite a bit of output, so you may want to redirect it to a file. There are a very small percentage of tests (10 of 12,144) that will indicate a round off error at the last digit.

```
echo "quit" | ./bc/bc -l Test/checklib.b
```

Install the package:

```
make install
```

6.34.2. Contents of Bc

**Installed programs:** bc and dc

**Short Descriptions**

- **bc** is a command line calculator
- **dc** is a reverse-polish command line calculator
6.35. Libtool-2.4.6

The Libtool package contains the GNU generic library support script. It wraps the complexity of using shared libraries in a consistent, portable interface.

Approximate build time: 2.0 SBU
Required disk space: 44 MB

6.35.1. Installation of Libtool

Prepare Libtool for compilation:

```
./configure --prefix=/usr
```

Compile the package:

```
make
```

To test the results (about 11.0 SBU), issue:

```
make check
```

Five tests are known to fail in the LFS build environment due to a circular dependency, but all tests pass if rechecked after automake is installed.

Install the package:

```
make install
```

6.35.2. Contents of Libtool

<table>
<thead>
<tr>
<th>Installed programs:</th>
<th>libtool and libtoolize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed libraries:</td>
<td>libltdl.so</td>
</tr>
<tr>
<td>Installed directories:</td>
<td>/usr/include/libltdl and /usr/share/libtool</td>
</tr>
</tbody>
</table>

Short Descriptions

<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>libtool</td>
<td>Provides generalized library-building support services</td>
</tr>
<tr>
<td>libtoolize</td>
<td>Provides a standard way to add libtool support to a package</td>
</tr>
<tr>
<td>libltdl</td>
<td>Hides the various difficulties of dlopening libraries</td>
</tr>
</tbody>
</table>
6.36. GDBM-1.11

The GDBM package contains the GNU Database Manager. It is a library of database functions that use extensible hashing and work similar to the standard UNIX dbm. The library provides primitives for storing key/data pairs, searching and retrieving the data by its key and deleting a key along with its data.

**Approximate build time:** 0.1 SBU  
**Required disk space:** 9.1 MB

6.36.1. Installation of GDBM

Prepare GDBM for compilation:

```
./configure --prefix=/usr \
  --disable-static \
  --enable-libgdbm-compat
```

The meaning of the configure option:

```
--enable-libgdbm-compat
```
This switch enables the libgdbm compatibility library to be built, as some packages outside of LFS may require the older DBM routines it provides.

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

6.36.2. Contents of GDBM

**Installed programs:** gdbm_dump, gdbm_load, and gdbmtool  
**Installed libraries:** libgdbm.so and libgdbm_compat.so

**Short Descriptions**

- **gdbm_dump**: Dumps a GDBM database to a file
- **gdbm_load**: Recreates a GDBM database from a dump file
- **gdbmtool**: Tests and modifies a GDBM database
- **libgdbm**: Contains functions to manipulate a hashed database
- **libgdbm_compat**: Compatibility library containing older DBM functions
6.37. Gperf-3.0.4

Gperf generates a perfect hash function from a key set.

Approximate build time:  less than 0.1 SBU
Required disk space:  5.6 MB

6.37.1. Installation of Gperf

Prepare Gperf for compilation:

```
./configure --prefix=/usr --docdir=/usr/share/doc/gperf-3.0.4
```

Compile the package:

```
make
```

The tests are known to fail if running multiple simultaneous tests (-j option greater than 1). To test the results, issue:

```
make -j1 check
```

Install the package:

```
make install
```

6.37.2. Contents of Gperf

Installed program:  gperf
Installed directory:  /usr/share/doc/gperf-3.0.4

Short Descriptions

**gperf**  Generates a perfect hash from a key set
6.38. Expat-2.1.0

The Expat package contains a stream oriented C library for parsing XML.

Approximate build time: less than 0.1 SBU
Required disk space: 6.7 MB

6.38.1. Installation of Expat

Prepare Expat for compilation:

```
./configure --prefix=/usr --disable-static
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

If desired, install the documentation:

```
install -v -dm755 /usr/share/doc/expat-2.1.0
install -v -m644 doc/*.{html,png,css} /usr/share/doc/expat-2.1.0
```

6.38.2. Contents of Expat

Installed program: xmlwf
Installed libraries: libexpat.so
Installed directory: /usr/share/doc/expat-2.1.0

Short Descriptions

xmlwf is a non-validating utility to check whether or not XML documents are well formed
libexpat contains API functions for parsing XML
6.39. Inetutils-1.9.4

The Inetutils package contains programs for basic networking.

<table>
<thead>
<tr>
<th>Approximate build time:</th>
<th>0.4 SBU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required disk space:</td>
<td>28 MB</td>
</tr>
</tbody>
</table>

6.39.1. Installation of Inetutils

Prepare Inetutils for compilation:

```
./configure --prefix=/usr        \
    --localstatedir=/var        \
    --disable-logger       \
    --disable-whois       \
    --disable-rcp        \
    --disable-rexec      \
    --disable-rlogin     \
    --disable-rsh        \
    --disable-servers
```

The meaning of the configure options:

```
--disable-r*
These parameters disable building obsolete programs that should not be used due to security issues. The functions provided by these programs can be provided by the openssh package in the BLFS book.

--disable-logger
This option prevents Inetutils from installing the logger program, which is used by scripts to pass messages to the System Log Daemon. Do not install it because Util-linux installs a more recent version.

--disable-whois
This option disables the building of the Inetutils whois client, which is out of date. Instructions for a better whois client are in the BLFS book.

--disable-servers
This disables the installation of the various network servers included as part of the Inetutils package. These servers are deemed not appropriate in a basic LFS system. Some are insecure by nature and are only considered safe on trusted networks. Note that better replacements are available for many of these servers.
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

Move some programs so they are available if `/usr` is not accessible:

```
mv -v /usr/bin/{hostname,ping,ping6,traceroute} /bin
mv -v /usr/bin/ifconfig /sbin
```
6.39.2. Contents of Inetutils

**Installed programs:** dnsdomainname, ftp, ifconfig, hostname, ping, ping6, talk, telnet, tftp, and traceroute

**Short Descriptions**

- **dnsdomainname**: Show the system's DNS domain name
- **ftp**: Is the file transfer protocol program
- **hostname**: Reports or sets the name of the host
- **ifconfig**: Manages network interfaces
- **ping**: Sends echo-request packets and reports how long the replies take
- **ping6**: A version of ping for IPv6 networks
- **talk**: Is used to chat with another user
- **telnet**: An interface to the TELNET protocol
- **tftp**: A trivial file transfer program
- **traceroute**: Traces the route your packets take from the host you are working on to another host on a network, showing all the intermediate hops (gateways) along the way
6.40. Perl-5.22.1

The Perl package contains the Practical Extraction and Report Language.

**Approximate build time:** 6.2 SBU  
**Required disk space:** 240 MB

### 6.40.1. Installation of Perl

First create a basic `/etc/hosts` file to be referenced in one of Perl's configuration files as well as the optional test suite:

```
echo "127.0.0.1 localhost $(hostname)" > /etc/hosts
```

This version of Perl now builds the Compress::Raw::Zlib and Compress::Raw::BZip2 modules. By default Perl will use an internal copy of the sources for the build. Issue the following command so that Perl will use the libraries installed on the system:

```
export BUILD_ZLIB=False  
export BUILD_BZIP2=0
```

To have full control over the way Perl is set up, you can remove the “-des” options from the following command and hand-pick the way this package is built. Alternatively, use the command exactly as below to use the defaults that Perl auto-detects:

```
sh Configure -des -Dprefix=/usr                 
    -Dvendorprefix=/usr           
    -Dman1dir=/usr/share/man/man1 \  
    -Dman3dir=/usr/share/man/man3 \  
    -Dpager="/usr/bin/less -isR"  \  
    -Duseshrplib
```

**The meaning of the configure options:**

```
-Dvendorprefix=/usr
```

This ensures perl knows how to tell packages where they should install their perl modules.

```
-Dpager="/usr/bin/less -isR"
```

This ensures that less is used instead of more.

```
-Dman1dir=/usr/share/man/man1  
-Dman3dir=/usr/share/man/man3
```

Since Groff is not installed yet, `Configure` thinks that we do not want man pages for Perl. Issuing these parameters overrides this decision.

```
-Duseshrplib
```

Build a shared libperl needed by some perl modules.

Compile the package:

```
make
```

To test the results (approximately 2.5 SBU), issue:

```
make -k test
```
Install the package and clean up:

```
make install
unset BUILD_ZLIB BUILD_BZIP2
```

## 6.40.2. Contents of Perl

### Installed programs:
- c2ph, corelist, cpan, enc2xs, encguess, h2ph, h2xs, instmodsh, json_pp, libnetcfg, perl, perl5.22.1 (hard link to perl), perlbug, perldoc, perlvp, perlthanks (hard link to perlbug), piconv, pl2pm, pod2html, pod2man, pod2text, pod2usage, podchecker, podselect, prove, pstruct (hard link to c2ph), ptar, ptardiff, ptargrep, shasum, splain, xsubpp, and zipdetails

### Installed libraries:
Many which cannot all be listed here

### Installed directory:
/usr/lib/perl5

### Short Descriptions

- **a2p** Translates awk to Perl
- **c2ph** Dumps C structures as generated from `cc -g -S`
- **corelist** A commandline frontend to Module::CoreList
- **cpan** Interact with the Comprehensive Perl Archive Network (CPAN) from the command line
- **cpan2dist** The CPANPLUS distribution creator
- **cpanp** The CPANPLUS launcher
- **cpanp-run-perl** Perl script that is used to enable flushing of the output buffer after each write in spawned processes
- **enc2xs** Builds a Perl extension for the Encode module from either Unicode Character Mappings or Tcl Encoding Files
- **encguess** Guess the encoding type of one or several files
- **find2perl** Translates `find` commands to Perl
- **h2ph** Converts `.h` C header files to `.ph` Perl header files
- **h2xs** Converts `.h` C header files to Perl extensions
- **instmodsh** Shell script for examining installed Perl modules, and can even create a tarball from an installed module
- **json_pp** Converts data between certain input and output formats
- **libnetcfg** Can be used to configure the `libnet` Perl module
- **perl** Combines some of the best features of C, `sed`, `awk` and `sh` into a single swiss-army language
- **perl5.22.1** A hard link to `perl`
- **perlbug** Used to generate bug reports about Perl, or the modules that come with it, and mail them
- **perldoc** Displays a piece of documentation in pod format that is embedded in the Perl installation tree or in a Perl script
- **perlvp** The Perl Installation Verification Procedure; it can be used to verify that Perl and its libraries have been installed correctly
- **perlthanks** Used to generate thank you messages to mail to the Perl developers
piconv  A Perl version of the character encoding converter **iconv**
pl2pm  A rough tool for converting Perl4 .pl files to Perl5 .pm modules
pod2html  Converts files from pod format to HTML format
pod2latex  Converts files from pod format to LaTeX format
pod2man  Converts pod data to formatted *roff input
pod2text  Converts pod data to formatted ASCII text
pod2usage  Prints usage messages from embedded pod docs in files
podchecker  Checks the syntax of pod format documentation files
podselect  Displays selected sections of pod documentation
prove  Command line tool for running tests against the Test::Harness module
pstruct  Dumps C structures as generated from cc -g -S stabs
ptar  A **tar**-like program written in Perl
ptardiff  A Perl program that compares an extracted archive with an unextracted one
ptargrep  A Perl program that applies pattern matching to the contents of files in a tar archive
s2p  Translates **sed** scripts to Perl
shasum  Prints or checks SHA checksums
splain  Is used to force verbose warning diagnostics in Perl
xsubpp  Converts Perl XS code into C code
zipdetails  Displays details about the internal structure of a Zip file
6.41. XML::Parser-2.44

The XML::Parser module is a Perl interface to James Clark's XML parser, Expat.

Approximate build time: less than 0.1 SBU
Required disk space: 2.0 MB

6.41.1. Installation of XML::Parser

Prepare XML::Parser for compilation:

```
perl Makefile.PL
```

Compile the package:

```
make
```

To test the results, issue:

```
make test
```

Install the package:

```
make install
```

6.41.2. Contents of XML::Parser

Installed module: Expat.so

Short Descriptions

Expat provides the Perl Expat interface
6.42. Intltool-0.51.0

The Intltool is an internationalization tool used for extracting translatable strings from source files.

**Approximate build time:** less than 0.1 SBU  
**Required disk space:** 1.5 MB

6.42.1. Installation of Intltool

First fix a warning that is caused by perl-5.22 and later:

```
    sed -i 's:\\${:\$\{:' intltool-update.in
```

Prepare Intltool for compilation:

```
    ./configure --prefix=/usr
```

Compile the package:

```
    make
```

To test the results, issue:

```
    make check
```

Install the package:

```
    make install
    install -v -Dm644 doc/I18N-HOWTO /usr/share/doc/intltool-0.51.0/I18N-HOWTO
```

6.42.2. Contents of Intltool

**Installed programs:** intltool-extract, intltool-merge, intltool-prepare, intltool-update, and intltoolize  
**Installed directories:** /usr/share/doc/intltool-0.51.0 and /usr/share/intltool

Short Descriptions

- `intltoolize` Prepares a package to use Intltool
- `intltool-extract` Generates header files that can be read by `gettext`
- `intltool-merge` Merges translated strings into various file types
- `intltool-prepare` Updates pot files and merges them with translation files
- `intltool-update` Updates the po template files and merges them with the translations
6.43. Autoconf-2.69

The Autoconf package contains programs for producing shell scripts that can automatically configure source code.

**Approximate build time:** less than 0.1 SBU (about 3.5 SBU with tests)

**Required disk space:** 18 MB

### 6.43.1. Installation of Autoconf

Prepare Autoconf for compilation:

```
./configure --prefix=/usr
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

This takes a long time, about less than 0.1 SBU (about 3.5 SBU with tests) SBUs. In addition, several steps are skipped that use Automake. For full test coverage, Autoconf can be re-tested after Automake has been installed. In addition, two tests fail due to changes in libtool-2.4.3 and later.

Install the package:

```
make install
```

### 6.43.2. Contents of Autoconf

**Installed programs:** autoconf, autoheader, autom4te, autoreconf, autoscan, autoupdate, and ifnames

**Installed directory:** /usr/share/autoconf

**Short Descriptions**

- **autoconf**: Produces shell scripts that automatically configure software source code packages to adapt to many kinds of Unix-like systems; the configuration scripts it produces are independent—running them does not require the `autoconf` program

- **autoheader**: A tool for creating template files of C `define` statements for `configure` to use

- **autom4te**: A wrapper for the M4 macro processor

- **autoreconf**: Automatically runs `autoconf`, `autoheader`, `aclocal`, `automake`, `gettextize`, and `libtoolize` in the correct order to save time when changes are made to `autoconf` and `automake` template files

- **autoscan**: Helps to create a `configure.in` file for a software package; it examines the source files in a directory tree, searching them for common portability issues, and creates a `configure.scan` file that serves as a preliminary `configure.in` file for the package

- **autoupdate**: Modifies a `configure.in` file that still calls `autoconf` macros by their old names to use the current macro names

- **ifnames**: Helps when writing `configure.in` files for a software package; it prints the identifiers that the package uses in C preprocessor conditionals [If a package has already been set up to have some...
portability, this program can help determine what \texttt{configure} needs to check for. It can also fill in gaps in a \texttt{configure.in} file generated by \texttt{autoscan}.]
6.44. Automake-1.15

The Automake package contains programs for generating Makefiles for use with Autoconf.

Approximate build time: less than 0.1 SBU (about 10.3 SBU with tests)
Required disk space: 109 MB

6.44.1. Installation of Automake

First fix a warning that is caused by perl-5.22 and later:

```
    sed -i 's:/\\${:/\$\{:' bin/automake.in
```

Prepare Automake for compilation:

```
    ./configure --prefix=/usr --docdir=/usr/share/doc/automake-1.15
```

Compile the package:

```
    make
```

There are a couple of tests that incorrectly link to the wrong version of the flex library, so we temporarily work around the problem. Also, using the -j4 make option speeds up the tests, even on systems with only one processor, due to internal delays in individual tests. To test the results, issue:

```
    sed -i "s:/configure:LEXLIB=/usr/lib/libfl.a &:" t/lex-{clean,depend}-cxx.sh
    make -j4 check
```

Install the package:

```
    make install
```

6.44.2. Contents of Automake

Installed programs: aclocal, aclocal-1.15 (hard linked with aclocal), automake, and automake-1.15 (hard linked with automake)

Installed directories: /usr/share/aclocal-1.15, /usr/share/automake-1.15, and /usr/share/doc/automake-1.15

Short Descriptions

- **aclocal**
  Generates `aclocal.m4` files based on the contents of `configure.in` files

- **aclocal-1.15**
  A hard link to `aclocal`

- **automake**
  A tool for automatically generating `Makefile.in` files from `Makefile.am` files [To create all the `Makefile.in` files for a package, run this program in the top-level directory. By scanning the `configure.in` file, it automatically finds each appropriate `Makefile.am` file and generates the corresponding `Makefile.in` file.]

- **automake-1.15**
  A hard link to `automake`
6.45. Xz-5.2.2

The Xz package contains programs for compressing and decompressing files. It provides capabilities for the lzma and the newer xz compression formats. Compressing text files with xz yields a better compression percentage than with the traditional gzip or bzip2 commands.

Approximate build time: 0.2 SBU
Required disk space: 15 MB

6.45.1. Installation of Xz

First, fix an internal problem:

```
sed -e '/mf\ .buffer = NULL/a next->coder->mf.size = 0;' \n   -i src/liblzma/lz/lz_encoder.c
```

Prepare Xz for compilation with:

```
./configure --prefix=/usr    \n   --disable-static \n   --docdir=/usr/share/doc/xz-5.2.2
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package and make sure that all essential files are in the correct directory:

```
make install
mv -v /usr/bin/{lzma,unlzma,lzcat,xz,xunz,xzcat} /bin
mv -v /usr/lib/liblzma.so.* /lib
ln -svf ../../lib/$(readlink /usr/lib/liblzma.so) /usr/lib/liblzma.so
```

6.45.2. Contents of Xz

**Installed programs:** lzcat (link to xz), lzcmp (link to xzdiff), lzdif (link to xzdiff), lzgrep (link to xzgrep), lzfgrep (link to xzgrep), lzgrep (link to xzgrep), lzless (link to xzless), lzma (link to xz), lmadec, lzmainfo, lzmore (link to xzmore), unlzma (link to xz), unxz (link to xz), xz, xzcat (link to xz), xzcmp (link to xzdiff), xzdec, xzdiff, xzgrep (link to xzgrep), xzfgrep (link to xzgrep), xzgrep, xzless, and xzmore

**Installed libraries:** liblzma.so

**Installed directories:** /usr/include/lzma and /usr/share/doc/xz-5.2.2

**Short Descriptions**

- **lzcat** Decompresses to standard output
- **lzcmp** Runs `cmp` on LZMA compressed files
- **lzdif** Runs `diff` on LZMA compressed files
lzegrep  Runs `grep` on LZMA compressed files
lzfgrep  Runs `fgrep` on LZMA compressed files
lzgrep  Runs `grep` on LZMA compressed files
lzless  Runs `less` on LZMA compressed files
lzma  Compreses or decompresses files using the LZMA format
lzmadec  A small and fast decoder for LZMA compressed files
lzmainfo  Shows information stored in the LZMA compressed file header
lzmore  Runs `more` on LZMA compressed files
unlzma  Decompresses files using the LZMA format
unxz  Decompresses files using the XZ format
xz  Compresses or decompresses files using the XZ format
xzcat  Decompresses to standard output
xzcmp  Runs `cmp` on XZ compressed files
xzdec  A small and fast decoder for XZ compressed files
xdiff  Runs `diff` on XZ compressed files
xzegrep  Runs `egrep` on XZ compressed files files
xzfgrep  Runs `fgrep` on XZ compressed files
xzgrep  Runs `grep` on XZ compressed files
xzless  Runs `less` on XZ compressed files
xzmore  Runs `more` on XZ compressed files
liblzma  The library implementing lossless, block-sorting data compression, using the Lempel-Ziv-Markov chain algorithm
6.46. Kmod-22

The Kmod package contains libraries and utilities for loading kernel modules

**Approximate build time:** 0.1 SBU
**Required disk space:** 11 MB

6.46.1. Installation of Kmod

Prepare Kmod for compilation:

```
./configure --prefix=/usr          
  --bindir=/bin          
  --sysconfdir=/etc      
  --with-rootlibdir=/lib 
  --with-xz              
  --with-zlib
```

The meaning of the configure options:

---with-xz, --with-zlib
These options enable Kmod to handle compressed kernel modules.

--with-rootlibdir=/lib
This option ensures different library related files are placed in the correct directories.

Compile the package:

```
make
```

This package does not come with a test suite that can be run in the LFS chroot environment. At a minimum the git
program is required and several tests will not run outside of a git repository.

Install the package, and create symlinks for compatibility with Module-Init-Tools (the package that previously handled
Linux kernel modules):

```
make install

for target in depmod insmod lsmod modinfo modprobe rmmod; do
  ln -sv ../bin/kmod /sbin/$target
done

ln -sv kmod /bin/lsmod
```

6.46.2. Contents of Kmod

**Installed programs:**
- depmod (link to kmod), insmod (link to kmod), kmod, lsmod (link to kmod), modinfo (link to kmod), modprobe (link to kmod), and rmmod (link to kmod)

**Installed library:**
- libkmod.so

**Short Descriptions**

**depmod**  Creates a dependency file based on the symbols it finds in the existing set of modules; this dependency
file is used by **modprobe** to automatically load the required modules
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>insmod</td>
<td>Installs a loadable module in the running kernel</td>
</tr>
<tr>
<td>kmod</td>
<td>Loads and unloads kernel modules</td>
</tr>
<tr>
<td>lsmod</td>
<td>Lists currently loaded modules</td>
</tr>
<tr>
<td>modinfo</td>
<td>Examines an object file associated with a kernel module and displays any information that it can glean</td>
</tr>
<tr>
<td>modprobe</td>
<td>Uses a dependency file, created by depmod, to automatically load relevant modules</td>
</tr>
<tr>
<td>rmmod</td>
<td>Unloads modules from the running kernel</td>
</tr>
<tr>
<td>libkmod</td>
<td>This library is used by other programs to load and unload kernel modules</td>
</tr>
</tbody>
</table>
6.47. Gettext-0.19.7

The Gettext package contains utilities for internationalization and localization. These allow programs to be compiled with NLS (Native Language Support), enabling them to output messages in the user's native language.

**Approximate build time:** 2.6 SBU  
**Required disk space:** 204 MB

### 6.47.1. Installation of Gettext

Prepare Gettext for compilation:

```bash
./configure --prefix=/usr    \   
  --disable-static \   
  --docdir=/usr/share/doc/gettext-0.19.7
```

Compile the package:

```bash
make
```

To test the results (this takes a long time, around 3 SBUs), issue:

```bash
make check
```

Nine tests fail due to missing dependencies.

Install the package:

```bash
make install  
chmod -v 0755 /usr/lib/preloadable_libintl.so
```

### 6.47.2. Contents of Gettext

**Installed programs:** autopoint, envsubst, gettext, gettext.sh, gettextize, hostname, msgattrib, msgcat, msgcmp, msgcomm, msgconv, msgen, msgexec, msgfilter, msgfmt, msggrep, msginit, msgmerge, msgunfmt, msguniq, ngettext, recode-sr-latin, and xgettext

**Installed libraries:** libasprintf.so, libgettextlib.so, libgettextpo.so, libgettextsrc.so, and preloadable_libintl.so

**Installed directories:** /usr/lib/gettext, /usr/share/doc/gettext-0.19.7, and /usr/share/gettext

**Short Descriptions**

- **autopoint**: Copies standard Gettext infrastructure files into a source package  
- **envsubst**: Substitutes environment variables in shell format strings  
- **gettext**: Translates a natural language message into the user's language by looking up the translation in a message catalog  
- **gettext.sh**: Primarily serves as a shell function library for gettext  
- **gettextize**: Copies all standard Gettext files into the given top-level directory of a package to begin internationalizing it  
- **hostname**: Displays a network hostname in various forms
msgattrib  Filters the messages of a translation catalog according to their attributes and manipulates the attributes
msgcat  Concatenates and merges the given .po files
msgcmp  Compares two .po files to check that both contain the same set of msgid strings
msgcomm  Finds the messages that are common to to the given .po files
msgconv  Converts a translation catalog to a different character encoding
msgen  Creates an English translation catalog
msgexec  Applies a command to all translations of a translation catalog
msgfilter  Applies a filter to all translations of a translation catalog
msgfmt  Generates a binary message catalog from a translation catalog
msggrep  Extracts all messages of a translation catalog that match a given pattern or belong to some given source files
msginit  Creates a new .po file, initializing the meta information with values from the user’s environment
msgmerge  Combines two raw translations into a single file
msgunfmt  Decompiles a binary message catalog into raw translation text
msguniq  Unifies duplicate translations in a translation catalog
ngettext  Displays native language translations of a textual message whose grammatical form depends on a number
recode-sr-latin  Recodes Serbian text from Cyrillic to Latin script
xgettext  Extracts the translatable message lines from the given source files to make the first translation template
libasprintf  defines the autosprintf class, which makes C formatted output routines usable in C++ programs, for use with the <string> strings and the <iostream> streams
libgettextlib  a private library containing common routines used by the various Gettext programs; these are not intended for general use
libgettextpo  Used to write specialized programs that process .po files; this library is used when the standard applications shipped with Gettext (such as msgcomm, msgcmp, msgattrib, and msgen) will not suffice
libgettextsrc  A private library containing common routines used by the various Gettext programs; these are not intended for general use
preloadable_libintl  A library, intended to be used by LD_PRELOAD that assists libintl in logging untranslated messages
6.48. Systemd-229

The systemd package contains programs for controlling the startup, running, and shutdown of the system.

**Approximate build time:** 5.1 SBU  
**Required disk space:** 1.1 GB

### 6.48.1. Installation of systemd

First, fix a build error when using Util-Linux built in Chapter 5:

```
$ sed -i "s:blkid/::" $(grep -rl "blkid/blkid.h")
```

Apply the following patch so that compat **pkg-config** files get installed without installing compat libs which are useless on LFS:

```
$ patch -Np1 -i ../../../systemd-229-compat-1.patch
```

Disable two tests that always fail:

```
$ sed -e 's@test/udev-test.pl @@' \  
     -e 's@test-copy$(EXEEXT) @@' \  
     -i Makefile.in
```

Rebuild generated files after modifying Makefile.am and Makefile.in:

```
$ autoreconf -fi
```

Create a file to allow systemd to build when using Util-Linux built in Chapter 5, to disable LTO by default, and to build without xlstproc:

```
$ cat > config.cache << "EOF"
KILL=/bin/kill
MOUNT_PATH=/bin/mount
UMOUNT_PATH=/bin/umount
HAVE_BLKID=1
BLKID_LIBS="-lblkid"
BLKID_CFLAGS="-I/tools/include/blkid"
HAVE_LIBMOUNT=1
MOUNT_LIBS="-lmount"
MOUNT_CFLAGS="-I/tools/include/libmount"
cc_cv_CFLAGS__flto=no
XSLTPROC="/usr/bin/xsltproc"
EOF
```

LTO is disabled by default because it causes systemd and other auxiliary programs to link to libgcc_s.so, slows the build down and makes the compiled code larger.
Prepare systemd for compilation:

```
./configure --prefix=/usr          
    --sysconfdir=/etc      
    --localstatedir=/var   
    --config-cache         
    --with-rootprefix=     
    --with-rootlibdir=/lib 
    --enable-split-usr     
    --disable-firstboot    
    --disable-ldconfig     
    --disable-sysusers     
    --without-python       
    --docdir=/usr/share/doc/systemd-229
```

The meaning of the configure options:

```
--config-cache
This switch tells the build system to use the config.cache file which was created earlier.

--with-root*
These switches ensure that core programs and shared libraries are installed in the subdirectories of the root partition.

--enable-split-usr
This switch ensures that systemd will work on systems where /bin, /lib and /sbin directories are not symlinks to their /usr counterparts.

--without-python
This switch prevents configure from trying to use Python which isn't built in LFS.

--disable-firstboot
This switch prevents installation of systemd services responsible for setting up the system for the first time. They are not useful for LFS because everything is done manually.

--disable-ldconfig
This switch prevents installation of a systemd unit that runs ldconfig at boot, making the boot time longer. Remove it if the described feature is desired, even though it's not useful for source distributions such as LFS.

--disable-sysusers
This switch prevents installation of systemd services responsible for setting up the /etc/group and /etc/passwd files. Both files were created early in this chapter.
```

Compile the package:

```
make LIBRARY_PATH=/tools/lib
```

This package has a test suite, but it can only be run after the package has been installed.

Install the package:

```
make LD_LIBRARY_PATH=/tools/lib install
```

Move NSS libraries to /lib:

```
mv -v /usr/lib/libnss_{myhostname,mymachines,resolve}.so.2 /lib
```
Remove an unnecessary directory:

```
rm -rfv /usr/lib/rpm
```

Create the Sysvinit compatibility symlinks, so systemd is used as the default init system:

```
for tool in runlevel reboot shutdown poweroff halt telinit; do
    ln -sfv ../bin/systemctl /sbin/${tool}
done
ln -sfv ../lib/systemd/systemd /sbin/init
```

Create the `/etc/machine-id` file needed by `systemd-journald`:

```
systemd-machine-id-setup
```

Since the testsuite largely depends on the host system kernel configuration, some tests may fail. It also needs a modification in order not to look for a program that will be installed by Util-Linux package later in this chapter. To test the results, issue:

```
 sed -i "s:minix:ext4:g" src/test/test-path-util.c
 make LD_LIBRARY_PATH=/tools/lib -k check
```

### 6.48.2. Contents of systemd

**Installed programs:**


**Installed libraries:**

- libnss_myhostname.so.2, libnss_mymachines.so.2, libnss_resolve.so.2, libsysteemd.so, and libudev.so

**Installed directories:**


**Short Descriptions**

- **bootctl** used to query the firmware and boot manager settings
- **busctl** Used to introspect and monitor the D-Bus bus
- **coredumpctl** Used to retrieve coredumps from the systemd Journal
- **halt** normally invokes `shutdown` with the `-h` option, except when already in run-level 0, then it tells the kernel to halt the system; it notes in the file `/var/log/wtmp` that the system is being brought down
- **hostnamectl** Used to query and change the system hostname and related settings
The first process to be started when the kernel has initialized the hardware which takes over the boot process and starts all the processes it is instructed to

journalctl
- Used to query the contents of the systemd Journal

kernel-install
- Used to add and remove kernel and initramfs images to and from /boot

localectl
- Used to query and change the system locale and keyboard layout settings

loginctl
- Used to introspect and control the state of the systemd Login Manager

machinectl
- Used to introspect and control the state of the systemd Virtual Machine and Container Registration Manager

networkctl
- Used to introspect the state of the network links as seen by systemd-networkd

poweroff
- Tells the kernel to halt the system and switch off the computer (see halt)

reboot
- Tells the kernel to reboot the system (see halt)

runlevel
- Reports the previous and the current run-level, as noted in the last run-level record in /var/run/utmp

shutdown
- Brings the system down in a secure way, signaling all processes and notifying all logged-in users

systemctl
- Used to introspect and control the state of the systemd system and service manager

systemd-analyze
- Used to determine system boot-up performance of the current boot

systemd-ask-password
- Used to query a system password or passphrase from the user, using a question message specified on the command line

systemd-cat
- Used to connect STDOUT and STDERR of a process with the Journal

systemd-cgls
- Recursively shows the contents of the selected Linux control group hierarchy in a tree

systemd-cgtop
- Shows the top control groups of the local Linux control group hierarchy, ordered by their CPU, memory and disk I/O load

systemd-delta
- Used to identify and compare configuration files in /etc that override default counterparts in /usr

systemd-detect-virt
- Detects execution in a virtualized environment

systemd-escape
- Used to escape strings for inclusion in systemd unit names

systemd-hwdb
- Used to manage hardware database (hwdb)

systemd-inhibit
- Used to execute a program with a shutdown, sleep or idle inhibitor lock taken

systemd-machine-id-setup
- Used by system installer tools to initialize the machine ID stored in /etc/machine-id at install time with a randomly generated ID

systemd-notify
- Used by daemon scripts to notify the init system about status changes

systemd-nspawn
- Used to run a command or OS in a light-weight namespace container
<table>
<thead>
<tr>
<th>Tool</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>systemd-path</td>
<td>Used to query system and user paths</td>
</tr>
<tr>
<td>systemd-resolve</td>
<td>Used to resolve domain names, IPV4 and IPv6 addresses, DNS resource records, and services</td>
</tr>
<tr>
<td>systemd-run</td>
<td>Used to create and start a transient .service or a .scope unit and run the specified command in it</td>
</tr>
<tr>
<td>systemd-tmpfiles</td>
<td>Creates, deletes and cleans up volatile and temporary files and directories, based on the configuration file format and location specified in tmpfiles.d directories</td>
</tr>
<tr>
<td>systemd-tty-ask-password-agent</td>
<td>Used to list or process pending systemd password requests</td>
</tr>
<tr>
<td>telinit</td>
<td>Tells init which run-level to change to</td>
</tr>
<tr>
<td>timedatectl</td>
<td>Used to query and change the system clock and its settings</td>
</tr>
<tr>
<td>udevadm</td>
<td>Generic Udev administration tool: controls the udevd daemon, provides info from the Udev database, monitors uevents, waits for uevents to finish, tests Udev configuration, and triggers uevents for a given device</td>
</tr>
<tr>
<td>libsystemd</td>
<td>systemd utility library</td>
</tr>
<tr>
<td>libudev</td>
<td>A library to access Udev device information</td>
</tr>
</tbody>
</table>
6.49. Procps-ng-3.3.11

The Procps-ng package contains programs for monitoring processes.

**Approximate build time:** 0.2 SBU  
**Required disk space:** 15 MB

6.49.1. Installation of Procps-ng

Now prepare procps-ng for compilation:

```
./configure --prefix=/usr  
  --exec-prefix=  
  --libdir=/usr/lib  
  --docdir=/usr/share/doc/procps-ng-3.3.11  
  --disable-static  
  --disable-kill  
  --with-systemd
```

The meaning of the configure options:

```
--disable-kill  
This switch disables building the kill command that will be installed by the Util-linux package.
```

Compile the package:

```
make
```

The test suite needs some custom modifications for LFS. Remove the test that fails when scripting does not use a tty device. To run the test suite, run the following commands:

```
sed -i -r 's|(pmap_initname)\$|1|' testsuite/pmap.test/pmap.exp  
make check
```

Install the package:

```
make install
```

Finally, move essential libraries to a location that can be found if /usr is not mounted.

```
mv -v /usr/lib/libprocps.so.* /lib  
ln -sfv ../../lib/$(readlink /usr/lib/libprocps.so) /usr/lib/libprocps.so
```

6.49.2. Contents of Procps-ng

**Installed programs:** free, pgrep, pidof, pkill, pmap, ps, pwdx, slabtop, sysctl, tload, top, uptime, vmstat, w, and watch  
**Installed library:** libprocps.so  
**Installed directories:** /usr/include/proc and /usr/share/doc/procps-ng-3.3.11

**Short Descriptions**

free Reports the amount of free and used memory (both physical and swap memory) in the system
pgrep  Looks up processes based on their name and other attributes
pidof  Reports the PIDs of the given programs
pkill  Signals processes based on their name and other attributes
pmap   Reports the memory map of the given process
ps     Lists the current running processes
pwdx   Reports the current working directory of a process
slabtop Displays detailed kernel slap cache information in real time
sysctl Modifies kernel parameters at run time
tload  Prints a graph of the current system load average
top    Displays a list of the most CPU intensive processes; it provides an ongoing look at processor activity in real time
uptime Reports how long the system has been running, how many users are logged on, and the system load averages
vmstat Reports virtual memory statistics, giving information about processes, memory, paging, block Input/Output (IO), traps, and CPU activity
w      Shows which users are currently logged on, where, and since when
watch Runs a given command repeatedly, displaying the first screen-full of its output; this allows a user to watch the output change over time
libprocps Contains the functions used by most programs in this package
6.50. E2fsprogs-1.42.13

The E2fsprogs package contains the utilities for handling the ext2 file system. It also supports the ext3 and ext4 journaling file systems.

Approximate build time: 1.9 SBU
Required disk space: 46 MB

6.50.1. Installation of E2fsprogs

The E2fsprogs documentation recommends that the package be built in a subdirectory of the source tree:

```
mkdir -v build
cd build
```

Prepare E2fsprogs for compilation:

```
LIBS=-L/tools/lib                    \ 
CFLAGS=-I/tools/include              \ 
PKG_CONFIG_PATH=/tools/lib/pkgconfig \ 
../configure --prefix=/usr           \ 
     --bindir=/bin                  \ 
     --with-root-prefix=""           \ 
     --enable-elf-shlibs             \ 
     --disable-libblkid              \ 
     --disable-libuuid               \ 
     --disable-uuidd                 \ 
     --disable-fsck
```

The meaning of the environment variable and configure options:

PKG_CONFIG_PATH, LIBS, CFLAGS
These variables enable e2fsprogs to be built using the Section 5.33, “Util-linux-2.27.1” package built earlier.

--with-root-prefix="" and --bindir=/bin
Certain programs (such as the e2fsck program) are considered essential programs. When, for example, /usr is not mounted, these programs still need to be available. They belong in directories like /lib and /sbin. If this option is not passed to E2fsprogs’ configure, the programs are installed into the /usr directory.

--enable-elf-shlibs
This creates the shared libraries which some programs in this package use.

--disable--*
This prevents E2fsprogs from building and installing the libuuid and libblkid libraries, the uuidd daemon, and the fsck wrapper, as Util-Linux installs more recent versions.

Compile the package:

```
make
```

To set up and run the test suite we need to first link some libraries from /tools/lib to a location where the test programs look. To run the tests, issue:

```
ln -sfv /tools/lib/lib{blk,uu}id.so.1 lib
make LD_LIBRARY_PATH=/tools/lib check
```
One of the E2fsprogs tests will attempt to allocate 256 MB of memory. If you do not have significantly more RAM than this, be sure to enable sufficient swap space for the test. See Section 2.3, “Creating a File System on the Partition” and Section 2.5, “Mounting the New Partition” for details on creating and enabling swap space.

Install the binaries, documentation, and shared libraries:

```
make install
```

Install the static libraries and headers:

```
make install-libs
```

Make the installed static libraries writable so debugging symbols can be removed later:

```
chmod -v u+w /usr/lib/{libcom_err,libe2p,libext2fs,libss}.a
```

This package installs a gzipped .info file but doesn't update the system-wide dir file. Unzip this file and then update the system dir file using the following commands.

```
gunzip -v /usr/share/info/libext2fs.info.gz
install-info --dir-file=/usr/share/info/dir /usr/share/info/libext2fs.info
```

If desired, create and install some additional documentation by issuing the following commands:

```
makeinfo -o doc/com_err.info ../lib/et/com_err.texinfo
install -v -m644 doc/com_err.info /usr/share/info
install-info --dir-file=/usr/share/info/dir /usr/share/info/com_err.info
```

### 6.50.2. Contents of E2fsprogs

**Installed programs:**
- badblocks, chattr, compile_et, debugfs, dumpe2fs, e2freefrag, e2fsck, e2image, e2label, e2undo, e4defrag, filefrag, fsck.ext2, fsck.ext3, fsck.ext4, fsck.ext4dev, logsave, lsattr, mk_cmds, mke2fs, mkfs.ext2, mkfs.ext3, mkfs.ext4, mkfs.ext4dev, mklost+found, resize2fs, and tune2fs

**Installed libraries:**
- libcom_err.so, libe2p.so, libext2fs.so, and libss.so

**Installed directories:**
- /usr/include/e2p, /usr/include/et, /usr/include/ext2fs, /usr/include/ss, /usr/share/et, and /usr/share/ss

**Short Descriptions**

- **badblocks**
  Searches a device (usually a disk partition) for bad blocks

- **chattr**
  Changes the attributes of files on an ext2 file system; it also changes ext3 file systems, the journaling version of ext2 file systems

- **compile_et**
  An error table compiler; it converts a table of error-code names and messages into a C source file suitable for use with the com_err library

- **debugfs**
  A file system debugger; it can be used to examine and change the state of an ext2 file system

- **dumpe2fs**
  Prints the super block and blocks group information for the file system present on a given device

- **e2freefrag**
  Reports free space fragmentation information

- **e2fsck**
  Is used to check, and optionally repair ext2 file systems and ext3 file systems

- **e2image**
  Is used to save critical ext2 file system data to a file
e2label Displays or changes the file system label on the ext2 file system present on a given device

e2undo Replays the undo log undo_log for an ext2/ext3/ext4 filesystem found on a device [This can be used to undo a failed operation by an e2fsprogs program.]

e4defrag Online defragmenter for ext4 file systems

filefrag Reports on how badly fragmented a particular file might be

fsck.ext2 By default checks ext2 file systems and is a hard link to e2fsck

fsck.ext3 By default checks ext3 file systems and is a hard link to e2fsck

fsck.ext4 By default checks ext4 file systems and is a hard link to e2fsck

fsck.ext4dev By default checks ext4 development file systems and is a hard link to e2fsck

logsave Saves the output of a command in a log file

lsattr Lists the attributes of files on a second extended file system

mk_cmds Converts a table of command names and help messages into a C source file suitable for use with the libss subsystem library

mke2fs Creates an ext2 or ext3 file system on the given device

mkfs.ext2 By default creates ext2 file systems and is a hard link to mke2fs

mkfs.ext3 By default creates ext3 file systems and is a hard link to mke2fs

mkfs.ext4 By default creates ext4 file systems and is a hard link to mke2fs

mkfs.ext4dev By default creates ext4 development file systems and is a hard link to mke2fs

mklost+found Used to create a lost+found directory on an ext2 file system; it pre-allocates disk blocks to this directory to lighten the task of e2fsck

resize2fs Can be used to enlarge or shrink an ext2 file system

tune2fs Adjusts tunable file system parameters on an ext2 file system

libcom_err The common error display routine

libe2p Used by dumpe2fs, chattr, and lsattr

libext2fs Contains routines to enable user-level programs to manipulate an ext2 file system

libss Used by debugfs
6.51. Coreutils-8.25

The Coreutils package contains utilities for showing and setting the basic system characteristics.

**Approximate build time:** 2.1 SBU  
**Required disk space:** 170 MB

### 6.51.1. Installation of Coreutils

POSIX requires that programs from Coreutils recognize character boundaries correctly even in multibyte locales. The following patch fixes this non-compliance and other internationalization-related bugs.

```
patch -Np1 -i ../coreutils-8.25-i18n-2.patch
```

**Note**

In the past, many bugs were found in this patch. When reporting new bugs to Coreutils maintainers, please check first if they are reproducible without this patch.

Now prepare Coreutils for compilation:

```
FORCE_UNSAFE_CONFIGURE=1 ./configure \
   --prefix=/usr \
   --enable-no-install-program=kill,uptime
```

The meaning of the configure options:

- `FORCE_UNSAFE_CONFIGURE=1`  
  This environment variable allows the package to be built as the root user.

- `--enable-no-install-program=kill,uptime`  
  The purpose of this switch is to prevent Coreutils from installing binaries that will be installed by other packages later.

Compile the package:

```
FORCE_UNSAFE_CONFIGURE=1 make
```

Skip down to “Install the package” if not running the test suite.

Now the test suite is ready to be run. First, run the tests that are meant to be run as user **root**:

```
make NON_ROOT_USERNAME=nobody check-root
```

We’re going to run the remainder of the tests as the **nobody** user. Certain tests, however, require that the user be a member of more than one group. So that these tests are not skipped we’ll add a temporary group and make the user **nobody** a part of it:

```
echo "dummy:x:1000:nobody" >> /etc/group
```

Fix some of the permissions so that the non-root user can compile and run the tests:

```
chown -Rv nobody .
```
Now run the tests. Make sure the PATH in the su environment includes /tools/bin.

```
su nobody -s /bin/bash \\
   -c "PATH=$PATH make RUN_EXPENSIVE_TESTS=yes check"
```

The stty-pairs test is known to fail on a virtual console, but passes if run in a X terminal.

Remove the temporary group:

```
sed -i '/dummy/d' /etc/group
```

Install the package:

```
make install
```

Move programs to the locations specified by the FHS:

```
mv -v /usr/bin/{cat,chgrp,chmod,chown,cp,date,dd,df,echo} /bin
mv -v /usr/bin/{false,ln,ls,mkdir,mknod,mv,pwd,rm} /bin
mv -v /usr/bin/{rmdir,stty,sync,true,uname} /bin
mv -v /usr/bin/chroot /usr/sbin
mv -v /usr/share/man/man1/chroot.1 /usr/share/man/man8/chroot.8
sed -i s/"1"/"8"/1 /usr/share/man/man8/chroot.8
```

Some packages in BLFS and beyond expect the following programs in /bin, so make sure they are placed there:

```
mv -v /usr/bin/{head,sleep,nice,test,[]} /bin
```

### 6.51.2. Contents of Coreutils

**Installed programs:**

<table>
<thead>
<tr>
<th>item</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>base32</td>
<td>Encodes and decodes data according to the base32 specification (RFC 4648)</td>
</tr>
<tr>
<td>base64</td>
<td>Encodes and decodes data according to the base64 specification (RFC 4648)</td>
</tr>
<tr>
<td>basename</td>
<td>Strips any path and a given suffix from a file name</td>
</tr>
<tr>
<td>cat</td>
<td>Concatenates files to standard output</td>
</tr>
<tr>
<td>chcon</td>
<td>Changes security context for files and directories</td>
</tr>
<tr>
<td>chgrp</td>
<td>Changes the group ownership of files and directories</td>
</tr>
<tr>
<td>chmod</td>
<td>Changes the permissions of each file to the given mode; the mode can be</td>
</tr>
<tr>
<td></td>
<td>either a symbolic representation of the changes to make or an octal number</td>
</tr>
<tr>
<td></td>
<td>representing the new permissions</td>
</tr>
<tr>
<td>chroot</td>
<td></td>
</tr>
<tr>
<td>csplit</td>
<td></td>
</tr>
<tr>
<td>cut</td>
<td></td>
</tr>
<tr>
<td>dir</td>
<td></td>
</tr>
<tr>
<td>dircolors</td>
<td></td>
</tr>
<tr>
<td>dirname</td>
<td></td>
</tr>
<tr>
<td>du</td>
<td></td>
</tr>
<tr>
<td>echo</td>
<td></td>
</tr>
<tr>
<td>env</td>
<td></td>
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<tr>
<td>expand</td>
<td></td>
</tr>
<tr>
<td>expr</td>
<td></td>
</tr>
<tr>
<td>factor</td>
<td></td>
</tr>
<tr>
<td>false</td>
<td></td>
</tr>
<tr>
<td>fmt</td>
<td></td>
</tr>
<tr>
<td>fold</td>
<td></td>
</tr>
<tr>
<td>groups</td>
<td></td>
</tr>
<tr>
<td>head</td>
<td></td>
</tr>
<tr>
<td>hostid</td>
<td></td>
</tr>
<tr>
<td>id</td>
<td></td>
</tr>
<tr>
<td>install</td>
<td></td>
</tr>
<tr>
<td>join</td>
<td></td>
</tr>
<tr>
<td>link</td>
<td></td>
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<tr>
<td>ln</td>
<td></td>
</tr>
<tr>
<td>logname</td>
<td></td>
</tr>
<tr>
<td>ls</td>
<td></td>
</tr>
<tr>
<td>md5sum</td>
<td></td>
</tr>
<tr>
<td>mkdir</td>
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<tr>
<td>mkfifo</td>
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<tr>
<td>mknod</td>
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<tr>
<td>mktemp</td>
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<tr>
<td>mv</td>
<td></td>
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<tr>
<td>nice</td>
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<tr>
<td>nl</td>
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<tr>
<td>nohup</td>
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<tr>
<td>nproc</td>
<td></td>
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<tr>
<td>numfmt</td>
<td></td>
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<tr>
<td>od</td>
<td></td>
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<tr>
<td>paste</td>
<td></td>
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<tr>
<td>pathchk</td>
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<tr>
<td>pinky</td>
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<tr>
<td>pr</td>
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<tr>
<td>printenv</td>
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<tr>
<td>printf</td>
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<td>ptx</td>
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<tr>
<td>pwd</td>
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<td>readlink</td>
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<td>realpath</td>
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<tr>
<td>rm</td>
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<td>rmdir</td>
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<td>runcon</td>
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<tr>
<td>seq</td>
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<tr>
<td>sha1sum</td>
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<td>sha224sum</td>
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<td>sha256sum</td>
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<td>sha384sum</td>
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<td>sha512sum</td>
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<tr>
<td>shred</td>
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<tr>
<td>shuf</td>
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<tr>
<td>sleep</td>
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<tr>
<td>sort</td>
<td></td>
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<tr>
<td>split</td>
<td></td>
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<tr>
<td>stat</td>
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<tr>
<td>stdbuf</td>
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<tr>
<td>stty</td>
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<td>sync</td>
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<td>tac</td>
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<tr>
<td>tail</td>
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<td>tee</td>
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<td>test</td>
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<td>timeout</td>
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<td>touch</td>
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<tr>
<td>true</td>
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<tr>
<td>truncate</td>
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<td>tsort</td>
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<td>tty</td>
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<td>uname</td>
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<td>unexpand</td>
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<td>uniq</td>
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<td>unlink</td>
<td></td>
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<tr>
<td>users</td>
<td></td>
</tr>
<tr>
<td>vdir</td>
<td></td>
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<tr>
<td>wc</td>
<td></td>
</tr>
<tr>
<td>who</td>
<td></td>
</tr>
<tr>
<td>whoami</td>
<td></td>
</tr>
<tr>
<td>and</td>
<td></td>
</tr>
<tr>
<td>yes</td>
<td></td>
</tr>
</tbody>
</table>

**Installed library:**

libstdbuf.so

**Installed directory:**

/usr/libexec/coreutils
**chown**  Changes the user and/or group ownership of files and directories

**chroot**  Runs a command with the specified directory as the / directory

**cksum**  Prints the Cyclic Redundancy Check (CRC) checksum and the byte counts of each specified file

**comm**  Compares two sorted files, outputting in three columns the lines that are unique and the lines that are common

**cp**  Copies files

**csplit**  Splits a given file into several new files, separating them according to given patterns or line numbers and outputting the byte count of each new file

**cut**  Prints sections of lines, selecting the parts according to given fields or positions

**date**  Displays the current time in the given format, or sets the system date

**dd**  Copies a file using the given block size and count, while optionally performing conversions on it

**df**  Reports the amount of disk space available (and used) on all mounted file systems, or only on the file systems holding the selected files

**dir**  Lists the contents of each given directory (the same as the `ls` command)

**dircolors**  Outputs commands to set the `LS_COLOR` environment variable to change the color scheme used by `ls`

**dirname**  Strips the non-directory suffix from a file name

**du**  Reports the amount of disk space used by the current directory, by each of the given directories (including all subdirectories) or by each of the given files

**echo**  Displays the given strings

**env**  Runs a command in a modified environment

**expand**  Converts tabs to spaces

**expr**  Evaluates expressions

**factor**  Prints the prime factors of all specified integer numbers

**false**  Does nothing, unsuccessfully; it always exits with a status code indicating failure

**fmt**  Reformats the paragraphs in the given files

**fold**  Wraps the lines in the given files

**groups**  Reports a user’s group memberships

**head**  Prints the first ten lines (or the given number of lines) of each given file

**hostid**  Reports the numeric identifier (in hexadecimal) of the host

**id**  Reports the effective user ID, group ID, and group memberships of the current user or specified user

**install**  Copies files while setting their permission modes and, if possible, their owner and group

**join**  Joins the lines that have identical join fields from two separate files

**link**  Creates a hard link with the given name to a file

**ln**  Makes hard links or soft (symbolic) links between files

**logname**  Reports the current user’s login name

**ls**  Lists the contents of each given directory

**md5sum**  Reports or checks Message Digest 5 (MD5) checksums
mkdir
  Creates directories with the given names
mkfifo
  Creates First-In, First-Outs (FIFOs), a "named pipe" in UNIX parlance, with the given names
mknod
  Creates device nodes with the given names; a device node is a character special file, a block special file, or a FIFO
mktemp
  Creates temporary files in a secure manner; it is used in scripts
mv
  Moves or renames files or directories
nice
  Runs a program with modified scheduling priority
nl
  Numbers the lines from the given files
nohup
  Runs a command immune to hangups, with its output redirected to a log file
nproc
  Prints the number of processing units available to a process
numfmt
  Converts numbers to or from human-readable strings
od
  Dumps files in octal and other formats
paste
  Merges the given files, joining sequentially corresponding lines side by side, separated by tab characters
pathchk
  Checks if file names are valid or portable
pinky
  Is a lightweight finger client; it reports some information about the given users
pr
  Paginates and columnates files for printing
printenv
  Prints the environment
printf
  Prints the given arguments according to the given format, much like the C printf function
ptx
  Produces a permuted index from the contents of the given files, with each keyword in its context
pwd
  Reports the name of the current working directory
readlink
  Reports the value of the given symbolic link
realpath
  Prints the resolved path
rm
  Removes files or directories
rmdir
  Removes directories if they are empty
runcon
  Runs a command with specified security context
seq
  Prints a sequence of numbers within a given range and with a given increment
sha1sum
  Prints or checks 160-bit Secure Hash Algorithm 1 (SHA1) checksums
sha224sum
  Prints or checks 224-bit Secure Hash Algorithm checksums
sha256sum
  Prints or checks 256-bit Secure Hash Algorithm checksums
sha384sum
  Prints or checks 384-bit Secure Hash Algorithm checksums
sha512sum
  Prints or checks 512-bit Secure Hash Algorithm checksums
shred
  Overwrites the given files repeatedly with complex patterns, making it difficult to recover the data
shuf
  Shuffles lines of text
sleep
  Pauses for the given amount of time
sort
  Sorts the lines from the given files
split
  Splits the given file into pieces, by size or by number of lines
stat Displays file or filesystem status
stdbuf Runs commands with altered buffering operations for its standard streams
stty Sets or reports terminal line settings
sum Prints checksum and block counts for each given file
sync Flushes file system buffers; it forces changed blocks to disk and updates the super block
tac Concatenates the given files in reverse
tail Prints the last ten lines (or the given number of lines) of each given file
tee Reads from standard input while writing both to standard output and to the given files
test Compares values and checks file types
timeout Runs a command with a time limit
touch Changes file timestamps, setting the access and modification times of the given files to the current time; files that do not exist are created with zero length
tr Translates, squeezes, and deletes the given characters from standard input
true Does nothing, successfully; it always exits with a status code indicating success
truncate Shrinks or expands a file to the specified size
tsort Performs a topological sort; it writes a completely ordered list according to the partial ordering in a given file
tty Reports the file name of the terminal connected to standard input
uname Reports system information
unexpand Converts spaces to tabs
uniq Discards all but one of successive identical lines
unlink Removes the given file
users Reports the names of the users currently logged on
vdir Is the same as ls -l
wc Reports the number of lines, words, and bytes for each given file, as well as a total line when more than one file is given
who Reports who is logged on
whoami Reports the user name associated with the current effective user ID
yes Repeatedly outputs “y” or a given string until killed
libstdbuf Library used by stdbuf
6.52. Diffutils-3.3

The Diffutils package contains programs that show the differences between files or directories.

**Approximate build time:** 0.4 SBU  
**Required disk space:** 28 MB

6.52.1. Installation of Diffutils

First fix a file so locale files are installed:

```
sed -i 's:= @mkdir_p@:= /bin/mkdir -p:' po/Makefile.in.in
```

Prepare Diffutils for compilation:

```
./configure --prefix=/usr
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

The test-update-copyright.sh failure can be safely ignored.

Install the package:

```
make install
```

6.52.2. Contents of Diffutils

**Installed programs:** cmp, diff, diff3, and sdiff

**Short Descriptions**

- **cmp**  
  Compares two files and reports whether or in which bytes they differ

- **diff**  
  Compares two files or directories and reports which lines in the files differ

- **diff3**  
  Compares three files line by line

- **sdiff**  
  Merges two files and interactively outputs the results
6.53. Gawk-4.1.3

The Gawk package contains programs for manipulating text files.

Approximate build time: 0.3 SBU
Required disk space: 36 MB

6.53.1. Installation of Gawk

Prepare Gawk for compilation:

./configure --prefix=/usr

Compile the package:

make

To test the results, issue:

make check

Install the package:

make install

If desired, install the documentation:

mkdir -v /usr/share/doc/gawk-4.1.3
cp -v doc/*.{eps,pdf,jpg} /usr/share/doc/gawk-4.1.3

6.53.2. Contents of Gawk

Installed programs: awk (link to gawk), gawk, gawk-4.1.3, and igawk
Installed libraries: filefuncs.so, fnmatch.so, fork.so, inplace.so, ordchr.so, readdir.so, readFile.so, revoutput.so, revtwoWay.so, rwarray.so, testExt.so, and time.so
Installed directories: /usr/lib/gawk, /usr/libexec/awk, /usr/share/awk, and /usr/share/doc/gawk-4.1.3

Short Descriptions

awk A link to gawk

gawk A program for manipulating text files; it is the GNU implementation of awk

gawk-4.1.3 A hard link to gawk

igawk Gives gawk the ability to include files
6.54. Findutils-4.6.0

The Findutils package contains programs to find files. These programs are provided to recursively search through a directory tree and to create, maintain, and search a database (often faster than the recursive find, but unreliable if the database has not been recently updated).

**Approximate build time:** 0.7 SBU  
**Required disk space:** 50 MB

### 6.54.1. Installation of Findutils

Prepare Findutils for compilation:

```
./configure --prefix=/usr --localstatedir=/var/lib/locate
```

The meaning of the configure options:

---

--localstatedir

This option changes the location of the locate database to be in `/var/lib/locate`, which is FHS-compliant.

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

Some packages in BLFS and beyond expect the `find` program in `/bin`, so make sure it's placed there:

```
mv -v /usr/bin/find /bin
sed -i 's|find:=${BINDIR}|find:=/bin|' /usr/bin/updatedb
```

### 6.54.2. Contents of Findutils

**Installed programs:** code, find, locate, oldfind, updatedb, and xargs

**Short Descriptions**

- **code**  
  Was formerly used to produce locate databases; it is the ancestor of frcode

- **find**  
  Searches given directory trees for files matching the specified criteria

- **locate**  
  Searches through a database of file names and reports the names that contain a given string or match a given pattern

- **oldfind**  
  Older version of find, using a different algorithm

- **updatedb**  
  Updates the locate database; it scans the entire file system (including other file systems that are currently mounted, unless told not to) and puts every file name it finds into the database

- **xargs**  
  Can be used to apply a given command to a list of files
6.55. Groff-1.22.3

The Groff package contains programs for processing and formatting text.

Approximate build time: 0.5 SBU
Required disk space: 84 MB

6.55.1. Installation of Groff

Groff expects the environment variable PAGE to contain the default paper size. For users in the United States, PAGE=letter is appropriate. Elsewhere, PAGE=A4 may be more suitable. While the default paper size is configured during compilation, it can be overridden later by echoing either “A4” or “letter” to the /etc/papersize file.

Prepare Groff for compilation:

```
PAGE=<paper_size> ./configure --prefix=/usr
```

Compile the package:

```
make
```

This package does not come with a test suite.

Install the package:

```
make install
```

6.55.2. Contents of Groff

 Installed programs: addftinfo, afmtodit, chem, eqn, eqn2graph, gdiffmk, glilypond, gperl, gpinyin, grap2graph, grn, grodvi, groff, groffer, grog, grolbp, grolj4, gropdf, grosps, grotty, hpftodit, indxbib, lkbib, lookbib, mmroff, neqn, nroff, pdfmom, pdfroff, pbtops, pic, pic2graph, post-grohtml, preconv, pre-grohtml, refer, roff2dvi, roff2html, roff2pdf, roff2ps, roff2text, roff2x, soelim, tbl, tfmtodit, and troff

 Installed directories: /usr/lib/groff and /usr/share/doc/groff-1.22.3, /usr/share/groff

Short Descriptions

<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>addftinfo</td>
<td>Reads a troff font file and adds some additional font-metric information that is used by the groff system</td>
</tr>
<tr>
<td>afmtodit</td>
<td>Creates a font file for use with groff and props</td>
</tr>
<tr>
<td>chem</td>
<td>Groff preprocessor for producing chemical structure diagrams</td>
</tr>
<tr>
<td>eqn</td>
<td>Compiles descriptions of equations embedded within troff input files into commands that are understood by troff</td>
</tr>
<tr>
<td>eqn2graph</td>
<td>Converts a troff EQN (equation) into a cropped image</td>
</tr>
<tr>
<td>gdiffmk</td>
<td>Marks differences between groff/nroff/troff files</td>
</tr>
<tr>
<td>glilypond</td>
<td>Transforms sheet music written in the lilypond language into the groff language</td>
</tr>
<tr>
<td>gperl</td>
<td>Preprocessor for groff, allowing addition of perl code into groff files</td>
</tr>
<tr>
<td>gpinyin</td>
<td>Preprocessor for groff, allowing addition of Chinese European-like language Pinyin into groff files</td>
</tr>
</tbody>
</table>
grap2graph  Converts a grap diagram into a cropped bitmap image
grn A groff preprocessor for gremlin files
grodvi A driver for groff that produces TeX dvi format
groff A front-end to the groff document formatting system; normally, it runs the troff program and a post-processor appropriate for the selected device
groffer Displays groff files and man pages on X and tty terminals
grog Reads files and guesses which of the groff options -e, -man, -me, -mm, -ms, -p, -s, and -t are required for printing files, and reports the groff command including those options
grolbp Is a groff driver for Canon CAPSL printers (LBP-4 and LBP-8 series laser printers)
grolj4 Is a driver for groff that produces output in PCL5 format suitable for an HP LaserJet 4 printer
ropdf Translates the output of GNU troff to PDF
grops Translates the output of GNU troff to PostScript
grotty Translates the output of GNU troff into a form suitable for typewriter-like devices
hpftodit Creates a font file for use with groff -TLj4 from an HP-tagged font metric file
indxbib Creates an inverted index for the bibliographic databases with a specified file for use with refer, lookbib, and lkbib
lkbib Searches bibliographic databases for references that contain specified keys and reports any references found
lookbib Prints a prompt on the standard error (unless the standard input is not a terminal), reads a line containing a set of keywords from the standard input, searches the bibliographic databases in a specified file for references containing those keywords, prints any references found on the standard output, and repeats this process until the end of input
mmroff A simple preprocessor for groff
neqn Formats equations for American Standard Code for Information Interchange (ASCII) output
nroff A script that emulates the nroff command using groff
pdfmom Is a wrapper around groff that facilitates the production of PDF documents from files formatted with the mom macros.
pdfroff Creates pdf documents using groff
pfbtops Translates a PostScript font in .pfb format to ASCII
pic Compiles descriptions of pictures embedded within troff or TeX input files into commands understood by TeX or troff
pic2graph Converts a PIC diagram into a cropped image
post-grohtml Translates the output of GNU troff to HTML
preconv Converts encoding of input files to something GNU troff understands
pre-grohtml Translates the output of GNU troff to HTML
refer Copies the contents of a file to the standard output, except that lines between ./ and ./ are interpreted as citations, and lines between .R1 and .R2 are interpreted as commands for how citations are to be processed
roff2dvi Transforms roff files into DVI format
**roff2html**  
Transforms roff files into HTML format

**roff2pdf**  
Transforms roff files into PDFs

**roff2ps**  
Transforms roff files into ps files

**roff2text**  
Transforms roff files into text files

**roff2x**  
Transforms roff files into other formats

**soelim**  
Reads files and replaces lines of the form `.so file` by the contents of the mentioned *file*

**tbl**  
Compiles descriptions of tables embedded within troff input files into commands that are understood by **troff**

**tfmtodit**  
Creates a font file for use with **groff -Tdvi**

**troff**  
Is highly compatible with Unix **troff**; it should usually be invoked using the **groff** command, which will also run preprocessors and post-processors in the appropriate order and with the appropriate options
6.56. GRUB-2.02~beta2

The GRUB package contains the GRand Unified Bootloader.

**Approximate build time:** 0.8 SBU  
**Required disk space:** 142 MB

6.56.1. Installation of GRUB

Prepare GRUB for compilation:

```bash
./configure --prefix=/usr          
--sbindir=/sbin        
--sysconfdir=/etc      
--disable-grub-emu-usb 
--disable-efiemu       
--disable-werror
```

The meaning of the new configure options:

```
--disable-werror  
This allows the build to complete with warnings introduced by more recent Flex versions.

--disable-grub-emu-usb --disable-efiemu  
These options minimize what is built by disabling features and testing programs not needed for LFS.
```

Compile the package:

```
make
```

This package does not come with a test suite.

Install the package:

```
make install
```

Using GRUB to make your LFS system bootable will be discussed in Section 8.4, “Using GRUB to Set Up the Boot Process”.

6.56.2. Contents of GRUB


**Installed directories:** /usr/lib/grub, /etc/grub.d, /usr/share/grub, and boot/grub (when grub-install is first run)

**Short Descriptions**

- **grub-bios-setup** 
  Is a helper program for grub-install

- **grub-editenv** 
  A tool to edit the environment block

- **grub-file** 
  Checks if FILE is of the specified type.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>grub-fstest</td>
<td>Tool to debug the filesystem driver</td>
</tr>
<tr>
<td>grub-glue-efi</td>
<td>Processes ia32 and amd64 EFI images and glues them according to Apple format.</td>
</tr>
<tr>
<td>grub-install</td>
<td>Install GRUB on your drive</td>
</tr>
<tr>
<td>grub-kbdcomp</td>
<td>Script that converts an xkb layout into one recognized by GRUB</td>
</tr>
<tr>
<td>grub-macbless</td>
<td>Mac-style bless on HFS or HFS+ files</td>
</tr>
<tr>
<td>grub-menulst2cfg</td>
<td>Converts a GRUB Legacy menu.lst into a grub.cfg for use with GRUB 2</td>
</tr>
<tr>
<td>grub-mkconfig</td>
<td>Generate a grub config file</td>
</tr>
<tr>
<td>grub-mkimage</td>
<td>Make a bootable image of GRUB</td>
</tr>
<tr>
<td>grub-mklayout</td>
<td>Generates a GRUB keyboard layout file</td>
</tr>
<tr>
<td>grub-mknetdir</td>
<td>Prepares a GRUB netboot directory</td>
</tr>
<tr>
<td>grub-mkpasswd-pbkdf2</td>
<td>Generates an encrypted PBKDF2 password for use in the boot menu</td>
</tr>
<tr>
<td>grub-mkrelpath</td>
<td>Makes a system pathname relative to its root</td>
</tr>
<tr>
<td>grub-mkrescue</td>
<td>Make a bootable image of GRUB suitable for a floppy disk or CDROM/DVD</td>
</tr>
<tr>
<td>grub-mkstandalone</td>
<td>Generates a standalone image</td>
</tr>
<tr>
<td>grub-ofpathname</td>
<td>Is a helper program that prints the path of a GRUB device</td>
</tr>
<tr>
<td>grub-probe</td>
<td>Probe device information for a given path or device</td>
</tr>
<tr>
<td>grub-reboot</td>
<td>Sets the default boot entry for GRUB for the next boot only</td>
</tr>
<tr>
<td>grub-render-label</td>
<td>Render Apple .disk_label for Apple Macs</td>
</tr>
<tr>
<td>grub-script-check</td>
<td>Checks GRUB configuration script for syntax errors</td>
</tr>
<tr>
<td>grub-set-default</td>
<td>Sets the default boot entry for GRUB</td>
</tr>
<tr>
<td>grub-sparc64-setup</td>
<td>Is a helper program for grub-setup</td>
</tr>
<tr>
<td>grub-syslinux2cfg</td>
<td>Transform a syslinux config file into grub.cfg format</td>
</tr>
</tbody>
</table>


6.57. Less-481

The Less package contains a text file viewer.

Approximate build time: 0.1 SBU
Required disk space: 3.8 MB

6.57.1. Installation of Less

Prepare Less for compilation:

```
./configure --prefix=/usr --sysconfdir=/etc
```

The meaning of the configure options:

```
--sysconfdir=/etc
```
This option tells the programs created by the package to look in /etc for the configuration files.

Compile the package:

```
make
```

This package does not come with a test suite.

Install the package:

```
make install
```

6.57.2. Contents of Less

Installed programs: less, lessecho, and lesskey

Short Descriptions

- **less**: A file viewer or pager; it displays the contents of the given file, letting the user scroll, find strings, and jump to marks
- **lessecho**: Needed to expand meta-characters, such as * and ?, in filenames on Unix systems
- **lesskey**: Used to specify the key bindings for less
6.58. Gzip-1.6

The Gzip package contains programs for compressing and decompressing files.

Approximate build time: 0.2 SBU
Required disk space: 20 MB

6.58.1. Installation of Gzip

Prepare Gzip for compilation:

```
./configure --prefix=/usr --bindir=/bin
```

Compile the package:

```
made
```

To test the results, issue:

```
made check
```

Install the package:

```
made install
```

Move some programs that do not need to be on the root filesystem:

```
mv -v /bin/{gzexe,uncompress,zcmp,zdiff,zegrep} /usr/bin
mv -v /bin/{zfgrep,zforce,zgrep,zless,zmore,znew} /usr/bin
```

6.58.2. Contents of Gzip

**Installed programs:**

- gunzip, gzexe, gzip, uncompress (hard link with gunzip), zcat, zcmp, zdiff, zegrep, zfgrep, zforce, zgrep, zless, zmore, and znew

**Short Descriptions**

- **gunzip**
  Decompresses gzipped files

- **gzexe**
  Creates self-decompressing executable files

- **gzip**
  Compresses the given files using Lempel-Ziv (LZ77) coding

- **uncompress**
  Decompresses compressed files

- **zcat**
  Decompresses the given gzipped files to standard output

- **zcmp**
  Runs `cmp` on gzipped files

- **zdiff**
  Runs `diff` on gzipped files

- **zegrep**
  Runs `egrep` on gzipped files

- **zfgrep**
  Runs `fgrep` on gzipped files

- **zforce**
  Forces a `.gz` extension on all given files that are gzipped files, so that `gzip` will not compress them again; this can be useful when file names were truncated during a file transfer

- **zgrep**
  Runs `grep` on gzipped files
zless  Runs **less** on gzipped files

zmore  Runs **more** on gzipped files

znew  Re-compresses files from **compress** format to **gzip** format—.Z to .gz
6.59. IPRoute2-4.4.0

The IPRoute2 package contains programs for basic and advanced IPV4-based networking.

Approximate build time: 0.2 SBU
Required disk space: 10 MB

6.59.1. Installation of IPRoute2

The `arpd` program included in this package will not be built since it is dependent on Berkeley DB, which is not installed in LFS. However, documentation files and a directory for `arpd` will still be installed. Prevent this by running the commands below. If the `arpd` binary is needed, instructions for compiling Berkeley DB can be found in the BLFS Book at [http://www.linuxfromscratch.org/blfs/view/systemd/server/databases.html#db](http://www.linuxfromscratch.org/blfs/view/systemd/server/databases.html#db).

```
sed -i /ARPD/d Makefile
sed -i 's/arpd.8//' man/man8/Makefile
rm -v doc/arpd.sgml
```

Compile the package:

```
make
```

This package comes with a test suite, but due to assumptions it makes, it is not possible to reliably run these tests from within the chroot environment. If you wish to run these tests after booting into your new LFS system, ensure you enable `/proc/config.gz` support in your kernel ("General setup" -> "Enable access to .config through /proc/config.gz" [CONFIG_IKCONFIG_PROC]), then run 'make alltests' from the `testsuite/` subdirectory.

Install the package:

```
make DOCDIR=/usr/share/doc/iproute2-4.4.0 install
```

6.59.2. Contents of IPRoute2

Installed programs: bridge, ctstat (link to lnstat), genl, ifcfg, ifstat, ip, lnstat, nstat, routef, routel, rtacct, rtmon, rtpr, rtstat (link to lnstat), ss, and tc

Installed directories: `/etc/iproute2`, `/usr/lib/tc`, and `/usr/share/doc/iproute2-4.4.0`

Short Descriptions

- **bridge**: Configures network bridges
- **ctstat**: Connection status utility
- **genl**: A shell script wrapper for the `ip` command [Note that it requires the `arping` and `rdisk` programs from the iputils package found at [http://www.skbuff.net/iputils/](http://www.skbuff.net/iputils/)]
- **ifcfg**: Shows the interface statistics, including the amount of transmitted and received packets by interface
- **ip**: The main executable. It has several different functions:
  - **ip link <device>** allows users to look at the state of devices and to make changes
  - **ip addr** allows users to look at addresses and their properties, add new addresses, and delete old ones
  - **ip neighbor** allows users to look at neighbor bindings and their properties, add new neighbor entries, and delete old ones
ip rule allows users to look at the routing policies and change them
ip route allows users to look at the routing table and change routing table rules
ip tunnel allows users to look at the IP tunnels and their properties, and change them
ip maddr allows users to look at the multicast addresses and their properties, and change them
ip mrout allows users to set, change, or delete the multicast routing
ip monitor allows users to continuously monitor the state of devices, addresses and routes

Instat Provides Linux network statistics; it is a generalized and more feature-complete replacement for the old rtstat program
nstat Shows network statistics
routef A component of ip route. This is for flushing the routing tables
routel A component of ip route. This is for listing the routing tables
rtacct Displays the contents of /proc/net/rt_acct
rtmon Route monitoring utility
rtpr Converts the output of ip -o back into a readable form
rtstat Route status utility
ss Similar to the netstat command; shows active connections
tc Traffic Controlling Executable; this is for Quality Of Service (QOS) and Class Of Service (COS) implementations
tc qdisc allows users to setup the queueing discipline
tc class allows users to setup classes based on the queueing discipline scheduling
tc estimator allows users to estimate the network flow into a network
tc filter allows users to setup the QOS/COS packet filtering
tc policy allows users to setup the QOS/COS policies
6.60. Kbd-2.0.3

The Kbd package contains key-table files, console fonts, and keyboard utilities.

Approximate build time: 0.1 SBU
Required disk space: 30 MB

6.60.1. Installation of Kbd

The behaviour of the Backspace and Delete keys is not consistent across the keymaps in the Kbd package. The following patch fixes this issue for i386 keymaps:

```
patch -Np1 -i ../kbd-2.0.3-backspace-1.patch
```

After patching, the Backspace key generates the character with code 127, and the Delete key generates a well-known escape sequence.

Remove the redundant `resizecons` program (it requires the defunct svgalib to provide the video mode files - for normal use `setfont` sizes the console appropriately) together with its manpage.

```
sed -i 's/\(RESIZECONS_PROGS=\)yes/\1no/g' configure
sed -i 's/resizecons.8 ///' docs/man/man8/Makefile.in
```

Prepare Kbd for compilation:

```
PKG_CONFIG_PATH=/tools/lib/pkgconfig ./configure --prefix=/usr --disable-vlock
```

The meaning of the configure options:

```
--disable-vlock
```

This option prevents the vlock utility from being built, as it requires the PAM library, which isn't available in the chroot environment.

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

Note

For some languages (e.g., Belarusian) the Kbd package doesn't provide a useful keymap where the stock “by” keymap assumes the ISO-8859-5 encoding, and the CP1251 keymap is normally used. Users of such languages have to download working keymaps separately.

If desired, install the documentation:

```
mkdir -v /usr/share/doc/kbd-2.0.3
cp -R -v docs/doc/* /usr/share/doc/kbd-2.0.3
```
6.60.2. Contents of Kbd

**Installed programs:** chvt, deallocvt, dumpkeys, fgconsole, getkeycodes, kbdinfo, kbd_mode, kbdrate, loadkeys, loadunimap, mapscrn, openvt, psfaddtable (link to psfxtable), psfgettable (link to psfxtable), psfstripetable (link to psfxtable), psfxtable, setfont, setkeycodes, setleds, setmetamode, setvtrgb, showconsolefont, showkey, unicode_start, and unicode_stop

**Installed directories:** /usr/share/consolefonts, /usr/share/consoletrans, /usr/share/keymaps, /usr/share/doc/kbd-2.0.3, and /usr/share/unimaps

**Short Descriptions**

**chvt** Changes the foreground virtual terminal

**deallocvt** Deallocates unused virtual terminals

**dumpkeys** Dumps the keyboard translation tables

**fgconsole** Prints the number of the active virtual terminal

**getkeycodes** Prints the kernel scancode-to-keycode mapping table

**kbdinfo** Obtains information about the status of a console

**kbd_mode** Reports or sets the keyboard mode

**kbdrate** Sets the keyboard repeat and delay rates

**loadkeys** Loads the keyboard translation tables

**loadunimap** Loads the kernel unicode-to-font mapping table

**mapscrn** An obsolete program that used to load a user-defined output character mapping table into the console driver; this is now done by **setfont**

**openvt** Starts a program on a new virtual terminal (VT)

**psfaddtable** Adds a Unicode character table to a console font

**psfgettable** Extracts the embedded Unicode character table from a console font

**psfstripetable** Removes the embedded Unicode character table from a console font

**psfxtable** Handles Unicode character tables for console fonts

**setfont** Changes the Enhanced Graphic Adapter (EGA) and Video Graphics Array (VGA) fonts on the console

**setkeycodes** Loads kernel scancode-to-keycode mapping table entries; this is useful if there are unusual keys on the keyboard

**setleds** Sets the keyboard flags and Light Emitting Diodes (LEDs)

**setmetamode** Defines the keyboard meta-key handling

**setvtrgb** Sets the console color map in all virtual terminals

**showconsolefont** Shows the current EGA/VGA console screen font

**showkey** Reports the scancodes, keycodes, and ASCII codes of the keys pressed on the keyboard

**unicode_start** Puts the keyboard and console in UNICODE mode [Don't use this program unless your keymap file is in the ISO-8859-1 encoding. For other encodings, this utility produces incorrect results.]

**unicode_stop** Reverts keyboard and console from UNICODE mode

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6.61. Libpipeline-1.4.1

The Libpipeline package contains a library for manipulating pipelines of subprocesses in a flexible and convenient way.

Approximate build time: 0.1 SBU
Required disk space: 8.1 MB

6.61.1. Installation of Libpipeline

Prepare Libpipeline for compilation:

```
PKG_CONFIG_PATH=/tools/lib/pkgconfig ./configure --prefix=/usr
```

The meaning of the configure options:

- **PKG_CONFIG_PATH**
  Use pkg-config to obtain the location of the test library metadata built in Section 5.14, “Check-0.10.0”.

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

6.61.2. Contents of Libpipeline

Installed library: libpipeline.so

Short Descriptions

**libpipeline**  This library is used to safely construct pipelines between subprocesses
6.62. Make-4.1

The Make package contains a program for compiling packages.

Approximate build time: 0.4 SBU
Required disk space: 12.4 MB

6.62.1. Installation of Make

Prepare Make for compilation:

```
./configure --prefix=/usr
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

6.62.2. Contents of Make

Installed program: make

Short Descriptions

- **make**: Automatically determines which pieces of a package need to be (re)compiled and then issues the relevant commands
6.63. Patch-2.7.5

The Patch package contains a program for modifying or creating files by applying a “patch” file typically created by the diff program.

- **Approximate build time:** 0.2 SBU
- **Required disk space:** 11 MB

### 6.63.1. Installation of Patch

Prepare Patch for compilation:

```
./configure --prefix=/usr
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

### 6.63.2. Contents of Patch

- **Installed program:** patch

### Short Descriptions

**patch**  Modifies files according to a patch file [A patch file is normally a difference listing created with the diff program. By applying these differences to the original files, patch creates the patched versions.]
6.64. D-Bus-1.10.6

D-Bus is a message bus system, a simple way for applications to talk to one another. D-Bus supplies both a system daemon (for events such as "new hardware device added" or "printer queue changed") and a per-user-login-session daemon (for general IPC needs among user applications). Also, the message bus is built on top of a general one-to-one message passing framework, which can be used by any two applications to communicate directly (without going through the message bus daemon).

<table>
<thead>
<tr>
<th>Approximate build time:</th>
<th>0.2 SBU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required disk space:</td>
<td>23 MB</td>
</tr>
</tbody>
</table>

6.64.1. Installation of D-Bus

Prepare D-Bus for compilation:

```bash
./configure --prefix=/usr                       \
   --sysconfdir=/etc                   \
   --localstatedir=/var                \
   --disable-static                    \
   --disable-doxygen-docs              \
   --disable-xml-docs                  \
   --docdir=/usr/share/doc/dbus-1.10.6 \
   --with-console-auth-dir=/run/console
```

The meaning of the configure options:

```
--with-console-auth-dir=/run/console
```

This specifies the location of the ConsoleKit auth directory.

Compile the package:

```
make
```

This package does come with a test suite, but it requires several packages that are not included in LFS. Instructions for running the test suite can be found in the BLFS book at [http://www.linuxfromscratch.org/blfs/view/systemd/general/dbus.html](http://www.linuxfromscratch.org/blfs/view/systemd/general/dbus.html).

Install the package:

```
make install
```

The shared library needs to be moved to /lib, and as a result the .so file in /usr/lib will need to be recreated:

```
mv -v /usr/lib/libdbus-1.so.* /lib
ln -s $PWD/../lib/$(readlink /usr/lib/libdbus-1.so) /usr/lib/libdbus-1.so
```

Create a symlink, so that D-Bus and systemd can use the same machine-id file:

```
ln -s /etc/machine-id /var/lib/dbus
```
### 6.64.2. Contents of D-Bus

**Installed programs:**
- dbus-cleanup-sockets, dbus-daemon, dbus-launch, dbus-monitor, dbus-run-session, dbus-send, and dbus-uuidgen

**Installed libraries:**
- libdbus-1.{a,so}

**Installed directories:**
- /etc/dbus-1, /usr/include/dbus-1.0, /usr/lib/dbus-1.0, /usr/share/dbus-1, /usr/share/doc/dbus-1.10.6, and /var/lib/dbus

### Short Descriptions

- **dbus-cleanup-sockets**
  - Used to clean up leftover sockets in a directory

- **dbus-daemon**
  - The D-Bus message bus daemon

- **dbus-launch**
  - Starts **dbus-daemon** from a shell script

- **dbus-monitor**
  - Monitors messages passing through a D-Bus message bus

- **dbus-run-session**
  - Starts a session bus instance of **dbus-daemon** from a shell script and starts a specified program in that session

- **dbus-send**
  - Sends a message to a D-Bus message bus

- **dbus-uuidgen**
  - Generates a universally unique ID

- **libdbus-1**
  - Contains API functions used to communicate with the D-Bus message bus
6.65. Util-linux-2.27.1

The Util-linux package contains miscellaneous utility programs. Among them are utilities for handling file systems, consoles, partitions, and messages.

Approximate build time: 0.9 SBU
Required disk space: 1.3 GB

6.65.1. FHS compliance notes

The FHS recommends using the /var/lib/hwclock directory instead of the usual /etc directory as the location for the adjtime file. First create a directory to enable storage for the hwclock program:

```
mkdir -pv /var/lib/hwclock
```

6.65.2. Installation of Util-linux

Prepare Util-linux for compilation:

```
./configure ADJTIME_PATH=/var/lib/hwclock/adjtime     \
   --docdir=/usr/share/doc/util-linux-2.27.1     \
   --disable-chfn-chsh     \
   --disable-login        \
   --disable-nologin      \
   --disable-su           \
   --disable-setpriv      \
   --disable-runuser      \
   --disable-pylibmount   \
   --disable-static       \
   --without-python
```

The --disable and --without options prevent warnings about building components that require packages not in LFS or are inconsistent with programs installed by other packages.

Compile the package:

```
make
```

If desired, run the test suite as a non-root user:

```
Warning
Running the test suite as the root user can be harmful to your system. To run it, the CONFIG_SCSI_DEBUG option for the kernel must be available in the currently running system, and must be built as a module. Building it into the kernel will prevent booting. For complete coverage, other BLFS packages must be installed. If desired, this test can be run after rebooting into the completed LFS system and running:

```
bash tests/run.sh --srcdir=$PWD --builddir=$PWD
```

```
chown -Rv nobody .

su nobody -s /bin/bash -c "PATH=$PATH make -k check"
```
One test above, tests/ts/ipcs/limits2, will fail when the host is using a recent kernel. The failure can safely be ignored.

Install the package:

```
make install
```

# 6.65.3. Contents of Util-linux

**Installed programs:**
- addpart
- agetty
- blkdiscard
- blkid
- blockdev
- cal
- cfdisk
- chcpu
- chrt
- col
- colcrt
- colrm
- column
- ctrlaltdel
- delpart
- dmesg
- eject
- fallocate
- fdformat
- fdisk
- findfs
- findmnt
- flock
- fsck
- fsck.cramfs
- fsck.minix
- fsfreeze
- fstrim
- getopt
- hexdump
- hwclock
- i386
- ionice
- ipcmk
- ipcrm
- ipcs
- isosize
- kill
- last
- lastb
- ldattach
- linux32
- linux64
- logger
- look
- losetup
- lsblk
- lscpu
- lsipc
- lslocks
- lslogins
- mcookie
- mesg
- mkfs
- mkfs.bfs
- mkfs.cramfs
- mkfs.minix
- mkswap
- more
- mount
- mountpoint
- namei
- nsenter
- partx
- pg
- pivot_root
- prlimit
- raw
- readprofile
- rename
- renice
- resizepart
- rev
- rtcwake
- script
- scriptreplay
- setarch
- setsid
- setterm
- sfdisk
- sulogin
- swaplabel
- swapoff
- swapon
- switch_root
- tailf
- taskset
- ul
- umount
- uname26
- unshare
- utmpdump
- uuidd
- uuidgen
- wall
- wdctl
- whereis
- wipefs
- x86_64
- zramctl

**Installed libraries:**
- libblkid.so
- libfdisk.so
- libmount.so
- libsmartcols.so
- libuuid.so

**Installed directories:**
- /usr/include/blkid
- /usr/include/libfdisk
- /usr/include/libmount
- /usr/include/libsmartcols
- /usr/include/uuid
- /usr/share/doc/util-linux-2.27.1
- /var/lib/hwclock

**Short Descriptions**

- **addpart**: Informs the Linux kernel of new partitions
- **agetty**: Opens a tty port, prompts for a login name, and then invokes the `login` program
- **blkdiscard**: Discards sectors on a device
- **blkid**: A command line utility to locate and print block device attributes
- **blockdev**: Allows users to call block device ioctls from the command line
- **cal**: Displays a simple calendar
- **cfdisk**: Manipulates the partition table of the given device
- **chcpu**: Modifies the state of CPUs
- **chrt**: Manipulates real-time attributes of a process
- **col**: Filters out reverse line feeds
- **colcrt**: Filters `nroff` output for terminals that lack some capabilities, such as overstriking and half-lines
- **colrm**: Filters out the given columns
- **column**: Formats a given file into multiple columns
- **ctrlaltdel**: Sets the function of the Ctrl+Alt+Del key combination to a hard or a soft reset
- **delpart**: Asks the Linux kernel to remove a partition
- **dmesg**: Dumps the kernel boot messages
- **eject**: Ejects removable media
fallocate  Preallocates space to a file
fdformat  Low-level formats a floppy disk
fdisk  Manipulates the partition table of the given device
findfs  Finds a file system by label or Universally Unique Identifier (UUID)
findmnt  Is a command line interface to the libmount library for work with mountinfo, fstab and mtab files
flock  Acquires a file lock and then executes a command with the lock held
fsck  Is used to check, and optionally repair, file systems
fsck.cramfs  Performs a consistency check on the Cramfs file system on the given device
fsck.minix  Performs a consistency check on the Minix file system on the given device
fsfreeze  Is a very simple wrapper around FIFREEZE/FITHAW ioctl kernel driver operations
fstrim  Discards unused blocks on a mounted filesystem
getopt  Parses options in the given command line
hexdump  Dumps the given file in hexadecimal or in another given format
hwclock  Reads or sets the system's hardware clock, also called the Real-Time Clock (RTC) or Basic Input-Output System (BIOS) clock
i386  A symbolic link to setarch
ionice  Gets or sets the io scheduling class and priority for a program
ipcmk  Creates various IPC resources
ipcrm  Removes the given Inter-Process Communication (IPC) resource
ipcs  Provides IPC status information
isosize  Reports the size of an iso9660 file system
kill  Sends signals to processes
last  Shows which users last logged in (and out), searching back through the /var/log/wtmp file; it also shows system boots, shutdowns, and run-level changes
lastb  Shows the failed login attempts, as logged in /var/log/btmp
ldattach  Attaches a line discipline to a serial line
linux32  A symbolic link to setarch
linux64  A symbolic link to setarch
logger  Enters the given message into the system log
look  Displays lines that begin with the given string
losetup  Sets up and controls loop devices
lsblk  Lists information about all or selected block devices in a tree-like format
lscpu  Prints CPU architecture information
lsipc  Prints information on IPC facilities currently employed in the system
lslocks  Lists local system locks
lslogins  Lists information about users, groups and system accounts
mcookie Generates magic cookies (128-bit random hexadecimal numbers) for xauth
mesg Controls whether other users can send messages to the current user's terminal
mkfs Builds a file system on a device (usually a hard disk partition)
mkfs.bfs Creates a Santa Cruz Operations (SCO) bfs file system
mkfs.cramfs Creates a cramfs file system
mkfs.minix Creates a Minix file system
mkswap Initializes the given device or file to be used as a swap area
more A filter for paging through text one screen at a time
mount Attaches the file system on the given device to a specified directory in the file-system tree
mountpoint Checks if the directory is a mountpoint
namei Shows the symbolic links in the given pathnames
nsenter Runs a program with namespaces of other processes
partx Tells the kernel about the presence and numbering of on-disk partitions
pg Displays a text file one screen full at a time
pivot_root Makes the given file system the new root file system of the current process
prlimit Get and set a process' resource limits
raw Bind a Linux raw character device to a block device
readprofile Reads kernel profiling information
rename Renames the given files, replacing a given string with another
renice Alters the priority of running processes
resizepart Asks the Linux kernel to resize a partition
rev Reverses the lines of a given file
rtcwake Used to enter a system sleep state until specified wakeup time
script Makes a typescript of a terminal session
scriptreplay Plays back typescripts using timing information
setarch Changes reported architecture in a new program environment and sets personality flags
setsid Runs the given program in a new session
setterm Sets terminal attributes
sfdisk A disk partition table manipulator
sulogin Allows root to log in; it is normally invoked by init when the system goes into single user mode
swaplabel Allows to change swaparea UUID and label
swapoff Disables devices and files for paging and swapping
swapon Enables devices and files for paging and swapping and lists the devices and files currently in use
switch_root Switches to another filesystem as the root of the mount tree
tailf Tracks the growth of a log file; displays the last 10 lines of a log file, then continues displaying any new entries in the log file as they are created
**taskset** Retrieves or sets a process’ CPU affinity

**ul** A filter for translating underscores into escape sequences indicating underlining for the terminal in use

**umount** Disconnects a file system from the system's file tree

**uname26** A symbolic link to setarch

**unshare** Runs a program with some namespaces unshared from parent

**utmpdumps** Displays the content of the given login file in a more user-friendly format

**uuidd** A daemon used by the UUID library to generate time-based UUIDs in a secure and guaranteed-unique fashion

**uuidgen** Creates new UUIDs. Each new UUID can reasonably be considered unique among all UUIDs created, on the local system and on other systems, in the past and in the future

**wall** Displays the contents of a file or, by default, its standard input, on the terminals of all currently logged in users

**wdctl** Shows hardware watchdog status

**whereis** Reports the location of the binary, source, and man page for the given command

**wipes** Wipes a filesystem signature from a device

**x86_64** A symbolic link to setarch

**zramctl** A program to set up and control zram (compressed ram disk) devices

**libblkid** Contains routines for device identification and token extraction

**libfdisk** Contains routines for manipulating partition tables

**libmount** Contains routines for block device mounting and unmounting

**libsmartcols** Contains routines for aiding screen output in tabular form

**libuuid** Contains routines for generating unique identifiers for objects that may be accessible beyond the local system
6.66. Man-DB-2.7.5

The Man-DB package contains programs for finding and viewing man pages.

Approximate build time:  0.4 SBU
Required disk space:  31 MB

6.66.1. Installation of Man-DB

Prepare Man-DB for compilation:

```
./configure --prefix=/usr                        
  --docdir=/usr/share/doc/man-db-2.7.5 
  --sysconfdir=/etc                    
  --disable-setuid                     
  --with-browser=/usr/bin/lynx         
  --with-vgrind=/usr/bin/vgrind        
  --with-grap=/usr/bin/grap
```

The meaning of the configure options:

--disable-setuid
This disables making the man program setuid to user man.

--with-...
These three parameters are used to set some default programs. lynx is a text-based web browser (see BLFS for installation instructions), vgrind converts program sources to Groff input, and grap is useful for typesetting graphs in Groff documents. The vgrind and grap programs are not normally needed for viewing manual pages. They are not part of LFS or BLFS, but you should be able to install them yourself after finishing LFS if you wish to do so.

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

Remove a reference to a non-existent user:

```
sed -i "s:man root:root root:g" /usr/lib/tmpfiles.d/man-db.conf
```

6.66.2. Non-English Manual Pages in LFS

The following table shows the character set that Man-DB assumes manual pages installed under /usr/share/man/ <ll> will be encoded with. In addition to this, Man-DB correctly determines if manual pages installed in that directory are UTF-8 encoded.

<table>
<thead>
<tr>
<th>Language (code)</th>
<th>Encoding</th>
<th>Language (code)</th>
<th>Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danish (da)</td>
<td>ISO-8859-1</td>
<td>Croatian (hr)</td>
<td>ISO-8859-2</td>
</tr>
<tr>
<td>Language (code)</td>
<td>Encoding</td>
<td>Language (code)</td>
<td>Encoding</td>
</tr>
<tr>
<td>------------------</td>
<td>------------</td>
<td>------------------</td>
<td>------------</td>
</tr>
<tr>
<td>German (de)</td>
<td>ISO-8859-1</td>
<td>Hungarian (hu)</td>
<td>ISO-8859-2</td>
</tr>
<tr>
<td>English (en)</td>
<td>ISO-8859-1</td>
<td>Japanese (ja)</td>
<td>EUC-JP</td>
</tr>
<tr>
<td>Spanish (es)</td>
<td>ISO-8859-1</td>
<td>Korean (ko)</td>
<td>EUC-KR</td>
</tr>
<tr>
<td>Estonian (et)</td>
<td>ISO-8859-1</td>
<td>Lithuanian (lt)</td>
<td>ISO-8859-13</td>
</tr>
<tr>
<td>Finnish (fi)</td>
<td>ISO-8859-1</td>
<td>Latvian (lv)</td>
<td>ISO-8859-13</td>
</tr>
<tr>
<td>French (fr)</td>
<td>ISO-8859-1</td>
<td>Macedonian (mk)</td>
<td>ISO-8859-5</td>
</tr>
<tr>
<td>Irish (ga)</td>
<td>ISO-8859-1</td>
<td>Polish (pl)</td>
<td>ISO-8859-2</td>
</tr>
<tr>
<td>Galician (gl)</td>
<td>ISO-8859-1</td>
<td>Romanian (ro)</td>
<td>ISO-8859-2</td>
</tr>
<tr>
<td>Indonesian (id)</td>
<td>ISO-8859-1</td>
<td>Russian (ru)</td>
<td>KOI8-R</td>
</tr>
<tr>
<td>Icelandic (is)</td>
<td>ISO-8859-1</td>
<td>Slovak (sk)</td>
<td>ISO-8859-2</td>
</tr>
<tr>
<td>Italian (it)</td>
<td>ISO-8859-1</td>
<td>Slovenian (sl)</td>
<td>ISO-8859-2</td>
</tr>
<tr>
<td>Norwegian (nb)</td>
<td>ISO-8859-1</td>
<td>Serbian Latin (sr@latin)</td>
<td>ISO-8859-2</td>
</tr>
<tr>
<td>Norwegian (nn)</td>
<td>ISO-8859-1</td>
<td>Turkish (tr)</td>
<td>ISO-8859-9</td>
</tr>
<tr>
<td>Norwegian (no)</td>
<td>ISO-8859-1</td>
<td>Ukrainian (uk)</td>
<td>KOI8-U</td>
</tr>
<tr>
<td>Portuguese (pt)</td>
<td>ISO-8859-1</td>
<td>Vietnamese (vi)</td>
<td>TCVN5712-1</td>
</tr>
<tr>
<td>Swedish (sv)</td>
<td>ISO-8859-1</td>
<td>Simplified Chinese (zh_CN)</td>
<td>GBK</td>
</tr>
<tr>
<td>Belarusian (be)</td>
<td>CP1251</td>
<td>Simplified Chinese, Singapore (zh_SG)</td>
<td>GBK</td>
</tr>
<tr>
<td>Bulgarian (bg)</td>
<td>CP1251</td>
<td>Traditional Chinese, Hong Kong (zh_HK)</td>
<td>BIG5HKSCS</td>
</tr>
<tr>
<td>Czech (cs)</td>
<td>ISO-8859-2</td>
<td>Traditional Chinese (zh_TW)</td>
<td>BIG5</td>
</tr>
<tr>
<td>Greek (el)</td>
<td>ISO-8859-7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note**

Manual pages in languages not in the list are not supported.

### 6.66.3. Contents of Man-DB

**Installed programs:** accessdb, apropos (link to whatis), catman, lexgrog, man, mandb, manpath, and whatis

**Installed libraries:** libman.so and libmandb.so

**Installed directories:** /usr/lib/man-db, /usr/lib/tmpfiles.d, /usr/libexec/man-db, and /usr/share/doc/man-db-2.7.5

**Short Descriptions**

**accessdb** Dumps the **whatis** database contents in human-readable form
apropos  Searches the **whatis** database and displays the short descriptions of system commands that contain a given string

catman  Creates or updates the pre-formatted manual pages

lexgrog  Displays one-line summary information about a given manual page

man     Formats and displays the requested manual page

mandb   Creates or updates the **whatis** database

manpath Displays the contents of $MANPATH or (if $MANPATH is not set) a suitable search path based on the settings in man.conf and the user’s environment

whatis  Searches the **whatis** database and displays the short descriptions of system commands that contain the given keyword as a separate word

libman  Contains run-time support for **man**

libmandb Contains run-time support for **man**
6.67. Tar-1.28

The Tar package contains an archiving program.

Approximate build time: 1.9 SBU
Required disk space: 40 MB

6.67.1. Installation of Tar

Prepare Tar for compilation:

```
FORCE_UNSAFE_CONFIGURE=1 \ 
./configure --prefix=/usr \ 
--bindir=/bin
```

The meaning of the configure options:

FORCE_UNSAFE_CONFIGURE=1

This forces the test for `mknod` to be run as root. It is generally considered dangerous to run this test as the root user, but as it is being run on a system that has only been partially built, overriding it is OK.

Compile the package:

```
make
```

To test the results (about 1 SBU), issue:

```
make check
```

Install the package:

```
make install
make -C doc install-html docdir=/usr/share/doc/tar-1.28
```

6.67.2. Contents of Tar

Installed programs: tar
Installed directory: /usr/share/doc/tar-1.28

Short Descriptions

- **tar**: Creates, extracts files from, and lists the contents of archives, also known as tarballs
6.68. Texinfo-6.1

The Texinfo package contains programs for reading, writing, and converting info pages.

Approximate build time: 0.6 SBU
Required disk space: 110 MB

6.68.1. Installation of Texinfo

Prepare Texinfo for compilation:

```
./configure --prefix=/usr
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

Optionally, install the components belonging in a TeX installation:

```
make TEXMF=/usr/share/texmf install-tex
```

The meaning of the make parameter:

```
TEXMF=/usr/share/texmf
```

The `TEXMF` makefile variable holds the location of the root of the TeX tree if, for example, a TeX package will be installed later.

The Info documentation system uses a plain text file to hold its list of menu entries. The file is located at `/usr/share/info/dir`. Unfortunately, due to occasional problems in the Makefiles of various packages, it can sometimes get out of sync with the info pages installed on the system. If the `/usr/share/info/dir` file ever needs to be recreated, the following optional commands will accomplish the task:

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

6.68.2. Contents of Texinfo

Installed programs: info, install-info, makeinfo (link to texi2any), pdftexi2dvi, pod2texi, texi2any, texi2dvi, texi2pdf, and texindex

Installed directory: `/usr/share/texinfo`
Short Descriptions

**info**  
Used to read info pages which are similar to man pages, but often go much deeper than just explaining all the available command line options [For example, compare *man bison* and *info bison*.]  

**install-info**  
Used to install info pages; it updates entries in the *info* index file  

**makeinfo**  
Translates the given Texinfo source documents into info pages, plain text, or HTML  

**pdftexi2dvi**  
Used to format the given Texinfo document into a Portable Document Format (PDF) file  

**pod2texi**  
Converts Pod to Texinfo format  

**texi2any**  
Translate Texinfo source documentation to various other formats  

**texi2dvi**  
Used to format the given Texinfo document into a device-independent file that can be printed  

**texi2pdf**  
Used to format the given Texinfo document into a Portable Document Format (PDF) file  

**texindex**  
Used to sort Texinfo index files
6.69. Vim-7.4

The Vim package contains a powerful text editor.

**Approximate build time:** 1.2 SBU  
**Required disk space:** 112 MB

---

### Alternatives to Vim

If you prefer another editor—such as Emacs, Joe, or Nano—please refer to [http://www.linuxfromscratch.org/blfs/view/systemd/postlfs/editors.html](http://www.linuxfromscratch.org/blfs/view/systemd/postlfs/editors.html) for suggested installation instructions.

---

#### 6.69.1. Installation of Vim

First, change the default location of the `vimrc` configuration file to `/etc`:

```bash
echo '#define SYS_VIMRC_FILE "/etc/vimrc"' >> src/feature.h
```

Prepare Vim for compilation:

```bash
./configure --prefix=/usr
```

Compile the package:

```bash
make
```

To test the results, issue:

```bash
make -j1 test
```

However, this test suite outputs a lot of binary data to the screen, which can cause issues with the settings of the current terminal. This can be resolved by redirecting the output to a log file. A successful test will result in the words "ALL DONE" at completion.

Install the package:

```bash
make install
```

Many users are used to using vi instead of vim. To allow execution of vim when users habitually enter vi, create a symlink for both the binary and the man page in the provided languages:

```bash
ln -sv vim /usr/bin/vi
for L in /usr/share/man/{,*/}man1/vim.1; do
  ln -sv vim.1 $(dirname $L)/vi.1
done
```

By default, Vim's documentation is installed in `/usr/share/vim`. The following symlink allows the documentation to be accessed via `/usr/share/doc/vim-7.4`, making it consistent with the location of documentation for other packages:

```bash
ln -sv ../vim/vim74/doc /usr/share/doc/vim-7.4
```

If an X Window System is going to be installed on the LFS system, it may be necessary to recompile Vim after installing X. Vim comes with a GUI version of the editor that requires X and some additional libraries to be installed. For more information on this process, refer to the Vim documentation and the Vim installation page in the BLFS book at [http://www.linuxfromscratch.org/blfs/view/systemd/postlfs/vim.html](http://www.linuxfromscratch.org/blfs/view/systemd/postlfs/vim.html).
6.69.2. Configuring Vim

By default, vim runs in vi-incompatible mode. This may be new to users who have used other editors in the past. The "nocompatible" setting is included below to highlight the fact that a new behavior is being used. It also reminds those who would change to "compatible" mode that it should be the first setting in the configuration file. This is necessary because it changes other settings, and overrides must come after this setting. Create a default vim configuration file by running the following:

```
cat > /etc/vimrc << "EOF"
    " Begin /etc/vimrc
    set nocompatible
    set backspace=2
    syntax on
    if (&term == "iterm") || (&term == "putty")
        set background=dark
    endif
    " End /etc/vimrc
EOF
```

The `set nocompatible` setting makes vim behave in a more useful way (the default) than the vi-compatible manner. Remove the "no" to keep the old vi behavior. The `set backspace=2` setting allows backspacing over line breaks, autoindents, and the start of insert. The `syntax on` parameter enables vim's syntax highlighting. Finally, the `if` statement with the `set background=dark` setting corrects vim's guess about the background color of some terminal emulators. This gives the highlighting a better color scheme for use on the black background of these programs.

Documentation for other available options can be obtained by running the following command:

```
vim -c ':options'
```

**Note**

By default, Vim only installs spell files for the English language. To install spell files for your preferred language, download the *.spl and optionally, the *.sug files for your language and character encoding from ftp://ftp.vim.org/pub/vim/runtime/spell/ and save them to /usr/share/vim/vim74/spell/.

To use these spell files, some configuration in /etc/vimrc is needed, e.g.:

```
set spelllang=en,ru
set spell
```

For more information, see the appropriate README file located at the URL above.

6.69.3. Contents of Vim

**Installed programs:**  
ex (link to vim), rview (link to vim), rvim (link to vim), vi (link to vim), view (link to vim), vim, vimdiff (link to vim), vmtutor, and xxd

**Installed directory:**  
/usr/share/vim

**Short Descriptions**

ex  
Starts vim in ex mode
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rview</td>
<td>Is a restricted version of <code>view</code>; no shell commands can be started and <code>view</code> cannot be suspended</td>
</tr>
<tr>
<td>rvim</td>
<td>Is a restricted version of <code>vim</code>; no shell commands can be started and <code>vim</code> cannot be suspended</td>
</tr>
<tr>
<td>vi</td>
<td>Link to <code>vim</code></td>
</tr>
<tr>
<td>view</td>
<td>Starts <code>vim</code> in read-only mode</td>
</tr>
<tr>
<td>vim</td>
<td>Is the editor</td>
</tr>
<tr>
<td>vimdiff</td>
<td>Edits two or three versions of a file with <code>vim</code> and show differences</td>
</tr>
<tr>
<td>vmtutor</td>
<td>Teaches the basic keys and commands of <code>vim</code></td>
</tr>
<tr>
<td>xxd</td>
<td>Creates a hex dump of the given file; it can also do the reverse, so it can be used for binary patching</td>
</tr>
</tbody>
</table>
6.70. About Debugging Symbols

Most programs and libraries are, by default, compiled with debugging symbols included (with gcc’s \texttt{-g} option). This means that when debugging a program or library that was compiled with debugging information included, the debugger can provide not only memory addresses, but also the names of the routines and variables.

However, the inclusion of these debugging symbols enlarges a program or library significantly. The following is an example of the amount of space these symbols occupy:

- A \texttt{bash} binary with debugging symbols: 1200 KB
- A \texttt{bash} binary without debugging symbols: 480 KB
- Glibc and GCC files (\texttt{/lib} and \texttt{/usr/lib}) with debugging symbols: 87 MB
- Glibc and GCC files without debugging symbols: 16 MB

Sizes may vary depending on which compiler and C library were used, but when comparing programs with and without debugging symbols, the difference will usually be a factor between two and five.

Because most users will never use a debugger on their system software, a lot of disk space can be regained by removing these symbols. The next section shows how to strip all debugging symbols from the programs and libraries.

6.71. Stripping Again

If the intended user is not a programmer and does not plan to do any debugging on the system software, the system size can be decreased by about 90 MB by removing the debugging symbols from binaries and libraries. This causes no inconvenience other than not being able to debug the software fully anymore.

Most people who use the command mentioned below do not experience any difficulties. However, it is easy to make a typo and render the new system unusable, so before running the \texttt{strip} command, it is a good idea to make a backup of the LFS system in its current state.

Before performing the stripping, take special care to ensure that none of the binaries that are about to be stripped are running. If unsure whether the user entered chroot with the command given in Section 6.4, “Entering the Chroot Environment,” first exit from chroot:

\texttt{logout}

Then reenter it with:

\begin{verbatim}
chroot $LFS /tools/bin/env -i \ HOME=/root TERM=$TERM PS1='\u: \w $' \ PATH=/bin:/usr/bin:/sbin:/usr/sbin \ /tools/bin/bash --login
\end{verbatim}

Now the binaries and libraries can be safely stripped:

\begin{verbatim}
/tools/bin/find /{,usr/}{bin,lib,sbin} -type f \ -exec /tools/bin/strip --strip-debug '{}' ';'
\end{verbatim}

A large number of files will be reported as having their file format not recognized. These warnings can be safely ignored. These warnings indicate that those files are scripts instead of binaries.
6.72. Cleaning Up

Finally, clean up some extra files left around from running tests:

```
rm -rf /tmp/*
```

From now on, when reentering the chroot environment after exiting, use the following modified chroot command:

```
chroot "$LFS" /usr/bin/env -i              \\ HOME=/root TERM="$TERM" PS1='\u:\w\$ ' \ PATH=/bin:/usr/bin:/sbin:/usr/sbin     \\ /bin/bash --login
```

The reason for this is that the programs in `/tools` are no longer needed. Since they are no longer needed you can delete the `/tools` directory if so desired.

**Note**

Removing `/tools` will also remove the temporary copies of Tcl, Expect, and DejaGNU which were used for running the toolchain tests. If you need these programs later on, they will need to be recompiled and re-installed. The BLFS book has instructions for this (see [http://www.linuxfromscratch.org/blfs/](http://www.linuxfromscratch.org/blfs/)).

If the virtual kernel file systems have been unmounted, either manually or through a reboot, ensure that the virtual kernel file systems are mounted when reentering the chroot. This process was explained in Section 6.2.2, “Mounting and Populating /dev” and Section 6.2.3, “Mounting Virtual Kernel File Systems”.

Finally, there were several static libraries that were not suppressed earlier in the chapter in order to satisfy the regression tests in several packages. These libraries are from binutils, bzip2, e2fsprogs, flex, libtool, and zlib. If desired, remove them now:

```
rm -f /usr/lib/lib{bfd,opcodes}.a
rm -f /usr/lib/libbz2.a
rm -f /usr/lib/lib{com_err,e2p,ext2fs,ss}.a
rm -f /usr/lib/libltdl.a
rm -f /usr/lib/libfl.a
rm -f /usr/lib/libfl_pic.a
rm -f /usr/lib/libz.a
```
Chapter 7. Basic System Configuration

7.1. Introduction

This chapter discusses configuration files and systemd services. First, the general configuration files needed to set up networking are presented.

- Section 7.2, “General Network Configuration.”
- Section 7.2.3, “Configuring the system hostname.”
- Section 7.2.4, “Customizing the /etc/hosts File.”

Second, issues that affect the proper setup of devices are discussed.

- Section 7.3, “Device and Module Handling on an LFS System.”
- Section 7.4, “Creating Custom Symlinks to Devices.”

Third, configuring the system clock and keyboard layout.

- Section 7.5, “Configuring the system clock.”
- Section 7.6, “Configuring the Linux Console.”

Fourth, a brief introduction to the scripts and configuration files used when the user logs into the system.

- Section 7.7, “Configuring the System Locale.”
- Section 7.8, “Creating the /etc/inputrc File.”

And finally, configuring the systemd behavior.

- Section 7.10, “Systemd Usage and Configuration.”

7.2. General Network Configuration

This section only applies if a network card is to be configured.

7.2.1. Network Interface Configuration Files

Starting with version 209, systemd ships a network configuration daemon called `systemd-networkd` which can be used for basic network configuration. Additionally, since version 213, DNS name resolution can be handled by `systemd-resolved` in place of a static `/etc/resolv.conf` file. Both services are enabled by default, and absolutely should not be disabled.

Configuration files for `systemd-networkd` (and `systemd-resolved`) can be placed in `/usr/lib/systemd/network` or `/etc/systemd/network`. Files in `/etc/systemd/network` have a higher priority than the ones in `/usr/lib/systemd/network`. There are three types of configuration files: `.link`, `.netdev` and `.network` files. For detailed descriptions and example contents of these configuration files, consult the `systemd-link(5)`, `systemd-netdev(5)` and `systemd-network(5)` manual pages.

Note

Udev may assign network card interface names based on system physical characteristics such as enp2s1. If you are not sure what your interface name is, you can always run `ip link` after you have booted your system.
7.2.1.1. Static IP Configuration

The command below creates a basic configuration file for a Static IP setup (using both systemd-networkd and systemd-resolved):

```
cat > /etc/systemd/network/10-eth0-static.network << "EOF"
[Match]
Name=eth0

[Network]
Address=192.168.0.2/24
Gateway=192.168.0.1
DNS=192.168.0.1
EOF
```

Multiple DNS entries can be added if you have more than one DNS server.

7.2.1.2. DHCP Configuration

The command below creates a basic configuration file for an IPv4 DHCP setup:

```
cat > /etc/systemd/network/10-eth0-dhcp.network << "EOF"
[Match]
Name=eth0

[Network]
DHCP=ipv4
EOF
```

7.2.2. Creating the /etc/resolv.conf File

If the system is going to be connected to the Internet, it will need some means of Domain Name Service (DNS) name resolution to resolve Internet domain names to IP addresses, and vice versa. This is best achieved by placing the IP address of the DNS server, available from the ISP or network administrator, into `/etc/resolv.conf`.

7.2.2.1. systemd-resolved Configuration

**Note**

If using another means to configure your network interfaces (ex: ppp, network-manager, etc.), or if using any type of local resolver (ex: bind, dnsmasq, etc.), or any other software that generates an `/etc/resolv.conf` (ex: resolvconf), the **systemd-resolved** service should not be used.

When using **systemd-resolved** for DNS configuration, it is responsible for creating the `/etc/resolv.conf` file. Since version 226, the symlink for `/etc/resolv.conf` is created by systemd when needed, so no further configuration is necessary.
7.2.2.2. Static resolv.conf Configuration

If a static /etc/resolv.conf is desired, create it by running the following command:

```
cat > /etc/resolv.conf << "EOF"
# Begin /etc/resolv.conf

domain <Your Domain Name>

nameserver <IP address of your primary nameserver>
nameserver <IP address of your secondary nameserver>

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

The `domain` statement can be omitted or replaced with a `search` statement. See the man page for resolv.conf for more details.

Replace `<IP address of the nameserver>` with the IP address of the DNS most appropriate for the setup. There will often be more than one entry (requirements demand secondary servers for fallback capability). If you only need or want one DNS server, remove the second `nameserver` line from the file. The IP address may also be a router on the local network.

**Note**


7.2.3. Configuring the system hostname

During the boot process, the file `/etc/hostname` is used for establishing the system's hostname.

Create the `/etc/hostname` file and enter a hostname by running:

```
echo "<lfs>" > /etc/hostname
```

<lfs> needs to be replaced with the name given to the computer. Do not enter the Fully Qualified Domain Name (FQDN) here. That information is put in the `/etc/hosts` file.

7.2.4. Customizing the `/etc/hosts` File

Decide on the IP address, fully-qualified domain name (FQDN), and possible aliases for use in the `/etc/hosts` file. The syntax is:

```
IP_address myhost.example.org aliases
```

Unless the computer is to be visible to the Internet (i.e., there is a registered domain and a valid block of assigned IP addresses—most users do not have this), make sure that the IP address is in the private network IP address range. Valid ranges are:

<table>
<thead>
<tr>
<th>Private Network Address Range</th>
<th>Normal Prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0.0.1 - 10.255.255.254</td>
<td>8</td>
</tr>
<tr>
<td>172.x.0.1 - 172.x.255.254</td>
<td>16</td>
</tr>
<tr>
<td>192.168.y.1 - 192.168.y.254</td>
<td>24</td>
</tr>
</tbody>
</table>
x can be any number in the range 16-31. y can be any number in the range 0-255.

A valid private IP address could be 192.168.1.1. A valid FQDN for this IP could be lfs.example.org.

Even if not using a network card, a valid FQDN is still required. This is necessary for certain programs to operate correctly.

Create the /etc/hosts file by running:

```
cat > /etc/hosts << "EOF"
# Begin /etc/hosts (network card version)
127.0.0.1 localhost
::1 localhost
<192.168.0.2> <HOSTNAME.example.org> [alias1] [alias2] ...
# End /etc/hosts (network card version)
EOF
```

The <192.168.0.2> and <HOSTNAME.example.org> values need to be changed for specific uses or requirements (if assigned an IP address by a network/system administrator and the machine will be connected to an existing network). The optional alias name(s) can be omitted.

If a network card is not going to be configured, create the /etc/hosts file by running:

```
cat > /etc/hosts << "EOF"
# Begin /etc/hosts (no network card version)
127.0.0.1 <HOSTNAME.example.org> <HOSTNAME> localhost
::1 localhost
# End /etc/hosts (no network card version)
EOF
```

The ::1 entry is the IPv6 counterpart of 127.0.0.1 and represents the IPv6 loopback interface.

### 7.3. Device and Module Handling on an LFS System

In Chapter 6, we installed Udev from the systemd source package. Before we go into the details regarding how this works, a brief history of previous methods of handling devices is in order.

Linux systems in general traditionally use a static device creation method, whereby a great many device nodes are created under /dev (sometimes literally thousands of nodes), regardless of whether the corresponding hardware devices actually exist. This is typically done via a MAKEDEV script, which contains a number of calls to the mknod program with the relevant major and minor device numbers for every possible device that might exist in the world.

Using the Udev method, only those devices which are detected by the kernel get device nodes created for them. Because these device nodes will be created each time the system boots, they will be stored on a devtmpfs file system (a virtual file system that resides entirely in system memory). Device nodes do not require much space, so the memory that is used is negligible.
7.3.1. History

In February 2000, a new filesystem called devfs was merged into the 2.3.46 kernel and was made available during the 2.4 series of stable kernels. Although it was present in the kernel source itself, this method of creating devices dynamically never received overwhelming support from the core kernel developers.

The main problem with the approach adopted by devfs was the way it handled device detection, creation, and naming. The latter issue, that of device node naming, was perhaps the most critical. It is generally accepted that if device names are allowed to be configurable, then the device naming policy should be up to a system administrator, not imposed on them by any particular developer(s). The devfs file system also suffers from race conditions that are inherent in its design and cannot be fixed without a substantial revision to the kernel. It was marked as deprecated for a long period – due to a lack of maintenance – and was finally removed from the kernel in June, 2006.

With the development of the unstable 2.5 kernel tree, later released as the 2.6 series of stable kernels, a new virtual filesystem called sysfs came to be. The job of sysfs is to export a view of the system's hardware configuration to userspace processes. With this userspace-visible representation, the possibility of seeing a userspace replacement for devfs became much more realistic.

7.3.2. Udev Implementation

7.3.2.1. Sysfs

The sysfs filesystem was mentioned briefly above. One may wonder how sysfs knows about the devices present on a system and what device numbers should be used for them. Drivers that have been compiled into the kernel directly register their objects with a sysfs (devtmpfs internally) as they are detected by the kernel. For drivers compiled as modules, this registration will happen when the module is loaded. Once the sysfs filesystem is mounted (on /sys), data which the drivers register with sysfs are available to userspace processes and to udevd for processing (including modifications to device nodes).

7.3.2.2. Device Node Creation

Device files are created by the kernel by the devtmpfs filesystem. Any driver that wishes to register a device node will go through devtmpfs (via the driver core) to do it. When a devtmpfs instance is mounted on /dev, the device node will initially be created with a fixed name, permissions, and owner.

A short time later, the kernel will send a uevent to udevd. Based on the rules specified in the files within the /etc/udev/rules.d, /lib/udev/rules.d, and /run/udev/rules.d directories, udevd will create additional symlinks to the device node, or change its permissions, owner, or group, or modify the internal udevd database entry (name) for that object.

The rules in these three directories are numbered in a similar fashion to the LFS-Bootscripts package and all three directories are merged together. If udevd can't find a rule for the device it is creating, it will leave the permissions and ownership at whatever devtmpfs used initially.

7.3.2.3. Module Loading

Device drivers compiled as modules may have aliases built into them. Aliases are visible in the output of the modinfo program and are usually related to the bus-specific identifiers of devices supported by a module. For example, the snd-fm801 driver supports PCI devices with vendor ID 0x1319 and device ID 0x0801, and has an alias of “pci:v00001319d00000801sv*sd*bc04sc01i*”. For most devices, the bus driver exports the alias of the driver that would handle the device via sysfs. E.g., the /sys/bus/pci/devices/0000:00:0d.0/modalias file might
contain the string “pci:v00001319d00000801sv00001319sd00001319bc04sc01i00”. The default rules provided with Udev will cause **udevd** to call out to `/sbin/modprobe` with the contents of the `MODALIAS` uevent environment variable (which should be the same as the contents of the `modalias` file in `sysfs`), thus loading all modules whose aliases match this string after wildcard expansion.

In this example, this means that, in addition to `snd-fm801`, the obsolete (and unwanted) `forte` driver will be loaded if it is available. See below for ways in which the loading of unwanted drivers can be prevented.

The kernel itself is also able to load modules for network protocols, filesystems and NLS support on demand.

### 7.3.2.4. Handling Hotpluggable/Dynamic Devices

When you plug in a device, such as a Universal Serial Bus (USB) MP3 player, the kernel recognizes that the device is now connected and generates a uevent. This uevent is then handled by **udevd** as described above.

### 7.3.3. Problems with Loading Modules and Creating Devices

There are a few possible problems when it comes to automatically creating device nodes.

#### 7.3.3.1. A kernel module is not loaded automatically

Udev will only load a module if it has a bus-specific alias and the bus driver properly exports the necessary aliases to `sysfs`. In other cases, one should arrange module loading by other means. With Linux-4.4.2, Udev is known to load properly-written drivers for INPUT, IDE, PCI, USB, SCSI, SERIO, and FireWire devices.

To determine if the device driver you require has the necessary support for Udev, run `modinfo` with the module name as the argument. Now try locating the device directory under `/sys/bus` and check whether there is a `modalias` file there.

If the `modalias` file exists in `sysfs`, the driver supports the device and can talk to it directly, but doesn't have the alias, it is a bug in the driver. Load the driver without the help from Udev and expect the issue to be fixed later.

If there is no `modalias` file in the relevant directory under `/sys/bus`, this means that the kernel developers have not yet added modalias support to this bus type. With Linux-4.4.2, this is the case with ISA busses. Expect this issue to be fixed in later kernel versions.

Udev is not intended to load “wrapper” drivers such as `snd-pcm-oss` and non-hardware drivers such as `loop` at all.

#### 7.3.3.2. A kernel module is not loaded automatically, and Udev is not intended to load it

If the “wrapper” module only enhances the functionality provided by some other module (e.g., `snd-pcm-oss` enhances the functionality of `snd-pcm` by making the sound cards available to OSS applications), configure `modprobe` to load the wrapper after Udev loads the wrapped module. To do this, add a “softdep” line in any `/etc/modprobe.d/ <filename>.conf` file. For example:

```
softdep snd-pcm post: snd-pcm-oss
```

Note that the “softdep” command also allows `pre:` dependencies, or a mixture of both `pre:` and `post:`. See the `modprobe.d(5)` manual page for more information on “softdep” syntax and capabilities.

If the module in question is not a wrapper and is useful by itself, configure the `modules` bootscript to load this module on system boot. To do this, add the module name to the `/etc/sysconfig/modules` file on a separate line. This works for wrapper modules too, but is suboptimal in that case.
7.3.3.3. Udev loads some unwanted module

Either don't build the module, or blacklist it in a /etc/modprobe.d/blacklist.conf file as done with the forte module in the example below:

```
blacklist forte
```

Blacklisted modules can still be loaded manually with the explicit modprobe command.

7.3.3.4. Udev creates a device incorrectly, or makes a wrong symlink

This usually happens if a rule unexpectedly matches a device. For example, a poorly-written rule can match both a SCSI disk (as desired) and the corresponding SCSI generic device (incorrectly) by vendor. Find the offending rule and make it more specific, with the help of the udevadm info command.

7.3.3.5. Udev rule works unreliably

This may be another manifestation of the previous problem. If not, and your rule uses sysfs attributes, it may be a kernel timing issue, to be fixed in later kernels. For now, you can work around it by creating a rule that waits for the used sysfs attribute and appending it to the /etc/udev/rules.d/10-wait_for_sysfs.rules file (create this file if it does not exist). Please notify the LFS Development list if you do so and it helps.

7.3.3.6. Udev does not create a device

Further text assumes that the driver is built statically into the kernel or already loaded as a module, and that you have already checked that Udev doesn't create a misnamed device.

Udev has no information needed to create a device node if a kernel driver does not export its data to sysfs. This is most common with third party drivers from outside the kernel tree. Create a static device node in /lib/udev/devices with the appropriate major/minor numbers (see the file devices.txt inside the kernel documentation or the documentation provided by the third party driver vendor). The static device node will be copied to /dev by the udev bootscript.

7.3.3.7. Device naming order changes randomly after rebooting

This is due to the fact that Udev, by design, handles uevents and loads modules in parallel, and thus in an unpredictable order. This will never be “fixed”. You should not rely upon the kernel device names being stable. Instead, create your own rules that make symlinks with stable names based on some stable attributes of the device, such as a serial number or the output of various *_id utilities installed by Udev. See Section 7.4, “Creating Custom Symlinks to Devices” and Section 7.2, “General Network Configuration” for examples.

7.3.4. Useful Reading

Additional helpful documentation is available at the following sites:

7.4. Creating Custom Symlinks to Devices

7.4.1. Dealing with duplicate devices

As explained in Section 7.3, “Device and Module Handling on an LFS System”, the order in which devices with the same function appear in /dev is essentially random. E.g., if you have a USB web camera and a TV tuner, sometimes /dev/video0 refers to the camera and /dev/video1 refers to the tuner, and sometimes after a reboot the order changes to the opposite one. For all classes of hardware except sound cards and network cards, this is fixable by creating udev rules for custom persistent symlinks. The case of network cards is covered separately in Section 7.2, “General Network Configuration”, and sound card configuration can be found in BLFS.

For each of your devices that is likely to have this problem (even if the problem doesn’t exist in your current Linux distribution), find the corresponding directory under /sys/class or /sys/block. For video devices, this may be /sys/class/video4linux/videoX. Figure out the attributes that identify the device uniquely (usually, vendor and product IDs and/or serial numbers work):

```bash
udevadm info -a -p /sys/class/video4linux/video0
```

Then write rules that create the symlinks, e.g.:

```bash
cat > /etc/udev/rules.d/83-duplicate_devs.rules << "EOF"
# Persistent symlinks for webcam and tuner
KERNEL=="video*", ATTRS{idProduct}=="1910", ATTRS{idVendor}=="0d81", \ 
  SYMLINK+="webcam"
KERNEL=="video*", ATTRS{device}=="0x036f", ATTRS{vendor}=="0x109e", \ 
  SYMLINK+="tvtuner"
EOF
```

The result is that /dev/video0 and /dev/video1 devices still refer randomly to the tuner and the web camera (and thus should never be used directly), but there are symlinks /dev/tvtuner and /dev/webcam that always point to the correct device.

7.5. Configuring the system clock

This section discusses how to configure the systemd-timedated system service, which configures system clock and timezone.

If you cannot remember whether or not the hardware clock is set to UTC, find out by running the `hwclock --localtime --show` command. This will display what the current time is according to the hardware clock. If this time matches whatever your watch says, then the hardware clock is set to local time. If the output from `hwclock` is not local time, chances are it is set to UTC time. Verify this by adding or subtracting the proper amount of hours for the timezone to the time shown by `hwclock`. For example, if you are currently in the MST timezone, which is also known as GMT -0700, add seven hours to the local time.

`systemd-timedated` reads /etc/adjtime, and depending on the contents of the file, it sets the clock to either UTC or local time.
Create the `/etc/adjtime` file with the following contents if your hardware clock is set to local time:

```
cat > /etc/adjtime << "EOF"
0.0 0 0.0
0
LOCAL
EOF
```

If `/etc/adjtime` isn't present at first boot, `systemd-timedated` will assume that hardware clock is set to UTC and adjust the file according to that.

You can also use the `timedatectl` utility to tell `systemd-timedated` if your hardware clock is set to UTC or local time:

```
timedatectl set-local-rtc 1
```

`timedatectl` can also be used to change system time and time zone.

To change your current system time, issue:

```
timedatectl set-time YYYY-MM-DD HH:MM:SS
```

Hardware clock will also be updated accordingly.

To change your current time zone, issue:

```
timedatectl set-timezone TIMEZONE
```

You can get list of available time zones by running:

```
timedatectl list-timezones
```

**Note**

Please note that `timedatectl` command can be used only on a system booted with systemd.

### 7.5.1. Network Time Synchronization

Starting with version 213, systemd ships a daemon called `systemd-timesyncd` which can be used to synchronize the system time with remote NTP servers.

The daemon is not intended as a replacement for the well established NTP daemon, but as a client only implementation of the SNTP protocol which can be used for less advanced tasks and on resource limited systems.

Starting with systemd version 216, the `systemd-timesyncd` daemon is enabled by default. If you want to disable it, issue the following command:

```
systemctl disable systemd-timesyncd
```

The `/etc/systemd/timesyncd.conf` file can be used to change the NTP servers that `systemd-timesyncd` synchronizes with.

Please note that when system clock is set to Local Time, `systemd-timesyncd` won't update hardware clock.
7.6. Configuring the Linux Console

This section discusses how to configure the `systemd-vconsole-setup` system service, which configures the virtual console font and console keymap.

The `systemd-vconsole-setup` service reads the `/etc/vconsole.conf` file for configuration information. Decide which keymap and screen font will be used. Various language-specific HOWTOs can also help with this, see [http://www.tldp.org/HOWTO/HOWTO-INDEX/other-lang.html](http://www.tldp.org/HOWTO/HOWTO-INDEX/other-lang.html). Examine `localectl list-keymaps` output for a list of valid console keymaps. Look in `/usr/share/consolefonts` directory for valid screen fonts.

The `/etc/vconsole.conf` file should contain lines of the form: `VARIABLE="value"`. The following variables are recognized:

- **KEYMAP**
  This variable specifies the key mapping table for the keyboard. If unset, it defaults to `us`.

- **KEYMAP_TOGGLE**
  This variable can be used to configure a second toggle keymap and is unset by default.

- **FONT**
  This variable specifies the font used by the virtual console.

- **FONT_MAP**
  This variable specifies the console map to be used.

- **FONT_UNIMAP**
  This variable specifies the Unicode font map.

An example for a German keyboard and console is given below:

```
cat > /etc/vconsole.conf << "EOF"
KEYMAP=de-latin1
FONT=Lat2-Terminus16
EOF
```

You can change KEYMAP value at runtime by using the `localectl` utility:

```
localectl set-keymap MAP
```

**Note**

Please note that `localectl` command can be used only on a system booted with systemd.

You can also use `localectl` utility with the corresponding parameters to change X11 keyboard layout, model, variant and options:

```
localectl set-x11-keymap LAYOUT [MODEL] [VARIANT] [OPTIONS]
```

To list possible values for `localectl set-x11-keymap` parameters, run `localectl` with parameters listed below:

- list-x11-keymap-models
  Show known X11 keyboard mapping models.
- list-x11-keymap-layouts
  Show known X11 keyboard mapping layouts.
list-x11-keymap-variants
  Show known X11 keyboard mapping variants.

list-x11-keymap-options
  Show known X11 keyboard mapping options.

Note
Using any of the parameters listed above requires XKeyboard Config package from BLFS.

7.7. Configuring the System Locale

The /etc/locale.conf below sets some environment variables necessary for native language support. Setting them properly results in:

- The output of programs translated into the native language
- Correct classification of characters into letters, digits and other classes. This is necessary for bash to properly accept non-ASCII characters in command lines in non-English locales
- The correct alphabetical sorting order for the country
- Appropriate default paper size
- Correct formatting of monetary, time, and date values

Replace <ll> below with the two-letter code for the desired language (e.g., “en”) and <CC> with the two-letter code for the appropriate country (e.g., “GB”). <charmap> should be replaced with the canonical charmap for your chosen locale. Optional modifiers such as “@euro” may also be present.

The list of all locales supported by Glibc can be obtained by running the following command:

```
locale -a
```

Charmaps can have a number of aliases, e.g., “ISO-8859-1” is also referred to as “iso8859-1” and “iso88591”. Some applications cannot handle the various synonyms correctly (e.g., require that “UTF-8” is written as “UTF-8”, not “utf8”), so it is safest in most cases to choose the canonical name for a particular locale. To determine the canonical name, run the following command, where <locale name> is the output given by locale -a for your preferred locale (“en_GB.iso88591” in our example).

```
LC_ALL=<locale name> locale charmap
```

For the “en_GB.iso88591” locale, the above command will print:

```
ISO-8859-1
```

This results in a final locale setting of “en_GB.ISO-8859-1”. It is important that the locale found using the heuristic above is tested prior to it being added to the Bash startup files:

```
LC_ALL=<locale name> locale language
LC_ALL=<locale name> locale charmap
LC_ALL=<locale name> locale int_curr_symbol
LC_ALL=<locale name> locale int_prefix
```
The above commands should print the language name, the character encoding used by the locale, the local currency, and the prefix to dial before the telephone number in order to get into the country. If any of the commands above fail with a message similar to the one shown below, this means that your locale was either not installed in Chapter 6 or is not supported by the default installation of Glibc.

```
locale: Cannot set LC_* to default locale: No such file or directory
```

If this happens, you should either install the desired locale using the `localedef` command, or consider choosing a different locale. Further instructions assume that there are no such error messages from Glibc.

Some packages beyond LFS may also lack support for your chosen locale. One example is the X library (part of the X Window System), which outputs the following error message if the locale does not exactly match one of the character map names in its internal files:

```
Warning: locale not supported by Xlib, locale set to C
```

In several cases Xlib expects that the character map will be listed in uppercase notation with canonical dashes. For instance, "ISO-8859-1" rather than "iso88591". It is also possible to find an appropriate specification by removing the charmap part of the locale specification. This can be checked by running the `locale charmap` command in both locales. For example, one would have to change "de_DE.ISO-8859-15@euro" to "de_DE@euro" in order to get this locale recognized by Xlib.

Other packages can also function incorrectly (but may not necessarily display any error messages) if the locale name does not meet their expectations. In those cases, investigating how other Linux distributions support your locale might provide some useful information.

Once the proper locale settings have been determined, create the `/etc/locale.conf` file:

```
cat > /etc/locale.conf << "EOF"
LANG=<ll>_<CC>_<charmap><@modifiers>
EOF
```

Note that you can modify `/etc/locale.conf` with systemd `localectl` utility. To use `localectl` for the example above, run:

```
localectl set-locale LANG="<ll>_<CC>_<charmap><@modifiers>"
```

You can also specify other language specific environment variables such as `LANG`, `LC_CTYPE`, `LC_NUMERIC` or any other environment variable from `locale` output. Just separate them with a space. An example where `LANG` is set as `en_US.UTF-8` but `LC_CTYPE` is set as just `en_US` is:

```
localectl set-locale LANG="en_US.UTF-8" LC_CTYPE="en_US"
```

**Note**

Please note that `localectl` command can be used only on a system booted with systemd.

The “C” (default) and “en_US” (the recommended one for United States English users) locales are different. “C” uses the US-ASCII 7-bit character set, and treats bytes with the high bit set as invalid characters. That's why, e.g., the `ls` command substitutes them with question marks in that locale. Also, an attempt to send mail with such characters from Mutt or Pine results in non-RFC-conforming messages being sent (the charset in the outgoing mail is indicated as “unknown 8-bit”). So you can use the “C” locale only if you are sure that you will never need 8-bit characters.
UTF-8 based locales are not supported well by many programs. Work is in progress to document and, if possible, fix such problems, see http://www.linuxfromscratch.org/blfs/view/systemd/introduction/locale-issues.html.

7.8. Creating the /etc/inputrc File

The inputrc file handles keyboard mapping for specific situations. This file is the startup file used by Readline — the input-related library — used by Bash and most other shells.

Most people do not need user-specific keyboard mappings so the command below creates a global /etc/inputrc used by everyone who logs in. If you later decide you need to override the defaults on a per-user basis, you can create a .inputrc file in the user's home directory with the modified mappings.

For more information on how to edit the inputrc file, see info bash under the Readline Init File section. info readline is also a good source of information.
Below is a generic global `inputrc` along with comments to explain what the various options do. Note that comments cannot be on the same line as commands. Create the file using the following command:

```
cat > /etc/inputrc << "EOF"
# Begin /etc/inputrc
# Modified by Chris Lynn <roryo@roryo.dynup.net>

# Allow the command prompt to wrap to the next line
set horizontal-scroll-mode Off

# Enable 8bit input
set meta-flag On
set input-meta On

# Turns off 8th bit stripping
set convert-meta Off

# Keep the 8th bit for display
set output-meta On

# none, visible or audible
set bell-style none

# All of the following map the escape sequence of the value
# contained in the 1st argument to the readline specific functions
"\eOd": backward-word
"\eOc": forward-word

# for linux console
"\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

# for xterm
"\eOH": beginning-of-line
"\eOF": end-of-line

# for Konsole
"\e[H": beginning-of-line
"\e[F": end-of-line

# End /etc/inputrc
EOF
```
7.9. Creating the /etc/shells File

The `shells` file contains a list of login shells on the system. Applications use this file to determine whether a shell is valid. For each shell a single line should be present, consisting of the shell's path, relative to the root of the directory structure (/).

For example, this file is consulted by `chsh` to determine whether an unprivileged user may change the login shell for her own account. If the command name is not listed, the user will be denied of change.

It is a requirement for applications such as GDM which does not populate the face browser if it can't find `/etc/shells`, or FTP daemons which traditionally disallow access to users with shells not included in this file.

```bash
cat > /etc/shells << "EOF"
# Begin /etc/shells
/bin/sh
/bin/bash
# End /etc/shells
EOF
```

7.10. Systemd Usage and Configuration

7.10.1. Basic Configuration

The `/etc/systemd/system.conf` file contains a set of options to control basic systemd operations. The default file has all entries commented out with the default settings indicated. This file is where the log level may be changed as well as some basic logging settings. See `systemd-system.conf(5)` manual page for details on each configuration option.

7.10.2. Disabling Screen Clearing at Boot Time

The normal behavior for systemd is to clear the screen at the end of the boot sequence. If desired, this behavior may be changed by running the following command:

```bash
mkdir -pv /etc/systemd/system/getty@tty1.service.d

cat > /etc/systemd/system/getty@tty1.service.d/noclear.conf << EOF
[Service]
TTYVTDisallocate=no
EOF
```

The boot messages can always be reviewed by using the `journalctl -b` command as the root user.

7.10.3. Disabling tmpfs for /tmp

By default, `/tmp` is created as a tmpfs. If this is not desired, it can be overridden by the following:

```bash
ln -sfv /dev/null /etc/systemd/system/tmp.mount
```

This is not necessary if there is a separate partition for `/tmp` specified in `/etc/fstab`. 

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7.10.4. Configuring Automatic File Creation and Deletion

There are several services that create or delete files or directories:

- systemd-tmpfiles-clean.service
- systemd-tmpfiles-setup-dev.service
- systemd-tmpfiles-setup.service

The system location for the configuration files is /usr/lib/tmpfiles.d/*.conf. The local configuration files are in /etc/tmpfiles.d. Files in /etc/tmpfiles.d override files with the same name in /usr/lib/tmpfiles.d. See tmpfiles.d(5) manual page for file format details.

7.10.5. Overriding Default Services Behavior

A systemd service contents can be overridden by creating a directory and a configuration file in /etc/systemd/system. For example:

```bash
mkdir -pv /etc/systemd/system/foobar.service.d

cat > /etc/systemd/system/foobar.service.d/foobar.conf << EOF
[Service]
Restart=always
RestartSec=30
EOF
```

See systemd.unit(5) manual page for more information. After creating the configuration file, run `systemctl daemon-reload` and `systemctl restart foobar` to activate the changes to a service.

7.10.6. Debugging the Boot Sequence

There are several commands that can be used to help debug the systemd boot process. Here are some examples:

- systemctl list-units -t service [--all]
- systemctl list-units -t target [--all]
- systemctl show -p Wants multi-user.target
- systemctl status sshd.service
Chapter 8. Making the LFS System Bootable

8.1. Introduction

It is time to make the LFS system bootable. This chapter discusses creating an *fstab* file, building a kernel for the new LFS system, and installing the GRUB boot loader so that the LFS system can be selected for booting at startup.

8.2. Creating the */etc/fstab* File

The */etc/fstab* file is used by some programs to determine where file systems are to be mounted by default, in which order, and which must be checked (for integrity errors) prior to mounting. Create a new file systems table like this:

```bash
cat > /etc/fstab << "EOF"
# Begin /etc/fstab
# file system  mount-point  type     options             dump  fsck
#                                                              order
/dev/<xxx> / defaults            1     1
/dev/<yyy> swap         swap     pri=1               0     0
# End /etc/fstab
EOF
```

Replace `<xxx>`, `<yyy>`, and `<fff>` with the values appropriate for the system, for example, `sda2`, `sda5`, and `ext4`. For details on the six fields in this file, see `man 5 fstab`.

Filesystems with MS-DOS or Windows origin (i.e.: vfat, ntfs, smbfs, cifs, iso9660, udf) need the “iocharset” mount option in order for non-ASCII characters in file names to be interpreted properly. The value of this option should be the same as the character set of your locale, adjusted in such a way that the kernel understands it. This works if the relevant character set definition (found under File systems -> Native Language Support) has been compiled into the kernel or built as a module. The “codepage” option is also needed for vfat and smbfs filesystems. It should be set to the codepage number used under MS-DOS in your country. E.g., in order to mount USB flash drives, a ru_RU.KOI8-R user would need the following in the options portion of its mount line in */etc/fstab*:

```bash
noauto,user,quiet,showexec,iocharset=koi8r,codepage=866
```

The corresponding options fragment for ru_RU.UTF-8 users is:

```bash
noauto,user,quiet,showexec,iocharset=utf8,codepage=866
```

**Note**

In the latter case, the kernel emits the following message:

```
FAT: utf8 is not a recommended IO charset for FAT filesystems, filesystem will be case sensitive!
```

This negative recommendation should be ignored, since all other values of the “iocharset” option result in wrong display of filenames in UTF-8 locales.
It is also possible to specify default codepage and iocharset values for some filesystems during kernel configuration. The relevant parameters are named “Default NLS Option” (CONFIG_NLS_DEFAULT), “Default Remote NLS Option” (CONFIG_SMB_NLS_DEFAULT), “Default codepage for FAT” (CONFIG_FAT_DEFAULT_CODEPAGE), and “Default iocharset for FAT” (CONFIG_FAT_DEFAULT_IOCHARSET). There is no way to specify these settings for the ntfs filesystem at kernel compilation time.

It is possible to make the ext3 filesystem reliable across power failures for some hard disk types. To do this, add the barrier=1 mount option to the appropriate entry in /etc/fstab. To check if the disk drive supports this option, run hdparm on the applicable disk drive. For example, if:

```
hdparm -I /dev/sda | grep NCQ
```

returns non-empty output, the option is supported.

Note: Logical Volume Management (LVM) based partitions cannot use the barrier option.
8.3. Linux-4.4.2

The Linux package contains the Linux kernel.

Approximate build time: 3.0 - 49.0 SBU (typically about 6 SBU)
Required disk space: 700 - 6800 MB (typically about 800-900 MB)

8.3.1. Installation of the kernel

Building the kernel involves a few steps—configuration, compilation, and installation. Read the README file in the kernel source tree for alternative methods to the way this book configures the kernel.

Prepare for compilation by running the following command:

```
make mrproper
```

This ensures that the kernel tree is absolutely clean. The kernel team recommends that this command be issued prior to each kernel compilation. Do not rely on the source tree being clean after un-tarring.

Configure the kernel via a menu-driven interface. For general information on kernel configuration see http://www.linuxfromscratch.org/hints/downloads/files/kernel-configuration.txt. BLFS has some information regarding particular kernel configuration requirements of packages outside of LFS at http://www.linuxfromscratch.org/blfs/view/systemd/longindex.html#kernel-config-index. Additional information about configuring and building the kernel can be found at http://www.kroah.com/lkn/
Note
A good starting place for setting up the kernel configuration is to run **make defconfig**. This will set the base configuration to a good state that takes your current system architecture into account.

Be sure to enable or disable following features or the system might not work correctly or boot at all:

<table>
<thead>
<tr>
<th>General setup</th>
<th>----&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>[*] open by fhandle syscalls [CONFIG_FHANDLE]</td>
<td></td>
</tr>
<tr>
<td>[ ] Auditing support [CONFIG_AUDIT]</td>
<td></td>
</tr>
<tr>
<td>[*] Control Group support [CONFIG_CGROUPS]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Processor type and features</th>
<th>----&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>[*] Enable seccomp to safely compute untrusted bytecode [CONFIG_SECCOMP]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Networking support</th>
<th>----&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ ] The IPv6 protocol [CONFIG_IPV6]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Device Drivers</th>
<th>----&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>[*] Support for uevent helper [CONFIG_UEVENT_HELPER]</td>
<td></td>
</tr>
<tr>
<td>[ ] Maintain a devtmpfs filesystem to mount at /dev [CONFIG_DEVTMPFS]</td>
<td></td>
</tr>
<tr>
<td>[ ] Fallback user-helper invocation for firmware loading [CONFIG_FW_LOADER_USER_HELPER]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Firmware Drivers</th>
<th>----&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>[*] Export DMI identification via sysfs to userspace [CONFIG_DMIID]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>File systems</th>
<th>----&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>[*] Inotify support for userspace [CONFIG_INOTIFY_USER]</td>
<td></td>
</tr>
<tr>
<td>[ ] Kernel automounter version 4 support (also supports v3) [CONFIG_AUTOFS]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pseudo filesystems</th>
<th>----&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>[*] Tmpfs POSIX Access Control Lists [CONFIG_TMPFS_POSIX_ACL]</td>
<td></td>
</tr>
<tr>
<td>[*] Tmpfs extended attributes [CONFIG_TMPFS_XATTR]</td>
<td></td>
</tr>
</tbody>
</table>

Note
While "The IPv6 Protocol" is not strictly required, it is highly recommended by the systemd developers.

The rationale for the above configuration items:

**Support for uevent helper**
Having this option set may interfere with device management when using Udev/Eudev.

**Maintain a devtmpfs**
This will create automated device nodes which are populated by the kernel, even without Udev running. Udev then runs on top of this, managing permissions and adding symlinks. This configuration item is required for all users of Udev/Eudev.

```
make LANG=<host_LANG_value> LC_ALL= menuconfig
```

The meaning of the make parameters:

```
LANG=<host_LANG_value> LC_ALL=
```
This establishes the locale setting to the one used on the host. This is needed for a proper menuconfig ncurses interface line drawing on UTF-8 linux text console.
Be sure to replace `<host_LANG_value>` by the value of the `$LANG` variable from your host. If not set, you could use instead the host's value of `$LC_ALL` or `$LC_CTYPE`.

Alternatively, `make oldconfig` may be more appropriate in some situations. See the README file for more information.

If desired, skip kernel configuration by copying the kernel config file, `.config`, from the host system (assuming it is available) to the unpacked `linux-4.4.2` directory. However, we do not recommend this option. It is often better to explore all the configuration menus and create the kernel configuration from scratch.

Compile the kernel image and modules:

```
make
```

If using kernel modules, module configuration in `/etc/modprobe.d` may be required. Information pertaining to modules and kernel configuration is located in Section 7.3, “Device and Module Handling on an LFS System” and in the kernel documentation in the `linux-4.4.2/Documentation` directory. Also, `modprobe.d(5)` may be of interest.

Install the modules, if the kernel configuration uses them:

```
make modules_install
```

After kernel compilation is complete, additional steps are required to complete the installation. Some files need to be copied to the `/boot` directory.

The path to the kernel image may vary depending on the platform being used. The filename below can be changed to suit your taste, but the stem of the filename should be `vmlinuz` to be compatible with the automatic setup of the boot process described in the next section. The following command assumes an x86 architecture:

```
cp -v arch/x86/boot/bzImage /boot/vmlinuz-4.4.2-lfs-20160304-systemd
```

`System.map` is a symbol file for the kernel. It maps the function entry points of every function in the kernel API, as well as the addresses of the kernel data structures for the running kernel. It is used as a resource when investigating kernel problems. Issue the following command to install the map file:

```
cp -v System.map /boot/System.map-4.4.2
```

The kernel configuration file `.config` produced by the `make menuconfig` step above contains all the configuration selections for the kernel that was just compiled. It is a good idea to keep this file for future reference:

```
cp -v .config /boot/config-4.4.2
```

Install the documentation for the Linux kernel:

```
install -d /usr/share/doc/linux-4.4.2
cp -r Documentation/* /usr/share/doc/linux-4.4.2
```

It is important to note that the files in the kernel source directory are not owned by `root`. Whenever a package is unpacked as user `root` (like we did inside `chroot`), the files have the user and group IDs of whatever they were on the packager’s computer. This is usually not a problem for any other package to be installed because the source tree is removed after the installation. However, the Linux source tree is often retained for a long time. Because of this, there is a chance that whatever user ID the packager used will be assigned to somebody on the machine. That person would then have write access to the kernel source.
Note

In many cases, the configuration of the kernel will need to be updated for packages that will be installed later in BLFS. Unlike other packages, it is not necessary to remove the kernel source tree after the newly built kernel is installed.

If the kernel source tree is going to be retained, run `chown -R 0:0` on the `linux-4.4.2` directory to ensure all files are owned by user `root`.

Warning

Some kernel documentation recommends creating a symlink from `/usr/src/linux` pointing to the kernel source directory. This is specific to kernels prior to the 2.6 series and must not be created on an LFS system as it can cause problems for packages you may wish to build once your base LFS system is complete.

Warning

The headers in the system's include directory (`/usr/include`) should always be the ones against which Glibc was compiled, that is, the sanitised headers installed in Section 6.7, “Linux-4.4.2 API Headers”. Therefore, they should never be replaced by either the raw kernel headers or any other kernel sanitized headers.

8.3.2. Configuring Linux Module Load Order

Most of the time Linux modules are loaded automatically, but sometimes it needs some specific direction. The program that loads modules, `modprobe` or `insmod`, uses `/etc/modprobe.d/usb.conf` for this purpose. This file needs to be created so that if the USB drivers (ehci_hcd, ohci_hcd and uhci_hcd) have been built as modules, they will be loaded in the correct order; ehci_hcd needs to be loaded prior to ohci_hcd and uhci_hcd in order to avoid a warning being output at boot time.

Create a new file `/etc/modprobe.d/usb.conf` by running the following:

```
install -v -m755 -d /etc/modprobe.d
cat > /etc/modprobe.d/usb.conf << "EOF"
# Begin /etc/modprobe.d/usb.conf
install ohci_hcd /sbin/modprobe ehci_hcd ; /sbin/modprobe -i ohci_hcd ; true
install uhci_hcd /sbin/modprobe ehci_hcd ; /sbin/modprobe -i uhci_hcd ; true
# End /etc/modprobe.d/usb.conf
EOF
```

8.3.3. Contents of Linux

Installed files:
- `config-4.4.2`
- `vmlinuz-4.4.2-lfs-20160304-systemd`
- `System.map-4.4.2`

Installed directories:
- `/lib/modules`
- `/usr/share/doc/linux-4.4.2`

Short Descriptions

`config-4.4.2` Contains all the configuration selections for the kernel
vmlinuz-4.4.2-lfs-20160304-systemd

The engine of the Linux system. When turning on the computer, the kernel is the first part of the operating system that gets loaded. It detects and initializes all components of the computer’s hardware, then makes these components available as a tree of files to the software and turns a single CPU into a multitasking machine capable of running scores of programs seemingly at the same time.

System.map-4.4.2

A list of addresses and symbols; it maps the entry points and addresses of all the functions and data structures in the kernel.
8.4. Using GRUB to Set Up the Boot Process

8.4.1. Introduction

Warning

Configuring GRUB incorrectly can render your system inoperable without an alternate boot device such as a CD-ROM. This section is not required to boot your LFS system. You may just want to modify your current boot loader, e.g. Grub-Legacy, GRUB2, or LILO.

Ensure that an emergency boot disk is ready to “rescue” the computer if the computer becomes unusable (un-bootable). If you do not already have a boot device, you can create one. In order for the procedure below to work, you need to jump ahead to BLFS and install xorriso from the libisoburn package.

```
cd /tmp
grub-mkrescue --output=grub-img.iso
xorriso -as cdrecord -v dev=/dev/cdrw blank=as_needed grub-img.iso
```

8.4.2. GRUB Naming Conventions

GRUB uses its own naming structure for drives and partitions in the form of (hdn,m), where n is the hard drive number and m is the partition number. The hard drive number starts from zero, but the partition number starts from one for normal partitions and five for extended partitions. Note that this is different from earlier versions where both numbers started from zero. For example, partition sda1 is (hd0,1) to GRUB and sdb3 is (hd1,3). In contrast to Linux, GRUB does not consider CD-ROM drives to be hard drives. For example, if using a CD on hdb and a second hard drive on hdc, that second hard drive would still be (hd1).

8.4.3. Setting Up the Configuration

GRUB works by writing data to the first physical track of the hard disk. This area is not part of any file system. The programs there access GRUB modules in the boot partition. The default location is /boot/grub/.

The location of the boot partition is a choice of the user that affects the configuration. One recommendation is to have a separate small (suggested size is 100 MB) partition just for boot information. That way each build, whether LFS or some commercial distro, can access the same boot files and access can be made from any booted system. If you choose to do this, you will need to mount the separate partition, move all files in the current /boot directory (e.g. the linux kernel you just built in the previous section) to the new partition. You will then need to unmount the partition and remount it as /boot. If you do this, be sure to update /etc/fstab.

Using the current lfs partition will also work, but configuration for multiple systems is more difficult.

Using the above information, determine the appropriate designator for the root partition (or boot partition, if a separate one is used). For the following example, it is assumed that the root (or separate boot) partition is sda2.

Install the GRUB files into /boot/grub and set up the boot track:

Warning

The following command will overwrite the current boot loader. Do not run the command if this is not desired, for example, if using a third party boot manager to manage the Master Boot Record (MBR).

```
grub-install /dev/sda
```
8.4.4. Creating the GRUB Configuration File

Generate `/boot/grub/grub.cfg`:

```bash
cat > /boot/grub/grub.cfg << "EOF"
# Begin /boot/grub/grub.cfg
set default=0
set timeout=5

insmod ext2
set root=(hd0,2)

menuentry "GNU/Linux, Linux 4.4.2-lfs-20160304-systemd" {
    linux   /boot/vmlinuz-4.4.2-lfs-20160304-systemd root=/dev/sda2 ro
}
EOF
```

**Note**

From GRUB's perspective, the kernel files are relative to the partition used. If you used a separate `/boot` partition, remove `/boot` from the above `linux` line. You will also need to change the `set root` line to point to the boot partition.

GRUB is an extremely powerful program and it provides a tremendous number of options for booting from a wide variety of devices, operating systems, and partition types. There are also many options for customization such as graphical splash screens, playing sounds, mouse input, etc. The details of these options are beyond the scope of this introduction.

**Caution**

There is a command, `grub-mkconfig`, that can write a configuration file automatically. It uses a set of scripts in `/etc/grub.d/` and will destroy any customizations that you make. These scripts are designed primarily for non-source distributions and are not recommended for LFS. If you install a commercial Linux distribution, there is a good chance that this program will be run. Be sure to back up your `grub.cfg` file.
Chapter 9. The End

9.1. The End

Well done! The new LFS system is installed! We wish you much success with your shiny new custom-built Linux system.

Create an `/etc/os-release` file required by systemd:

```bash
cat > /etc/os-release << "EOF"
NAME="Linux From Scratch"
VERSION="20160304-systemd"
ID=lfs
PRETTY_NAME="Linux From Scratch 20160304-systemd"
EOF
```

It is recommended to create `/etc/lfs-release` for compatibility with non systemd branch. By having this file, it is very easy for you (and for us if you need to ask for help at some point) to find out which LFS version is installed on the system. Create this file by running:

```bash
echo 20160304-systemd > /etc/lfs-release
```

It is also a good idea to create a file to show the status of your new system with respect to the Linux Standards Base (LSB). To create this file, run:

```bash
cat > /etc/lsb-release << "EOF"
DISTRIB_ID="Linux From Scratch"
DISTRIB_RELEASE="20160304-systemd"
DISTRIB_CODENAME="<your name here>"
DISTRIB_DESCRIPTION="Linux From Scratch"
EOF
```

Be sure to put some sort of customization for the field 'DISTRIB_CODENAME' to make the system uniquely yours.

9.2. Get Counted

Now that you have finished the book, do you want to be counted as an LFS user? Head over to `http://www.linuxfromscratch.org/cgi-bin/lfscounter.php` and register as an LFS user by entering your name and the first LFS version you have used.

Let's reboot into LFS now.

9.3. Rebooting the System

Now that all of the software has been installed, it is time to reboot your computer. However, you should be aware of a few things. The system you have created in this book is quite minimal, and most likely will not have the functionality you would need to be able to continue forward. By installing a few extra packages from the BLFS book while still in our current chroot environment, you can leave yourself in a much better position to continue on once you reboot into your new LFS installation. Here are some suggestions:
• A text mode browser such as Lynx will allow you to easily view the BLFS book in one virtual terminal, while building packages in another.

• The GPM package will allow you to perform copy/paste actions in your virtual terminals.

• If you are in a situation where static IP configuration does not meet your networking requirements, installing a package such as dhcepcl or the client portion of dhcp may be useful.

• Installing sudo may be useful for building packages as a non-root user and easily installing the resulting packages in your new system.

• If you want to access your new system from a remote system within a comfortable GUI environment, install openssh and its prerequisite, openssl.

• To make fetching files over the internet easier, install wget.

• If one or more of your disk drives have a GUID partition table (GPT), either gptfdisk or parted will be useful.

• Finally, a review of the following configuration files is also appropriate at this point.
  
  • /etc/bashrc
  • /etc/dircolors
  • /etc/fstab
  • /etc/hosts
  • /etc/inputrc
  • /etc/profile
  • /etc/resolv.conf
  • /etc/vimrc
  • /root/.bash_profile
  • /root/.bashrc

Now that we have said that, let's move on to booting our shiny new LFS installation for the first time! First exit from the chroot environment:

```
logout
```

Then unmount the virtual file systems:

```
umount -v $LFS/dev/pts
umount -v $LFS/dev
umount -v $LFS/run
umount -v $LFS/proc
umount -v $LFS/sys
```

Unmount the LFS file system itself:

```
umount -v $LFS
```

If multiple partitions were created, unmount the other partitions before unmounting the main one, like this:

```
umount -v $LFS/usr
umount -v $LFS/home
umount -v $LFS
```
Now, reboot the system with:

```
shutdown -r now
```

Assuming the GRUB boot loader was set up as outlined earlier, the menu is set to boot `LFS 20160304-systemd` automatically.

When the reboot is complete, the LFS system is ready for use and more software may be added to suit your needs.

### 9.4. What Now?

Thank you for reading this LFS book. We hope that you have found this book helpful and have learned more about the system creation process.

Now that the LFS system is installed, you may be wondering “What next?” To answer that question, we have compiled a list of resources for you.

- **Maintenance**

  Bugs and security notices are reported regularly for all software. Since an LFS system is compiled from source, it is up to you to keep abreast of such reports. There are several online resources that track such reports, some of which are shown below:

  - **CERT (Computer Emergency Response Team)**
    
    CERT has a mailing list that publishes security alerts concerning various operating systems and applications. Subscription information is available at [http://www.us-cert.gov/cas/signup.html](http://www.us-cert.gov/cas/signup.html).

  - **Bugtraq**
    
    Bugtraq is a full-disclosure computer security mailing list. It publishes newly discovered security issues, and occasionally potential fixes for them. Subscription information is available at [http://www.securityfocus.com/archive](http://www.securityfocus.com/archive).

- **Beyond Linux From Scratch**

  The Beyond Linux From Scratch book covers installation procedures for a wide range of software beyond the scope of the LFS Book. The BLFS project is located at [http://www.linuxfromscratch.org/blfs/](http://www.linuxfromscratch.org/blfs/).

- **LFS Hints**

  The LFS Hints are a collection of educational documents submitted by volunteers in the LFS community. The hints are available at [http://www.linuxfromscratch.org/hints/list.html](http://www.linuxfromscratch.org/hints/list.html).

- **Mailing lists**

  There are several LFS mailing lists you may subscribe to if you are in need of help, want to stay current with the latest developments, want to contribute to the project, and more. See Chapter 1 - Mailing Lists for more information.

- **The Linux Documentation Project**

  The goal of The Linux Documentation Project (TLDP) is to collaborate on all of the issues of Linux documentation. The TLDP features a large collection of HOWTOs, guides, and man pages. It is located at [http://www.tldp.org/](http://www.tldp.org/).
Part IV. Appendices
## Appendix A. Acronyms and Terms

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<td>Application Binary Interface</td>
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<td>ALFS</td>
<td>Automated Linux From Scratch</td>
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<td>API</td>
<td>Application Programming Interface</td>
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<td>ASCII</td>
<td>American Standard Code for Information Interchange</td>
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<td>BIOS</td>
<td>Basic Input/Output System</td>
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<td>BSD</td>
<td>Berkeley Software Distribution</td>
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<td>chroot</td>
<td>change root</td>
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<td>CMOS</td>
<td>Complementary Metal Oxide Semiconductor</td>
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<td>COS</td>
<td>Class Of Service</td>
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<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
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<td>CRC</td>
<td>Cyclic Redundancy Check</td>
</tr>
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<td>CSV</td>
<td>Concurrent Versions System</td>
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<td>DHCP</td>
<td>Dynamic Host Configuration Protocol</td>
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<td>DNS</td>
<td>Domain Name Service</td>
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<td>EGA</td>
<td>Enhanced Graphics Adapter</td>
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<td>ELF</td>
<td>Executable and Linkable Format</td>
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<td>EOF</td>
<td>End of File</td>
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<td>EQN</td>
<td>equation</td>
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<tr>
<td>ext2</td>
<td>second extended file system</td>
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<td>ext3</td>
<td>third extended file system</td>
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<tr>
<td>ext4</td>
<td>fourth extended file system</td>
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<tr>
<td>FAQ</td>
<td>Frequently Asked Questions</td>
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<td>FHS</td>
<td>Filesystem Hierarchy Standard</td>
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<tr>
<td>FIFO</td>
<td>First-In, First Out</td>
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<tr>
<td>FQDN</td>
<td>Fully Qualified Domain Name</td>
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<td>FTP</td>
<td>File Transfer Protocol</td>
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<td>GB</td>
<td>Gigabytes</td>
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<td>GCC</td>
<td>GNU Compiler Collection</td>
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<td>GID</td>
<td>Group Identifier</td>
</tr>
<tr>
<td>GMT</td>
<td>Greenwich Mean Time</td>
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<tr>
<td>HTML</td>
<td>Hypertext Markup Language</td>
</tr>
<tr>
<td>IDE</td>
<td>Integrated Drive Electronics</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronic Engineers</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
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</tr>
<tr>
<td>IO</td>
<td>Input/Output</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>IPC</td>
<td>Inter-Process Communication</td>
</tr>
<tr>
<td>IRC</td>
<td>Internet Relay Chat</td>
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<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
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<tr>
<td>ISP</td>
<td>Internet Service Provider</td>
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<tr>
<td>KB</td>
<td>Kilobytes</td>
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<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
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<td>LFS</td>
<td>Linux From Scratch</td>
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<td>LSB</td>
<td>Linux Standard Base</td>
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<tr>
<td>MB</td>
<td>Megabytes</td>
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<tr>
<td>MBR</td>
<td>Master Boot Record</td>
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<tr>
<td>MD5</td>
<td>Message Digest 5</td>
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<tr>
<td>NIC</td>
<td>Network Interface Card</td>
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<tr>
<td>NLS</td>
<td>Native Language Support</td>
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<tr>
<td>NNTP</td>
<td>Network News Transport Protocol</td>
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<tr>
<td>NPTL</td>
<td>Native POSIX Threading Library</td>
</tr>
<tr>
<td>OSS</td>
<td>Open Sound System</td>
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<tr>
<td>PCH</td>
<td>Pre-Compiled Headers</td>
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<tr>
<td>PCRE</td>
<td>Perl Compatible Regular Expression</td>
</tr>
<tr>
<td>PID</td>
<td>Process Identifier</td>
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<tr>
<td>PTY</td>
<td>pseudo terminal</td>
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<tr>
<td>QOS</td>
<td>Quality Of Service</td>
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<tr>
<td>RAM</td>
<td>Random Access Memory</td>
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<tr>
<td>RPC</td>
<td>Remote Procedure Call</td>
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<td>RTC</td>
<td>Real Time Clock</td>
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<tr>
<td>SBU</td>
<td>Standard Build Unit</td>
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<td>SCO</td>
<td>The Santa Cruz Operation</td>
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<td>SHA1</td>
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<td>TLDP</td>
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<td>TFTP</td>
<td>Trivial File Transfer Protocol</td>
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<td>TLS</td>
<td>Thread-Local Storage</td>
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<td>UID</td>
<td>User Identifier</td>
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<tr>
<td>umask</td>
<td>user file-creation mask</td>
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<tr>
<td>USB</td>
<td>Universal Serial Bus</td>
</tr>
<tr>
<td>UTC</td>
<td>Coordinated Universal Time</td>
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<tr>
<td>UUID</td>
<td>Universally Unique Identifier</td>
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<tr>
<td>VC</td>
<td>Virtual Console</td>
</tr>
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<td>VGA</td>
<td>Video Graphics Array</td>
</tr>
<tr>
<td>VT</td>
<td>Virtual Terminal</td>
</tr>
</tbody>
</table>
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We would like to thank the following people and organizations for their contributions to the Linux From Scratch Project.

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Appendix C. Dependencies

Every package built in LFS relies on one or more other packages in order to build and install properly. Some packages even participate in circular dependencies, that is, the first package depends on the second which in turn depends on the first. Because of these dependencies, the order in which packages are built in LFS is very important. The purpose of this page is to document the dependencies of each package built in LFS.

For each package we build, we have listed three, and sometimes four, types of dependencies. The first lists what other packages need to be available in order to compile and install the package in question. The second lists what packages, in addition to those on the first list, need to be available in order to run the test suites. The third list of dependencies are packages that require this package to be built and installed in its final location before they are built and installed. In most cases, this is because these packages will hard code paths to binaries within their scripts. If not built in a certain order, this could result in paths of /tools/bin/[binary] being placed inside scripts installed to the final system. This is obviously not desirable.

The last list of dependencies are optional packages that are not addressed in LFS, but could be useful to the user. These packages may have additional mandatory or optional dependencies of their own. For these dependencies, the recommended practice is to install them after completion of the LFS book and then go back and rebuild the LFS package. In several cases, re-installation is addressed in BLFS.

**acl**

- **Installation depends on:** Attr, Bash, Binutils, Coreutils, GCC, Gettext, Grep, M4, Make, Perl, Sed, and Texinfo
- **Test suite depends on:** Automake, Diffutils, Findutils, and Libtool
- **Must be installed before:** Coreutils, Sed, Systemd, Tar, Vim
- **Optional dependencies:** None

**attr**

- **Installation depends on:** Bash, Binutils, Coreutils, GCC, Gettext, Grep, M4, Make, Perl, Sed, and Texinfo
- **Test suite depends on:** Automake, Diffutils, Findutils, and Libtool
- **Must be installed before:** Acl, Libcap, Systemd
- **Optional dependencies:** None

**Autoconf**

- **Installation depends on:** Bash, Coreutils, Grep, M4, Make, Perl, Sed, and Texinfo
- **Test suite depends on:** Automake, Diffutils, Findutils, GCC, and Libtool
- **Must be installed before:** Automake
- **Optional dependencies:** Emacs

**Automake**

- **Installation depends on:** Autoconf, Bash, Coreutils, Gettext, Grep, M4, Make, Perl, Sed, and Texinfo
- **Test suite depends on:** Binutils, Bison, Bzip2, DejaGNU, Diffutils, Expect, Findutils, Flex, GCC, Gettext, Gzip, Libtool, and Tar.
- **Must be installed before:** None
- **Optional dependencies:** None
<table>
<thead>
<tr>
<th>Package</th>
<th>Installation depends on</th>
<th>Test suite depends on</th>
<th>Must be installed before</th>
<th>Optional dependencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bash</td>
<td>Bash, Binutils, Bison, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, Make, Ncurses, Patch, Readline, Sed, and Texinfo</td>
<td>Shadow</td>
<td>None</td>
<td>Xorg</td>
</tr>
<tr>
<td>Bc</td>
<td>Bash, Binutils, Bison, Coreutils, GCC, Glibc, Grep, Make, and Readline</td>
<td>Gawk</td>
<td>Linux Kernel</td>
<td>None</td>
</tr>
<tr>
<td>Binutils</td>
<td>Bash, Binutils, Coreutils, Diffutils, File, Gawk, GCC, Glibc, Grep, Make, Perl, Sed, Texinfo and Zlib</td>
<td>DejaGNU and Expect</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Bison</td>
<td>Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, M4, Make, Perl, and Sed</td>
<td>Diffutils, Findutils, and Flex</td>
<td>Kbd and Tar</td>
<td>Doxygen (test suite)</td>
</tr>
<tr>
<td>Bzip2</td>
<td>Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, Make, and Patch</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Check</td>
<td>GCC, Grep, Make, Sed, and Texinfo</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Coreutils</td>
<td>Bash, Binutils, Coreutils, GCC, Gettext, Glibc, GMP, Grep, Make, Patch, Perl, Sed, and Texinfo</td>
<td>Diffutils, E2fsprogs, Findutils, Shadow, and Util-linux</td>
<td>Bash, Diffutils, Findutils, Man-DB, and Systemd</td>
<td>Perl Expect and IO:Tty modules (for test suite)</td>
</tr>
</tbody>
</table>
D-Bus
Installation depends on: Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, Make, Sed, and Util-linux
Test suite depends on: None
Must be installed before: None
Optional dependencies: Xorg Libs

DejaGNU
Installation depends on: Bash, Coreutils, Diffutils, GCC, Grep, Make, and Sed
Test suite depends on: None
Must be installed before: None
Optional dependencies: None

Diffutils
Installation depends on: Bash, Binutils, Coreutils, Gawk, GCC, Gettext, Glibc, Grep, Make, Sed, and Texinfo
Test suite depends on: Diffutils, Perl
Must be installed before: None
Optional dependencies: None

Expat
Installation depends on: Bash, Binutils, Coreutils, Gawk, GCC, Glibc, Grep, Gperf, Make, and Sed
Test suite depends on: None
Must be installed before: XML::Parser
Optional dependencies: None

Expect
Installation depends on: Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, Grep, Make, Patch, Sed, and Tcl
Test suite depends on: None
Must be installed before: None
Optional dependencies: None

E2fsprogs
Installation depends on: Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, Gzip, Make, Sed, Texinfo, and Util-linux
Test suite depends on: Procps-ng,Psmisc
Must be installed before: None
Optional dependencies: None

File
Installation depends on: Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, Make, Sed, and Zlib
Test suite depends on: None
Must be installed before: None
Optional dependencies: None
<table>
<thead>
<tr>
<th>Package</th>
<th>Installation depends on:</th>
<th>Test suite depends on:</th>
<th>Must be installed before:</th>
<th>Optional dependencies:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Findutils</strong></td>
<td>Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Sed, and Texinfo</td>
<td>DejaGNU, Diffutils, and Expect</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>Flex</strong></td>
<td>Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, M4, Make, Patch, Sed, and Texinfo</td>
<td>Bison and Gawk</td>
<td>IPRoute2, Kbd, and Man-DB</td>
<td>None</td>
</tr>
<tr>
<td><strong>Gawk</strong></td>
<td>Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Patch, Sed and, Texinfo</td>
<td>Diffutils</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>Gcc</strong></td>
<td>Bash, Binutils, Coreutils, Diffutils, Findutils, Gawk, GCC, Gettext, Glibc, GMP, Grep, M4, Make, MPC, MPFR, Patch, Perl, Sed, Tar, and Texinfo</td>
<td>DejaGNU and Expect</td>
<td>None</td>
<td>CLooG-PPL, GNAT and PPL</td>
</tr>
<tr>
<td><strong>GDBM</strong></td>
<td>Bash, Binutils, Coreutils, Diffutils, GCC, Grep, Make, and Sed</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>Gettext</strong></td>
<td>Bash, Binutils, Coreutils, Gawk, GCC, Glibc, Grep, Make, Sed, and Texinfo</td>
<td>Diffutils, Perl, and Tcl</td>
<td>Automake</td>
<td>None</td>
</tr>
<tr>
<td><strong>Glibc</strong></td>
<td>Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Gettext, Grep, Gzip, Linux API Headers, Make, Perl, Sed, and Texinfo</td>
<td>File</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
GMP

Installation depends on: Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, M4, Make, Sed and Texinfo
Test suite depends on: None
Must be installed before: MPFR, GCC
Optional dependencies: None

Gperf

Installation depends on: Bash, Binutils, Coreutils, GCC, Glibc, Make
Test suite depends on: Diffutils, Expect
Must be installed before: None
Optional dependencies: None

Grep

Installation depends on: Bash, Binutils, Coreutils, Diffutils, GCC, Gettext, Glibc, Grep, Make, Patch, Sed, and Texinfo
Test suite depends on: Gawk
Must be installed before: Man-DB
Optional dependencies: Pcre

Groff

Installation depends on: Bash, Binutils, Bison, Coreutils, Gawk, GCC, Glibc, Grep, Make, Patch, Sed, and Texinfo
Test suite depends on: No test suite available
Must be installed before: Man-DB and Perl
Optional dependencies: GPL Ghostscript

GRUB

Installation depends on: Bash, Binutils, Bison, Coreutils, Diffutils, GCC, Gettext, Glibc, Grep, Make, Ncurses, Sed, Texinfo, and Xz
Test suite depends on: None
Must be installed before: None
Optional dependencies: None

Gzip

Installation depends on: Bash, Binutils, Coreutils, GCC, Glibc, Grep, Make, Sed, and Texinfo
Test suite depends on: Diffutils, Less
Must be installed before: Man-DB
Optional dependencies: None

Iana-Etc

Installation depends on: Coreutils, Gawk, and Make
Test suite depends on: No test suite available
Must be installed before: Perl
Optional dependencies: None
**Inetutils**

- **Installation depends on:** Bash, Binutils, Coreutils, GCC, Glibc, Grep, Make, Ncurses, Patch, Sed, Texinfo, and Zlib
- **Test suite depends on:** No test suite available
- **Must be installed before:** Tar
- **Optional dependencies:** None

**Intltool**

- **Installation depends on:** Bash, Gawk, Glibc, Make, Perl, Sed, and XML::Parser
- **Test suite depends on:** Perl
- **Must be installed before:** None
- **Optional dependencies:** None

**IProute2**

- **Installation depends on:** Bash, Bison, Coreutils, Flex, GCC, Glibc, Make, and Linux API Headers
- **Test suite depends on:** No test suite available
- **Must be installed before:** None
- **Optional dependencies:** None

**Kbd**

- **Installation depends on:** Bash, Binutils, Bison, Check, Coreutils, Flex, GCC, Gettext, Glibc, Gzip, Make, Patch, and Sed
- **Test suite depends on:** No test suite available
- **Must be installed before:** None
- **Optional dependencies:** None

**Kmod**

- **Installation depends on:** Bash, Binutils, Bison, Coreutils, Flex, GCC, Gettext, Glibc, Gzip, Make, Sed, Xz-Utils, Zlib
- **Test suite depends on:** No test suite available
- **Must be installed before:** Systemd
- **Optional dependencies:** None

**Less**

- **Installation depends on:** Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, Grep, Make, Ncurses, and Sed
- **Test suite depends on:** No test suite available
- **Must be installed before:** Gzip
- **Optional dependencies:** Pcre

**Libcap**

- **Installation depends on:** Attr, Bash, Binutils, Coreutils, GCC, Glibc, Perl, Make, and Sed
- **Test suite depends on:** No test suite available
- **Must be installed before:** Systemd
- **Optional dependencies:** Linux-PAM
Libpipeline
  Installation depends on: Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, Make, Sed, and Texinfo
  Test suite depends on: Check
  Must be installed before: Man-DB
  Optional dependencies: None

Libtool
  Installation depends on: Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, Make, Sed, and Texinfo
  Test suite depends on: Autoconf, Automake, Findutils
  Must be installed before: None
  Optional dependencies: None

Linux Kernel
  Installation depends on: Bash, Bc, Binutils, Coreutils, Diffutils, Findutils, GCC, Glibc, Grep, Gzip, Kmod, Make, Ncurses, Perl, and Sed
  Test suite depends on: No test suite available
  Must be installed before: OpenSSL
  Optional dependencies: None

M4
  Installation depends on: Bash, Binutils, Coreutils, GCC, Glibc, Grep, Make, Sed, and Texinfo
  Test suite depends on: Diffutils
  Must be installed before: Autoconf and Bison
  Optional dependencies: libsigsegv

Make
  Installation depends on: Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Sed, and Texinfo
  Test suite depends on: Perl and Procps-ng
  Must be installed before: None
  Optional dependencies: None

Man-DB
  Installation depends on: Bash, Binutils, Bzip2, Coreutils, Flex, GCC, GDBM, Gettext, Glibc, Grep, Groff, Gzip, Less, Libpipeline, Make, Sed, and Xz
  Test suite depends on: Util-linux
  Must be installed before: None
  Optional dependencies: None

Man-Pages
  Installation depends on: Bash, Coreutils, and Make
  Test suite depends on: No test suite available
  Must be installed before: None
  Optional dependencies: None
### MPC
- **Installation depends on:** Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, GMP, Make, MPFR, Sed and Texinfo
- **Test suite depends on:** None
- **Must be installed before:** GCC
- **Optional dependencies:** None

### MPFR
- **Installation depends on:** Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, GMP, Make, Sed and Texinfo
- **Test suite depends on:** None
- **Must be installed before:** GCC
- **Optional dependencies:** None

### Ncurses
- **Installation depends on:** Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, Make, Patch, and Sed
- **Test suite depends on:** No test suite available
- **Must be installed before:** Bash, GRUB, Inetutils, Less, Procps-ng, Psmisc, Readline, Texinfo, Util-linux, and Vim
- **Optional dependencies:** None

### Patch
- **Installation depends on:** Bash, Binutils, Coreutils, GCC, Glibc, Grep, Make, and Sed
- **Test suite depends on:** Diffutils
- **Must be installed before:** None
- **Optional dependencies:** Ed

### Perl
- **Installation depends on:** Bash, Binutils, Coreutils, Gawk, GCC, GDBM, Glibc, Grep, Groff, Make, Sed, and Zlib
- **Test suite depends on:** Iana-Etc and Procps-ng
- **Must be installed before:** Autoconf
- **Optional dependencies:** None

### Pkg-config
- **Installation depends on:** Bash, Binutils, Coreutils, Gawk, GCC, Glibc, Grep, Make, Popt, and Sed
- **Test suite depends on:** None
- **Must be installed before:** Kmod
- **Optional dependencies:** None

### Popt
- **Installation depends on:** Bash, Binutils, Coreutils, Gawk, GCC, Glibc, Grep, Make
- **Test suite depends on:** Diffutils and Sed
- **Must be installed before:** Pkg-config
- **Optional dependencies:** None
## Procps-ng

**Installation depends on:** Bash, Binutils, Coreutils, GCC, Glibc, Make, and Ncurses  
**Test suite depends on:** DejaGNU  
**Must be installed before:** None  
**Optional dependencies:** None

## Psmisc

**Installation depends on:** Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Ncurses, and Sed  
**Test suite depends on:** No test suite available  
**Must be installed before:** None  
**Optional dependencies:** None

## Readline

**Installation depends on:** Bash, Binutils, Coreutils, Gawk, GCC, Glibc, Grep, Make, Ncurses, Patch, Sed, and Texinfo  
**Test suite depends on:** No test suite available  
**Must be installed before:** Bash  
**Optional dependencies:** None

## Sed

**Installation depends on:** Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Sed, and Texinfo  
**Test suite depends on:** Diffutils and Gawk  
**Must be installed before:** E2fsprogs, File, Libtool, and Shadow  
**Optional dependencies:** None

## Shadow

**Installation depends on:** Bash, Binutils, Coreutils, Diffutils, Findutils, Gawk, GCC, Gettext, Glibc, Grep, Make, and Sed  
**Test suite depends on:** No test suite available  
**Must be installed before:** Coreutils  
**Optional dependencies:** Acl, Attr, Cracklib, PAM

## Systemd

**Installation depends on:** Acl, Attr, Bash, Binutils, Coreutils, Diffutils, Expat, Gawk, GCC, Gettext, Glibc, Gperf, Grep, Inteltool, Kmod, Libcap, Make, Sed, and Util-linux  
**Test suite depends on:** None  
**Must be installed before:** None  
**Optional dependencies:** None

## Tar

**Installation depends on:** Acl, Attr, Bash, Binutils, Bison, Coreutils, GCC, Gettext, Glibc, Grep, Inetutils, Make, Sed, and Texinfo  
**Test suite depends on:** Autoconf, Diffutils, Findutils, Gawk, and Gzip  
**Must be installed before:** None  
**Optional dependencies:** None
Tcl
Installation depends on: Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, Grep, Make, and Sed
Test suite depends on: None
Must be installed before: None
Optional dependencies: None

Texinfo
Installation depends on: Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Ncurses, Patch, and Sed
Test suite depends on: None
Must be installed before: None
Optional dependencies: None

Util-linux
Installation depends on: Bash, Binutils, Coreutils, Diffutils, Findutils, Gawk, GCC, Gettext, Glibc, Grep, Make, Ncurses, Sed, Systemd, and Zlib
Test suite depends on: None
Must be installed before: None
Optional dependencies: libcap-ng

Vim
Installation depends on: Acl, Attr, Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, Grep, Make, Ncurses, and Sed
Test suite depends on: None
Must be installed before: None
Optional dependencies: Xorg, GTK+2, LessTif, Python, Tcl, Ruby, and GPM

XML::Parser
Installation depends on: Bash, Binutils, Coreutils, Expat, GCC, Glibc, Make, and Perl
Test suite depends on: Perl
Must be installed before:Intltool
Optional dependencies: None

Xz
Installation depends on: Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, and Make.
Test suite depends on: None
Must be installed before: GRUB, Kmod, Man-DB, Systemd
Optional dependencies: None

Zlib
Installation depends on: Bash, Binutils, Coreutils, GCC, Glibc, Make, and Sed
Test suite depends on: None
Must be installed before: File, Kmod, Perl, and Util-linux
Optional dependencies: None
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