

Linux From Scratch

Version 7.10-systemd

Created by Gerard Beekmans
Managing Editor: Bruce Dubbs
Editor: Douglas R. Reno
Editor: DJ Lucas

Linux From Scratch: Version 7.10-systemd

by Created by Gerard Beekmans, Managing Editor: Bruce Dubbs, Editor: Douglas R. Reno, and Editor: DJ Lucas
Copyright © 1999-2016 Gerard Beekmans

Copyright © 1999-2016, Gerard Beekmans

All rights reserved.

This book is licensed under a Creative Commons License.

Computer instructions may be extracted from the book under the MIT License.

Linux® is a registered trademark of Linus Torvalds.

Table of Contents

Preface	vii
i. Foreword	vii
ii. Audience	vii
iii. LFS Target Architectures	viii
iv. LFS and Standards	ix
v. Rationale for Packages in the Book	x
vi. Prerequisites	xv
vii. Typography	xv
viii. Structure	xvi
ix. Errata	xvii
I. Introduction	1
1. Introduction	2
1.1. How to Build an LFS System	2
1.2. What's new since the last release	2
1.3. Changelog	4
1.4. Resources	7
1.5. Help	8
II. Preparing for the Build	10
2. Preparing the Host System	11
2.1. Introduction	11
2.2. Host System Requirements	11
2.3. Building LFS in Stages	15
2.4. Creating a New Partition	16
2.5. Creating a File System on the Partition	18
2.6. Setting The \$LFS Variable	18
2.7. Mounting the New Partition	19
3. Packages and Patches	20
3.1. Introduction	20
3.2. All Packages	20
3.3. Needed Patches	27
4. Final Preparations	29
4.1. Introduction	29
4.2. Creating the \$LFS/tools Directory	29
4.3. Adding the LFS User	29
4.4. Setting Up the Environment	30
4.5. About SBUs	31
4.6. About the Test Suites	32
5. Constructing a Temporary System	34
5.1. Introduction	34
5.2. Toolchain Technical Notes	34
5.3. General Compilation Instructions	36
5.4. Binutils-2.27 - Pass 1	37
5.5. GCC-6.2.0 - Pass 1	39
5.6. Linux-4.7.2 API Headers	42
5.7. Glibc-2.24	43

5.8. Libstdc++-6.2.0	46
5.9. Binutils-2.27 - Pass 2	48
5.10. GCC-6.2.0 - Pass 2	50
5.11. Tcl-core-8.6.6	53
5.12. Expect-5.45	55
5.13. DejaGNU-1.6	57
5.14. Check-0.10.0	58
5.15. Ncurses-6.0	59
5.16. Bash-4.3.30	60
5.17. Bzip2-1.0.6	61
5.18. Coreutils-8.25	62
5.19. Diffutils-3.5	63
5.20. File-5.28	64
5.21. Findutils-4.6.0	65
5.22. Gawk-4.1.3	66
5.23. Gettext-0.19.8.1	67
5.24. Grep-2.25	68
5.25. Gzip-1.8	69
5.26. M4-1.4.17	70
5.27. Make-4.2.1	71
5.28. Patch-2.7.5	72
5.29. Perl-5.24.0	73
5.30. Sed-4.2.2	74
5.31. Tar-1.29	75
5.32. Texinfo-6.1	76
5.33. Util-linux-2.28.1	77
5.34. Xz-5.2.2	78
5.35. Stripping	79
5.36. Changing Ownership	79
III. Building the LFS System	80
6. Installing Basic System Software	81
6.1. Introduction	81
6.2. Preparing Virtual Kernel File Systems	82
6.3. Package Management	83
6.4. Entering the Chroot Environment	86
6.5. Creating Directories	87
6.6. Creating Essential Files and Symlinks	88
6.7. Linux-4.7.2 API Headers	92
6.8. Man-pages-4.07	93
6.9. Glibc-2.24	94
6.10. Adjusting the Toolchain	101
6.11. Zlib-1.2.8	103
6.12. File-5.28	104
6.13. Binutils-2.27	105
6.14. GMP-6.1.1	107
6.15. MPFR-3.1.4	109
6.16. MPC-1.0.3	110

6.17. GCC-6.2.0	111
6.18. Bzip2-1.0.6	116
6.19. Pkg-config-0.29.1	118
6.20. Ncurses-6.0	119
6.21. Attr-2.4.47	122
6.22. Acl-2.2.52	123
6.23. Libcap-2.25	125
6.24. Sed-4.2.2	126
6.25. Shadow-4.2.1	127
6.26. Psmisc-22.21	131
6.27. Iana-Etc-2.30	132
6.28. M4-1.4.17	133
6.29. Bison-3.0.4	134
6.30. Flex-2.6.1	135
6.31. Grep-2.25	136
6.32. Readline-6.3	137
6.33. Bash-4.3.30	139
6.34. Bc-1.06.95	141
6.35. Libtool-2.4.6	142
6.36. GDBM-1.12	143
6.37. Gperf-3.0.4	144
6.38. Expat-2.2.0	145
6.39. Inetutils-1.9.4	146
6.40. Perl-5.24.0	148
6.41. XML::Parser-2.44	151
6.42. Intltool-0.51.0	152
6.43. Autoconf-2.69	153
6.44. Automake-1.15	155
6.45. Xz-5.2.2	156
6.46. Kmod-23	158
6.47. Gettext-0.19.8.1	160
6.48. Systemd-231	162
6.49. Procps-ng-3.3.12	167
6.50. E2fsprogs-1.43.1	169
6.51. Coreutils-8.25	172
6.52. Diffutils-3.5	177
6.53. Gawk-4.1.3	178
6.54. Findutils-4.6.0	179
6.55. Groff-1.22.3	180
6.56. GRUB-2.02~beta3	183
6.57. Less-481	185
6.58. Gzip-1.8	186
6.59. IPRoute2-4.7.0	188
6.60. Kbd-2.0.3	190
6.61. Libpipeline-1.4.1	192
6.62. Make-4.2.1	193
6.63. Patch-2.7.5	194

6.64. D-Bus-1.10.10	195
6.65. Util-linux-2.28.1	197
6.66. Man-DB-2.7.5	202
6.67. Tar-1.29	205
6.68. Texinfo-6.1	206
6.69. Vim-7.4	208
6.70. About Debugging Symbols	211
6.71. Stripping Again	211
6.72. Cleaning Up	212
7. System Configuration	213
7.1. Introduction	213
7.2. General Network Configuration	213
7.3. Overview of Device and Module Handling	216
7.4. Managing Devices	219
7.5. Configuring the system clock	220
7.6. Configuring the Linux Console	221
7.7. Configuring the System Locale	222
7.8. Creating the /etc/inputrc File	224
7.9. Creating the /etc/shells File	226
7.10. Systemd Usage and Configuration	226
8. Making the LFS System Bootable	229
8.1. Introduction	229
8.2. Creating the /etc/fstab File	229
8.3. Linux-4.7.2	231
8.4. Using GRUB to Set Up the Boot Process	236
9. The End	238
9.1. The End	238
9.2. Get Counted	238
9.3. Rebooting the System	238
9.4. What Now?	240
IV. Appendices	241
A. Acronyms and Terms	242
B. Acknowledgments	245
C. Dependencies	248
D. LFS Licenses	259
D.1. Creative Commons License	259
D.2. The MIT License	263
Index	264

Preface

Foreword

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
gerard@linuxfromscratch.org

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:

Architecture	Build Time	Build Size
32-bit	198.5 minutes	648 MB
64-bit	190.6 minutes	709 MB

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

<i>LSB Core:</i>	Bash, Bc, Binutils, Coreutils, Diffutils, File, Findutils, Gawk, Grep, GTK+2, Gzip, M4, Man-DB, Ncurses, Procps, Psmisc, Sed, Shadow, Tar, Util-linux, Zlib
<i>LSB Desktop:</i>	None
<i>LSB Runtime Languages:</i>	Perl
<i>LSB Imaging:</i>	None
<i>LSB Gtk3 and LSB Graphics (Trial Use):</i>	None

Packages supplied by BLFS needed to satisfy the LSB Requirements

<i>LSB Core:</i>	At, Batch (a part of At), Cpio, Ed, Fcfrontab, Initd-tools, Lsb_release, NSPR, NSS, PAM, Pax, Sendmail (or Postfix or Exim), time
<i>LSB Desktop:</i>	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
<i>LSB Runtime Languages:</i>	Python, Libxml2, Libxslt
<i>LSB Imaging:</i>	CUPS, Cups-filters, Ghostscript, SANE
<i>LSB Gtk3 and LSB Graphics (Trial Use):</i>	GTK+3

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

<i>LSB Core:</i>	None
<i>LSB Desktop:</i>	None

<i>LSB Runtime Languages:</i>	None
<i>LSB Imaging:</i>	None
<i>LSB Gtk3 and LSB Graphics (Trial Use):</i>	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 is a simple way for applications to talk to one another.

- 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 Eudev.

- 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 commercial distributions. In LFS it is installed side-by-side with Sysvinit to provide the user with alternative boot systems for comparison.

- 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:

- 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.

- Beginner's Guide to Installing from Source <http://moi.vonos.net/linux/beginners-installing-from-source/>

This guide provides a good summary of basic skills and techniques needed to build software from source code.

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.

<http://www.linuxfromscratch.org/>

This format is used for hyperlinks both within the LFS community and to external pages. It includes HOWTOs, download locations, and websites.

```
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/7.10/> 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 2.27
- DejaGNU 1.6
- D-Bus-1.10.10
- Diffutils 3.5
- E2fsprogs 1.43.1
- Expat-2.2.0
- File 5.28
- Flex 2.6.1
- GCC 6.2.0
- GDBM 1.12
- Gettext 0.19.8.1
- Glibc 2.24
- GMP 6.1.1
- Grep 2.25
- GRUB 2.02~beta3
- Gzip 1.8
- IPRoute2 4.7.0
- Kmod 23
- Linux 4.7.2
- Make 4.2.1
- Man-pages 4.07
- MPFR 3.1.4
- Perl 5.24.0
- Pkg-config 0.29.1
- Procps-ng 3.3.12
- Systemd 231
- Tar 1.29
- Tcl-core-8.6.6
- Tzdata 2016f
- Util-Linux 2.28.1

Added:

-

Removed:

-

- binutils-2.26-upstream_fix-2.patch
- mpfr-3.1.3-upstream_fixes-2.patch
- systemd-229-compat-1.patch

1.3. Changelog

This is version 7.10-systemd of the Linux From Scratch book, dated September 7, 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:

- 2016-09-07
 - [bdubbs] - Release LFS-7.10.
- 2016-08-22
 - [bdubbs] - Release LFS-7.10-rc1.
 - [bdubbs] - Update to linux-4.7.2. Fixes #3972.
 - [bdubbs] - Update to dbus-1.10.10. Fixes #3967.
- 2016-08-22
 - [bdubbs] - Update to diffutils-3.5. Fixes #3968.
 - [bdubbs] - Update to linux-4.7.1. Fixes #3969.
 - [bdubbs] - Update to gcc-6.2.0. Fixes #3970.
- 2016-08-12
 - [bdubbs] - Update to diffutils-3.4. Fixes #3964.
 - [bdubbs] - Update to iproute2-4.7.0. Fixes #3965.
 - [bdubbs] - Update to util-linux 2.28.1. Fixes #3966.
- 2016-08-11
 - [renodr] - Update to systemd-231. Fixes #3958.
- 2016-08-09
 - [dj] - Added explanatory text for systemd-230+ process lingering changes.
- 2016-08-06
 - [bdubbs] - Update to binutils-2.27. Fixes #3962.
- 2016-08-05
 - [bdubbs] - Update to grub-2.02~beta3. Fixes #3897.
 - [bdubbs] - Update to glibc-2.24. Fixes #3963.
- 2016-07-29
 - [bdubbs] - Update to linux-4.7. Fixes #3957.
 - [bdubbs] - Update to flex-2.6.1. Fixes #3959.

- [bdubbs] - Update to tcl-core8.6.6. Fixes #3960.
- 2016-07-20
 - [bdubbs] - Update to man-pages-4.07. Fixes #3956.
 - [bdubbs] - Update to kmod-23. Fixes #3955.
 - [renodr] - Update systemd kernel configuration page to disable CONFIG_SYSFS_DEPRECATED{, _V2}.
- 2016-07-19
 - [bdubbs] - Update to procps-ng-3.3.12. Fixes #3953.
 - [bdubbs] - Update to linux-4.6.4. Fixes #3954.
- 2016-07-10
 - [bdubbs] - Add discussion of Grub Bios Partition to Section 2.4 - Creating a New Partition.
 - [bdubbs] - Update to tzdata-2016f. Fixes #3952.
- 2016-07-02
 - [bdubbs] - Update to binutils-2.26.1. Fixes #3951.
 - [bdubbs] - Update to linux-4.6.3. Fixes #3950.
- 2016-06-22
 - [bdubbs] - Update to gmp-6.1.1. Fixes #3949.
 - [bdubbs] - Update to expat-2.2.0. Fixes #3948.
 - [bdubbs] - Update to tzdata-2016e. Fixes #3947.
 - [bdubbs] - Update to file-5.28. Fixes #3946.
 - [bdubbs] - Update to gettext-0.19.8.1. Fixes #3945.
- 2016-06-11
 - [bdubbs] - Update to make-4.2.1. Fixes #3944.
- 2016-06-10
 - [bdubbs] - Update to e2fsprogs-1.43.1. Fixes #3942.
 - [bdubbs] - Update to linux-4.6.2. Fixes #3940.
 - [bdubbs] - Update to gettext-0.19.8. Fixes #3943.
 - [bdubbs] - Add make-4.2-upstream_fixes-1.patch. Fixes #3941.
- 2016-05-27
 - [dj] - Update to dbus-1.10.8. Fixes #3938.
 - [bdubbs] - Update to e2fsprogs-1.43. Fixes #3935.
 - [bdubbs] - Update to gdbm-1.12. Fixes #3933.
 - [bdubbs] - Update to iproute2-4.6.0. Fixes #3934.
 - [bdubbs] - Update to make-4.2. Fixes #3936.
 - [dj] - Update to systemd-230. Fixes #3937.
- 2016-05-20
 - [dj] - Add additional explanatory text for systemctl and journalctl commands.

- 2016-05-19
 - [dj] - Adjust hosts file instructions to account for hosts using automatic configuration. Adjusted explanatory text to account for additional configurations.
- 2016-05-16
 - [bdubbs] - Enhance the stripping commands at the end of Chapter 6.
 - [bdubbs] - Made editorial changes to the kernel section.
 - [bdubbs] - Moved Host System Requirements to Chapter 2 and made minor editorial changes.
 - [bdubbs] - Updated to tar-1.29. Fixes #3932.
 - [bdubbs] - Updated to linux-4.6. Fixes #3930.
 - [bdubbs] - Updated to perl-5.24.0. Fixes #3931.
- 2016-05-15
 - [bdubbs] - Updated to file-5.27. Fixes #3929.
 - [bdubbs] - Updated to man-pages-4.06. Fixes #3928.
 - [bdubbs] - Updated to linux-4.5.4. Fixes #3927.
 - [bdubbs] - Updated to perl-5.22.2. Fixes #3926.
- 2016-05-03
 - [ken] - Note that configure in texinfo-6.1 incorrectly complains about the --disable-static switch.
- 2016-04-28
 - [krejzi] - Updated to file-5.26. Fixes #3919.
 - [krejzi] - Updated to gcc-6.1.0. Fixes #3924.
 - [krejzi] - Updated to grep-2.25. Fixes #3922.
 - [krejzi] - Updated to gzip-1.8. Fixes #3923.
 - [krejzi] - Updated to linux-4.5.2. Fixes #3921.
 - [krejzi] - Updated to tzdata-2016d. Fixes #3920.
 - [krejzi] - Updated binutils upstream fixes patch.
 - [krejzi] - Added a patch for glibc which addresses a security issue and a build failure with GCC 6.
- 2016-04-16
 - [bdubbs] - Update to dejagnu-1.6. Fixes #3918.
 - [bdubbs] - Update to linux-4.5.1. Fixes #3917.
 - [bdubbs] - Wording change in Chapter 6 GCC. Fixes #3915.
- 2016-04-12
 - [bdubbs] - Update to util-linux-2.28. Fixes #3906.
 - [bdubbs] - Simplify gzip instructions. Fixes #3914.
- 2016-04-07
 - [bdubbs] - Add a caution in the gmp section about possible "Illegal Instruction" errors if the host is misidentified or the libraries are copied to different systems.

- 2016-04-05
 - [bdubbs] - Remove obsolete note about iconv() in Chapter 6 Glibc. Minor adjustments to text in the same section. Fixes #3904.
 - [bdubbs] - Add a note about UEFI and Secure Boot to Chapter 8 "Using GRUB to Set Up the Boot Process". Fixes #3908.
 - [bdubbs] - Add notes about paths for 64-bit systems in Chapter 6 "Adjusting the Toolchain". Fixes #3912.
- 2016-04-04
 - [bdubbs] - Update to linux-4.5. Fixes #3903.
 - [bdubbs] - Update to grep-2.24. Fixes #3905.
 - [bdubbs] - Update to expat-2.1.1. Fixes #3907.
 - [bdubbs] - Update to tzdata-2016c. Fixes #3909.
 - [bdubbs] - Update to iproute2-4.5.0. Fixes #3910.
 - [bdubbs] - Update to man-pages-4.05. Fixes #3911.
 - [bdubbs] - Update to gzip-1.7. Fixes #3913.
- 2016-03-13
 - [Chris] - Updated dependencies - Gawk can use GMP, MPFR, Readline.
- 2016-03-09
 - [bdubbs] - Update to mpfr-3.1.4. Fixes #3902.
 - [bdubbs] - Update to linux-4.4.4. Fixes #3893.
 - [bdubbs] - Update to pkg-config-0.29.1. Fixes #3901.
 - [bdubbs] - Update to tcl-6.8.5. Fixes #3898.
 - [bdubbs] - Remove --disable-profile from Glibc instructions. Fixes #3895.
 - [bdubbs] - Create /var/log/faillog. Fixes #3899.
 - [bdubbs] - Remove --enable-obsolete-rpc from Chapter 5 glibc. Fixes #3900.
- 2016-03-08
 - [bdubbs] - LFS-7.9 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 7.10-systemd)
- The host distribution and version being used to create LFS
- The output from the 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**:

```
gcc -DALIAPATH=\"/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 the Host System

2.1. Introduction

In this chapter, the host tools needed for building LFS are checked and, if necessary, installed. Then a 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. 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 have not been tested.

- **Bash-3.2** (/bin/sh should be a symbolic or hard link to bash)
- **Binutils-2.17** (Versions greater than 2.27 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 6.2.0 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 2.24 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-1.22**
- **Texinfo-4.7**
- **Xz-5.0.0**



Important

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:

```

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

```

```
gcc --version | head -n1
g++ --version | head -n1
ldd --version | head -n1 | cut -d" " -f2- # glibc version
grep --version | head -n1
gzip --version | head -n1
cat /proc/version
m4 --version | head -n1
make --version | head -n1
patch --version | head -n1
echo Perl `perl -V:version`
sed --version | head -n1
tar --version | head -n1
makeinfo --version | head -n1
xz --version | head -n1
```

```

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
EOF
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.

2.3. Building LFS in Stages

LFS is designed to be built in one session. That is, the instructions assume that the system will not be shut down during the process. That does not mean that the system has to be done in one sitting. The issue is that certain procedures have to be re-accomplished after a reboot if resuming LFS at different points.

2.3.1. Chapters 1-4

These chapters are accomplished on the host system. When restarting, be careful of the following:

- Procedures done as the root user after Section 2.4 need to have the LFS environment variable set *FOR THE ROOT USER*.

2.3.2. Chapter 5

- The /mnt/lfs partition must be mounted.
- *ALL* instructions in Chapter 5 must be done by user *lfs*. A **su - lfs** needs to be done before any task in Chapter 5.
- The procedures in Section 5.3, “General Compilation Instructions” are critical. If there is any doubt about installing a package, ensure any previously expanded tarballs are removed, re-extract the package files, and complete all instructions in that section.

2.3.3. Chapters 6-8

- The /mnt/lfs partition must be mounted.

- When entering `chroot`, the `LFS` environment variable must be set for root. The `LFS` variable is not used otherwise.
- The virtual file systems must be mounted. This can be done before or after entering `chroot` by changing to a host virtual terminal and, as root, running the commands in Section 6.2.2, “Mounting and Populating `/dev`” and Section 6.2.3, “Mounting Virtual Kernel File Systems”.

2.4. 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 6 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 20 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 as well as for adding additional capabilities after LFS is complete. Additionally, 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 `cdisk` 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 `cdisk(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.

2.4.1. 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.

2.4.1.1. 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.

2.4.1.2. 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.

2.4.1.3. The Grub Bios Partition

If the *boot disk* has been partitioned with a GUID Partition Table (GPT), then a small, typically 1 MB, partition must be created if it does not already exist. This partition is not formatted, but must be available for GRUB to use during installation of the boot loader. This partition will normally be labeled 'BIOS Boot' if using **fdisk** or have a code of *EF02* if using **gdisk**.



Note

The Grub Bios partition must be on the drive that the BIOS uses to boot the system. This is not necessarily the same drive where the LFS root partition is located. Disks on a system may use different partition table types. The requirement for this partition depends only on the partition table type of the boot disk.

2.4.1.4. 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”.

2.5. 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.

2.6. 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.

2.7. 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:

```
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:

```
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:

```
/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://savannah.nongnu.org/projects/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/>

Download: <http://ftp.gnu.org/gnu/autoconf/autoconf-2.69.tar.xz>

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: 9a1ddb0e053474d9d1105cfe39b0c48d

- **Bash (4.3.30) - 7,7791 KB:**

Home page: <http://www.gnu.org/software/bash/>

Download: <http://ftp.gnu.org/gnu/bash/bash-4.3.30.tar.gz>

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 (2.27) - 25,488 KB:**

Home page: <http://www.gnu.org/software/binutils/>

Download: <http://ftp.gnu.org/gnu/binutils/binutils-2.27.tar.bz2>

MD5 sum: 2869c9bf3e60ee97c74ac2a6bf4e9d68

- **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: <https://libcheck.github.io/check>

Download: <http://sourceforge.net/projects/check/files/check/0.10.0/check-0.10.0.tar.gz>

MD5 sum: 53c5e5c77d090e103a17f3ed7fd7d8b8

- **Coreutils (8.25) - 5,591 KB:**

Home page: <http://www.gnu.org/software/coreutils/>

Download: <http://ftp.gnu.org/gnu/coreutils/coreutils-8.25.tar.xz>

MD5 sum: 070e43ba7f618d747414ef56ab248a48

- **D-Bus (1.10.10) - 1,938 KB:**

Home page: <http://www.freedesktop.org/wiki/Software/dbus>

Download: <http://dbus.freedesktop.org/releases/dbus/dbus-1.10.10.tar.gz>

MD5 sum: 495676d240eb982921b3ad1343526849

- **DejaGNU (1.6) - 512 KB:**

Home page: <http://www.gnu.org/software/dejagnu/>

Download: <http://ftp.gnu.org/gnu/dejagnu/dejagnu-1.6.tar.gz>

MD5 sum: 1fdc2eb0d592c4f89d82d24dfdf02f0b

- **Diffutils (3.5) - 1,330 KB:**

Home page: <http://www.gnu.org/software/diffutils/>

Download: <http://ftp.gnu.org/gnu/diffutils/diffutils-3.5.tar.xz>

MD5 sum: 569354697ff1cfc9a9de3781361015fa

- **E2fsprogs (1.43.1) - 6,846 KB:**

Home page: <http://e2fsprogs.sourceforge.net/>

Download: <http://downloads.sourceforge.net/project/e2fsprogs/e2fsprogs/v1.43.1/e2fsprogs-1.43.1.tar.gz>

MD5 sum: 1775f3f0eed9dee1c5f39e08d1964a97

- **Expat (2.2.0) - 405 KB:**

Home page: <http://expat.sourceforge.net/>

Download: <http://prdownloads.sourceforge.net/expat/expat-2.2.0.tar.bz2>

MD5 sum: 2f47841c829facb346eb6e3fab5212e2

- **Expect (5.45) - 614 KB:**

Home page: <http://expect.sourceforge.net/>

Download: <http://prdownloads.sourceforge.net/expect/expect5.45.tar.gz>

MD5 sum: 44e1a4f4c877e9ddc5a542dfa7ecc92b

- **File (5.28) - 760 KB:**

Home page: <http://www.darwinsys.com/file/>

Download: <ftp://ftp.astron.com/pub/file/file-5.28.tar.gz>

MD5 sum: 3f7771424aa855f32094b49571e19b33



Note

File (5.28) 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/>

Download: <http://ftp.gnu.org/gnu/findutils/findutils-4.6.0.tar.gz>

MD5 sum: 9936aa8009438ce185bea2694a997fc1

- **Flex (2.6.1) - 816 KB:**

Home page: <http://flex.sourceforge.net>

Download: <https://github.com/westes/flex/releases/download/v2.6.1/flex-2.6.1.tar.xz>

MD5 sum: cd3c86290fc2676a641aefafeb10848a

- **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 (6.2.0) - 97,441 KB:**

Home page: <http://gcc.gnu.org/>

Download: <http://ftp.gnu.org/gnu/gcc/gcc-6.2.0/gcc-6.2.0.tar.bz2>

MD5 sum: 9768625159663b300ae4de2f4745fcc4

• **GDBM (1.12) - 822 KB:**

Home page: <http://www.gnu.org/software/gdbm/>

Download: <http://ftp.gnu.org/gnu/gdbm/gdbm-1.12.tar.gz>

MD5 sum: 9ce96ff4c99e74295ea19040931c8fb9

• **Gettext (0.19.8.1) - 7,041 KB:**

Home page: <http://www.gnu.org/software/gettext/>

Download: <http://ftp.gnu.org/gnu/gettext/gettext-0.19.8.1.tar.xz>

MD5 sum: df3f5690eaa30fd228537b00cb7b7590

• **Glibc (2.24) - 13,237 KB:**

Home page: <http://www.gnu.org/software/libc/>

Download: <http://ftp.gnu.org/gnu/glibc/glibc-2.24.tar.xz>

MD5 sum: 97dc5517f92016f3d70d83e3162ad318

• **GMP (6.1.1) - 1,898 KB:**

Home page: <http://www.gnu.org/software/gmp/>

Download: <http://ftp.gnu.org/gnu/gmp/gmp-6.1.1.tar.xz>

MD5 sum: e70e183609244a332d80529e7e155a35

• **Gperf (3.0.4) - 960 KB:**

Home page: <http://www.gnu.org/software/gperf/>

Download: <http://ftp.gnu.org/gnu/gperf/gperf-3.0.4.tar.gz>

MD5 sum: c1f1db32fb6598d6a93e6e88796a8632

• **Grep (2.25) - 1,300 KB:**

Home page: <http://www.gnu.org/software/grep/>

Download: <http://ftp.gnu.org/gnu/grep/grep-2.25.tar.xz>

MD5 sum: 04e96b0e6f0fe6a180ae62c88fcd0af6

• **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~beta3) - 5,890 KB:**

Home page: <http://www.gnu.org/software/grub/>

Download: <http://alpha.gnu.org/gnu/grub/grub-2.02~beta3.tar.xz>

MD5 sum: ab399fc6f74a97d66ff77f04b743149c

• **Gzip (1.8) - 712 KB:**

Home page: <http://www.gnu.org/software/gzip/>

Download: <http://ftp.gnu.org/gnu/gzip/gzip-1.8.tar.xz>

MD5 sum: f7caabb65cddc1a4165b398009bd05b9

• **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: 3ba3afb1d1b261383d247f46cb135ee8

• **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: 87fef1fa3f603aef11c41dcc097af75e

- **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 (4.7.0) - 577 KB:**

Home page: <https://www.kernel.org/pub/linux/utils/net/iproute2/>

Download: <https://www.kernel.org/pub/linux/utils/net/iproute2/iproute2-4.7.0.tar.xz>

MD5 sum: d4b205830cdc2702f8a0cbd6232129cd

- **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 (23) - 440 KB:**

Download: <https://www.kernel.org/pub/linux/utils/kernel/kmod/kmod-23.tar.xz>

MD5 sum: 3cf469f40ec2ed51f56ba45ea03793e7

- **Less (481) - 310 KB:**

Home page: <http://www.greenwoodsoftware.com/less/>

Download: <http://www.greenwoodsoftware.com/less/less-481.tar.gz>

MD5 sum: 50ef46065c65257141a7340123527767

- **Libcap (2.25) - 64 KB:**

Home page: <https://sites.google.com/site/fullycapable/>

Download: <https://www.kernel.org/pub/linux/libs/security/linux-privs/libcap2/libcap-2.25.tar.xz>

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/>

Download: <http://ftp.gnu.org/gnu/libtool/libtool-2.4.6.tar.xz>

MD5 sum: 1bf9b9b923f2c1339b4d2ce1807064aa5

- **Linux (4.7.2) - 88,290 KB:**

Home page: <http://www.kernel.org/>

Download: <https://www.kernel.org/pub/linux/kernel/v4.x/linux-4.7.2.tar.xz>

MD5 sum: ae493473d074185205a54bc8ad49c3b4



Note

The Linux kernel is updated relatively often, many times due to discoveries of security vulnerabilities. The latest available 4.7.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 (4.2.1) - 1,375 KB:**

Home page: <http://www.gnu.org/software/make/>

Download: <http://ftp.gnu.org/gnu/make/make-4.2.1.tar.bz2>

MD5 sum: 15b012617e7c44c0ed482721629577ac

• **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 (4.07) - 1,445 KB:**

Home page: <http://www.kernel.org/doc/man-pages/>

Download: <https://www.kernel.org/pub/linux/docs/man-pages/man-pages-4.07.tar.xz>

MD5 sum: 6d6c59b83431852ba44930785def30d4

• **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 (3.1.4) - 1,096 KB:**

Home page: <http://www.mpfr.org/>

Download: <http://www.mpfr.org/mpfr-3.1.4/mpfr-3.1.4.tar.xz>

MD5 sum: 064b2c18185038e404a401b830d59be8

• **Ncurses (6.0) - 3,059 KB:**

Home page: <http://www.gnu.org/software/ncurses/>

Download: <http://ftp.gnu.org/gnu/ncurses/ncurses-6.0.tar.gz>

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 (5.24.0) - 13,825 KB:**

Home page: <http://www.perl.org/>

Download: <http://www.cpan.org/src/5.0/perl-5.24.0.tar.bz2>

MD5 sum: 99f39abe614b50719d9915431e54fc1e

• **Pkg-config (0.29.1) - 1,967 KB:**

Home page: <http://www.freedesktop.org/wiki/Software/pkg-config>

Download: <https://pkg-config.freedesktop.org/releases/pkg-config-0.29.1.tar.gz>

MD5 sum: f739a28cae4e0ca291f82d1d41ef107d

- **Procps (3.3.12) - 826 KB:**

Home page: <http://sourceforge.net/projects/procps-ng>

Download: <http://sourceforge.net/projects/procps-ng/files/Production/procps-ng-3.3.12.tar.xz>

MD5 sum: 957e42e8b193490b2111252e4a2b443c

- **Psmisc (22.21) - 447 KB:**

Home page: <http://psmisc.sourceforge.net/>

Download: <http://downloads.sourceforge.net/project/psmisc/psmisc/psmisc-22.21.tar.gz>

MD5 sum: 935c0fd6eb208288262b385fa656f1bf

- **Readline (6.3) - 2,411 KB:**

Home page: <http://cnswww.cns.cwru.edu/php/chet/readline/rltop.html>

Download: <http://ftp.gnu.org/gnu/readline/readline-6.3.tar.gz>

MD5 sum: 33c8fb279e981274f485fd91da77e94a

- **Sed (4.2.2) - 1,035 KB:**

Home page: <http://www.gnu.org/software/sed/>

Download: <http://ftp.gnu.org/gnu/sed/sed-4.2.2.tar.bz2>

MD5 sum: 7ffe1c7cdc3233e1e0c4b502df253974

- **Shadow (4.2.1) - 1,558 KB:**

Download: <http://pkg-shadow.alioth.debian.org/releases/shadow-4.2.1.tar.xz>

MD5 sum: 2bfafe7d4962682d31b5eba65dba4fc8

- **Systemd (231) - 3,840 KB:**

Home page: <http://www.freedesktop.org/wiki/Software/systemd/>

Download: <http://andu.in.linuxfromscratch.org/sources/other/systemd/systemd-231.tar.xz>

MD5 sum: 2647855c8f9cdf824953f1091db2d2b2

- **Tar (1.29) - 1,950 KB:**

Home page: <http://www.gnu.org/software/tar/>

Download: <http://ftp.gnu.org/gnu/tar/tar-1.29.tar.xz>

MD5 sum: a1802fec550baaeecff6c381629653ef

- **Tcl (8.6.6) - 5,731 KB:**

Home page: <http://tcl.sourceforge.net/>

Download: <http://sourceforge.net/projects/tcl/files/Tcl/8.6.6/tcl-core8.6.6-src.tar.gz>

MD5 sum: 98ebf13bbd90257e006c219369dd5f67

- **Texinfo (6.1) - 4,416 KB:**

Home page: <http://www.gnu.org/software/texinfo/>

Download: <http://ftp.gnu.org/gnu/texinfo/texinfo-6.1.tar.xz>

MD5 sum: 1d7ec1888fae00730693597852b00cde

- **Time Zone Data (2016f) - 306 KB:**

Home page: <http://www.iana.org/time-zones>

Download: <http://www.iana.org/time-zones/repository/releases/tzdata2016f.tar.gz>

MD5 sum: b20b3c1618db1984aac685e763de001d

- **Util-linux (2.28.1) - 4,061 KB:**

Home page: <http://freecode.com/projects/util-linux>

Download: <https://www.kernel.org/pub/linux/utils/util-linux/v2.28/util-linux-2.28.1.tar.xz>

MD5 sum: e2d863efaf4fd330a42c5efe9f1b02b4

- **Vim (7.4) - 9,632 KB:**

Home page: <http://www.vim.org>

Download: <ftp://ftp.vim.org/pub/vim/unix/vim-7.4.tar.bz2>

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: 28f1205d8dd2001f26fec1e8c2cebe37

Total size of these packages: about 417 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/7.10/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/7.10/bc-1.06.95-memory_leak-1.patch

MD5 sum: 877e81fba316fe487ec23501059d54b8

- **Bzip2 Documentation Patch - 1.6 KB:**

Download: http://www.linuxfromscratch.org/patches/lfs/7.10/bzip2-1.0.6-install_docs-1.patch

MD5 sum: 6a5ac7e89b791aae556de0f745916f7f

- **Coreutils Internationalization Fixes Patch - 146 KB:**

Download: <http://www.linuxfromscratch.org/patches/lfs/7.10/coreutils-8.25-i18n-2.patch>

MD5 sum: c6334ed5b03062ef7e9649e8ceb2cfc1

- **Glibc FHS Patch - 2.8 KB:**

Download: <http://www.linuxfromscratch.org/patches/lfs/7.10/glibc-2.24-fhs-1.patch>

MD5 sum: 9a5997c3452909b1769918c759eff8a2

- **Kbd Backspace/Delete Fix Patch - 12 KB:**

Download: <http://www.linuxfromscratch.org/patches/lfs/7.10/kbd-2.0.3-backspace-1.patch>

MD5 sum: f75cca16a38da6caa7d52151f7136895

• **Readline Upstream Fixes Patch - 8 KB:**

Download: http://www.linuxfromscratch.org/patches/lfs/7.10/readline-6.3-upstream_fixes-3.patch

MD5 sum: 6b0d9f4e79319d56a7fee9b35e5cfd1b

Total size of these patches: about 186.8 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/> 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`:

```
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:

```
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:

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

The meaning of the command line options:

```
-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='-j 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>.

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/7.10/> 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, the compiler will be **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`.

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-2.27 - 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: 519 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:

```
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:

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

The meaning of the configure options:

--prefix=/tools

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

--with-sysroot=\$LFS

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

--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 Binutils'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-6.2.0 - Pass 1

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

Approximate build time: 8.3 SBU

Required disk space: 2.5 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:



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-3.1.4.tar.xz
mv -v mpfr-3.1.4 mpfr
tar -xf ../gmp-6.1.1.tar.xz
mv -v gmp-6.1.1 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:

```
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\((64\)\)?\((32\)\)?/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:

```
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-libmpx \
  --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.

```
--disable-decimal-float, --disable-threads, --disable-libatomic, --disable-libgomp, --disable-libmpx, --disable-libquadmath, --disable-libssp, --disable-libvtv, --disable-libstdcxx
```

These switches disable support for the decimal floating point extension, threading, libatomic, libgomp, libmpx, 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-4.7.2 API Headers

The Linux API Headers (in `linux-4.7.2.tar.xz`) expose the kernel's API for use by Glibc.

Approximate build time: less than 0.1 SBU

Required disk space: 750 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:

```
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.

```
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-2.24

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: 4.0 SBU

Required disk space: 715 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) \
  --enable-kernel=2.6.32 \
  --with-headers=/tools/include \
  libc_cv_forced_unwind=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`.

--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.

--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-2.27 - 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.

During this stage the following warning might appear:

```
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
```

Install the package:

```
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++-6.2.0

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: 896 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-6.2.0` 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++/6.2.0
```

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++/6.2.0`

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-2.27 - 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: 533 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:

-C ld clean

This tells the make program to remove all compiled files in the `ld` subdirectory.

-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-6.2.0 - Pass 2

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

Approximate build time: 11 SBU

Required disk space: 2.9 nGB

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\)\?@(32\)\?/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
```

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-3.1.4.tar.xz
mv -v mpfr-3.1.4 mpfr
tar -xf ../gmp-6.1.1.tar.xz
mv -v gmp-6.1.1 gmp
tar -xf ../mpc-1.0.3.tar.gz
mv -v mpc-1.0.3 mpc
```

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-8.6.6

The Tcl package contains the Tool Command Language.

Approximate build time: 0.4 SBU

Required disk space: 40 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:

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

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 Tcl test suite anyway, issue the following command:

```
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:

```
make install
```

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

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

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

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

Now make a necessary symbolic link:

```
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

tclsh8.6	The Tcl command shell
tclsh	A link to tclsh8.6
libtcl8.6.so	The Tcl library
libtclstub8.6.a	The Tcl Stub library

5.12. Expect-5.45

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

Approximate build time: 0.1 SBU

Required disk space: 4.3 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:

```
cp -v configure{,.orig}
sed 's:/usr/local/bin:/bin:' configure.orig > configure
```

Now prepare Expect for compilation:

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

The meaning of the configure options:

`--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.

`--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:

```
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:

```
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:

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

The meaning of the make parameter:

`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

Short Descriptions

expect	Communicates with other interactive programs according to a script
<code>libexpect-5.45.so</code>	Contains functions that allow Expect to be used as a Tcl extension or to be used directly from C or C++ (without Tcl)

5.13. DejaGNU-1.6

The DejaGNU package contains a framework for testing other programs.

Approximate build time: less than 0.1 SBU

Required disk space: 3.2 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: 9.5 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: 54 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: 5.2 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: 0.6 SBU

Required disk space: 132 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-3.5

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

Approximate build time: 0.2 SBU

Required disk space: 21.5 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-5.28

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

Approximate build time: 0.1 SBU

Required disk space: 15 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: 35 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: 34 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-0.19.8.1

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: 164 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 intl 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-2.25

The Grep package contains programs for searching through files.

Approximate build time: 0.2 SBU

Required disk space: 18 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-1.8

The Gzip package contains programs for compressing and decompressing files.

Approximate build time: 0.1 SBU

Required disk space: 8.9 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: 18 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-4.2.1

The Make package contains a program for compiling packages.

Approximate build time: 0.1 SBU

Required disk space: 12.5 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-4.2.1 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: 10.4 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-5.24.0

The Perl package contains the Practical Extraction and Report Language.

Approximate build time: 1.3 SBU

Required disk space: 248 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/scripts/pod2man /tools/bin
mkdir -pv /tools/lib/perl5/5.24.0
cp -Rv lib/* /tools/lib/perl5/5.24.0
```

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: 10.0 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-1.29

The Tar package contains an archiving program.

Approximate build time: 0.3 SBU

Required disk space: 32 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: 99 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-2.28.1

The Util-linux package contains miscellaneous utility programs.

Approximate build time: 0.8 SBU

Required disk space: 114 MB

5.33.1. Installation of Util-linux

Prepare Util-linux for compilation:

```
./configure --prefix=/tools \
            --without-python \
            --disable-makeinstall-chown \
            --without-systemdsystemunitdir \
            --enable-libmount-force-mountinfo \
            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:

```
make
```

Install the package:

```
make 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: 16 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 `-march` and `-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 `/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 `/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.



Note

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

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 `--disable-static` option to **configure**. In other cases, alternate means are needed.

For a more complete discussion of libraries, see the discussion *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 `udev` 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.

```
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>.

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>.

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.

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 system 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:

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

```
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}

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

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++.so{,.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-remote:x:74:74:systemd Journal Remote:/:/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:

```
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>) 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:

```
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,faillog,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/faillog` file records failed login attempts. 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-4.7.2 API Headers

The Linux API Headers (in linux-4.7.2.tar.xz) expose the kernel's API for use by Glibc.

Approximate build time: less than 0.1 SBU

Required disk space: 755 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:

```
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. There are also some hidden files used by the kernel developers and not needed by LFS that are removed from the intermediate directory.

```
make INSTALL_HDR_PATH=dest headers_install
find dest/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, and /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, and /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-4.07

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-2.24

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: 17 SBU

Required disk space: 1.4 GB

6.9.1. Installation of Glibc



Note

The Glibc build system is self-contained and will install perfectly, even though the compiler specs file and linker are still pointing to `/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.

Some of the Glibc programs use non-FHS compliant `/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-2.24-fhs-1.patch
```

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

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

Prepare Glibc for compilation:

```
../configure --prefix=/usr \
              --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` will always fail due to not having the necessary networking applications when the tests are run. `posix/tst-getaddrinfo5` is also known to fail on some architectures.

- 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.
- The *nptl/tst-thread-affinity-{pthread,pthread2,sched}* tests may fail for reasons that have not been determined.
- 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
```

Next, install the locales that can make the system respond in a different language. None of the locales are required, but if some of them are missing, the test suites of future packages would skip important testcases.

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 ja_JP -f EUC-JP ja_JP
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-2.24/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-2.24/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:

```
cat > /etc/nsswitch.conf << "EOF"
# Begin /etc/nsswitch.conf

passwd: files
group: files
shadow: files

hosts: files dns
networks: files

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

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

6.9.2.2. Adding time zone data

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

```
tar -xf ../../tzdata2016f.tar.gz

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

for tz in etcetera southamerica northamerica europe africa antarctica \
        asia australasia backward pacificnew 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.

```
zic -L leapseconds ...
```

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.

```
zic ... -p ...
```

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, pldd, rpcgen, sln, sotruss, sprof, tzselect, xtrace, zdump, and zic
Installed libraries:	ld-2.24.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, libieee.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, 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/netinet, /usr/include/netipx, /usr/include/netiucv, /usr/include/netpacket, /usr/include/netrom, /usr/include/netrose, /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
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
zdump	The time zone dumper
zic	The time zone compiler
ld-2.24.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 <code>glibc-2.24/locale/broken_cur_max.c</code> 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 <code>getaddrinfo()</code> 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.
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`:

```
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:

```
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:

```
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):

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

Note that `/lib` is now the prefix of our dynamic linker.



Note

On 64-bit systems the interpreter should be `/lib64/ld-linux-x86-64.so.2`.

Now make sure that we're setup to use the correct start files:

```
grep -o '/usr/lib./crt[lin].*succeeded' dummy.log
```

The output of the last command should be:

```
/usr/lib/crt1.o succeeded
/usr/lib/crti.o succeeded
/usr/lib/crtn.o succeeded
```

**Note**

On 64-bit systems, the path above will be `/usr/lib/gcc/x86_64-unknown-linux-gnu/5.3.0/../../../../lib64/`. This reduces to `/usr/lib64` and `/usr/lib64` is a symlink that points to `/usr/lib`.

Verify that the compiler is searching for the correct header files:

```
grep -B1 '^ /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|; |\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/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: less than 0.1 SBU

Required disk space: 4.0 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-5.28

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

Approximate build time: 0.1 SBU

Required disk space: 15 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-2.27

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

Approximate build time: 2.5 SBU

Required disk space: 488 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.
```

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 -k check
```

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-6.1.1

The GMP package contains math libraries. These have useful functions for arbitrary precision arithmetic.

Approximate build time: 1.2 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   \  
            --docdir=/usr/share/doc/gmp-6.1.1
```

The meaning of the new configure options:

`--enable-cxx`

This parameter enables C++ support

`--docdir=/usr/share/doc/gmp-6.1.1`

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
```



Caution

The code in gmp is highly optimized for the processor where it is built. Occasionally, the code that detects the processor misidentifies the system capabilities and there will be errors in the tests or other applications using the gmp libraries with the message "Illegal instruction". In this case, gmp should be reconfigured with the option `--build=x86_64-unknown-linux-gnu` and rebuilt.

Ensure that all 190 tests in the test suite passed. Check the results by issuing the following command:

```
awk '/# PASS:/{total+=1} ; 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-6.1.1

Short Descriptions

libgmp Contains precision math functions
libgmpxx Contains C++ precision math functions

6.15. MPFR-3.1.4

The MPFR package contains functions for multiple precision math.

Approximate build time: 0.8 SBU

Required disk space: 45 MB

6.15.1. Installation of MPFR

Prepare MPFR for compilation:

```
./configure --prefix=/usr      \  
            --disable-static   \  
            --enable-thread-safe \  
            --docdir=/usr/share/doc/mpfr-3.1.4
```

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-3.1.4

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: 0.3 SBU

Required disk space: 17 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-6.2.0

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

Approximate build time: 79 SBU (with tests)

Required disk space: 3.3 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++ \
              --disable-multilib \
              --disable-bootstrap \
              --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/7.10/> 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.



Note

On some systems, numerous test failures (over 1100 unexpected failures out of over 200,000 tests) have been reported. These failures in `gcc.target/i386/mpx/` are related to the Intel MPX (Memory Protection Extensions) tests and failures are due to the kernel configuration or the specific CPU architecture. *These* test failures are harmless and can be ignored.

Install the package:

```
make install
```

Create a symlink required by the *FHS* for "historical" reasons.

```
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)/6.2.0/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
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):

```
[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[lin].*succeeded' dummy.log
```

The output of the last command should be:

```
/usr/lib/gcc/i686-pc-linux-gnu/6.2.0/../../../../crt1.o succeeded
/usr/lib/gcc/i686-pc-linux-gnu/6.2.0/../../../../crti.o succeeded
/usr/lib/gcc/i686-pc-linux-gnu/6.2.0/../../../../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/6.2.0/include
/usr/local/include
/usr/lib/gcc/i686-pc-linux-gnu/6.2.0/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, libsupc++.a, and libtsan.{a,so}
Installed directories:	/usr/include/c++, /usr/lib/gcc, /usr/libexec/gcc, and /usr/share/gcc-6.2.0

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
libasan	The Address Sanitizer runtime library
libgcc	Contains run-time support for gcc
libgcov	This library is linked in to a program when GCC is instructed to enable profiling
libgomp	GNU implementation of the OpenMP API for multi-platform shared-memory parallel programming in C/C++ and Fortran
libiberty	Contains routines used by various GNU programs, including getopt , obstack , strerror , strtol , and strtoul
liblto_plugin	GCC's Link Time Optimization (LTO) plugin allows GCC to perform optimizations across compilation units
libquadmath	GCC Quad Precision Math Library API
libssp	Contains routines supporting GCC's stack-smashing protection functionality
libstdc++	The standard C++ library
libsupc++	Provides supporting routines for the C++ programming language
libtsan	The Thread Sanitizer runtime library

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: 4.9 MB

6.18.1. Installation of Bzip2

Apply a patch that will install the documentation for this package:

```
patch -Np1 -i ../bzip2-1.0.6-install_docs-1.patch
```

The following command ensures installation of symbolic links are relative:

```
sed -i 's@\(ln -s -f \)\$(PREFIX)/bin/@\1@' Makefile
```

Ensure the man pages are installed into the correct location:

```
sed -i "s@(PREFIX)/man@(PREFIX)/share/man@g" Makefile
```

Prepare Bzip2 for compilation with:

```
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:

```
make
```

Install the programs:

```
make PREFIX=/usr install
```

Install the shared **bzip2** binary into the `/bin` directory, make some necessary symbolic links, and clean up:

```
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 bzdiff), bzdiff, bzegrep (link to bzgrep), bzfgrep (link to bzgrep), bzgrep, bzip2, bzip2recover, bzless (link to bzmored), and bzmored

Installed libraries: libbz2.{a,so}

Installed directory: /usr/share/doc/bzip2-1.0.6

Short Descriptions

bunzip2	Decompresses bziped files
bzcat	Decompresses to standard output
bzcmp	Runs cmp on bziped files
bzdiff	Runs diff on bziped files
bzegrep	Runs egrep on bziped files
bzfgrep	Runs fgrep on bziped files
bzgrep	Runs grep on bziped 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 bziped files
bzless	Runs less on bziped files
bzmore	Runs more on bziped files
<code>libbz2</code>	The library implementing lossless, block-sorting data compression, using the Burrows-Wheeler algorithm

6.19. Pkg-config-0.29.1

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: 28 MB

6.19.1. Installation of Pkg-config

Prepare Pkg-config for compilation:

```
./configure --prefix=/usr          \  
            --with-internal-glib   \  
            --disable-compile-warnings \  
            --disable-host-tool     \  
            --docdir=/usr/share/doc/pkg-config-0.29.1
```

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-compile-warnings

This option prevents the build system from using compiler flags which cause build failure when building with GCC 6.

--disable-host-tool

This option disables the creation of an undesired hard link to the pkg-config program.

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

6.19.2. Contents of Pkg-config

Installed program: pkg-config

Installed directory: /usr/share/doc/pkg-config-0.29.1

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-widenc
```

The meaning of the new configure options:

--enable-widenc

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:

```
ln -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:

```
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 `-lncurses` at build time are still buildable:

```
rm -vf /usr/lib/libcursesw.so
echo "INPUT(-lncursesw)" > /usr/lib/libcursesw.so
ln -sfv libncurses.so /usr/lib/libcurses.so
```

If desired, install the Ncurses documentation:

```
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:

```
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:** captinfo (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

- captinfo** 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
<code>libcursesw</code>	A link to <code>libncursesw</code>
<code>libncursesw</code>	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
<code>libformw</code>	Contains functions to implement forms
<code>libmenuw</code>	Contains functions to implement menus
<code>libpanelw</code>	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: 3.3 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:

```
make
```

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:

```
make -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: 4.8 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

getfacl	Gets file access control lists
setfacl	Sets file access control lists
<code>libacl</code>	Contains the library functions for manipulating Access Control Lists

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: 1.3 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: 10.7 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: 42 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/7.10/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:

```
make
```

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, chpasswd, 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 <code>/etc/group</code> and <code>/etc/gshadow</code>
grpconv	Creates or updates the shadow group file from the normal group file
grpunconv	Updates <code>/etc/group</code> from <code>/etc/gshadow</code> 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 <code>/etc/passwd</code> and <code>/etc/shadow</code>
pwconv	Creates or updates the shadow password file from the normal password file
pwunconv	Updates <code>/etc/passwd</code> from <code>/etc/shadow</code> and then deletes the latter

sg	Executes a given command while the user's GID is set to that of the given group
su	Runs a shell with substitute user and group IDs
useradd	Creates a new user with the given name, or updates the default new-user information
userdel	Deletes the given user account
usermod	Is used to modify the given user's login name, User Identification (UID), shell, initial group, home directory, etc.
vigr	Edits the <code>/etc/group</code> or <code>/etc/gshadow</code> files
vipw	Edits the <code>/etc/passwd</code> or <code>/etc/shadow</code> files

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: 4.0 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 (PIDs) 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

<code>/etc/protocols</code>	Describes the various DARPA Internet protocols that are available from the TCP/IP subsystem
<code>/etc/services</code>	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: 29 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: 32 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-2.6.1

The Flex package contains a utility for generating programs that recognize patterns in text.

Approximate build time: 0.4 SBU

Required disk space: 31 MB

6.30.1. Installation of Flex

Prepare Flex for compilation:

```
./configure --prefix=/usr --docdir=/usr/share/doc/flex-2.6.1
```

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-2.6.1

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-2.25

The Grep package contains programs for searching through files.

Approximate build time: 0.4 SBU

Required disk space: 28 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: 1.8 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: 3.6 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: 43 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

Installed programs: libtool and libtoolize

Installed libraries: libltdl.so

Installed directories: /usr/include/libltdl and /usr/share/libtool

Short Descriptions

libtool	Provides generalized library-building support services
libtoolize	Provides a standard way to add libtool support to a package
libltdl	Hides the various difficulties of dlopening libraries

6.36. GDBM-1.12

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: 8.8 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: 5.4 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-2.2.0

The Expat package contains a stream oriented C library for parsing XML.

Approximate build time: less than 0.1 SBU

Required disk space: 6.1 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-2.2.0
install -v -m644 doc/*.{html,png,css} /usr/share/doc/expat-2.2.0
```

6.38.2. Contents of Expat

Installed program: xmlwf
Installed libraries: libexpat.so
Installed directory: /usr/share/doc/expat-2.2.0

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.

Approximate build time: 0.4 SBU

Required disk space: 27 MB

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-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-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-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
```

One test, *libls.sh*, is known to fail due to hard coding of some support program paths. All tests pass if the tests are rerun at the end of Chapter 6.

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-5.24.0

The Perl package contains the Practical Extraction and Report Language.

Approximate build time: 6.2 SBU

Required disk space: 245 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, perl5.24.0 (hard link to perl), perlbug, perldoc, perlivp, 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
perl5.24.0	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
perlivp	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

picnv	A Perl version of the character encoding converter iconv
pl2pm	A rough tool for converting Perl4 <code>.pl</code> files to Perl5 <code>.pm</code> 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 <code>*roff</code> 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 <code>Test::Harness</code> module
pstruct	Dumps C structures as generated from <code>cc -g -S</code> 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: 17.5 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 3.5 SBUs. In addition, several tests 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 <i>#define</i> 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 <code>configure.in</code> file for a software package; it examines the source files in a directory tree, searching them for common portability issues, and creates a <code>configure.scan</code> file that serves as a preliminary <code>configure.in</code> file for the package
autoupdate	Modifies a <code>configure.in</code> file that still calls autoconf macros by their old names to use the current macro names
ifnames	Helps when writing <code>configure.in</code> 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 **configure** needs to check for. It can also fill in gaps in a `configure.in` file generated by **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 7.8 SBU with tests)

Required disk space: 110 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 <code>aclocal.m4</code> files based on the contents of <code>configure.in</code> files
aclocal-1.15	A hard link to aclocal
automake	A tool for automatically generating <code>Makefile.in</code> files from <code>Makefile.am</code> files [To create all the <code>Makefile.in</code> files for a package, run this program in the top-level directory. By scanning the <code>configure.in</code> file, it automatically finds each appropriate <code>Makefile.am</code> file and generates the corresponding <code>Makefile.in</code> 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;' \
-i src/liblzma/lz/lz_encoder.c
```

Prepare Xz for compilation with:

```
./configure --prefix=/usr \
--disable-static \
--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,unxz,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), lzdiff (link to xzdiff), lzegrep (link to xzgrep), lzfgrep (link to xzgrep), lzgrep (link to xzgrep), lzless (link to xzless), lzma (link to xz), lzmadec, lzmainfo, lzmore (link to xzmore), unlzma (link to xz), unxz (link to xz), xz, xzcat (link to xz), xzcmp (link to xzdiff), xzdec, xzdiff, xzegrep (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

lzdiff Runs **diff** on LZMA compressed files

lzgrep	Runs egrep 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	Compresses 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
xzdiff	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-23

The Kmod package contains libraries and utilities for loading kernel modules

Approximate build time: 0.1 SBU

Required disk space: 10.3 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 rmmmod; do
    ln -sfv ../bin/kmod /sbin/$target
done

ln -sfv 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 rmmmod (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

insmod	Installs a loadable module in the running kernel
kmod	Loads and unloads kernel modules
lsmod	Lists currently loaded modules
modinfo	Examines an object file associated with a kernel module and displays any information that it can glean
modprobe	Uses a dependency file, created by depmod , to automatically load relevant modules
rmmod	Unloads modules from the running kernel
libkmod	This library is used by other programs to load and unload kernel modules

6.47. Gettext-0.19.8.1

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: 3.6 SBU

Required disk space: 199 MB

6.47.1. Installation of Gettext

Prepare Gettext for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/gettext-0.19.8.1
```

Compile the package:

```
make
```

To test the results (this takes a long time, around 3 SBUs), issue:

```
make check
```

Nine tests fail due to missing dependencies.

Install the package:

```
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-0.19.8.1, 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 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
<code>libasprintf</code>	defines the <i>autosprintf</i> class, which makes C formatted output routines usable in C++ programs, for use with the <code><string></code> strings and the <code><iostream></code> streams
<code>libgettextlib</code>	a private library containing common routines used by the various Gettext programs; these are not intended for general use
<code>libgettextpo</code>	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
<code>libgettextsrc</code>	A private library containing common routines used by the various Gettext programs; these are not intended for general use
<code>preloadable_libintl</code>	A library, intended to be used by LD_PRELOAD that assists libintl in logging untranslated messages

6.48. Systemd-231

The systemd package contains programs for controlling the startup, running, and shutdown of the system.

Approximate build time: 6.7 SBU

Required disk space: 430 MB

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")
```

Disable two tests that always fail:

```
sed -e 's@test/udev-test.pl @@' \
    -e 's@test-copy$(EXEEXT) @@' \
    -i Makefile.in
```

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 \
            --with-default-dnssec=no \
            --docdir=/usr/share/doc/systemd-231
```

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.

--with-default-dnssec=no

This switch turns off the experimental DNSSEC support.

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 the 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
```

Fix a broken symlink created by the `systemd` installation process:

```
rm -fv /etc/resolv.conf
ln -s ../lib/systemd/resolv.conf /etc/resolv.conf
```

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:	<code>bootctl</code> , <code>busctl</code> , <code>coredumpctl</code> , <code>halt</code> , <code>hostnamectl</code> , <code>init</code> , <code>journalctl</code> , <code>kernel-install</code> , <code>localectl</code> , <code>loginctl</code> , <code>machinectl</code> , <code>networkctl</code> , <code>poweroff</code> , <code>reboot</code> , <code>runlevel</code> , <code>shutdown</code> , <code>systemctl</code> , <code>systemd-analyze</code> , <code>systemd-ask-password</code> , <code>systemd-cat</code> , <code>systemd-cgls</code> , <code>systemd-cgtop</code> , <code>systemd-delta</code> , <code>systemd-detect-virt</code> , <code>systemd-escape</code> , <code>systemd-hwdb</code> , <code>systemd-inhibit</code> , <code>systemd-machine-id-setup</code> , <code>systemd-notify</code> , <code>systemd-nspawn</code> , <code>systemd-path</code> , <code>systemd-resolve</code> , <code>systemd-run</code> , <code>systemd-stdio-bridge</code> , <code>systemd-tmpfiles</code> , <code>systemd-tty-ask-password-agent</code> , <code>telinit</code> , <code>timedatectl</code> , and <code>udevadm</code>
Installed libraries:	<code>libnss_myhostname.so.2</code> , <code>libnss_mymachines.so.2</code> , <code>libnss_resolve.so.2</code> , <code>libsystemd.so</code> , <code>libsystemd-shared-231.so</code> , and <code>libudev.so</code>
Installed directories:	<code>/etc/binfmt.d</code> , <code>/etc/init.d</code> , <code>/etc/kernel</code> , <code>/etc/modules-load.d</code> , <code>/etc/sysctl.d</code> , <code>/etc/systemd</code> , <code>/etc/tmpfiles.d</code> , <code>/etc/udev</code> , <code>/etc/xdg/systemd</code> , <code>/lib/systemd</code> , <code>/lib/udev</code> , <code>/usr/include/systemd</code> , <code>/usr/lib/binfmt.d</code> , <code>/usr/lib/kernel</code> , <code>/usr/lib/modules-load.d</code> , <code>/usr/lib/sysctl.d</code> , <code>/usr/lib/systemd</code> , <code>/usr/lib/tmpfiles.d</code> , <code>/usr/share/doc/systemd-231</code> , <code>/usr/share/factory</code> , <code>/usr/share/systemd</code> , <code>/var/lib/systemd</code> , and <code>/var/log/journal</code>

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 <code>-h</code> option, except when already in run-level 0, then it tells the kernel to halt the system; it notes in the file <code>/var/log/wtmp</code> that the system is being brought down
hostnamectl	Used to query and change the system hostname and related settings
init	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 <code>/boot</code>
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 <code>systemd-networkd</code>
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 <code>/var/run/utmp</code>
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 <code>STDOUT</code> and <code>STDERR</code> 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 <code>/etc</code> that override default counterparts in <code>/usr</code>
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 (<code>hwdb</code>)
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 <code>/etc/machine-id</code> 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
systemd-path	Used to query system and user paths
systemd-resolve	Used to resolve domain names, IPV4 and IPv6 addresses, DNS resource records, and services
systemd-run	Used to create and start a transient <code>.service</code> or a <code>.scope</code> unit and run the specified command in it
systemd-tmpfiles	Creates, deletes and cleans up volatile and temporary files and directories, based on the configuration file format and location specified in <code>tmpfiles.d</code> directories
systemd-tty-ask-password-agent	Used to list or process pending systemd password requests
telinit	Tells init which run-level to change to
timedatectl	Used to query and change the system clock and its settings
udevadm	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
<code>libsystemd</code>	systemd utility library
<code>libudev</code>	A library to access Udev device information

6.49. Procps-ng-3.3.12

The Procps-ng package contains programs for monitoring processes.

Approximate build time: 0.1 SBU

Required disk space: 14 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-3.3.12 \
            --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-3.3.12

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 slab cache information in real time
sysctl	Modifies kernel parameters at run time
load	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
<code>libprocps</code>	Contains the functions used by most programs in this package

6.50. E2fsprogs-1.43.1

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: 2.1 SBU

Required disk space: 54 MB

6.50.1. Installation of E2fsprogs

First, fix a script that adjusts testing output:

```
sed -i -e 's:[\.-\]::' tests/filter.sed
```

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-uuid \
              --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-2.28.1” 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 `uuid` 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 2.5, “Creating a File System on the Partition” and Section 2.7, “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 <code>ext2</code> file system; it also changes <code>ext3</code> file systems, the journaling version of <code>ext2</code> 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 <code>com_err</code> library
debugfs	A file system debugger; it can be used to examine and change the state of an <code>ext2</code> 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 <code>ext2</code> file systems and <code>ext3</code> file systems
e2image	Is used to save critical <code>ext2</code> file system data to a file
e2label	Displays or changes the file system label on the <code>ext2</code> file system present on a given device
e2undo	Replays the undo log <code>undo_log</code> for an <code>ext2/ext3/ext4</code> filesystem found on a device [This can be used to undo a failed operation by an <code>e2fsprogs</code> program.]
e4defrag	Online defragmenter for <code>ext4</code> filesystems
filefrag	Reports on how badly fragmented a particular file might be
fsck.ext2	By default checks <code>ext2</code> file systems and is a hard link to e2fsck
fsck.ext3	By default checks <code>ext3</code> file systems and is a hard link to e2fsck
fsck.ext4	By default checks <code>ext4</code> file systems and is a hard link to e2fsck
fsck.ext4dev	By default checks <code>ext4</code> 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 <code>libss</code> subsystem library
mke2fs	Creates an <code>ext2</code> or <code>ext3</code> file system on the given device
mkfs.ext2	By default creates <code>ext2</code> file systems and is a hard link to mke2fs
mkfs.ext3	By default creates <code>ext3</code> file systems and is a hard link to mke2fs
mkfs.ext4	By default creates <code>ext4</code> file systems and is a hard link to mke2fs
mkfs.ext4dev	By default creates <code>ext4</code> development file systems and is a hard link to mke2fs
mklost+found	Used to create a <code>lost+found</code> directory on an <code>ext2</code> 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 <code>ext2</code> file system
tune2fs	Adjusts tunable file system parameters on an <code>ext2</code> file system
<code>libcom_err</code>	The common error display routine
<code>libe2p</code>	Used by dumpe2fs , chattr , and lsattr
<code>libext2fs</code>	Contains routines to enable user-level programs to manipulate an <code>ext2</code> file system
<code>libss</code>	Used by debugfs

6.51. Coreutils-8.25

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

Approximate build time: 2.6 SBU

Required disk space: 168 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: `[], base32, base64, basename, cat, chcon, chgrp, chmod, chown, chroot, cksum, comm, cp, csplit, cut, date, dd, df, dir, dircolors, dirname, du, echo, env, expand, expr, factor, false, fmt, fold, groups, head, hostid, id, install, join, link, ln, logname, ls, md5sum, mkdir, mkfifo, mknod, mktemp, mv, nice, nl, nohup, nproc, numfmt, od, paste, pathchk, pinky, pr, printenv, printf, ptx, pwd, readlink, realpath, rm, rmdir, runcon, seq, sha1sum, sha224sum, sha256sum, sha384sum, sha512sum, shred, shuf, sleep, sort, split, stat, stdbuf, stty, sum, sync, tac, tail, tee, test, timeout, touch, tr, true, truncate, tsort, tty, uname, unexpand, uniq, unlink, users, vdir, wc, who, whoami, and yes`

Installed library: `libstdbuf.so`

Installed directory: `/usr/libexec/coreutils`

Short Descriptions

base32 Encodes and decodes data according to the base32 specification (RFC 4648)

base64 Encodes and decodes data according to the base64 specification (RFC 4648)

basename Strips any path and a given suffix from a file name

cat Concatenates files to standard output

chcon Changes security context for files and directories

chgrp Changes the group ownership of files and directories

chmod Changes the permissions of each file to the given mode; the mode can be either a symbolic representation of the changes to make or an octal number representing the new permissions

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 <code>LS_COLOR</code> 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-3.5

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

Approximate build time: 0.4 SBU

Required disk space: 30 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: 35 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/{awkforai.txt,*.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, rvarray.so, testtext.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: 1.6 SBU

Required disk space: 48 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 <code>find</code> , 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: 82 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, grops, grotty, hpftodit, indxbib, lkbib, lookbib, mmroff, neqn, nroff, pdfmom, pdfroff, pfbtops, 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

addftinfo	Reads a troff font file and adds some additional font-metric information that is used by the groff system
afmtodit	Creates a font file for use with groff and grops
chem	Groff preprocessor for producing chemical structure diagrams
eqn	Compiles descriptions of equations embedded within troff input files into commands that are understood by troff
eqn2graph	Converts a troff EQN (equation) into a cropped image
gdiffmk	Marks differences between groff/nroff/troff files
glilypond	Transforms sheet music written in the lilypond language into the groff language
gperl	Preprocessor for groff, allowing addition of perl code into groff files
gpinyin	Preprocessor for groff, allowing addition of Chinese European-like language Pinyin into groff files.

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 <code>-e</code> , <code>-man</code> , <code>-me</code> , <code>-mm</code> , <code>-ms</code> , <code>-p</code> , <code>-s</code> , and <code>-t</code> 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
gropdf	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 <code>.pfb</code> 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 <code>./</code> and <code>./</code> are interpreted as citations, and lines between <code>.R1</code> and <code>.R2</code> 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 <i>.so file</i> by the contents of the mentioned <i>file</i>
tbl	Compiles descriptions of tables embedded within troff input files into commands that are understood by troff
tfmtofit	Creates a font file for use with groff -Tdv
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~beta3

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:

```
./configure --prefix=/usr          \
            --sbindir=/sbin        \
            --sysconfdir=/etc       \
            --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-efiemu

This option minimizes what is built by disabling a feature 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 programs: grub-bios-setup, grub-editenv, grub-file, grub-fstest, grub-glue-efi, grub-install, grub-kbdcomp, grub-macbless, grub-menulst2cfg, grub-mkconfig, grub-mkimage, grub-mklayout, grub-mknetdir, grub-mkpasswd-pbkdf2, grub-mkrelpath, grub-mkrescue, grub-mkstandalone, grub-ofpathname, grub-probe, grub-reboot, grub-render-label, grub-script-check, grub-set-default, grub-sparc64-setup, and grub-syslinux2cfg

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.
grub-fstest	Tool to debug the filesystem driver

grub-glue-efi	Processes ia32 and amd64 EFI images and glues them according to Apple format.
grub-install	Install GRUB on your drive
grub-kbdcomp	Script that converts an xkb layout into one recognized by GRUB
grub-macbless	Mac-style bless on HFS or HFS+ files
grub-menulst2cfg	Converts a GRUB Legacy menu .lst into a grub.cfg for use with GRUB 2
grub-mkconfig	Generate a grub config file
grub-mkimage	Make a bootable image of GRUB
grub-mklayout	Generates a GRUB keyboard layout file
grub-mknetdir	Prepares a GRUB netboot directory
grub-mkpasswd-pbkdf2	Generates an encrypted PBKDF2 password for use in the boot menu
grub-mkrelpath	Makes a system pathname relative to its root
grub-mkrescue	Make a bootable image of GRUB suitable for a floppy disk or CDROM/DVD
grub-mkstandalone	Generates a standalone image
grub-ofpathname	Is a helper program that prints the path of a GRUB device
grub-probe	Probe device information for a given path or device
grub-reboot	Sets the default boot entry for GRUB for the next boot only
grub-render-label	Render Apple .disk_label for Apple Macs
grub-script-check	Checks GRUB configuration script for syntax errors
grub-set-default	Sets the default boot entry for GRUB
grub-sparc64-setup	Is a helper program for grub-setup
grub-syslinux2cfg	Transform a syslinux config file into grub.cfg format

6.57. Less-481

The Less package contains a text file viewer.

Approximate build time: less than 0.1 SBU

Required disk space: 3.5 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 <code>*</code> and <code>?</code> , in filenames on Unix systems |
| lesskey | Used to specify the key bindings for less |

6.58. Gzip-1.8

The Gzip package contains programs for compressing and decompressing files.

Approximate build time: 0.1 SBU

Required disk space: 19 MB

6.58.1. Installation of Gzip

Prepare Gzip for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

Move a program that needs to be on the root filesystem:

```
mv -v /usr/bin/gzip /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. IPRoute2-4.7.0

The IPRoute2 package contains programs for basic and advanced IPV4-based networking.

Approximate build time: 0.2 SBU

Required disk space: 11 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/7.10/server/databases.html#db>.

```
sed -i /ARPD/d Makefile
sed -i 's/arpd.8//' man/man8/Makefile
rm -v doc/arpd.sgml
```

It is also necessary to disable building one module that requires <http://www.linuxfromscratch.org/blfs/view/7.10/postlfs/iptables.html>.

```
sed -i 's/m_ipt.o//' tc/Makefile
```

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/iproute2-4.7.0 install
```

6.59.2. Contents of IPRoute2

Installed programs: bridge, ctstat (link to lstat), genl, ifcfg, ifstat, ip, lstat, nstat, route, routel, rtacct, rtmon, rtpr, rtstat (link to lstat), ss, and tc

Installed directories: /etc/iproute2, /usr/lib/tc, and /usr/share/doc/iproute2-4.7.0,

Short Descriptions

bridge Configures network bridges

ctstat Connection status utility

genl

ifcfg 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/>]

ifstat 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 mroute allows users to set, change, or delete the multicast routing

ip monitor allows users to continuously monitor the state of devices, addresses and routes

lnstat 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 queuing discipline

tc class allows users to setup classes based on the queuing 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: 29 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/\lno/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, kbinfo, kbd_mode, kbdrate, loadkeys, loadunimap, mapscrn, openvt, psfaddtable (link to psfxtable), psfgettable (link to psfxtable), psfstrietable (link to psfxtable), psfxtable, setfont, setkeycodes, settled, 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
kbinfo	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
psfstrietable	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
settleds	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

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: 7.9 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-4.2.1

The Make package contains a program for compiling packages.

Approximate build time: 0.6 SBU

Required disk space: 12.6 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: 19.7 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-1.10.10

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).

Approximate build time: 0.2 SBU

Required disk space: 23 MB

6.64.1. Installation of D-Bus

Prepare D-Bus for compilation:

```
./configure --prefix=/usr \
            --sysconfdir=/etc \
            --localstatedir=/var \
            --disable-static \
            --disable-doxygen-docs \
            --disable-xml-docs \
            --docdir=/usr/share/doc/dbus-1.10.10 \
            --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/7.10/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 -sfv ../../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 -sfv /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-1.10.10, 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-2.28.1

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

Approximate build time: 1.0 SBU
Required disk space: 158 MB

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-2.28.1 \
  --disable-chfn-chsh \
  --disable-login \
  --disable-nologin \
  --disable-su \
  --disable-setpriv \
  --disable-runuser \
  --disable-pylibmount \
  --disable-static \
  --without-python \
  --enable-libmount-force-mountinfo
```

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"
```

**Note**

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`, `cdfisk`, `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` (link to `last`), `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`, `swaponlabel`, `swapoff` (link to `swapon`), `swapon`, `switch_root`, `tailf`, `taskset`, `ul`, `umount`, `uname26`, `unshare`, `utmpdump`, `uuid`, `uuidgen`, `wall`, `wdctl`, `whereis`, `wipefs`, `x86_64`, and `zramctl`

Installed libraries: `libblkid.so`, `libfdisk.so`, `libmount.so`, `libsmartcols.so`, and `libuuid.so`

Installed directories: `/usr/include/blkid`, `/usr/include/libfdisk`, `/usr/include/libmount`, `/usr/include/libsmartcols`, `/usr/include/uuid`, `/usr/share/doc/util-linux-2.28.1`, and `/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
cdfisk	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
isozsize	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 <code>/var/log/wtmp</code> file; it also shows system boots, shutdowns, and run-level changes
lastb	Shows the failed login attempts, as logged in <code>/var/log/btmp</code>
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 <code>root</code> to log in; it is normally invoked by init when the system goes into single user mode
swaponlabel	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
utmpdump	Displays the content of the given login file in a more user-friendly format
uidd	A daemon used by the UUID library to generate time-based UUIDs in a secure and guranteed-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
wipefs	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: 30 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/` <11> will be encoded with. In addition to this, Man-DB correctly determines if manual pages installed in that directory are UTF-8 encoded.

Table 6.1. Expected character encoding of legacy 8-bit manual pages

Language (code)	Encoding	Language (code)	Encoding
Danish (da)	ISO-8859-1	Croatian (hr)	ISO-8859-2

Language (code)	Encoding	Language (code)	Encoding
German (de)	ISO-8859-1	Hungarian (hu)	ISO-8859-2
English (en)	ISO-8859-1	Japanese (ja)	EUC-JP
Spanish (es)	ISO-8859-1	Korean (ko)	EUC-KR
Estonian (et)	ISO-8859-1	Lithuanian (lt)	ISO-8859-13
Finnish (fi)	ISO-8859-1	Latvian (lv)	ISO-8859-13
French (fr)	ISO-8859-1	Macedonian (mk)	ISO-8859-5
Irish (ga)	ISO-8859-1	Polish (pl)	ISO-8859-2
Galician (gl)	ISO-8859-1	Romanian (ro)	ISO-8859-2
Indonesian (id)	ISO-8859-1	Russian (ru)	KOI8-R
Icelandic (is)	ISO-8859-1	Slovak (sk)	ISO-8859-2
Italian (it)	ISO-8859-1	Slovenian (sl)	ISO-8859-2
Norwegian Bokmal (nb)	ISO-8859-1	Serbian Latin (sr@latin)	ISO-8859-2
Dutch (nl)	ISO-8859-1	Serbian (sr)	ISO-8859-5
Norwegian Nynorsk (nn)	ISO-8859-1	Turkish (tr)	ISO-8859-9
Norwegian (no)	ISO-8859-1	Ukrainian (uk)	KOI8-U
Portuguese (pt)	ISO-8859-1	Vietnamese (vi)	TCVN5712-1
Swedish (sv)	ISO-8859-1	Simplified Chinese (zh_CN)	GBK
Belarusian (be)	CP1251	Simplified Chinese, Singapore (zh_SG)	GBK
Bulgarian (bg)	CP1251	Traditional Chinese, Hong Kong (zh_HK)	BIG5HKSCS
Czech (cs)	ISO-8859-2	Traditional Chinese (zh_TW)	BIG5
Greek (el)	ISO-8859-7		



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-1.29

The Tar package contains an archiving program.

Approximate build time: 2.2 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-1.29
```

6.67.2. Contents of Tar

Installed programs: tar

Installed directory: /usr/share/doc/tar-1.29

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: 0.5 SBU

Required disk space: 108 MB

6.68.1. Installation of Texinfo

Prepare Texinfo for compilation:

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

The meaning of the configure options:

--disable-static

In this case, the top-level configure script will complain that this is an unrecognized option, but the configure script for XSParagraph recognizes it and uses it to disable installing a static XSParagraph.a to /usr/lib/texinfo.

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
popd
```

6.68.2. Contents of Texinfo

Installed programs:	info, install-info, makeinfo (link to texi2any), pdftexi2dvi, pod2texi, texi2any, texi2dvi, texi2pdf, and texindex
Installed library:	XSParagraph.so
Installed directories:	/usr/share/texinfo and /usr/lib/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: 1.0 SBU

Required disk space: 109 MB



Alternatives to Vim

If you prefer another editor—such as Emacs, Joe, or Nano—please refer to <http://www.linuxfromscratch.org/blfs/view/7.10/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:

```
echo '#define SYS_VIMRC_FILE "/etc/vimrc"' >> src/feature.h
```

Prepare Vim for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
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:

```
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:

```
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:

```
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/7.10/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](#)), `rview` ([link to vim](#)), `vi` ([link to vim](#)), `view` ([link to vim](#)), `vim`, `vimdiff` ([link to vim](#)), `vimtutor`, and `xxd`

Installed directory: `/usr/share/vim`

Short Descriptions

ex Starts **vim** in `ex` mode

rview	Is a restricted version of view ; no shell commands can be started and view cannot be suspended
rvim	Is a restricted version of vim ; no shell commands can be started and vim cannot be suspended
vi	Link to vim
view	Starts vim in read-only mode
vim	Is the editor
vimdiff	Edits two or three versions of a file with vim and show differences
vimtutor	Teaches the basic keys and commands of vim
xxd	Creates a hex dump of the given file; it can also do the reverse, so it can be used for binary patching

6.70. About Debugging Symbols

Most programs and libraries are, by default, compiled with debugging symbols included (with **gcc**'s `-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 **bash** binary with debugging symbols: 1200 KB
- A **bash** binary without debugging symbols: 480 KB
- Glibc and GCC files (`/lib` and `/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 **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`:

```
logout
```

Then reenter it with:

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

Now the binaries and libraries can be safely stripped:

```
/tools/bin/find /usr/lib -type f -name \*.a \
  -exec /tools/bin/strip --strip-debug {} ';'

/tools/bin/find /lib /usr/lib -type f -name \*.so* \
  -exec /tools/bin/strip --strip-unnneeded {} ';'

/tools/bin/find /{bin,sbin} /usr/{bin,sbin,libexec} -type f \
  -exec /tools/bin/strip --strip-all {} ';'
```

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 reinstalled. The BLFS book has instructions for this (see <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. 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, “Overview of Device and Module Handling.”
- Section 7.4, “Managing 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
Domains=<Your Domain Name>
EOF
```

Multiple DNS entries can be added if you have more than one DNS server. Do not include DNS or Domains entries if you intend to use a static `/etc/resolv.conf` file.

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

[DHCP]
UseDomains=true
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

The Google Public IPv4 DNS addresses are `8.8.8.8` and `8.8.4.4` for IPv4, and `2001:4860:4860::8888` and `2001:4860:4860::8844` for IPv6.

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 a fully-qualified domain name (FQDN), and possible aliases for use in the `/etc/hosts` file. If using static addresses, you'll also need to decide on an IP address. The syntax for a hosts file entry 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:

Private Network Address Range	Normal Prefix
10.0.0.1 - 10.255.255.254	8
172.x.0.1 - 172.x.255.254	16
192.168.y.1 - 192.168.y.254	24

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.

If using DHCP, DHCPv6, IPv6 Autoconfiguration, or if a network card is not going to be configured, create the `/etc/hosts` file by running the following command:

```
cat > /etc/hosts << "EOF"
# Begin /etc/hosts

127.0.0.1 <HOSTNAME.example.org> <HOSTNAME> localhost [alias1] [alias2] ...
::1      <HOSTNAME.example.org> <HOSTNAME> localhost [alias1] [alias2] ...

# End /etc/hosts
EOF
```

The `::1` entry is the IPv6 counterpart of 127.0.0.1 and represents the IPv6 loopback interface.

If using a static address, create the `/etc/hosts` file by running this command instead:

```
cat > /etc/hosts << "EOF"
# Begin /etc/hosts

127.0.0.1 localhost
::1      localhost
<192.168.0.2> <HOSTNAME.example.org> <HOSTNAME> [alias1] [alias2] ...

# End /etc/hosts
EOF
```

The `<192.168.0.2>`, `<HOSTNAME.example.org>`, and `<HOSTNAME>` 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.

7.3. Overview of Device and Module Handling

In Chapter 6, we installed the Udev package when systemd was built. 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 used a static device creation method, whereby a great many device nodes were created under `/dev` (sometimes literally thousands of nodes), regardless of whether the corresponding hardware devices actually existed. This was 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 suffered from race conditions that were inherent in its design and could not 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 developing 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 `udev` 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 the `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 **udev**. Based on the rules specified in the files within the `/etc/udev/rules.d`, `/lib/udev/rules.d`, and `/run/udev/rules.d` directories, **udev** will create additional symlinks to the device node, or change its permissions, owner, or group, or modify the internal **udev** database entry (name) for that object.

The rules in these three directories are numbered and all three directories are merged together. If **udev** 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 **udev** 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 **udev** 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-4.7.2, 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-4.7.2, 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 **udev**.

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, “Managing Devices” and Section 7.2, “General Network Configuration” for examples.

7.3.4. Useful Reading

Additional helpful documentation is available at the following sites:

- A Userspace Implementation of `devfs` http://www.kroah.com/linux/talks/ols_2003_udev_paper/Reprint-Kroah-Hartman-OLS2003.pdf
- The `sysfs` Filesystem <http://www.kernel.org/pub/linux/kernel/people/mochel/doc/papers/ols-2005/mochel.pdf>

7.4. Managing Devices

7.4.1. Dealing with duplicate devices

As explained in Section 7.3, “Overview of Device and Module Handling”, 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):

```
udevadm info -a -p /sys/class/video4linux/video0
```

Then write rules that create the symlinks, e.g.:

```
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>. 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/7.10/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.

```
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:

```
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 revied 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:

```
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`.

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

The parameter of a unit can be overridden by creating a directory and a configuration file in `/etc/systemd/system`. For example:

```
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

Rather than plain shell scripts used in SysVinit or BSD style init systems, systemd uses a unified format for different types of startup files (or units). The command `systemctl` is used to enable, disable, control state, and obtain status of unit files. Here are some examples of frequently used commands:

- `systemctl list-units -t <service> [--all]`: lists loaded unit files of type service.
- `systemctl list-units -t <target> [--all]`: lists loaded unit files of type target.
- `systemctl show -p Wants <multi-user.target>`: shows all units that depend on the multi-user target. Targets are special unit files that are analogous to runlevels under SysVinit.
- `systemctl status <servicename.service>`: shows the status of the servicename service. The `.service` extension can be omitted if there are no other unit files with the same name, such as `.socket` files (which create a listening socket that provides similar functionality to `inetd/xinetd`).

7.10.7. Working with the Systemd Journal

Logging on a system booted with systemd is handled with `systemd-journald` (by default), rather than a typical unix `syslog` daemon. You can also add a normal `syslog` daemon and have both work side by side if desired. The `systemd-journald` program stores journal entries in a binary format rather than a plain text log file. To assist with parsing the file, the command `journaltl` is provided. Here are some examples of frequently used commands:

- `journaltl -r`: shows all contents of the journal in reverse chronological order.

- **journalctl -u UNIT**: shows the journal entries associated with the specified UNIT file.
- **journalctl -b[=ID] -r**: shows the journal entries since last successful boot (or for boot ID) in reverse chronological order.
- **journalctl -f**: provides functionality similar to tail -f (follow).

7.10.8. Long Running Processes

Beginning with systemd-230, all user processes are killed when a user session is ended, even if nohup is used, or the process uses `daemon()` or `setsid()`. This is a deliberate change from a historically permissive environment to a more restrictive one. The new behavior may cause issues if you depend on long running programs (e.g., **screen** or **tmux**) to remain active after ending your user session. There are three ways to enable lingering processes to remain after a user session is ended.

- *Enable process lingering for only needed users*: normal users have permission to enable process lingering with the command **loginctl enable-linger** for their own user. System administrators can use the same command with a *user* argument to enable for a user. That user can then use the **systemd-run** command to start long running processes. For example: **systemd-run --scope --user /usr/bin/screen**. If you enable lingering for your user, the `user@.service` will remain even after all login sessions are closed, and will automatically start at system boot. This has the advantage of explicitly allowing and disallowing processes to run after the user session has ended, but breaks backwards compatibility with tools like **nohup** and utilities that use `daemon()`.
- *Enable system-wide process lingering*: you can set `KillUserProcesses=no` in `/etc/logind.conf` to enable process lingering globally for all users. This has the benefit of leaving the old method available to all users at the expense of explicit control.
- *Disable at build-time*: You can enable lingering by default while building systemd by adding the switch `--without-kill-user-processes` to the **configure** command for systemd. This completely disables the ability of systemd to kill user processes at session end.

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:

```
cat > /etc/fstab << "EOF"
# Begin /etc/fstab

# file system  mount-point  type      options          dump  fsck
#                                     order

/dev/<xxx>     /             <fff>     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`:

```
noauto,user,quiet,showexec,iocharset=koi8r,codepage=866
```

The corresponding options fragment for `ru_RU.UTF-8` users is:

```
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-4.7.2

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/7.10/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:

```
General setup -->
  [ ] Enable deprecated sysfs features to support old userspace tools [CONF
  [ ] Enable deprecated sysfs features by default [CONFIG_SYSFS_DEPRECATED_
  [*] open by fhandle syscalls [CONFIG_FHANDLE]
  [ ] Auditing support [CONFIG_AUDIT]
  [*] Control Group support [CONFIG_CGROUPS]
Processor type and features --->
  [*] Enable seccomp to safely compute untrusted bytecode [CONFIG_SECCOMP]
Networking support --->
  Networking options --->
    <*> The IPv6 protocol [CONFIG_IPV6]
Device Drivers --->
  Generic Driver Options --->
    [ ] Support for uevent helper [CONFIG_UEVENT_HELPER]
    [*] Maintain a devtmpfs filesystem to mount at /dev [CONFIG_DEVTMPFS]
    [ ] Fallback user-helper invocation for firmware loading [CONFIG_FW_LOADE
Firmware Drivers --->
  [*] Export DMI identification via sysfs to userspace [CONFIG_DMIID]
File systems --->
  [*] Inotify support for userspace [CONFIG_INOTIFY_USER]
  <*> Kernel automounter version 4 support (also supports v3) [CONFIG_AUTOF
Pseudo filesystems --->
  [*] Tmpfs POSIX Access Control Lists [CONFIG_TMPFS_POSIX_ACL]
  [*] Tmpfs extended attributes [CONFIG_TMPFS_XATTR]
```



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 menuconfig

The meaning of optional make environment variables:

```
LANG=<host_LANG_value> LC_ALL=
```

This establishes the locale setting to the one used on the host. This may be needed for a proper menuconfig ncurses interface line drawing on a UTF-8 linux text console.

If used, be sure to replace *<host_LANG_value>* by the value of the \$LANG variable from your host. You can alternatively 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-4.7.2` 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, “Overview of Device and Module Handling” and in the kernel documentation in the `linux-4.7.2/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.

**Caution**

If the host system has a separate `/boot` partition, the files copied below should go there. The easiest way to do that is to bind `/boot` on the host to `/mnt/lfs/boot` before proceeding:

```
mount --bind /boot /mnt/lfs/boot
```

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-4.7.2-lfs-7.10-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-4.7.2
```

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-4.7.2
```

Install the documentation for the Linux kernel:

```
install -d /usr/share/doc/linux-4.7.2
cp -r Documentation/* /usr/share/doc/linux-4.7.2
```

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-4.7.2` 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-4.7.2 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-4.7.2`, `vmlinuz-4.7.2-lfs-7.10-systemd`, and `System.map-4.7.2`
Installed directories: `/lib/modules`, `/usr/share/doc/linux-4.7.2`

Short Descriptions

<code>config-4.7.2</code>	Contains all the configuration selections for the kernel
<code>vmlinuz-4.7.2-lfs-7.10-systemd</code>	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
<code>System.map-4.7.2</code>	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
```



Note

Most newer systems now come with system firmware that is in UEFI (Unified Extensible Firmware Interface) mode by default. To boot LFS on these systems using the instructions here, the UEFI Mode and Secure Boot capabilities need to be turned off. There are ways to boot with these capabilities still enabled, but then are not covered here. For details, see *the lfs-uefi.txt hint* at <http://www.linuxfromscratch.org/hints/downloads/files/lfs-uefi.txt>.

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`:

```
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 4.7.2-lfs-7.10-systemd" {
    linux /boot/vmlinuz-4.7.2-lfs-7.10-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`:

```
cat > /etc/os-release << "EOF"
NAME="Linux From Scratch"
VERSION="7.10-systemd"
ID=lfs
PRETTY_NAME="Linux From Scratch 7.10-systemd"
VERSION_CODENAME="<your name here>"
EOF
```

Creating the file `/etc/lfs-release` is recommended for compatibility with the 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:

```
echo 7.10-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:

```
cat > /etc/lsb-release << "EOF"
DISTRIB_ID="Linux From Scratch"
DISTRIB_RELEASE="7.10-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 *dhcpcd* 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 7.10* 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>.

- 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>.

- 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/>.

- 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>.

- 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/>.

Part IV. Appendices

Appendix A. Acronyms and Terms

ABI	Application Binary Interface
ALFS	Automated Linux From Scratch
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
BIOS	Basic Input/Output System
BLFS	Beyond Linux From Scratch
BSD	Berkeley Software Distribution
chroot	change root
CMOS	Complementary Metal Oxide Semiconductor
COS	Class Of Service
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CVS	Concurrent Versions System
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name Service
EGA	Enhanced Graphics Adapter
ELF	Executable and Linkable Format
EOF	End of File
EQN	equation
ext2	second extended file system
ext3	third extended file system
ext4	fourth extended file system
FAQ	Frequently Asked Questions
FHS	Filesystem Hierarchy Standard
FIFO	First-In, First Out
FQDN	Fully Qualified Domain Name
FTP	File Transfer Protocol
GB	Gigabytes
GCC	GNU Compiler Collection
GID	Group Identifier
GMT	Greenwich Mean Time
HTML	Hypertext Markup Language
IDE	Integrated Drive Electronics
IEEE	Institute of Electrical and Electronic Engineers

IO	Input/Output
IP	Internet Protocol
IPC	Inter-Process Communication
IRC	Internet Relay Chat
ISO	International Organization for Standardization
ISP	Internet Service Provider
KB	Kilobytes
LED	Light Emitting Diode
LFS	Linux From Scratch
LSB	Linux Standard Base
MB	Megabytes
MBR	Master Boot Record
MD5	Message Digest 5
NIC	Network Interface Card
NLS	Native Language Support
NNTP	Network News Transport Protocol
NPTL	Native POSIX Threading Library
OSS	Open Sound System
PCH	Pre-Compiled Headers
PCRE	Perl Compatible Regular Expression
PID	Process Identifier
PTY	pseudo terminal
QOS	Quality Of Service
RAM	Random Access Memory
RPC	Remote Procedure Call
RTC	Real Time Clock
SBU	Standard Build Unit
SCO	The Santa Cruz Operation
SHA1	Secure-Hash Algorithm 1
TLDP	The Linux Documentation Project
TFTP	Trivial File Transfer Protocol
TLS	Thread-Local Storage
UID	User Identifier
umask	user file-creation mask
USB	Universal Serial Bus
UTC	Coordinated Universal Time

UUID	Universally Unique Identifier
VC	Virtual Console
VGA	Video Graphics Array
VT	Virtual Terminal

Appendix B. Acknowledgments

We would like to thank the following people and organizations for their contributions to the Linux From Scratch Project.

- *Gerard Beekmans* <gerard@linuxfromscratch.org> – LFS Creator, LFS Project Leader
- *Matthew Burgess* <matthew@linuxfromscratch.org> – LFS Project Leader, LFS Technical Writer/Editor
- *Bruce Dubbs* <bdubbs@linuxfromscratch.org> – LFS Release Manager, LFS Technical Writer/Editor
- *Jim Gifford* <jim@linuxfromscratch.org> – CLFS Project Co-Leader
- *Bryan Kadzban* <bryan@linuxfromscratch.org> – LFS Technical Writer
- *Randy McMurphy* <randy@linuxfromscratch.org> – BLFS Project Leader, LFS Editor
- *DJ Lucas* <dj@linuxfromscratch.org> – LFS and BLFS Editor
- *Ken Moffat* <ken@linuxfromscratch.org> – LFS and CLFS Editor
- *Ryan Oliver* <ryan@linuxfromscratch.org> – CLFS Project Co-Leader
- Countless other people on the various LFS and BLFS mailing lists who helped make this book possible by giving their suggestions, testing the book, and submitting bug reports, instructions, and their experiences with installing various packages.

Translators

- *Manuel Canales Esparcia* <macana@macana-es.com> – Spanish LFS translation project
- *Johan Lenglet* <johan@linuxfromscratch.org> – French LFS translation project until 2008
- *Jean-Philippe Mengual* <jmengual@linuxfromscratch.org> – French LFS translation project 2008-present
- *Anderson Lizardo* <lizardo@linuxfromscratch.org> – Portuguese LFS translation project
- *Thomas Reitelbach* <tr@erdfunkstelle.de> – German LFS translation project

Mirror Maintainers

North American Mirrors

- *Scott Kveton* <scott@osuosl.org> – lfs.oregonstate.edu mirror
- *William Astle* <lost@l-w.net> – ca.linuxfromscratch.org mirror
- *Eujon Sellers* <jpolen@rackspace.com> – lfs.introspeed.com mirror
- *Justin Knierim* <tim@idge.net> – lfs-matrix.net mirror

South American Mirrors

- *Manuel Canales Esparcia* <manuel@linuxfromscratch.org> – lfsmirror.lfs-es.info mirror
- *Luis Falcon* <Luis Falcon> – torredehanoi.org mirror

European Mirrors

- *Guido Passet* <guido@primerelay.net> – nl.linuxfromscratch.org mirror
- *Bastiaan Jacques* <baafie@planet.nl> – lfs.pagefault.net mirror

- *Sven Cranshoff* <sven.cranshoff@lineo.be> – lfs.lineo.be mirror
- *Scarlet Belgium* – lfs.scarlet.be mirror
- *Sebastian Faulborn* <info@aliensoft.org> – lfs.aliensoft.org mirror
- *Stuart Fox* <stuart@dontuse.ms> – lfs.dontuse.ms mirror
- *Ralf Uhlemann* <admin@realhost.de> – lfs.oss-mirror.org mirror
- *Antonin Sprinzl* <Antonin.Sprinzl@tuwien.ac.at> – at.linuxfromscratch.org mirror
- *Fredrik Danerklint* <fredan-lfs@fredan.org> – se.linuxfromscratch.org mirror
- *Franck* <franck@linuxpourtous.com> – lfs.linuxpourtous.com mirror
- *Philippe Baque* <baque@cict.fr> – lfs.cict.fr mirror
- *Vitaly Chekasin* <gyouja@pilgrims.ru> – lfs.pilgrims.ru mirror
- *Benjamin Heil* <kontakt@wankoo.org> – lfs.wankoo.org mirror

Asian Mirrors

- *Satit Phermsawang* <satit@wbac.ac.th> – lfs.phayoune.org mirror
- *Shizunet Co.,Ltd.* <info@shizu-net.jp> – lfs.mirror.shizu-net.jp mirror
- *Init World* <<http://www.initworld.com/>> – lfs.initworld.com mirror

Australian Mirrors

- *Jason Andrade* <jason@dstc.edu.au> – au.linuxfromscratch.org mirror

Former Project Team Members

- *Christine Barczak* <theladyskye@linuxfromscratch.org> – LFS Book Editor
- *Archaic* <archaic@linuxfromscratch.org> – LFS Technical Writer/Editor, HLFS Project Leader, BLFS Editor, Hints and Patches Project Maintainer
- *Nathan Coulson* <nathan@linuxfromscratch.org> – LFS-Bootscripts Maintainer
- Timothy Bauscher
- Robert Briggs
- Ian Chilton
- *Jeroen Coumans* <jeroen@linuxfromscratch.org> – Website Developer, FAQ Maintainer
- *Manuel Canales Esparcia* <manuel@linuxfromscratch.org> – LFS/BLFS/HLFS XML and XSL Maintainer
- Alex Groenewoud – LFS Technical Writer
- Marc Heerdink
- *Jeremy Huntwork* <jhuntwork@linuxfromscratch.org> – LFS Technical Writer, LFS LiveCD Maintainer
- Mark Hymers
- Seth W. Klein – FAQ maintainer
- *Nicholas Leippe* <nicholas@linuxfromscratch.org> – Wiki Maintainer
- *Anderson Lizardo* <lizardo@linuxfromscratch.org> – Website Backend-Scripts Maintainer

- *Dan Nicholson* <dnicholson@linuxfromscratch.org> – LFS and BLFS Editor
- *Alexander E. Patrakov* <alexander@linuxfromscratch.org> – LFS Technical Writer, LFS Internationalization Editor, LFS Live CD Maintainer
- *Simon Perreault*
- *Scot Mc Pherson* <scot@linuxfromscratch.org> – LFS NNTP Gateway Maintainer
- *Greg Schafer* <gschafer@zip.com.au> – LFS Technical Writer and Architect of the Next Generation 64-bit-enabling Build Method
- *Jesse Tie-Ten-Quee* – LFS Technical Writer
- *James Robertson* <jwrober@linuxfromscratch.org> – Bugzilla Maintainer
- *Tushar Teredesai* <tushar@linuxfromscratch.org> – BLFS Book Editor, Hints and Patches Project Leader
- *Jeremy Utley* <jeremy@linuxfromscratch.org> – LFS Technical Writer, Bugzilla Maintainer, LFS-Bootscripts Maintainer
- *Zack Winkles* <zwinkles@gmail.com> – LFS Technical Writer

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, 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
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

Bash

Installation depends on: Bash, Binutils, Bison, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, Make, Ncurses, Patch, Readline, Sed, and Texinfo

Test suite depends on: Shadow

Must be installed before: None

Optional dependencies: Xorg

Bc

Installation depends on: Bash, Binutils, Bison, Coreutils, GCC, Glibc, Grep, Make, and Readline

Test suite depends on: Gawk

Must be installed before: Linux Kernel

Optional dependencies: None

Binutils

Installation depends on: Bash, Binutils, Coreutils, Diffutils, File, Gawk, GCC, Glibc, Grep, Make, Perl, Sed, Texinfo and Zlib

Test suite depends on: DejaGNU and Expect

Must be installed before: None

Optional dependencies: None

Bison

Installation depends on: Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, M4, Make, Perl, and Sed

Test suite depends on: Diffutils, Findutils, and Flex

Must be installed before: Kbd and Tar

Optional dependencies: Doxygen (test suite)

Bzip2

Installation depends on: Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, Make, and Patch

Test suite depends on: None

Must be installed before: None

Optional dependencies: None

Check

Installation depends on: GCC, Grep, Make, Sed, and Texinfo

Test suite depends on: None

Must be installed before: None

Optional dependencies: None

Coreutils

Installation depends on: Bash, Binutils, Coreutils, GCC, Gettext, Glibc, GMP, Grep, Make, Patch, Perl, Sed, and Texinfo

Test suite depends on: Diffutils, E2fsprogs, Findutils, Shadow, and Util-linux

Must be installed before: Bash, Diffutils, Findutils, Man-DB, and Eudev

Optional dependencies: Perl Expect and IO:Tty modules (for test suite)

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

Eudev

Installation depends on: Bash, Binutils, Coreutils, Gawk, GCC, Glibc, Grep, Gperf, Make, and Sed
Test suite depends on: None
Must be installed before: None
Optional dependencies: None

Expat

Installation depends on: Bash, Binutils, Coreutils, Gawk, GCC, Glibc, Grep, 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

Findutils

Installation depends on: Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Sed, and Texinfo
Test suite depends on: DejaGNU, Diffutils, and Expect
Must be installed before: None
Optional dependencies: None

Flex

Installation depends on: Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, M4, Make, Patch, Sed, and Texinfo
Test suite depends on: Bison and Gawk
Must be installed before: IPRoute2, Kbd, and Man-DB
Optional dependencies: None

Gawk

Installation depends on: Bash, Binutils, Coreutils, GCC, Gettext, Glibc, GMP, Grep, Make, MPFR, Patch, Readline, Sed and Texinfo
Test suite depends on: Diffutils
Must be installed before: None
Optional dependencies: None

Gcc

Installation depends on: Bash, Binutils, Coreutils, Diffutils, Findutils, Gawk, GCC, Gettext, Glibc, GMP, Grep, M4, Make, MPC, MPFR, Patch, Perl, Sed, Tar, and Texinfo
Test suite depends on: DejaGNU and Expect
Must be installed before: None
Optional dependencies: *CLooG-PPL*, *GNAT* and *PPL*

GDBM

Installation depends on: Bash, Binutils, Coreutils, Diffutils, GCC, Grep, Make, and Sed
Test suite depends on: None
Must be installed before: None
Optional dependencies: None

Gettext

Installation depends on: Bash, Binutils, Coreutils, Gawk, GCC, Glibc, Grep, Make, Sed, and Texinfo
Test suite depends on: Diffutils, Perl, and Tcl
Must be installed before: Automake
Optional dependencies: None

Glibc

Installation depends on: Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Gettext, Grep, Gzip, Linux API Headers, Make, Perl, Sed, and Texinfo
Test suite depends on: File
Must be installed before: None
Optional dependencies: None

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

lana-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, and Zlib

Test suite depends on: No test suite available

Must be installed before: Eudev

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: None

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: Gawk, 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, Gawk
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: Cracklib

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

Sysklogd

Installation depends on: Binutils, Coreutils, GCC, Glibc, Make, and Patch
Test suite depends on: No test suite available
Must be installed before: None
Optional dependencies: None

Sysvinit

Installation depends on: Binutils, Coreutils, GCC, Glibc, Make, and Sed
Test suite depends on: No test suite available
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, Eudev, and Zlib
Test suite depends on:	None
Must be installed before:	None
Optional dependencies:	<i>libcap-ng</i>

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, Eudev
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

Appendix D. LFS Licenses

This book is licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 2.0 License.

Computer instructions may be extracted from the book under the MIT License.

D.1. Creative Commons License

Creative Commons Legal Code

Attribution-NonCommercial-ShareAlike 2.0



Important

CREATIVE COMMONS CORPORATION IS NOT A LAW FIRM AND DOES NOT PROVIDE LEGAL SERVICES. DISTRIBUTION OF THIS LICENSE DOES NOT CREATE AN ATTORNEY-CLIENT RELATIONSHIP. CREATIVE COMMONS PROVIDES THIS INFORMATION ON AN "AS-IS" BASIS. CREATIVE COMMONS MAKES NO WARRANTIES REGARDING THE INFORMATION PROVIDED, AND DISCLAIMS LIABILITY FOR DAMAGES RESULTING FROM ITS USE.

License

THE WORK (AS DEFINED BELOW) IS PROVIDED UNDER THE TERMS OF THIS CREATIVE COMMONS PUBLIC LICENSE ("CCPL" OR "LICENSE"). THE WORK IS PROTECTED BY COPYRIGHT AND/OR OTHER APPLICABLE LAW. ANY USE OF THE WORK OTHER THAN AS AUTHORIZED UNDER THIS LICENSE OR COPYRIGHT LAW IS PROHIBITED.

BY EXERCISING ANY RIGHTS TO THE WORK PROVIDED HERE, YOU ACCEPT AND AGREE TO BE BOUND BY THE TERMS OF THIS LICENSE. THE LICENSOR GRANTS YOU THE RIGHTS CONTAINED HERE IN CONSIDERATION OF YOUR ACCEPTANCE OF SUCH TERMS AND CONDITIONS.

1. Definitions

- a. "Collective Work" means a work, such as a periodical issue, anthology or encyclopedia, in which the Work in its entirety in unmodified form, along with a number of other contributions, constituting separate and independent works in themselves, are assembled into a collective whole. A work that constitutes a Collective Work will not be considered a Derivative Work (as defined below) for the purposes of this License.
- b. "Derivative Work" means a work based upon the Work or upon the Work and other pre-existing works, such as a translation, musical arrangement, dramatization, fictionalization, motion picture version, sound recording, art reproduction, abridgment, condensation, or any other form in which the Work may be recast, transformed, or adapted, except that a work that constitutes a Collective Work will not be considered a Derivative Work for the purpose of this License. For the avoidance of doubt, where the Work is a musical composition or sound recording, the synchronization of the Work in timed-relation with a moving image ("synching") will be considered a Derivative Work for the purpose of this License.
- c. "Licensor" means the individual or entity that offers the Work under the terms of this License.
- d. "Original Author" means the individual or entity who created the Work.
- e. "Work" means the copyrightable work of authorship offered under the terms of this License.
- f. "You" means an individual or entity exercising rights under this License who has not previously violated the terms of this License with respect to the Work, or who has received express permission from the Licensor to exercise rights under this License despite a previous violation.

- g. "License Elements" means the following high-level license attributes as selected by Licensor and indicated in the title of this License: Attribution, Noncommercial, ShareAlike.
2. Fair Use Rights. Nothing in this license is intended to reduce, limit, or restrict any rights arising from fair use, first sale or other limitations on the exclusive rights of the copyright owner under copyright law or other applicable laws.
 3. License Grant. Subject to the terms and conditions of this License, Licensor hereby grants You a worldwide, royalty-free, non-exclusive, perpetual (for the duration of the applicable copyright) license to exercise the rights in the Work as stated below:
 - a. to reproduce the Work, to incorporate the Work into one or more Collective Works, and to reproduce the Work as incorporated in the Collective Works;
 - b. to create and reproduce Derivative Works;
 - c. to distribute copies or phonorecords of, display publicly, perform publicly, and perform publicly by means of a digital audio transmission the Work including as incorporated in Collective Works;
 - d. to distribute copies or phonorecords of, display publicly, perform publicly, and perform publicly by means of a digital audio transmission Derivative Works;

The above rights may be exercised in all media and formats whether now known or hereafter devised. The above rights include the right to make such modifications as are technically necessary to exercise the rights in other media and formats. All rights not expressly granted by Licensor are hereby reserved, including but not limited to the rights set forth in Sections 4(e) and 4(f).

4. Restrictions. The license granted in Section 3 above is expressly made subject to and limited by the following restrictions:
 - a. You may distribute, publicly display, publicly perform, or publicly digitally perform the Work only under the terms of this License, and You must include a copy of, or the Uniform Resource Identifier for, this License with every copy or phonorecord of the Work You distribute, publicly display, publicly perform, or publicly digitally perform. You may not offer or impose any terms on the Work that alter or restrict the terms of this License or the recipients' exercise of the rights granted hereunder. You may not sublicense the Work. You must keep intact all notices that refer to this License and to the disclaimer of warranties. You may not distribute, publicly display, publicly perform, or publicly digitally perform the Work with any technological measures that control access or use of the Work in a manner inconsistent with the terms of this License Agreement. The above applies to the Work as incorporated in a Collective Work, but this does not require the Collective Work apart from the Work itself to be made subject to the terms of this License. If You create a Collective Work, upon notice from any Licensor You must, to the extent practicable, remove from the Collective Work any reference to such Licensor or the Original Author, as requested. If You create a Derivative Work, upon notice from any Licensor You must, to the extent practicable, remove from the Derivative Work any reference to such Licensor or the Original Author, as requested.
 - b. You may distribute, publicly display, publicly perform, or publicly digitally perform a Derivative Work only under the terms of this License, a later version of this License with the same License Elements as this License, or a Creative Commons iCommons license that contains the same License Elements as this License (e.g. Attribution-NonCommercial-ShareAlike 2.0 Japan). You must include a copy of, or the Uniform Resource Identifier for, this License or other license specified in the previous sentence with every copy or phonorecord of each Derivative Work You distribute, publicly display, publicly perform, or publicly digitally perform. You may not offer or impose any terms on the Derivative Works that alter or restrict the terms of this License or the recipients' exercise of the rights granted hereunder, and You must keep intact all notices that refer to this License and to the disclaimer of warranties. You may not distribute, publicly display, publicly perform, or publicly digitally perform the Derivative Work with any technological measures that control access or use of the Work in a manner

inconsistent with the terms of this License Agreement. The above applies to the Derivative Work as incorporated in a Collective Work, but this does not require the Collective Work apart from the Derivative Work itself to be made subject to the terms of this License.

- c. You may not exercise any of the rights granted to You in Section 3 above in any manner that is primarily intended for or directed toward commercial advantage or private monetary compensation. The exchange of the Work for other copyrighted works by means of digital file-sharing or otherwise shall not be considered to be intended for or directed toward commercial advantage or private monetary compensation, provided there is no payment of any monetary compensation in connection with the exchange of copyrighted works.
- d. If you distribute, publicly display, publicly perform, or publicly digitally perform the Work or any Derivative Works or Collective Works, You must keep intact all copyright notices for the Work and give the Original Author credit reasonable to the medium or means You are utilizing by conveying the name (or pseudonym if applicable) of the Original Author if supplied; the title of the Work if supplied; to the extent reasonably practicable, the Uniform Resource Identifier, if any, that Licensor specifies to be associated with the Work, unless such URI does not refer to the copyright notice or licensing information for the Work; and in the case of a Derivative Work, a credit identifying the use of the Work in the Derivative Work (e.g., "French translation of the Work by Original Author," or "Screenplay based on original Work by Original Author"). Such credit may be implemented in any reasonable manner; provided, however, that in the case of a Derivative Work or Collective Work, at a minimum such credit will appear where any other comparable authorship credit appears and in a manner at least as prominent as such other comparable authorship credit.
- e. For the avoidance of doubt, where the Work is a musical composition:
 - i. Performance Royalties Under Blanket Licenses. Licensor reserves the exclusive right to collect, whether individually or via a performance rights society (e.g. ASCAP, BMI, SESAC), royalties for the public performance or public digital performance (e.g. webcast) of the Work if that performance is primarily intended for or directed toward commercial advantage or private monetary compensation.
 - ii. Mechanical Rights and Statutory Royalties. Licensor reserves the exclusive right to collect, whether individually or via a music rights agency or designated agent (e.g. Harry Fox Agency), royalties for any phonorecord You create from the Work ("cover version") and distribute, subject to the compulsory license created by 17 USC Section 115 of the US Copyright Act (or the equivalent in other jurisdictions), if Your distribution of such cover version is primarily intended for or directed toward commercial advantage or private monetary compensation.
- f. Webcasting Rights and Statutory Royalties. For the avoidance of doubt, where the Work is a sound recording, Licensor reserves the exclusive right to collect, whether individually or via a performance-rights society (e.g. SoundExchange), royalties for the public digital performance (e.g. webcast) of the Work, subject to the compulsory license created by 17 USC Section 114 of the US Copyright Act (or the equivalent in other jurisdictions), if Your public digital performance is primarily intended for or directed toward commercial advantage or private monetary compensation.

5. Representations, Warranties and Disclaimer

UNLESS OTHERWISE MUTUALLY AGREED TO BY THE PARTIES IN WRITING, LICENSOR OFFERS THE WORK AS-IS AND MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND CONCERNING THE WORK, EXPRESS, IMPLIED, STATUTORY OR OTHERWISE, INCLUDING, WITHOUT LIMITATION, WARRANTIES OF TITLE, MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NON-INFRINGEMENT, OR THE ABSENCE OF LATENT OR OTHER DEFECTS, ACCURACY, OR THE PRESENCE OF ABSENCE OF ERRORS, WHETHER OR NOT DISCOVERABLE. SOME JURISDICTIONS DO NOT ALLOW THE EXCLUSION OF IMPLIED WARRANTIES, SO SUCH EXCLUSION MAY NOT APPLY TO YOU.

6. **Limitation on Liability.** EXCEPT TO THE EXTENT REQUIRED BY APPLICABLE LAW, IN NO EVENT WILL LICENSOR BE LIABLE TO YOU ON ANY LEGAL THEORY FOR ANY SPECIAL, INCIDENTAL, CONSEQUENTIAL, PUNITIVE OR EXEMPLARY DAMAGES ARISING OUT OF THIS LICENSE OR THE USE OF THE WORK, EVEN IF LICENSOR HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.
7. **Termination**
 - a. This License and the rights granted hereunder will terminate automatically upon any breach by You of the terms of this License. Individuals or entities who have received Derivative Works or Collective Works from You under this License, however, will not have their licenses terminated provided such individuals or entities remain in full compliance with those licenses. Sections 1, 2, 5, 6, 7, and 8 will survive any termination of this License.
 - b. Subject to the above terms and conditions, the license granted here is perpetual (for the duration of the applicable copyright in the Work). Notwithstanding the above, Licensor reserves the right to release the Work under different license terms or to stop distributing the Work at any time; provided, however that any such election will not serve to withdraw this License (or any other license that has been, or is required to be, granted under the terms of this License), and this License will continue in full force and effect unless terminated as stated above.
8. **Miscellaneous**
 - a. Each time You distribute or publicly digitally perform the Work or a Collective Work, the Licensor offers to the recipient a license to the Work on the same terms and conditions as the license granted to You under this License.
 - b. Each time You distribute or publicly digitally perform a Derivative Work, Licensor offers to the recipient a license to the original Work on the same terms and conditions as the license granted to You under this License.
 - c. If any provision of this License is invalid or unenforceable under applicable law, it shall not affect the validity or enforceability of the remainder of the terms of this License, and without further action by the parties to this agreement, such provision shall be reformed to the minimum extent necessary to make such provision valid and enforceable.
 - d. No term or provision of this License shall be deemed waived and no breach consented to unless such waiver or consent shall be in writing and signed by the party to be charged with such waiver or consent.
 - e. This License constitutes the entire agreement between the parties with respect to the Work licensed here. There are no understandings, agreements or representations with respect to the Work not specified here. Licensor shall not be bound by any additional provisions that may appear in any communication from You. This License may not be modified without the mutual written agreement of the Licensor and You.



Important

Creative Commons is not a party to this License, and makes no warranty whatsoever in connection with the Work. Creative Commons will not be liable to You or any party on any legal theory for any damages whatsoever, including without limitation any general, special, incidental or consequential damages arising in connection to this license. Notwithstanding the foregoing two (2) sentences, if Creative Commons has expressly identified itself as the Licensor hereunder, it shall have all rights and obligations of Licensor.

Except for the limited purpose of indicating to the public that the Work is licensed under the CCPL, neither party will use the trademark "Creative Commons" or any related trademark or logo of Creative Commons without the prior written consent of Creative Commons. Any permitted use will be in compliance with Creative Commons' then-current trademark usage guidelines, as may be published on its website or otherwise made available upon request from time to time.

Creative Commons may be contacted at <http://creativecommons.org/>.

D.2. The MIT License

Copyright © 1999-2016 Gerard Beekmans

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

Index

Packages

- Acl: 123
- Attr: 122
- Autoconf: 153
- Automake: 155
- Bash: 139
 - tools: 60
- Bash: 139
 - tools: 60
- Bc: 141
- Binutils: 105
 - tools, pass 1: 37
 - tools, pass 2: 48
- Binutils: 105
 - tools, pass 1: 37
 - tools, pass 2: 48
- Binutils: 105
 - tools, pass 1: 37
 - tools, pass 2: 48
- Bison: 134
- Bzip2: 116
 - tools: 61
- Bzip2: 116
 - tools: 61
- Check: 58
- Coreutils: 172
 - tools: 62
- Coreutils: 172
 - tools: 62
- D-Bus: 195
- DejaGNU: 57
- Diffutils: 177
 - tools: 63
- Diffutils: 177
 - tools: 63
- E2fsprogs: 169
- Expat: 145
- Expect: 55
- File: 104
 - tools: 64
- File: 104
 - tools: 64
- Findutils: 179
 - tools: 65
- Findutils: 179
 - tools: 65
- Flex: 135
- Gawk: 178
 - tools: 66
- Gawk: 178
 - tools: 66
- GCC: 111
 - tools, libstdc++: 46
 - tools, pass 1: 39
 - tools, pass 2: 50
- GCC: 111
 - tools, libstdc++: 46
 - tools, pass 1: 39
 - tools, pass 2: 50
- GCC: 111
 - tools, libstdc++: 46
 - tools, pass 1: 39
 - tools, pass 2: 50
- GCC: 111
 - tools, libstdc++: 46
 - tools, pass 1: 39
 - tools, pass 2: 50
- GCC: 111
 - tools, libstdc++: 46
 - tools, pass 1: 39
 - tools, pass 2: 50
- GDBM: 143
- Gettext: 160
 - tools: 67
- Gettext: 160
 - tools: 67
- Glibc: 94
 - tools: 43
- Glibc: 94
 - tools: 43
- GMP: 107
- Gperf: 144
- Grep: 136
 - tools: 68
- Grep: 136
 - tools: 68
- Groff: 180
- GRUB: 183
- Gzip: 186
 - tools: 69
- Gzip: 186
 - tools: 69
- Iana-Etc: 132
- Inetutils: 146
- Intltool: 152

IPRoute2: 188
 Kbd: 190
 Kmod: 158
 Less: 185
 Libcap: 125
 Libpipeline: 192
 Libtool: 142
 Linux: 231
 API headers: 92
 tools, API headers: 42
 Linux: 231
 API headers: 92
 tools, API headers: 42
 Linux: 231
 API headers: 92
 tools, API headers: 42
 M4: 133
 tools: 70
 M4: 133
 tools: 70
 Make: 193
 tools: 71
 Make: 193
 tools: 71
 Man-DB: 202
 Man-pages: 93
 MPC: 110
 MPFR: 109
 Ncurses: 119
 tools: 59
 Ncurses: 119
 tools: 59
 Patch: 194
 tools: 72
 Patch: 194
 tools: 72
 Perl: 148
 tools: 73
 Perl: 148
 tools: 73
 Pkgconfig: 118
 Procps-ng: 167
 Psmisc: 131
 Readline: 137
 Sed: 126
 tools: 74
 Sed: 126

 tools: 74
 Shadow: 127
 configuring: 128
 Shadow: 127
 configuring: 128
 systemd: 162
 Tar: 205
 tools: 75
 Tar: 205
 tools: 75
 Tcl-core: 53
 Texinfo: 206
 tools: 76
 Texinfo: 206
 tools: 76
 Udev
 usage: 216
 Util-linux: 197
 tools: 77
 Util-linux: 197
 tools: 77
 Vim: 208
 XML::Parser: 151
 Xz: 156
 tools: 78
 Xz: 156
 tools: 78
 Zlib: 103

Programs

a2p: 148, 149
 accessdb: 202, 203
 aclocal: 155, 155
 aclocal-1.15: 155, 155
 addftinfo: 180, 180
 addpart: 197, 198
 addr2line: 105, 106
 afmtodit: 180, 180
 agetty: 197, 198
 apropos: 202, 204
 ar: 105, 106
 as: 105, 106
 attr: 122, 122
 autoconf: 153, 153
 autoheader: 153, 153
 autom4te: 153, 153
 automake: 155, 155

automake-1.15: 155, 155
 autopoint: 160, 160
 autoreconf: 153, 153
 autoscan: 153, 153
 autoupdate: 153, 153
 awk: 178, 178
 badblocks: 169, 170
 base64: 172, 173, 172, 173
 base64: 172, 173, 172, 173
 basename: 172, 173
 bash: 139, 140
 bashbug: 139, 140
 bc: 141, 141
 bison: 134, 134
 blkdiscard: 197, 198
 blkid: 197, 198
 blockdev: 197, 198
 bootctl: 162, 164
 bridge: 188, 188
 bunzip2: 116, 117
 busctl: 162, 164
 bzcat: 116, 117
 bzcmp: 116, 117
 bzdiff: 116, 117
 bzegrep: 116, 117
 bzfgrep: 116, 117
 bzgrep: 116, 117
 bzip2: 116, 117
 bzip2recover: 116, 117
 bzless: 116, 117
 bzmores: 116, 117
 c++: 111, 114
 c++filt: 105, 106
 c2ph: 148, 149
 cal: 197, 198
 capsh: 125, 125
 captinfo: 119, 120
 cat: 172, 173
 catchsegv: 94, 99
 catman: 202, 204
 cc: 111, 114
 cfdisk: 197, 198
 chacl: 123, 123
 chage: 127, 129
 chattr: 169, 170
 chcon: 172, 173
 chcpu: 197, 198
 checkmk: 58, 58
 chem: 180, 180
 chfn: 127, 129
 chgpasswd: 127, 129
 chgrp: 172, 173
 chmod: 172, 173
 chown: 172, 174
 chpasswd: 127, 129
 chroot: 172, 174
 chrt: 197, 198
 chsh: 127, 129
 chvt: 190, 191
 cksum: 172, 174
 clear: 119, 121
 cmp: 177, 177
 code: 179, 179
 col: 197, 198
 colcrt: 197, 198
 colrm: 197, 198
 column: 197, 198
 comm: 172, 174
 compile_et: 169, 170
 coredumpctl: 162, 165
 corelist: 148, 149
 cp: 172, 174
 cpan: 148, 149
 cpan2dist: 148, 149
 cpanp: 148, 149
 cpanp-run-perl: 148, 149
 cpp: 111, 114
 csplit: 172, 174
 ctrlaltdel: 197, 198
 ctstat: 188, 188
 cut: 172, 174
 date: 172, 174
 dbus-cleanup-sockets: 195, 196
 dbus-daemon: 195, 196
 dbus-launch: 195, 196
 dbus-monitor: 195, 196
 dbus-run-session: 195, 196
 dbus-send: 195, 196
 dbus-uuidgen: 195, 196
 dc: 141, 141
 dd: 172, 174
 deallocvt: 190, 191
 debugfs: 169, 170
 delpart: 197, 198

depmod: 158, 158
 df: 172, 174
 diff: 177, 177
 diff3: 177, 177
 dir: 172, 174
 dircolors: 172, 174
 dirname: 172, 174
 dmesg: 197, 198
 dnsdomainname: 146, 147
 du: 172, 174
 dumpe2fs: 169, 171
 dumpkeys: 190, 191
 e2freefrag: 169, 171
 e2fsck: 169, 171
 e2image: 169, 171
 e2label: 169, 171
 e2undo: 169, 171
 e4defrag: 169, 171
 echo: 172, 174
 egrep: 136, 136
 eject: 197, 198
 elfedit: 105, 106
 enc2xs: 148, 149
 encguess: 148, 149
 env: 172, 174
 envsubst: 160, 160
 eqn: 180, 180
 eqn2graph: 180, 180
 ex: 208, 209
 expand: 172, 174
 expect: 55, 56
 expiry: 127, 129
 expr: 172, 174
 factor: 172, 174
 faillog: 127, 129
 fallocate: 197, 199
 false: 172, 174
 fdformat: 197, 199
 fdisk: 197, 199
 fgconsole: 190, 191
 fgrep: 136, 136
 file: 104, 104
 filefrag: 169, 171
 find: 179, 179
 find2perl: 148, 149
 findfs: 197, 199
 findmnt: 197, 199
 flex: 135, 135
 flex++: 135, 135
 flock: 197, 199
 fmt: 172, 174
 fold: 172, 174
 free: 167, 167
 fsck: 197, 199
 fsck.cramfs: 197, 199
 fsck.ext2: 169, 171
 fsck.ext3: 169, 171
 fsck.ext4: 169, 171
 fsck.ext4dev: 169, 171
 fsck.minix: 197, 199
 fsfreeze: 197, 199
 fstrim: 197, 199
 ftp: 146, 147
 fuser: 131, 131
 g++: 111, 114
 gawk: 178, 178
 gawk-4.1.3: 178, 178
 gcc: 111, 114
 gc-ar: 111, 114
 gc-nm: 111, 114
 gc-ranlib: 111, 115
 gcov: 111, 115
 gdbmtool: 143, 143
 gdbm_dump: 143, 143
 gdbm_load: 143, 143
 gdiffmk: 180, 180
 gencat: 94, 99
 genl: 188, 188
 getcap: 125, 125
 getconf: 94, 99
 getent: 94, 99
 getfacl: 123, 124
 getfattr: 122, 122
 getkeycodes: 190, 191
 getopt: 197, 199
 getpcaps: 125, 125
 gettext: 160, 160
 gettext.sh: 160, 160
 gettextize: 160, 160
 glilypond: 180, 180
 gpasswd: 127, 129
 gperf: 144, 144
 gperl: 180, 180
 gpinyin: 180, 180

gprof: 105, 106
 grap2graph: 180, 181
 grep: 136, 136
 grn: 180, 181
 grodvi: 180, 181
 groff: 180, 181
 groffer: 180, 181
 grog: 180, 181
 grolbp: 180, 181
 grolj4: 180, 181
 gropdf: 180, 181
 groups: 180, 181
 grotty: 180, 181
 groupadd: 127, 129
 groupdel: 127, 129
 groupmems: 127, 129
 groupmod: 127, 129
 groups: 172, 174
 grpck: 127, 129
 grpconv: 127, 129
 grpunconv: 127, 129
 grub-bios-setup: 183, 183
 grub-editenv: 183, 183
 grub-file: 183, 183
 grub-fstest: 183, 183
 grub-glue-efi: 183, 184
 grub-install: 183, 184
 grub-kbdcomp: 183, 184
 grub-macbless: 183, 184
 grub-menulst2cfg: 183, 184
 grub-mkconfig: 183, 184
 grub-mkimage: 183, 184
 grub-mklayout: 183, 184
 grub-mknetdir: 183, 184
 grub-mkpasswd-pbkdf2: 183, 184
 grub-mkreldir: 183, 184
 grub-mkrescue: 183, 184
 grub-mkstandalone: 183, 184
 grub-ofpathname: 183, 184
 grub-probe: 183, 184
 grub-reboot: 183, 184
 grub-render-label: 183, 184
 grub-script-check: 183, 184
 grub-set-default: 183, 184
 grub-setup: 183, 184
 grub-syslinux2cfg: 183, 184
 gunzip: 186, 186
 gzexe: 186, 186
 gzip: 186, 186
 h2ph: 148, 149
 h2xs: 148, 149
 halt: 162, 165
 head: 172, 174
 hexdump: 197, 199
 hostid: 172, 174
 hostname: 146, 147
 hostname: 160, 160
 hostnamed: 162, 165
 hpftodit: 180, 181
 hwclock: 197, 199
 i386: 197, 199
 iconv: 94, 99
 iconvconfig: 94, 99
 id: 172, 174
 ifcfg: 188, 188
 ifconfig: 146, 147
 ifnames: 153, 153
 ifstat: 188, 188
 igawk: 178, 178
 indxbib: 180, 181
 info: 206, 207
 infocmp: 119, 121
 infotocap: 119, 121
 init: 162, 165
 insmod: 158, 159
 install: 172, 174
 install-info: 206, 207
 instmodsh: 148, 149
 intltool-extract: 152, 152
 intltool-merge: 152, 152
 intltool-prepare: 152, 152
 intltool-update: 152, 152
 intltoolize: 152, 152
 ionice: 197, 199
 ip: 188, 188
 ipcmk: 197, 199
 ipcrm: 197, 199
 ipcs: 197, 199
 isosize: 197, 199
 join: 172, 174
 journalctl: 162, 165
 json_pp: 148, 149
 kbdfinfo: 190, 191
 kbdrate: 190, 191

kbd_mode: 190, 191
 kernel-install: 162, 165
 kill: 197, 199
 killall: 131, 131
 kmod: 158, 159
 last: 197, 199
 lastb: 197, 199
 lastlog: 127, 129
 ld: 105, 106
 ld.bfd: 105, 106
 ldattach: 197, 199
 ldconfig: 94, 99
 ldd: 94, 99
 lddlibc4: 94, 99
 less: 185, 185
 lessecho: 185, 185
 lesskey: 185, 185
 lex: 135, 135
 lexgrog: 202, 204
 lfskernel-4.7.2: 231, 235
 libasan: 111, 115
 libnetcfg: 148, 149
 libtool: 142, 142
 libtoolize: 142, 142
 link: 172, 174
 linux32: 197, 199
 linux64: 197, 199
 lkbib: 180, 181
 ln: 172, 174
 lstat: 188, 189
 loadkeys: 190, 191
 loadunimap: 190, 191
 locale: 94, 99
 localectl: 162, 165
 localedef: 94, 99
 locate: 179, 179
 logger: 197, 199
 login: 127, 129
 loginctl: 162, 165
 logname: 172, 174
 logoutd: 127, 129
 logsave: 169, 171
 look: 197, 199
 lookbib: 180, 181
 losetup: 197, 199
 ls: 172, 174
 lsattr: 169, 171
 lsblk: 197, 199
 lscpu: 197, 199
 lsipc: 197, 199
 lslocks: 197, 199
 lslogins: 197, 199
 lsmode: 158, 159
 lzcat: 156, 156
 lzcmp: 156, 156
 lzdiff: 156, 156
 lzegrep: 156, 157
 lzfgrep: 156, 157
 lzgrep: 156, 157
 lzless: 156, 157
 lzma: 156, 157
 lzmadec: 156, 157
 lzmainfo: 156, 157
 lzmore: 156, 157
 m4: 133, 133
 machinectl: 162, 165
 make: 193, 193
 makedb: 94, 99
 makeinfo: 206, 207
 man: 202, 204
 mandb: 202, 204
 manpath: 202, 204
 mapscrn: 190, 191
 mcookie: 197, 200
 md5sum: 172, 174
 mesg: 197, 200
 mkdir: 172, 175
 mke2fs: 169, 171
 mkfifo: 172, 175
 mkfs: 197, 200
 mkfs.bfs: 197, 200
 mkfs.cramfs: 197, 200
 mkfs.ext2: 169, 171
 mkfs.ext3: 169, 171
 mkfs.ext4: 169, 171
 mkfs.ext4dev: 169, 171
 mkfs.minix: 197, 200
 mklost+found: 169, 171
 mknod: 172, 175
 mkswap: 197, 200
 mktemp: 172, 175
 mk_cmds: 169, 171
 mmroff: 180, 181
 modinfo: 158, 159

modprobe: 158, 159
 more: 197, 200
 mount: 197, 200
 mountpoint: 197, 200
 msgattrib: 160, 161
 msgcat: 160, 161
 msgcmp: 160, 161
 msgcomm: 160, 161
 msgconv: 160, 161
 msgen: 160, 161
 msgexec: 160, 161
 msgfilter: 160, 161
 msgfmt: 160, 161
 msggrep: 160, 161
 msginit: 160, 161
 msgmerge: 160, 161
 msgunfmt: 160, 161
 msguniq: 160, 161
 mtrace: 94, 99
 mv: 172, 175
 namei: 197, 200
 ncursesw6-config: 119, 121
 neqn: 180, 181
 networkctl: 162, 165
 newgidmap: 127, 129
 newgrp: 127, 129
 newuidmap: 127, 129
 newusers: 127, 129
 ngettext: 160, 161
 nice: 172, 175
 nl: 172, 175
 nm: 105, 106
 nohup: 172, 175
 nologin: 127, 129
 nproc: 172, 175
 nroff: 180, 181
 nscd: 94, 99
 nsenter: 197, 200
 nstat: 188, 189
 numfmt: 172, 175
 objcopy: 105, 106
 objdump: 105, 106
 od: 172, 175
 oldfind: 179, 179
 openvt: 190, 191
 partx: 197, 200
 passwd: 127, 129
 paste: 172, 175
 patch: 194, 194
 pathchk: 172, 175
 pdfmom: 180, 181
 pdffroff: 180, 181
 pdftexi2dvi: 206, 207
 peekfd: 131, 131
 perl: 148, 149
 perl5.24.0: 148, 149
 perlbug: 148, 149
 perldoc: 148, 149
 perlvp: 148, 149
 perlthanks: 148, 149
 pfbtops: 180, 181
 pg: 197, 200
 pgrep: 167, 168
 pic: 180, 181
 pic2graph: 180, 181
 piconv: 148, 150
 pidof: 167, 168
 ping: 146, 147
 ping6: 146, 147
 pinky: 172, 175
 pivot_root: 197, 200
 pkg-config: 118, 118
 pkill: 167, 168
 pl2pm: 148, 150
 pldd: 94, 99
 pmap: 167, 168
 pod2html: 148, 150
 pod2latex: 148, 150
 pod2man: 148, 150
 pod2texi: 206, 207
 pod2text: 148, 150
 pod2usage: 148, 150
 podchecker: 148, 150
 podselect: 148, 150
 post-grohtml: 180, 181
 poweroff: 162, 165
 pr: 172, 175
 pre-grohtml: 180, 181
 preconv: 180, 181
 printenv: 172, 175
 printf: 172, 175
 prlimit: 197, 200
 prove: 148, 150
 prtstat: 131, 131

ps: 167, 168
 psfaddtable: 190, 191
 psfgettable: 190, 191
 psfstriptime: 190, 191
 psfxtable: 190, 191
 pstree: 131, 131
 pstree.x11: 131, 131
 pstruct: 148, 150
 ptar: 148, 150
 ptardiff: 148, 150
 ptargrep: 148, 150
 ptx: 172, 175
 pwck: 127, 129
 pwconv: 127, 129
 pwd: 172, 175
 pwdx: 167, 168
 pwunconv: 127, 129
 ranlib: 105, 106
 raw: 197, 200
 readelf: 105, 106
 readlink: 172, 175
 readprofile: 197, 200
 realpath: 172, 175
 reboot: 162, 165
 recode-sr-latin: 160, 161
 refer: 180, 181
 rename: 197, 200
 renice: 197, 200
 reset: 119, 121
 resize2fs: 169, 171
 resizepart: 197, 200
 rev: 197, 200
 rm: 172, 175
 rmdir: 172, 175
 rmmod: 158, 159
 roff2dvi: 180, 181
 roff2html: 180, 182
 roff2pdf: 180, 182
 roff2ps: 180, 182
 roff2text: 180, 182
 roff2x: 180, 182
 routef: 188, 189
 routel: 188, 189
 rpcgen: 94, 99
 rtacct: 188, 189
 rtcwake: 197, 200
 rtmon: 188, 189
 rtpr: 188, 189
 rtstat: 188, 189
 runcon: 172, 175
 runlevel: 162, 165
 runtest: 57, 57
 rview: 208, 210
 rvim: 208, 210
 s2p: 148, 150
 script: 197, 200
 scriptreplay: 197, 200
 sdiff: 177, 177
 sed: 126, 126
 seq: 172, 175
 setacl: 123, 124
 setarch: 197, 200
 setattr: 122, 122
 setfont: 190, 191
 setkeycodes: 190, 191
 settled: 190, 191
 setmetamode: 190, 191
 setsid: 197, 200
 setterm: 197, 200
 setvtrgb: 190, 191
 sfdisk: 197, 200
 sg: 127, 130
 sh: 139, 140
 sha1sum: 172, 175
 sha224sum: 172, 175
 sha256sum: 172, 175
 sha384sum: 172, 175
 sha512sum: 172, 175
 shasum: 148, 150
 showconsolefont: 190, 191
 showkey: 190, 191
 shred: 172, 175
 shuf: 172, 175
 shutdown: 162, 165
 size: 105, 106
 slabtop: 167, 168
 sleep: 172, 175
 sln: 94, 99
 soelim: 180, 182
 sort: 172, 175
 sotruss: 94, 99
 splain: 148, 150
 split: 172, 175
 sprof: 94, 99

ss: 188, 189
 stat: 172, 176
 stdbuf: 172, 176
 strings: 105, 106
 strip: 105, 106
 stty: 172, 176
 su: 127, 130
 sulogin: 197, 200
 sum: 172, 176
 swapon: 197, 200
 swapoff: 197, 200
 swapon: 197, 200
 switch_root: 197, 200
 sync: 172, 176
 sysctl: 167, 168
 systemctl: 162, 165
 systemd-analyze: 162, 165
 systemd-ask-password: 162, 165
 systemd-cat: 162, 165
 systemd-cgls: 162, 165
 systemd-cgtop: 162, 165
 systemd-delta: 162, 165
 systemd-detect-virt: 162, 165
 systemd-escape: 162, 165
 systemd-hwdb: 162, 165
 systemd-inhibit: 162, 165
 systemd-machine-id-setup: 162, 166
 systemd-notify: 162, 166
 systemd-nspawn: 162, 166
 systemd-path: 162, 166
 systemd-resolve: 162, 166
 systemd-run: 162, 166
 systemd-tmpfiles: 162, 166
 systemd-tty-ask-password-agent: 162, 166
 tabs: 119, 121
 tac: 172, 176
 tail: 172, 176
 tailf: 197, 200
 talk: 146, 147
 tar: 205, 205
 taskset: 197, 201
 tbl: 180, 182
 tc: 188, 189
 tclsh: 53, 54
 tclsh8.6: 53, 54
 tee: 172, 176
 telinit: 162, 166
 telnet: 146, 147
 test: 172, 176
 texi2dvi: 206, 207
 texi2pdf: 206, 207
 texi2any: 206, 207
 texindex: 206, 207
 tfmtodit: 180, 182
 tftp: 146, 147
 tic: 119, 121
 timedatectl: 162, 166
 timeout: 172, 176
 tload: 167, 168
 toe: 119, 121
 top: 167, 168
 touch: 172, 176
 tput: 119, 121
 tr: 172, 176
 traceroute: 146, 147
 troff: 180, 182
 true: 172, 176
 truncate: 172, 176
 tset: 119, 121
 tsort: 172, 176
 tty: 172, 176
 tune2fs: 169, 171
 tzselect: 94, 99
 udevadm: 162, 166
 ul: 197, 201
 umount: 197, 201
 uname: 172, 176
 uname26: 197, 201
 uncompress: 186, 186
 unexpand: 172, 176
 unicode_start: 190, 191
 unicode_stop: 190, 191
 uniq: 172, 176
 unlink: 172, 176
 unlzma: 156, 157
 unshare: 197, 201
 unxz: 156, 157
 updatedb: 179, 179
 uptime: 167, 168
 useradd: 127, 130
 userdel: 127, 130
 usermod: 127, 130
 users: 172, 176
 utmpdump: 197, 201

uuid: 197, 201
 uuidgen: 197, 201
 vdir: 172, 176
 vi: 208, 210
 view: 208, 210
 vigr: 127, 130
 vim: 208, 210
 vimdiff: 208, 210
 vimtutor: 208, 210
 vipw: 127, 130
 vmstat: 167, 168
 w: 167, 168
 wall: 197, 201
 watch: 167, 168
 wc: 172, 176
 wdctl: 197, 201
 whatis: 202, 204
 whereis: 197, 201
 who: 172, 176
 whoami: 172, 176
 wipefs: 197, 201
 x86_64: 197, 201
 xargs: 179, 179
 xgettext: 160, 161
 xmlwf: 145, 145
 xsubpp: 148, 150
 xtrace: 94, 100
 xxd: 208, 210
 xz: 156, 157
 xzcat: 156, 157
 xzcmp: 156, 157
 xzdec: 156, 157
 xzdiff: 156, 157
 xzegrep: 156, 157
 xzfgrep: 156, 157
 xzgrep: 156, 157
 xzless: 156, 157
 xzmore: 156, 157
 yacc: 134, 134
 yes: 172, 176
 zcat: 186, 186
 zcmp: 186, 186
 zdiff: 186, 186
 zdump: 94, 100
 zegrep: 186, 186
 zfgrep: 186, 186
 zforce: 186, 186

zgrep: 186, 186
 zic: 94, 100
 zipdetails: 148, 150
 zless: 186, 186
 zmore: 186, 187
 znew: 186, 187
 zramctl: 197, 201

Libraries

Expat: 151, 151
 ld-2.24.so: 94, 100
 libacl: 123, 124
 libanl: 94, 100
 libasprintf: 160, 161
 libattr: 122, 122
 libbfd: 105, 106
 libblkid: 197, 201
 libBrokenLocale: 94, 100
 libbz2: 116, 117
 libc: 94, 100
 libcap: 125, 125
 libcheck: 58, 58
 libcidn: 94, 100
 libcom_err: 169, 171
 libcrypt: 94, 100
 libcursesw: 119, 121
 libdbus-1: 195, 196
 libdl: 94, 100
 libe2p: 169, 171
 libexpat: 145, 145
 libexpect-5.45: 55, 56
 libext2fs: 169, 171
 libfdisk: 197, 201
 libfl: 135, 135
 libformw: 119, 121
 libg: 94, 100
 libgcc: 111, 115
 libgcov: 111, 115
 libgdbm: 143, 143
 libgdbm_compat: 143, 143
 libgettextlib: 160, 161
 libgettextpo: 160, 161
 libgettextsrc: 160, 161
 libgmp: 107, 108
 libgmpxx: 107, 108
 libgomp: 111, 115
 libhistory: 137, 138

libiberty: 111, 115
 libieee: 94, 100
 libkmod: 158
 libltdl: 142, 142
 liblto_plugin: 111, 115
 liblzma: 156, 157
 libm: 94, 100
 libmagic: 104, 104
 libman: 202, 204
 libmandb: 202, 204
 libmcheck: 94, 100
 libmemusage: 94, 100
 libmenuw: 119, 121
 libmount: 197, 201
 libmpc: 110, 110
 libmpfr: 109, 109
 libncursesw: 119, 121
 libnsl: 94, 100
 libnss: 94, 100
 libopcodes: 105, 106
 libpanelw: 119, 121
 libpipeline: 192
 libprocps: 167, 168
 libpthread: 94, 100
 libquadmath: 111, 115
 libreadline: 137, 138
 libresolv: 94, 100
 librpcsvc: 94, 100
 librt: 94, 100
 libSegFault: 94, 100
 libsmartcols: 197, 201
 libss: 169, 171
 libssp: 111, 115
 libstdbuf: 172, 176
 libstdc++: 111, 115
 libsupc++: 111, 115
 libsystemd: 162, 166
 libtcl8.6.so: 53, 54
 libtclstub8.6.a: 53, 54
 libthread_db: 94, 100
 libtsan: 111, 115
 libudev: 162, 166
 libutil: 94, 100
 libuuid: 197, 201
 liby: 134, 134
 libz: 103, 103
 preloadable_libintl: 160, 161

Scripts

clock
 configuring: 220
 console
 configuring: 221
 hostname
 configuring: 215
 localnet
 /etc/hosts: 215
 network
 /etc/hosts: 215
 configuring: 213
 network
 /etc/hosts: 215
 configuring: 213

Others

/boot/config-4.7.2: 231, 235
 /boot/System.map-4.7.2: 231, 235
 /dev/*: 82
 /etc/fstab: 229
 /etc/group: 88
 /etc/hosts: 215
 /etc/inputrc: 224
 /etc/ld.so.conf: 98
 /etc/lfs-release: 238
 /etc/localtime: 96
 /etc/lsb-release: 238
 /etc/modprobe.d/usb.conf: 234
 /etc/nsswitch.conf: 96
 /etc/os-release: 238
 /etc/passwd: 88
 /etc/protocols: 132
 /etc/resolv.conf: 214
 /etc/services: 132
 /etc/vimrc: 209
 /usr/include/asm-generic/*.h: 92, 92
 /usr/include/asm/*.h: 92, 92
 /usr/include/drm/*.h: 92, 92
 /usr/include/linux/*.h: 92, 92
 /usr/include/mtd/*.h: 92, 92
 /usr/include/rdma/*.h: 92, 92
 /usr/include/scsi/*.h: 92, 92
 /usr/include/sound/*.h: 92, 92
 /usr/include/video/*.h: 92, 92
 /usr/include/xen/*.h: 92, 92

/var/log/btmp: 88
/var/log/lastlog: 88
/var/log/wtmp: 88
/var/run/utmp: 88
/etc/locale.conf: 222
/etc/shells: 226
man pages: 93, 93
Systemd Customization: 226