

# Linux From Scratch

Version 9.0-systemd

Published September 1st, 2019

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

# Linux From Scratch: Version 9.0-systemd: Published September 1st, 2019

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

Copyright © 1999-2019 Gerard Beekmans

Copyright © 1999-2019, 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 .....	viii
v. Rationale for Packages in the Book .....	ix
vi. Prerequisites .....	xiv
vii. Typography .....	xiv
viii. Structure .....	xv
ix. Errata .....	xv
I. 介绍 .....	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 .....	3
1.4. Resources .....	6
1.5. Help .....	6
II. 准备构建 .....	9
2. Preparing the Host System .....	10
2.1. Introduction .....	10
2.2. Host System Requirements .....	10
2.3. Building LFS in Stages .....	13
2.4. Creating a New Partition .....	13
2.5. Creating a File System on the Partition .....	15
2.6. Setting The \$LFS Variable .....	15
2.7. Mounting the New Partition .....	16
3. Packages and Patches .....	18
3.1. Introduction .....	18
3.2. All Packages .....	18
3.3. Needed Patches .....	24
4. Final Preparations .....	26
4.1. Introduction .....	26
4.2. Creating the \$LFS/tools Directory .....	26
4.3. Adding the LFS User .....	26
4.4. Setting Up the Environment .....	27
4.5. About SBUs .....	28
4.6. About the Test Suites .....	28
5. Constructing a Temporary System .....	30
5.1. Introduction .....	30
5.2. Toolchain Technical Notes .....	30
5.3. General Compilation Instructions .....	31
5.4. Binutils-2.32 - Pass 1 .....	33
5.5. GCC-9.2.0 - Pass 1 .....	35
5.6. Linux-5.2.8 API Headers .....	38
5.7. Glibc-2.30 .....	39
5.8. Libstdc++ from GCC-9.2.0 .....	41
5.9. Binutils-2.32 - Pass 2 .....	42
5.10. GCC-9.2.0 - Pass 2 .....	43
5.11. Tcl-8.6.9 .....	46
5.12. Expect-5.45.4 .....	47
5.13. DejaGNU-1.6.2 .....	48
5.14. M4-1.4.18 .....	49
5.15. Ncurses-6.1 .....	50
5.16. Bash-5.0 .....	51
5.17. Bison-3.4.1 .....	52
5.18. Bzip2-1.0.8 .....	53
5.19. Coreutils-8.31 .....	54
5.20. Diffutils-3.7 .....	55

5.21. File-5.37 .....	56
5.22. Findutils-4.6.0 .....	57
5.23. Gawk-5.0.1 .....	58
5.24. Gettext-0.20.1 .....	59
5.25. Grep-3.3 .....	60
5.26. Gzip-1.10 .....	61
5.27. Make-4.2.1 .....	62
5.28. Patch-2.7.6 .....	63
5.29. Perl-5.30.0 .....	64
5.30. Python-3.7.4 .....	65
5.31. Sed-4.7 .....	66
5.32. Tar-1.32 .....	67
5.33. Texinfo-6.6 .....	68
5.34. Util-linux-2.34 .....	69
5.35. Xz-5.2.4 .....	70
5.36. Stripping .....	71
5.37. Changing Ownership .....	71
III. 构建 LFS 系统 .....	72
6. Installing Basic System Software .....	73
6.1. Introduction .....	73
6.2. Preparing Virtual Kernel File Systems .....	73
6.3. Package Management .....	74
6.4. Entering the Chroot Environment .....	77
6.5. Creating Directories .....	78
6.6. Creating Essential Files and Symlinks .....	78
6.7. Linux-5.2.8 API Headers .....	82
6.8. Man-pages-5.02 .....	83
6.9. Glibc-2.30 .....	84
6.10. Adjusting the Toolchain .....	90
6.11. Zlib-1.2.11 .....	92
6.12. File-5.37 .....	93
6.13. Readline-8.0 .....	94
6.14. M4-1.4.18 .....	95
6.15. Bc-2.1.3 .....	96
6.16. Binutils-2.32 .....	97
6.17. GMP-6.1.2 .....	99
6.18. MPFR-4.0.2 .....	101
6.19. MPC-1.1.0 .....	102
6.20. Shadow-4.7 .....	103
6.21. GCC-9.2.0 .....	106
6.22. Bzip2-1.0.8 .....	110
6.23. Pkg-config-0.29.2 .....	112
6.24. Ncurses-6.1 .....	113
6.25. Attr-2.4.48 .....	115
6.26. Acl-2.2.53 .....	116
6.27. Libcap-2.27 .....	117
6.28. Sed-4.7 .....	118
6.29. Psmisc-23.2 .....	119
6.30. Iana-Etc-2.30 .....	120
6.31. Bison-3.4.1 .....	121
6.32. Flex-2.6.4 .....	122
6.33. Grep-3.3 .....	123
6.34. Bash-5.0 .....	124
6.35. Libtool-2.4.6 .....	125
6.36. GDBM-1.18.1 .....	126
6.37. Gperf-3.1 .....	127
6.38. Expat-2.2.7 .....	128
6.39. Inetutils-1.9.4 .....	129
6.40. Perl-5.30.0 .....	131
6.41. XML::Parser-2.44 .....	133
6.42. Intltool-0.51.0 .....	134

6.43. Autoconf-2.69 .....	135
6.44. Automake-1.16.1 .....	136
6.45. Xz-5.2.4 .....	137
6.46. Kmod-26 .....	139
6.47. Gettext-0.20.1 .....	140
6.48. Libelf from Elfutils-0.177 .....	142
6.49. Libffi-3.2.1 .....	143
6.50. OpenSSL-1.1.1c .....	144
6.51. Python-3.7.4 .....	145
6.52. Ninja-1.9.0 .....	147
6.53. Meson-0.51.1 .....	148
6.54. Coreutils-8.31 .....	149
6.55. Check-0.12.0 .....	153
6.56. Diffutils-3.7 .....	154
6.57. Gawk-5.0.1 .....	155
6.58. Findutils-4.6.0 .....	156
6.59. Groff-1.22.4 .....	157
6.60. GRUB-2.04 .....	159
6.61. Less-551 .....	161
6.62. Gzip-1.10 .....	162
6.63. IPRoute2-5.2.0 .....	163
6.64. Kbd-2.2.0 .....	165
6.65. Libpipeline-1.5.1 .....	167
6.66. Make-4.2.1 .....	168
6.67. Patch-2.7.6 .....	169
6.68. Man-DB-2.8.6.1 .....	170
6.69. Tar-1.32 .....	172
6.70. Texinfo-6.6 .....	173
6.71. Vim-8.1.1846 .....	175
6.72. Systemd-241 .....	178
6.73. D-Bus-1.12.16 .....	183
6.74. Procs-ng-3.3.15 .....	185
6.75. Util-linux-2.34 .....	187
6.76. E2fsprogs-1.45.3 .....	191
6.77. About Debugging Symbols .....	194
6.78. Stripping Again .....	194
6.79. Cleaning Up .....	195
7. System Configuration .....	196
7.1. Introduction .....	196
7.2. General Network Configuration .....	196
7.3. Overview of Device and Module Handling .....	199
7.4. Managing Devices .....	202
7.5. Configuring the system clock .....	202
7.6. Configuring the Linux Console .....	203
7.7. Configuring the System Locale .....	204
7.8. Creating the /etc/inputrc File .....	206
7.9. Creating the /etc/shells File .....	207
7.10. Systemd Usage and Configuration .....	207
8. Making the LFS System Bootable .....	210
8.1. Introduction .....	210
8.2. Creating the /etc/fstab File .....	210
8.3. Linux-5.2.8 .....	211
8.4. Using GRUB to Set Up the Boot Process .....	215
9. The End .....	217
9.1. The End .....	217
9.2. Get Counted .....	217
9.3. Rebooting the System .....	217
9.4. What Now? .....	218
IV. 附录 .....	220
A. Acronyms and Terms .....	221
B. Acknowledgments .....	223

C. Dependencies .....	225
D. LFS Licenses .....	235
D.1. Creative Commons License .....	235
D.2. The MIT License .....	238
Index .....	239

# Preface

## Foreword

My journey to learn and better understand Linux began 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 nevertheless 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 of arbitrary programs 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.

### Note

The above discussion is only appropriate when comparing builds on the same hardware. Modern 64-bit systems are considerably faster than older 64-bit systems and the LFS authors recommend building on a 64-bit system when given a choice.

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 (2015)

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 special use: Gtk3 and Graphics. LFS attempts to conform to the architectures discussed in the previous section.



## Note

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

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

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

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

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

LSB Core:	At, Batch (a part of At), Cpio, Ed, Fcfront, Initd-tools, Lsb_release, NSPR, NSS, PAM, Pax, Sendmail (or Postfix or Exim), time
LSB Desktop:	Aalsa, ATK, Cairo, Desktop-file-utils, Freetype, Fontconfig, Gdk-pixbuf, Glib2, GTK+2, Icon-naming-utils, Libjpeg-turbo, Libpng, Libtiff, Libxml2, MesaLib, Pango, Xdg-utils, Xorg
LSB Runtime Languages:	Python, Libxml2, Libxslt
LSB Imaging:	CUPS, CUPS-filters, Ghostscript, SANE
LSB Gtk3 and LSB Graphics (Trial Use):	GTK+3

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

LSB Core:	None
LSB Desktop:	Qt4 (but Qt5 is provided)
LSB Runtime Languages:	None
LSB Imaging:	None
LSB Gtk3 and LSB Graphics (Trial Use):	None

## Rationale for Packages in the Book

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

- Acl

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

- Attr

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

- Autoconf

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

- Automake

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

- Bash

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

- Bc

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

- Binutils

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

- Bison

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

- Bzip2

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

- Check

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

- Coreutils

This package contains a number of essential programs for viewing and manipulating files and directories. These programs are needed for command line file management, and are necessary for the installation procedures of every package in LFS.

- D-Bus

This package contains programs to implement a message bus system, which a simple way for applications to talk to one another.

- 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.

- Libelf

The elfutils project provides libraries and tools for ELF files and DWARF data. Most utilities in this package are available in other packages, but the library is needed to build the Linux kernel using the default (and most efficient) configuration.

- Libffi

This package implements a portable, high level programming interface to various calling conventions. Some programs may not know at the time of compilation what arguments are to be passed to a function. For instance, an interpreter may be told at run-time about the number and types of arguments used to call a given function. Libffi can be used in such programs to provide a bridge from the interpreter program to compiled code.

- 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.

- Meson

This package provides a software tool for automating the building of software. The main goal for Meson is to minimize the amount of time that software developers need to spend configuring their build system.

- 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.

- Ninja

This package contains a small build system with a focus on speed. It is designed to have its input files generated by a higher-level build system, and to run builds as fast as possible.

- 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.

- Openssl

This package provides management tools and libraries relating to cryptography. These are useful for providing cryptographic functions to other packages, including the Linux kernel.

- 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.

- Python 3

This package provides an interpreted language that has a design philosophy that emphasizes code readability.

- 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.

- 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/systemd/> before proceeding with your build. You should note any changes shown and apply them to the relevant section of the book as you progress with building the LFS system.

# Part I. 介绍



# 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:

- 
- Bc 2.1.3
- Bison-3.4.1
- Bzip2-1.0.8
- Coreutils-8.31
- D-Bus-1.12.16
- E2fsprogs-1.45.3
- Expat-2.2.7

- File-5.37
- Gawk-5.0.1
- GCC-9.2.0
- Gettext-0.20.1
- Glibc-2.30
- GRUB-2.04
- IPRoute2-5.2.0
- Kbd-2.2.0
- Less-551
- LFS-Bootscripts-20190524
- Libcap-2.27
- Libelf-0.177 (from elfutils)
- Linux-5.2.8
- Man-DB-2.8.6.1
- Man-pages-5.02
- Meson-0.51.1
- Openssl-1.1.1c
- Perl-5.30.0
- Python-3.7.4
- Shadow-4.7
- Systemd-241
- Tar-1.32
- Texinfo-6.6
- Tzdata-2019b
- Util-Linux-2.34
- Vim-8.1.1846

Added:

- 

Removed:

- 

## 1.3. Changelog

This is version 9.0-systemd of the Linux From Scratch book, dated September 1st, 2019. 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:

- 2019-09-01
  - [bdubbs] - LFS-9.0 released.
- 2019-08-14
  - [bdubbs] - Update to vim-8.1.1846. Fixes #4500.
  - [bdubbs] - Update to elfutils-0.177. Fixes #4516.
  - [bdubbs] - Update to gcc-9.2.0. Fixes #4514.
  - [bdubbs] - Update to bc-2.1.3. Fixes #4513.
  - [bdubbs] - Update to man-db-2.8.6.1. Fixes #4512.
  - [bdubbs] - Update to linux-5.2.8. Fixes #4511.
- 2019-08-04
  - [bdubbs] - Fix a problem introduced by linux-5.2 by adding an include file to a glibc header.
- 2019-08-03

- [renodr] - Add a patch to systemd to fix issues with networkd on kernel versions 5.2+, and to fix issues with AMD Ryzen CPUs. Fixes #4506.
- [bdubbs] - Update to linux-5.2.5. Fixes #4505.
- [bdubbs] - Update to kbd-2.2.0. Fixes #4507.
- [bdubbs] - Update to glibc-2.30. Fixes #4508.
- [bdubbs] - Update to man-pages-5.02. Fixes #4509.
- 2019-07-21
  - [bdubbs] - Update to linux-5.2.2. Fixes #4504.
  - [bdubbs] - Update to bc-2.1.1. Fixes #4503.
  - [bdubbs] - Update to kbd-2.1.0. Fixes #4502.
  - [bdubbs] - Update to e2fsprogs-1.45.3. Fixes #4501.
- 2019-07-14
  - [bdubbs] - Fix testing of binutils-2.32 gold linker. Fixes #4498.
  - [bdubbs] - Update to tzdata-2019b. Fixes #4492.
  - [bdubbs] - Update to python3-3.7.4. Fixes #4496.
  - [bdubbs] - Update to meson-0.51.1. Fixes #4497.
  - [bdubbs] - Update to iproute2-5.2.0. Fixes #4495.
  - [bdubbs] - Update to grub-2.04. Fixes #4494.
  - [bdubbs] - Update to linux-5.2.1. Fixes #4493.
  - [bdubbs] - Update to bc-2.1.0. Fixes #4436.
  - [bdubbs] - Update to bzip2-1.0.8. Fixes #4499.
- 2019-07-12
  - [renodr] - Fix an FTBFS for systemd and do minor text and instructions improvements. Also, fix symlinks that were not removed.
- 2019-06-29
  - [bdubbs] - Properly initialize a data structure in OpenSSL to avoid valgrind uninitialized value errors. Fixes #4491.
  - [bdubbs] - Update to meson-0.51.0. Fixes #4483.
  - [bdubbs] - Update to gawk-5.0.1. Fixes #4486.
  - [bdubbs] - Update to expat-2.2.7. Fixes #4488.
  - [bdubbs] - Update to linux-5.1.15. Fixes #4487.
  - [bdubbs] - Update to bzip2-1.0.7. Fixes #4490.
- 2019-06-24
  - [renodr] - Fixed issue with installing Check's documentation in a versioned directory. Thanks goes to Ryan Marsaw for the report. This was fixed by removing the unrecognized/unused --docdir and replacing it with a "docdir=" in the make install command.
- 2019-06-18
  - [renodr] - Update to linux-5.1.11. Fixes the SOCK PANIC issue. Fixes #4485.
- 2019-06-16
  - [bdubbs] - Update to vim-8.1.1535. Fixes #4482.
  - [bdubbs] - Update to shadow-4.7. Fixes #4481.
  - [bdubbs] - Update to linux-5.1.10. Fixes #4478.
  - [bdubbs] - Update to less-551. Fixes #4477.
  - [bdubbs] - Update to util-linux-2.34. Fixes #4462.
  - [bdubbs] - Remove eudev instructions referring to /tools. Fixes #4480.
- 2019-06-12
  - [renodr] - Update to dbus-1.12.16. Fixes #4470.
- 2019-06-08

- [renodr] - make it so that the instructions for removing symlinks before building Util-Linux in Chapter 6 are only visible in systemd.
- 2019-06-03
  - [bdubbs] - Update to perl-5.30.0. Fixes #4474.
  - [bdubbs] - Update to linux-5.1.6. Fixes #4473.
  - [bdubbs] - Update to openssl-1.1.1c. Fixes #4476.
  - [bdubbs] - Update to bison-3.4.1. Fixes #4471.
  - [bdubbs] - Update to e2fsprogs-1.45.2. Fixes #4475.
- 2019-05-19
  - [bdubbs] - Update to man-pages-5.01. Fixes #4467.
  - [bdubbs] - Update to linux-5.1.3. Fixes #4464.
  - [bdubbs] - Update to iproute2-5.1.0. Fixes #4467.
  - [bdubbs] - Update to gettext-0.20.1. Fixes #4465.
  - [bdubbs] - Update to file-5.37. Fixes #4469.
  - [bdubbs] - Update to e2fsprogs-1.45.1. Fixes #4468.
- 2019-05-11
  - [pierre] - Fix a hardcoded path to /usr/bin/find in the systemd unit of man-db.
- 2019-05-03
  - [bdubbs] - Update to gcc-9.1.0. Fixes #4463.
  - [bdubbs] - Update to linux-5.0.11. Fixes #4461.
- 2019-04-23
  - [bdubbs] - Apply a change to allow Perl to build correctly when building with the latest versions of gcc.
- 2019-04-20
  - [bdubbs] - Update to perl-5.28.2. Fixes #4460.
  - [bdubbs] - Update to meson-0.50.1. Fixes #4459.
  - [bdubbs] - Update to linux-5.0.9. Fixes #4458.
  - [bdubbs] - Update to libcap-2.27. Fixes #4457.
  - [renodr] - Fix the syntax used for configuring automatic file creation and deletion.
- 2019-04-15
  - [bdubbs] - Update bzip2 url. Fixes #4450.
  - [bdubbs] - Update to util-linux-2.33.2. Fixes #4454.
  - [bdubbs] - Update to linux-5.0.7. Fixes #4449.
  - [bdubbs] - Update to gawk-5.0.0. Fixes #4455.
- 2019-03-27
  - [bdubbs] - Revert to meson-0.49.2.
- 2019-03-26
  - [bdubbs] - Update to tzdata2019a. Fixes #4448.
  - [bdubbs] - Update to Python-3.7.3. Fixes #4447.
- 2019-03-25
  - [bdubbs] - Update to iproute2-5.0.0. Fixes #4446.
  - [bdubbs] - Update to linux-5.0.4. Fixes #4444.
  - [xry111] - Use -ffile-prefix-map instead of -isystem and symlinks in the Glibc build to simplify the instruction.
- 2019-03-13
  - [xry111] - Update contents and short descriptions of packages. Fixes #4443.
- 2019-03-12
  - [bdubbs] - Update to meson-0.50.0. Fixes #4442.

- [bdubbs] - Update to coreutils-8.31. Fixes #4441.
- [bdubbs] - Update to linux-5.0.1. Fixes #4440.
- [bdubbs] - Update to man-pages-5.00. Fixes #4439.
- [bdubbs] - Update to e2fsprogs-1.45.0. Fixes #4438.
- 2019-03-08
  - [renodr] - Update to systemd-241. Fixes #4424.
- 2019-03-05
  - [bdubbs] - Update to linux-5.0. Fixes #4437.
- 2019-03-01
  - [bdubbs] - Update to texinfo-6.6. Fixes #4427.
  - [bdubbs] - Update to tar-1.32. Fixes #4431.
  - [bdubbs] - Update to openssl-1.1.1b. Fixes #4435.
  - [bdubbs] - Update to gcc-8.3.0. Fixes #4430.
  - [bdubbs] - Update to linux-4.20.13. Fixes #4434.
- 2019-03-01
  - [bdubbs] - LFS-8.4 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](http://www.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](http://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 9.0-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 -DALIASPATH=\"/mnt/lfs/usr/share/locale:.\"
-DLOCALEDIR=\"/mnt/lfs/usr/share/locale\"
-DLIBDIR=\"/mnt/lfs/usr/lib\"
-DINCLUDEDIR=\"/mnt/lfs/usr/include\" -DHAVE_CONFIG_H -I. -I.
-g -O2 -c getopt1.c
gcc -g -O2 -static -o make ar.o arscan.o commands.o dir.o
expand.o file.o function.o getopt.o implicit.o job.o main.o
misc.o read.o remake.o rule.o signame.o variable.o vpath.o
default.o remote-stub.o version.o opt1.o
-lutil job.o: In function `load_too_high':
/lfs/tmp/make-3.79.1/job.c:1565: undefined reference
to `getloadavg'
collect2: ld returned 1 exit status
make[2]: *** [make] Error 1
make[2]: Leaving directory `/lfs/tmp/make-3.79.1'
make[1]: *** [all-recursive] Error 1
make[1]: Leaving directory `/lfs/tmp/make-3.79.1'
make: *** [all-recursive-am] Error 2
```

In this case, many people would just include the bottom section:

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

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

An excellent article about asking for help on the Internet is available online at <http://catb.org/~esr/faqs/smart-questions.html>. Read and follow the hints in this document to increase the likelihood of getting the help you need.

## Part II. 准备构建



# 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-2.25 (Versions greater than 2.32 are not recommended as they have not been tested)
- Bison-2.7 (/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-6.2 including the C++ compiler, g++ (Versions greater than 9.2.0 are not recommended as they have not been tested)
- Glibc-2.11 (Versions greater than 2.30 are not recommended as they have not been tested)
- Grep-2.5.1a
- Gzip-1.3.12
- Linux Kernel-3.2

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 3.2 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 3.2 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-4.0
- Patch-2.5.4
- Perl-5.8.8
- Python-3.4
- 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`
python3 --version
sed --version | head -n1
tar --version | head -n1
makeinfo --version | head -n1 # texinfo version
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

```

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

## Note

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

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

## 2.4.1. 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](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.

Another consideration is the method that is used to log into the host system. If logging in through a graphical display manager, the user's `.bash_profile` is not normally used when a virtual terminal is started. In this case, add the export command to the `.bashrc` file for the user and `root`. In addition, some distributions have instructions to not run the `.bashrc` instructions in a non-interactive bash invocation. Be sure to add the export command before the test for non-interactive use.

## 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.

## Warning

The above instructions assume that you will not be restarting your computer throughout the LFS process. If you shut down your system, you will either need to remount the LFS partition each time you restart the build process or modify your host system's `/etc/fstab` file to automatically remount it upon boot. For example:

```
/dev/<xxx> /mnt/lfs ext4 defaults 1 1
```

If you use additional optional partitions, be sure to add them also.

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:

- **Ac1 (2.2.53) - 513 KB:**

Download: <http://download.savannah.gnu.org/releases/acl/acl-2.2.53.tar.gz>

MD5 sum: 007aabf1dbb550bcdde52a244cd1070

- **Attr (2.4.48) - 457 KB:**

Home page: <https://savannah.nongnu.org/projects/attr>

Download: <http://download.savannah.gnu.org/releases/attr/attr-2.4.48.tar.gz>

MD5 sum: bc1e5cb5c96d99b24886f1f527d3bb3d

- **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 (1.16.1) - 1,499 KB:**

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

Download: <http://ftp.gnu.org/gnu/automake/automake-1.16.1.tar.xz>

MD5 sum: 53f38e7591fa57c3d2cee682be668e5b

- Bash (5.0) - 9,898 KB:  
 Home page: <http://www.gnu.org/software/bash/>  
 Download: <http://ftp.gnu.org/gnu/bash/bash-5.0.tar.gz>  
 MD5 sum: 2b44b47b905be16f45709648f671820b
- Bc (2.1.3) - 233 KB:  
 Home page: <https://github.com/gavinhoward/bc>  
 Download: <https://github.com/gavinhoward/bc/archive/2.1.3/bc-2.1.3.tar.gz>  
 MD5 sum: 2a882dc39c0fb8e36c12f590d54cc039
- Binutils (2.32) - 20,288 KB:  
 Home page: <http://www.gnu.org/software/binutils/>  
 Download: <http://ftp.gnu.org/gnu/binutils/binutils-2.32.tar.xz>  
 MD5 sum: 0d174cdaf85721c5723bf52355be41e6
- Bison (3.4.1) - 2,147 KB:  
 Home page: <http://www.gnu.org/software/bison/>  
 Download: <http://ftp.gnu.org/gnu/bison/bison-3.4.1.tar.xz>  
 MD5 sum: 201286a573b12da109df96282fe4ff4a
- Bzip2 (1.0.8) - 792 KB:  
 Download: <https://www.sourceware.org/pub/bzip2/bzip2-1.0.8.tar.gz>  
 MD5 sum: 67e051268d0c475ea773822f7500d0e5
- Check (0.12.0) - 747 KB:  
 Home page: <https://libcheck.github.io/check>  
 Download: <https://github.com/libcheck/check/releases/download/0.12.0/check-0.12.0.tar.gz>  
 MD5 sum: 31b17c6075820a434119592941186f70
- Coreutils (8.31) - 5,284 KB:  
 Home page: <http://www.gnu.org/software/coreutils/>  
 Download: <http://ftp.gnu.org/gnu/coreutils/coreutils-8.31.tar.xz>  
 MD5 sum: 0009a224d8e288e8ec406ef0161f9293
- D-Bus (1.12.16) - 2,048 KB:  
 Home page: <https://www.freedesktop.org/wiki/Software/dbus>  
 Download: <https://dbus.freedesktop.org/releases/dbus/dbus-1.12.16.tar.gz>  
 MD5 sum: 2dbeae80dfc9e3632320c6a53d5e8890
- DejaGNU (1.6.2) - 514 KB:  
 Home page: <http://www.gnu.org/software/dejagnu/>  
 Download: <http://ftp.gnu.org/gnu/dejagnu/dejagnu-1.6.2.tar.gz>  
 MD5 sum: e1b07516533f351b3aba3423fafeffd6
- Diffutils (3.7) - 1,415 KB:  
 Home page: <http://www.gnu.org/software/diffutils/>  
 Download: <http://ftp.gnu.org/gnu/diffutils/diffutils-3.7.tar.xz>  
 MD5 sum: 4824adc0e95dbbf11dfbdfaad6a1e461
- E2fsprogs (1.45.3) - 7,741 KB:  
 Home page: <http://e2fsprogs.sourceforge.net/>  
 Download: <https://downloads.sourceforge.net/project/e2fsprogs/e2fsprogs/v1.45.3/e2fsprogs-1.45.3.tar.gz>  
 MD5 sum: 447a225c05f0a81121f6ddffbf55b06c
- Elfutils (0.177) - 8,645 KB:  
 Home page: <https://sourceware.org/ftp/elfutils/>  
 Download: <https://sourceware.org/ftp/elfutils/0.177/elfutils-0.177.tar.bz2>  
 MD5 sum: 0b583722f911e1632544718d502aab87
- Expat (2.2.7) - 415 KB:  
 Home page: <https://libexpat.github.io/>  
 Download: <https://prdownloads.sourceforge.net/expat/expat-2.2.7.tar.xz>  
 MD5 sum: 3659bc0938db78815b5f5a9c24d732aa

- Expect (5.45.4) - 618 KB:  
Home page: <https://core.tcl.tk/expect/>  
Download: <https://prdownloads.sourceforge.net/expect/expect5.45.4.tar.gz>  
MD5 sum: 00fce8de158422f5ccd2666512329bd2
- File (5.37) - 867 KB:  
Home page: <https://www.darwinsys.com/file/>  
Download: <ftp://ftp.astron.com/pub/file/file-5.37.tar.gz>  
MD5 sum: 80c29aca745466c6c24d11f059329075

## Note

File (5.37) 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 (2.6.4) - 1,386 KB:  
Home page: <https://github.com/westes/flex>  
Download: <https://github.com/westes/flex/releases/download/v2.6.4/flex-2.6.4.tar.gz>  
MD5 sum: 2882e3179748cc9f9c23ec593d6adc8d
- Gawk (5.0.1) - 3,063 KB:  
Home page: <http://www.gnu.org/software/gawk/>  
Download: <http://ftp.gnu.org/gnu/gawk/gawk-5.0.1.tar.xz>  
MD5 sum: f9db3f6715207c6f13719713abc9c707
- GCC (9.2.0) - 68,953 KB:  
Home page: <https://gcc.gnu.org/>  
Download: <http://ftp.gnu.org/gnu/gcc/gcc-9.2.0/gcc-9.2.0.tar.xz>  
MD5 sum: 3818ad8600447f05349098232c2ddc78
- GDBM (1.18.1) - 920 KB:  
Home page: <http://www.gnu.org/software/gdbm/>  
Download: <http://ftp.gnu.org/gnu/gdbm/gdbm-1.18.1.tar.gz>  
MD5 sum: 988dc82182121c7570e0cb8b4fcd5415
- Gettext (0.20.1) - 9,128 KB:  
Home page: <http://www.gnu.org/software/gettext/>  
Download: <http://ftp.gnu.org/gnu/gettext/gettext-0.20.1.tar.xz>  
MD5 sum: 9ed9e26ab613b668e0026222a9c23639
- Glibc (2.30) - 16,189 KB:  
Home page: <http://www.gnu.org/software/libc/>  
Download: <http://ftp.gnu.org/gnu/glibc/glibc-2.30.tar.xz>  
MD5 sum: 2b1dbdf27b28620752956c061d62f60c
- GMP (6.1.2) - 1,901 KB:  
Home page: <http://www.gnu.org/software/gmp/>  
Download: <http://ftp.gnu.org/gnu/gmp/gmp-6.1.2.tar.xz>  
MD5 sum: f58fa8001d60c4c77595fbbb62b63c1d
- Gperf (3.1) - 1,188 KB:  
Home page: <http://www.gnu.org/software/gperf/>  
Download: <http://ftp.gnu.org/gnu/gperf/gperf-3.1.tar.gz>  
MD5 sum: 9e251c0a618ad0824b51117d5d9db87e
- Grep (3.3) - 1,440 KB:  
Home page: <http://www.gnu.org/software/grep/>  
Download: <http://ftp.gnu.org/gnu/grep/grep-3.3.tar.xz>  
MD5 sum: 05d0718a1b7cc706a4bdf8115363f1ed

- Groff (1.22.4) - 4,044 KB:  
 Home page: <http://www.gnu.org/software/groff/>  
 Download: <http://ftp.gnu.org/gnu/groff/groff-1.22.4.tar.gz>  
 MD5 sum: 08fb04335e2f5e73f23ea4c3adbf0c5f
- GRUB (2.04) - 6,245 KB:  
 Home page: <http://www.gnu.org/software/grub/>  
 Download: <https://ftp.gnu.org/gnu/grub/grub-2.04.tar.xz>  
 MD5 sum: 5aaca6713b47ca2456d8324a58755ac7
- Gzip (1.10) - 757 KB:  
 Home page: <http://www.gnu.org/software/gzip/>  
 Download: <http://ftp.gnu.org/gnu/gzip/gzip-1.10.tar.xz>  
 MD5 sum: 691b1221694c3394f1c537df4eee39d3
- 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
- Intlttool (0.51.0) - 159 KB:  
 Home page: <https://freedesktop.org/wiki/Software/intlttool>  
 Download: <https://launchpad.net/intlttool/trunk/0.51.0/+download/intlttool-0.51.0.tar.gz>  
 MD5 sum: 12e517cac2b57a0121cda351570f1e63
- IPRoute2 (5.2.0) - 713 KB:  
 Home page: <https://www.kernel.org/pub/linux/utils/net/iproute2/>  
 Download: <https://www.kernel.org/pub/linux/utils/net/iproute2/iproute2-5.2.0.tar.xz>  
 MD5 sum: 0cb2736e7bc2f56254a363d3d23703b7
- Kbd (2.2.0) - 1,090 KB:  
 Home page: <http://ftp.altlinux.org/pub/people/legion/kbd>  
 Download: <https://www.kernel.org/pub/linux/utils/kbd/kbd-2.2.0.tar.xz>  
 MD5 sum: d1d7ae0b5fb875dc082731e09cd0c8bc
- Kmod (26) - 540 KB:  
 Download: <https://www.kernel.org/pub/linux/utils/kernel/kmod/kmod-26.tar.xz>  
 MD5 sum: 1129c243199bdd7db01b55a61aa19601
- Less (551) - 339 KB:  
 Home page: <http://www.greenwoodsoftware.com/less/>  
 Download: <http://www.greenwoodsoftware.com/less/less-551.tar.gz>  
 MD5 sum: 4ad4408b06d7a6626a055cb453f36819
- Libcap (2.27) - 67 KB:  
 Home page: <https://sites.google.com/site/fullycapable/>  
 Download: <https://www.kernel.org/pub/linux/libs/security/linux-privs/libcap2/libcap-2.27.tar.xz>  
 MD5 sum: 2e8f9fab32eb5ccb37969fe317fd17aa
- Libffi (3.2.1) - 920 KB:  
 Home page: <https://sourceware.org/libffi/>  
 Download: <ftp://sourceware.org/pub/libffi/libffi-3.2.1.tar.gz>  
 MD5 sum: 83b89587607e3eb65c70d361f13bab43
- Libpipeline (1.5.1) - 965 KB:  
 Home page: <http://libpipeline.nongnu.org/>  
 Download: <http://download.savannah.gnu.org/releases/libpipeline/libpipeline-1.5.1.tar.gz>  
 MD5 sum: 4c8fe6cd85422baafd6e060f896c61bc
- 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: 1bfb9b923f2c1339b4d2ce1807064aa5

- Linux (5.2.8) - 104,555 KB:  
Home page: <https://www.kernel.org/>  
Download: <https://www.kernel.org/pub/linux/kernel/v5.x/linux-5.2.8.tar.xz>  
MD5 sum: 602dd0ecb8646e539fefb2beb6eb6fe0

## Note

The Linux kernel is updated relatively often, many times due to discoveries of security vulnerabilities. The latest available 5.2.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 (1.4.18) - 1,180 KB:  
Home page: <http://www.gnu.org/software/m4/>  
Download: <http://ftp.gnu.org/gnu/m4/m4-1.4.18.tar.xz>  
MD5 sum: 730bb15d96fffe47e148d1e09235af82
- Make (4.2.1) - 1,932 KB:  
Home page: <http://www.gnu.org/software/make/>  
Download: <http://ftp.gnu.org/gnu/make/make-4.2.1.tar.gz>  
MD5 sum: 7d0dcb6c474b258aab4d54098f2cf5a7
- Man-DB (2.8.6.1) - 1,787 KB:  
Home page: <https://www.nongnu.org/man-db/>  
Download: <http://download.savannah.gnu.org/releases/man-db/man-db-2.8.6.1.tar.xz>  
MD5 sum: 22e82fe1127f4ca95de7100168a927d1
- Man-pages (5.02) - 1,630 KB:  
Home page: <https://www.kernel.org/doc/man-pages/>  
Download: <https://www.kernel.org/pub/linux/docs/man-pages/man-pages-5.02.tar.xz>  
MD5 sum: 136e5e3380963571a079693d8ae38f52
- Meson (0.51.1) - 1,418 KB:  
Home page: <https://mesonbuild.com>  
Download: <https://github.com/mesonbuild/meson/releases/download/0.51.1/meson-0.51.1.tar.gz>  
MD5 sum: 48787e391ec5c052799a3dd491f73909
- MPC (1.1.0) - 685 KB:  
Home page: <http://www.multiprecision.org/>  
Download: <https://ftp.gnu.org/gnu/mpc/mpc-1.1.0.tar.gz>  
MD5 sum: 4125404e41e482ec68282a2e687f6c73
- MPFR (4.0.2) - 1,409 KB:  
Home page: <https://www.mpfr.org/>  
Download: <http://www.mpfr.org/mpfr-4.0.2/mpfr-4.0.2.tar.xz>  
MD5 sum: 320fbc4463d4c8cb1e566929d8adc4f8
- Ninja (1.9.0) - 187 KB:  
Home page: <https://ninja-build.org/>  
Download: <https://github.com/ninja-build/ninja/archive/v1.9.0/ninja-1.9.0.tar.gz>  
MD5 sum: f340be768a76724b83e6daab69009902
- Ncurses (6.1) - 3,288 KB:  
Home page: <http://www.gnu.org/software/ncurses/>  
Download: <http://ftp.gnu.org/gnu/ncurses/ncurses-6.1.tar.gz>  
MD5 sum: 98c889aaf8d23910d2b92d65be2e737a
- OpenSSL (1.1.1c) - 8,657 KB:  
Home page: <https://www.openssl.org/>  
Download: <https://www.openssl.org/source/openssl-1.1.1c.tar.gz>  
MD5 sum: 15e21da6efe8aa0e0768fffd8cd37a5f6

- Patch (2.7.6) - 766 KB:  
 Home page: <https://savannah.gnu.org/projects/patch/>  
 Download: <http://ftp.gnu.org/gnu/patch/patch-2.7.6.tar.xz>  
 MD5 sum: 78ad9937e4caadcba1526ef1853730d5
- Perl (5.30.0) - 12,129 KB:  
 Home page: <https://www.perl.org/>  
 Download: <https://www.cpan.org/src/5.0/perl-5.30.0.tar.xz>  
 MD5 sum: 037c35000550bdc47552ad0f6d3064d
- Pkg-config (0.29.2) - 1,970 KB:  
 Home page: <https://www.freedesktop.org/wiki/Software/pkg-config>  
 Download: <https://pkg-config.freedesktop.org/releases/pkg-config-0.29.2.tar.gz>  
 MD5 sum: f6e931e319531b736fadc017f470e68a
- Procps (3.3.15) - 884 KB:  
 Home page: <https://sourceforge.net/projects/procps-ng>  
 Download: <https://sourceforge.net/projects/procps-ng/files/Production/procps-ng-3.3.15.tar.xz>  
 MD5 sum: 2b0717a7cb474b3d6dfdeedfbad2eccc
- Psmisc (23.2) - 297 KB:  
 Home page: <http://psmisc.sourceforge.net/>  
 Download: <https://sourceforge.net/projects/psmisc/files/psmisc/psmisc-23.2.tar.xz>  
 MD5 sum: 0524258861f00be1a02d27d39d8e5e62
- Python (3.7.4) - 16,730 KB:  
 Home page: <https://www.python.org/>  
 Download: <https://www.python.org/ftp/python/3.7.4/Python-3.7.4.tar.xz>  
 MD5 sum: d33e4aae66097051c2eca45ee3604803
- Python Documentation (3.7.4) - 6,068 KB:  
 Download: <https://docs.python.org/ftp/python/doc/3.7.4/python-3.7.4-docs-html.tar.bz2>  
 MD5 sum: c410337e954dbba2d04fe169c355a6a2
- Readline (8.0) - 2,907 KB:  
 Home page: <https://tiswww.case.edu/php/chet/readline/rltop.html>  
 Download: <http://ftp.gnu.org/gnu/readline/readline-8.0.tar.gz>  
 MD5 sum: 7e6c1f16aee3244a69aba6e438295ca3
- Sed (4.7) - 1,268 KB:  
 Home page: <http://www.gnu.org/software/sed/>  
 Download: <http://ftp.gnu.org/gnu/sed/sed-4.7.tar.xz>  
 MD5 sum: 777ddfd9d71dd06711fe91f0925e1573
- Shadow (4.7) - 1,587 KB:  
 Download: <https://github.com/shadow-maint/shadow/releases/download/4.7/shadow-4.7.tar.xz>  
 MD5 sum: f7ce18c8dfd05f1a009266cb604d58b7
- Systemd (241) - 7,464 KB:  
 Home page: <https://www.freedesktop.org/wiki/Software/systemd/>  
 Download: <https://github.com/systemd/systemd/archive/v241/systemd-241.tar.gz>  
 MD5 sum: c5953c24c850b44fcf714326e567dc37
- Systemd Man Pages(241) - 456 KB:  
 Home page: <https://www.freedesktop.org/wiki/Software/systemd/>  
 Download: <http://anduin.linuxfromscratch.org/LFS/systemd-man-pages-241.tar.xz>  
 MD5 sum: 6942e1a9032e19da6639f9705241d119

## Note

The Linux From Scratch team generates its own tarball of the man pages using the systemd source. This is done in order to avoid unnecessary dependencies.

- Tar (1.32) - 2,055 KB:  
Home page: <http://www.gnu.org/software/tar/>  
Download: <http://ftp.gnu.org/gnu/tar/tar-1.32.tar.xz>  
MD5 sum: 83e38700a80a26e30b2df054e69956e5
  - Tcl (8.6.9) - 9,772 KB:  
Home page: <http://tcl.sourceforge.net/>  
Download: <https://downloads.sourceforge.net/tcl/tcl8.6.9-src.tar.gz>  
MD5 sum: aa0a121d95a0e7b73a036f26028538d4
  - Texinfo (6.6) - 4,831 KB:  
Home page: <http://www.gnu.org/software/texinfo/>  
Download: <http://ftp.gnu.org/gnu/texinfo/texinfo-6.6.tar.xz>  
MD5 sum: 5231da3e6aa106cd0532b8609e5b3702
  - Time Zone Data (2019b) - 376 KB:  
Home page: <https://www.iana.org/time-zones>  
Download: <https://www.iana.org/time-zones/repository/releases/tzdata2019b.tar.gz>  
MD5 sum: b26b5d7d844cb96c73ed2fb6d588daaf
  - Util-linux (2.34) - 4,859 KB:  
Home page: <http://freecode.com/projects/util-linux>  
Download: <https://www.kernel.org/pub/linux/utils/util-linux/v2.34/util-linux-2.34.tar.xz>  
MD5 sum: a78cbeaed9c39094b96a48ba8f891d50
  - Vim (8.1.1846) - 14,078 KB:  
Home page: <https://www.vim.org>  
Download: <https://github.com/vim/vim/archive/v8.1.1846/vim-8.1.1846.tar.gz>  
MD5 sum: 4f129a05254d93c739fcede843df87df
  - XML::Parser (2.44) - 232 KB:  
Home page: <https://github.com/chorny/XML-Parser>  
Download: <https://cpan.metacpan.org/authors/id/T/TO/TODDR/XML-Parser-2.44.tar.gz>  
MD5 sum: af4813fe3952362451201ced6fbce379
  - Xz Utils (5.2.4) - 1030 KB:  
Home page: <https://tukaani.org/xz>  
Download: <https://tukaani.org/xz/xz-5.2.4.tar.xz>  
MD5 sum: 003e4d0b1b1899fc6e3000b24feddf7c
  - Zlib (1.2.11) - 457 KB:  
Home page: <https://www.zlib.net/>  
Download: <https://zlib.net/zlib-1.2.11.tar.xz>  
MD5 sum: 85adef240c5f370b308da8c938951a68
- Total size of these packages: about 399 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:

- Bzip2 Documentation Patch - 1.6 KB:  
Download: [http://www.linuxfromscratch.org/patches/lfs/9.0/bzip2-1.0.8-install\\_docs-1.patch](http://www.linuxfromscratch.org/patches/lfs/9.0/bzip2-1.0.8-install_docs-1.patch)  
MD5 sum: 6a5ac7e89b791aae556de0f745916f7f
- Coreutils Internationalization Fixes Patch - 168 KB:  
Download: <http://www.linuxfromscratch.org/patches/lfs/9.0/coreutils-8.31-i18n-1.patch>  
MD5 sum: a9404fb575dfd5514f3c8f4120f9ca7d
- Glibc FHS Patch - 2.8 KB:  
Download: <http://www.linuxfromscratch.org/patches/lfs/9.0/glibc-2.30-fhs-1.patch>  
MD5 sum: 9a5997c3452909b1769918c759eff8a2
- Kbd Backspace/Delete Fix Patch - 12 KB:  
Download: <http://www.linuxfromscratch.org/patches/lfs/9.0/kbd-2.2.0-backspace-1.patch>  
MD5 sum: f75cca16a38da6caa7d52151f7136895

- Systemd networkd and rdnd patch - 8 KB:

Download: [http://www.linuxfromscratch.org/patches/lfs/9.0/systemd-241-networkd\\_and\\_rdnd\\_fixes-1.patch](http://www.linuxfromscratch.org/patches/lfs/9.0/systemd-241-networkd_and_rdnd_fixes-1.patch)

MD5 sum: bb26f26d7c3a17d1888ab3171366906b

Total size of these patches: about 192.4 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/9.0/> 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 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 `thelfs` 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-2.32 - 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: 580 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 Binutil's build system for building a cross linker.

**--disable-nls**

This disables internationalization as `i18n` is not needed for the temporary tools.



`--disable-werror`

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

Continue with compiling the package:

```
make
```

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

If building on x86\_64, create a symlink to ensure the sanity of the toolchain:

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

Install the package:

```
make install
```

Details on this package are located in Section#6.16.2, "Contents of Binutils."

## 5.5. GCC-9.2.0 - Pass 1

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

Approximate build time: 12 SBU

Required disk space: 3.1 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-4.0.2.tar.xz
mv -v mpfr-4.0.2 mpfr
tar -xf ../gmp-6.1.2.tar.xz
mv -v gmp-6.1.2 gmp
tar -xf ../mpc-1.1.0.tar.gz
mv -v mpc-1.1.0 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 gcc/config/{linux,i386/linux{,64}}.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 copy the files `gcc/config/linux.h`, `gcc/config/i386/linux.h`, and `gcc/config/i386/linux64.h` 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.

Finally, on `x86_64` hosts, set the default directory name for 64-bit libraries to `“lib”`:

```
case $(uname -m) in
  x86_64)
    sed -e '/m64=/s/lib64/lib/' \
        -i.orig gcc/config/i386/t-linux64
    ;;
esac
```

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-libquadmath \
--disable-libssp \
--disable-libvtv \
--disable-libstdc++ \
--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 normally translate 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-libquadmath*, *--disable-libssp*, *--disable-libvtv*, *--disable-libstdc++*

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

*--disable-multilib*

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

*--enable-languages=c,c++*

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

Compile GCC by running:

```
make
```

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

Install the package:

```
make install
```

Details on this package are located in Section#6.21.2, “Contents of GCC.”

## 5.6. Linux-5.2.8 API Headers

The Linux API Headers (in linux-5.2.8.tar.xz) expose the kernel's API for use by Glibc.

Approximate build time: 0.1 SBU

Required disk space: 960 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-2.30

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: 4.8 SBU

Required disk space: 896 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=3.2 \
  --with-headers=/tools/include
```

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=3.2`

This tells Glibc to compile the library with support for 3.2 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.

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/lib64/ld-linux-x86-64.so.2]
```

Note that for 32-bit machines, the interpreter name will be `/tools/lib/ld-linux.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++ from GCC-9.2.0

Libstdc++ is the standard C++ library. It is needed to compile C++ code (part of GCC is written in C++), but we had to defer its installation when we built gcc-pass1 because it depends on glibc, which was not yet available in /tools.

Approximate build time: 0.5 SBU  
Required disk space: 879 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-9.2.0 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++/9.2.0
```

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++/9.2.0`

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#6.21.2, "Contents of GCC."



## 5.9. Binutils-2.32 - 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: 879 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#6.16.2, “Contents of Binutils.”

## 5.10. GCC-9.2.0 - Pass 2

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

Approximate build time: 15 SBU

Required disk space: 3.7 GB

### 5.10.1. Installation of GCC

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

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

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

```
for file in gcc/config/{linux,i386/linux,{,64}}.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
```

If building on `x86_64`, change the default directory name for 64-bit libraries to “lib”:

```
case $(uname -m) in
  x86_64)
    sed -e '/m64=/s/lib64/lib/' \
        -i.orig gcc/config/i386/t-linux64
    ;;
esac
```

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-4.0.2.tar.xz
mv -v mpfr-4.0.2 mpfr
tar -xf ../gmp-6.1.2.tar.xz
mv -v gmp-6.1.2 gmp
tar -xf ../mpc-1.1.0.tar.gz
mv -v mpc-1.1.0 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/lib64/ld-linux-x86-64.so.2]
```

Note that the dynamic linker will be `/tools/lib/ld-linux.so.2` for 32-bit machines.

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#6.21.2, “Contents of GCC.”

## 5.11. Tcl-8.6.9

The Tcl package contains the Tool Command Language.

Approximate build time: 0.9 SBU

Required disk space: 71 MB

### 5.11.1. Installation of Tcl

This package and the next two (Expect and DejaGNU) are installed to support running the test suites for GCC and Binutils and other packages. Installing three 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

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-5.45.4

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

Approximate build time: 0.1 SBU

Required disk space: 4.0 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

`libexpect-5.45.so` 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-1.6.2

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. M4-1.4.18

The M4 package contains a macro processor.

Approximate build time: 0.2 SBU

Required disk space: 20 MB

### 5.14.1. Installation of M4

First, make some fixes required by glibc-2.28:

```
sed -i 's/IO_ftrylockfile/IO_EOF_SEEN/' lib/*.c
echo "#define _IO_IN_BACKUP 0x100" >> lib/stdio-impl.h
```

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#6.14.2, “Contents of M4.”



## 5.15. Ncurses-6.1

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

Approximate build time: 0.6 SBU

Required disk space: 41 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-widenc \
            --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-widenc*

This switch causes wide-character libraries (e.g., `libncursesw.so.6.1`) to be built instead of normal ones (e.g., `libncurses.so.6.1`). 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
ln -s libncursesw.so /tools/lib/libncurses.so
```

Details on this package are located in Section#6.24.2, “Contents of Ncurses.”

## 5.16. Bash-5.0

The Bash package contains the Bourne-Again SHell.

Approximate build time: 0.4 SBU

Required disk space: 67 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#6.34.2, "Contents of Bash."

## 5.17. Bison-3.4.1

The Bison package contains a parser generator.

Approximate build time: 0.3 SBU

Required disk space: 39 MB

### 5.17.1. Installation of Bison

Prepare Bison for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

Details on this package are located in Section#6.31.2, “Contents of Bison.”

## 5.18. Bzip2-1.0.8

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: 6.0 MB

### 5.18.1. 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#6.22.2, “Contents of Bzip2.”

## 5.19. Coreutils-8.31

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

Approximate build time: 0.8 SBU

Required disk space: 157 MB

### 5.19.1. 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#6.54.2, “Contents of Coreutils.”

## 5.20. Diffutils-3.7

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

Approximate build time: 0.2 SBU

Required disk space: 26 MB

### 5.20.1. 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#6.56.2, “Contents of Diffutils.”

## 5.21. File-5.37

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: 19 MB

### 5.21.1. 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.”

## 5.22. Findutils-4.6.0

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

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

### 5.22.1. Installation of Findutils

First, make some fixes required by glibc-2.28:

```
sed -i 's/IO_ftrylockfile/IO_EOF_SEEN/' gl/lib/*.c
sed -i '/unistd/a #include <sys/sysmacros.h>' gl/lib/mountlist.c
echo "#define _IO_IN_BACKUP 0x100" >> gl/lib/stdio-impl.h
```

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#6.58.2, “Contents of Findutils.”



## 5.23. Gawk-5.0.1

The Gawk package contains programs for manipulating text files.

Approximate build time: 0.2 SBU

Required disk space: 46 MB

### 5.23.1. 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#6.57.2, “Contents of Gawk.”

## 5.24. Gettext-0.20.1

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: 1.8 SBU  
Required disk space: 300 MB

### 5.24.1. Installation of Gettext

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

Prepare Gettext for compilation:

```
./configure --disable-shared
```

The meaning of the configure option:

*--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
```

Due to the limited environment, running the test suite at this stage is not recommended.

Install the msgfmt, msgmerge and xgettext programs:

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

Details on this package are located in Section#6.47.2, "Contents of Gettext."

## 5.25. Grep-3.3

The Grep package contains programs for searching through files.

Approximate build time: 0.2 SBU

Required disk space: 24 MB

### 5.25.1. 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#6.33.2, “Contents of Grep.”

## 5.26. Gzip-1.10

The Gzip package contains programs for compressing and decompressing files.

Approximate build time: 0.1 SBU

Required disk space: 10 MB

### 5.26.1. 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#6.62.2, “Contents of Gzip.”

## 5.27. Make-4.2.1

The Make package contains a program for compiling packages.

Approximate build time: 0.1 SBU

Required disk space: 13 MB

### 5.27.1. Installation of Make

First, work around an error caused by glibc-2.27 and later:

```
sed -i '211,217 d; 219,229 d; 232 d' glob/glob.c
```

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#6.66.2, “Contents of Make.”

## 5.28. Patch-2.7.6

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: 13 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#6.67.2, “Contents of Patch.”

## 5.29. Perl-5.30.0

The Perl package contains the Practical Extraction and Report Language.

Approximate build time: 1.6 SBU

Required disk space: 275 MB

### 5.29.1. Installation of Perl

Prepare Perl for compilation:

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

The meaning of the Configure options:

*-des*

This is a combination of three options: *-d* uses defaults for all items; *-e* ensures completion of all tasks; *-s* silences non-essential output.

*-Uloclibpth* and *-Ulocincpth*

These entries undefine variables that cause the configuration to search for locally installed components that may exist on the host system.

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/perl5/5.30.0
cp -Rv lib/* /tools/lib/perl5/5.30.0
```

Details on this package are located in Section#6.40.2, “Contents of Perl.”

## 5.30. Python-3.7.4

The Python 3 package contains the Python development environment. It is useful for object-oriented programming, writing scripts, prototyping large programs or developing entire applications.

Approximate build time: 1.4 SBU

Required disk space: 381 MB

### 5.30.1. Installation of Python

#### Note

There are two package files whose name starts with “python”. The one to extract from is `Python-3.7.4.tar.xz` (notice the uppercase first letter).

This package first builds the Python interpreter, then some standard Python modules. The main script for building modules is written in Python, and uses hard-coded paths to the host `/usr/include` and `/usr/lib` directories. To prevent them from being used, issue:

```
sed -i '/def add_multiarch_paths/a \          return' setup.py
```

Prepare Python for compilation:

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

The meaning of the configure option:

*--without-ensurepip*

This switch disables the Python package installer, which is not needed at this stage.

Compile the package:

```
make
```

Compilation is now complete. The test suite requires TK and X Windows and cannot be run at this time.

Install the package:

```
make install
```

Details on this package are located in Section#6.51.2, “Contents of Python 3.”



## 5.31. Sed-4.7

The Sed package contains a stream editor.

Approximate build time: 0.2 SBU

Required disk space: 20 MB

### 5.31.1. 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#6.28.2, “Contents of Sed.”

## 5.32. Tar-1.32

The Tar package contains an archiving program.

Approximate build time: 0.3 SBU

Required disk space: 38 MB

### 5.32.1. 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#6.69.2, “Contents of Tar.”

## 5.33. Texinfo-6.6

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

Approximate build time: 0.2 SBU

Required disk space: 103 MB

### 5.33.1. Installation of Texinfo

Prepare Texinfo for compilation:

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

#### Note

As part of the configure process, a test is made that indicates an error for TestXS\_la-TestXS.lo. This is not relevant for LFS and should be ignored.

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#6.70.2, “Contents of Texinfo.”

## 5.34. Util-linux-2.34

The Util-linux package contains miscellaneous utility programs.

Approximate build time: 1 SBU

Required disk space: 147 MB

### 5.34.1. Installation of Util-linux

Prepare Util-linux for compilation:

```
./configure --prefix=/tools \
            --without-python \
            --disable-makeinstall-chown \
            --without-systemdsystemunitdir \
            --without-ncurses \
            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-ncurses*

This switch disables using the `ncurses` library for the build process. This is not needed when installing into the `/tools` directory and avoids problems on some host distros.

*--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
```

Details on this package are located in Section#6.75.3, "Contents of Util-linux."

## 5.35. Xz-5.2.4

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

Approximate build time: 0.2 SBU

Required disk space: 18 MB

### 5.35.1. 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.”

## 5.36. 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}
```

Remove unneeded files:

```
find /tools/{lib,libexec} -name \*.la -delete
```

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.

## 5.37. 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. 构建 LFS 系统

# 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. Usually this is done by passing a `--disable-static` option to `configure`. In other cases, alternate means are needed. In a few cases, especially `glibc` and `gcc`, the use of static libraries remains essential to the general package building process.

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](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='(lfs chroot) \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}
mkdir -v /usr/lib/pkgconfig

case $(uname -m) in
  x86_64) mkdir -v /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://refspecs.linuxfoundation.org/fhs.shtml>). The FHS also specifies the optional existence of 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,chmod,dd,echo,ln,mkdir,pwd,rm,stat,touch} /bin
ln -sv /tools/bin/{env,install,perl,printf} /usr/bin
ln -sv /tools/lib/libgcc_s.so{,.1} /usr/lib
ln -sv /tools/lib/libstdc++.so{,.6} /usr/lib

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/dd`

The path to `dd` will be hard-coded into the `/usr/bin/libtool` utility.

`/bin/echo`

This is to satisfy one of the tests in Glibc's test suite, which expects `/bin/echo`.

`/usr/bin/env`

This pathname is hard-coded into some packages build procedures.

`/usr/bin/install`

The path to `install` will be hard-coded into the `/usr/lib/bash/Makefile.inc` file.

`/bin/ln`

The path to `ln` will be hard-coded into the `/usr/lib/perl5/5.30.0/<target-triplet>/Config_heavy.pl` file.

`/bin/pwd`

Some configure scripts, particularly Glibc's, have this pathname hard-coded.

`/bin/rm`

The path to `rm` will be hard-coded into the `/usr/lib/perl5/5.30.0/<target-triplet>/Config_heavy.pl` file.

`/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.

`/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:
kvm:x:61:
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:
wheel:x:97:
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-5.2.8 API Headers

The Linux API Headers (in linux-5.2.8.tar.xz) expose the kernel's API for use by Glibc.

Approximate build time: less than 0.1 SBU

Required disk space: 960 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/misc/*.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/misc, /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/misc/*.h	The Linux API Miscellaneous 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-5.02

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

Approximate build time: less than 0.1 SBU

Required disk space: 31 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-2.30

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: 21 SBU

Required disk space: 3.3 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 the 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-2.30-fhs-1.patch
```

Fix a problem introduced with the linux-5.2 kernel:

```
sed -i '/asm.socket.h/a# include <linux/sockios.h>' \
    sysdeps/unix/sysv/linux/bits/socket.h
```

Create a symlink for LSB compliance. Additionally, for `x86_64`, create a compatibility symlink required for the dynamic loader to function correctly:

```
case $(uname -m) in
    i?86)  ln -sfv ld-linux.so.2 /lib/ld-lsb.so.3
    ;;
    x86_64) ln -sfv ../lib/ld-linux-x86-64.so.2 /lib64
            ln -sfv ../lib/ld-linux-x86-64.so.2 /lib64/ld-lsb-x86-64.so.3
    ;;
esac
```

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

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

Prepare Glibc for compilation:

```
CC="gcc -ffile-prefix-map=/tools=/usr" \
../configure --prefix=/usr \
              --disable-werror \
              --enable-kernel=3.2 \
              --enable-stack-protector=strong \
              --with-headers=/usr/include \
              libc_cv_slibdir=/lib
```

The meaning of the options and new configure parameters:

`CC="gcc -ffile-prefix-map=/tools=/usr"`

Make GCC record any references to files in `/tools` in result of the compilation as if the files resided in `/usr`. This avoids introduction of invalid paths in debugging symbols.

`--disable-werror`

This option disables the `-Werror` option passed to GCC. This is necessary for running the test suite.

`--enable-stack-protector=strong`

This option increases system security by adding extra code to check for buffer overflows, such as stack smashing attacks.

```
--with-headers=/usr/include
```

This option tells the build system where to find the kernel API headers. By default, those headers are sought in `/tools/include`.

```
libc_cv_slibdir=/lib
```

This variable sets the correct library for all systems. We do not want `lib64` to be used.

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. The test failures listed below are usually safe to ignore.

```
case $(uname -m) in
  i?86)  ln -sfv $PWD/elf/ld-linux.so.2      /lib ;;
  x86_64) ln -sfv $PWD/elf/ld-linux-x86-64.so.2 /lib ;;
esac
```

## Note

The symbolic link above is needed to run the tests at this stage of building in the chroot environment. It will be overwritten in the install phase below.

```
make check
```

You may 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 some versions of LFS:

- `misc/tst-ttyname` is known to fail in the LFS chroot environment.
- `inet/tst-idna_name_classify` is known to fail in the LFS chroot environment.
- `posix/tst-getaddrinfo4` and `posix/tst-getaddrinfo5` may fail on some architectures.
- The `nss/tst-nss-files-hosts-multi` test may fail for reasons that have not been determined.
- The `rt/tst-cputimer{1,2,3}` tests depend on the host system kernel. Kernels 4.14.91–4.14.96, 4.19.13–4.19.18, and 4.20.0–4.20.5 are known to cause these tests to fail.
- The math tests sometimes fail when running on systems where the CPU is not a relatively new Intel or AMD processor.

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
```

Fix the generated Makefile to skip an unneeded sanity check that fails in the LFS partial environment:

```
sed '/test-installation/s@$(PERL)@echo not running@' -i ../Makefile
```

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 POSIX -f UTF-8 C.UTF-8 2> /dev/null || true
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 el_GR -f ISO-8859-7 el_GR
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 ja_JP -f SHIFT_JIS ja_JP.SIJS 2> /dev/null || true
localedef -i ja_JP -f UTF-8 ja_JP.UTF-8
localedef -i ru_RU -f KOI8-R ru_RU.KOI8-R
localedef -i ru_RU -f UTF-8 ru_RU.UTF-8
localedef -i tr_TR -f UTF-8 tr_TR.UTF-8
localedef -i zh_CN -f GB18030 zh_CN.GB18030
localedef -i zh_HK -f BIG5-HKSCS zh_HK.BIG5-HKSCS
```

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

Alternatively, install all locales listed in the `glibc-2.30/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-2.30/localedata/SUPPORTED` file in the unlikely case you need them.

## Note

Glibc now uses `libidn2` when resolving internationalized domain names. This is a run time dependency. If this capability is needed, the instructions for installing `libidn2` are in the BLFS `libidn2` page.

## 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 -xvf ../tzdata2019b.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 ${tz}
    zic -L /dev/null -d $ZONEINFO/posix ${tz}
    zic -L leapseconds -d $ZONEINFO/right ${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, pcprofiledump, pldd, sln, sotruss, sprof, tzselect, xtrace, zdump, and zic
Installed libraries:	ld-2.30.so, libBrokenLocale.{a,so}, libSegFault.so, libanl.{a,so}, libc.{a,so}, libc_nonshared.a, libcrypt.{a,so}, libdl.{a,so}, libg.a, libm.{a,so}, libmcheck.a, libmemusage.so, libmvec.{a,so}, libnsl.{a,so}, libnss_compat.so, libnss_dns.so, libnss_files.so, libnss_hesiod.so, libpcprofile.so, libpthread.{a,so}, libpthread_nonshared.a, libresolv.{a,so}, 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/sys, /usr/lib/audit, /usr/lib/gconv, /usr/lib/locale, /usr/libexec/getconf, /usr/share/i18n, /usr/share/zoneinfo, /var/cache/nscd, and /var/lib/nss_db

### Short Descriptions

catchsegv	Can be used to create a stack trace when a program terminates with a segmentation fault
gencat	Generates message catalogues
getconf	Displays the system configuration values for file system specific variables
getent	Gets entries from an administrative database
iconv	Performs character set conversion
iconvconfig	Creates fastloading iconv module configuration files
ldconfig	Configures the dynamic linker runtime bindings
ldd	Reports which shared libraries are required by each given program or shared library
lddlibc4	Assists ldd with object files
locale	Prints various information about the current locale
localedef	Compiles locale specifications
makedb	Creates a simple database from textual input

mtrace	Reads and interprets a memory trace file and displays a summary in human-readable format
nscd	A daemon that provides a cache for the most common name service requests
pcprofiledump	Dump information generated by PC profiling
pldd	Lists dynamic shared objects used by running processes
sln	A statically linked ln program
sotrust	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-2.30.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-2.30/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
libcrypt	The cryptography library
libdl	The dynamic linking interface library
libg	Dummy library containing no functions. Previously was a runtime library for g++
libm	The mathematical library
libmcheck	Turns on memory allocation checking when linked to
libmemusage	Used by memusage to help collect information about the memory usage of a program
libnsl	The network services library
libnss	The Name Service Switch libraries, containing functions for resolving host names, user names, group names, aliases, services, protocols, etc.
libpcprofile	Can be preloaded to PC profile an executable
libpthread	The POSIX threads library
libresolv	Contains functions for creating, sending, and interpreting packets to the Internet domain name servers
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: /lib64/ld-linux-x86-64.so.2]
```

Note that on 64-bit systems `/lib` is the location of our dynamic linker, but is accessed via a symbolic link in `/lib64`.

### Note

On 32-bit systems the interpreter should be `/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/../lib/crt1.o succeeded
/usr/lib/../lib/crti.o succeeded
/usr/lib/../lib/crtn.o succeeded
```

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 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):

```
found ld-linux-x86-64.so.2 at /lib/ld-linux-x86-64.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 with the process.

Once everything is working correctly, clean up the test files:

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

## 6.11. Zlib-1.2.11

The Zlib package contains compression and decompression routines used by some programs.

Approximate build time: less than 0.1 SBU

Required disk space: 5.1 MB

### 6.11.1. Installation of Zlib

Prepare Zlib for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

The shared library needs to be moved to `/lib`, and as a result the `.so` file in `/usr/lib` will need to be recreated:

```
mv -v /usr/lib/libz.so.* /lib
ln -sfv ../../lib/$(readlink /usr/lib/libz.so) /usr/lib/libz.so
```

### 6.11.2. Contents of Zlib

Installed libraries: `libz.{a,so}`

### Short Descriptions

`libz` Contains compression and decompression functions used by some programs

## 6.12. File-5.37

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: 19 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. Readline-8.0

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: 15 MB

### 6.13.1. Installation of Readline

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-8.0
```

Compile the package:

```
make SHLIB_LIBS="-L/tools/lib -lncursesw"
```

The meaning of the make option:

```
SHLIB_LIBS="-L/tools/lib -lncursesw"
```

This option forces Readline to link against the libncursesw library.

This package does not come with a test suite.

Install the package:

```
make SHLIB_LIBS="-L/tools/lib -lncursesw" install
```

Now move the dynamic libraries to a more appropriate location and fix up some permissions and symbolic links:

```
mv -v /usr/lib/lib{readline,history}.so.* /lib
chmod -v u+w /lib/lib{readline,history}.so.*
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-8.0
```

### 6.13.2. Contents of Readline

Installed libraries: libhistory.so and libreadline.so

Installed directories: /usr/include/readline and /usr/share/doc/readline-8.0

### Short Descriptions

**libhistory** Provides a consistent user interface for recalling lines of history

**libreadline** Provides a set of commands for manipulating text entered in an interactive session of a program.

## 6.14. M4-1.4.18

The M4 package contains a macro processor.

Approximate build time: 0.4 SBU

Required disk space: 33 MB

### 6.14.1. Installation of M4

First, make some fixes required by glibc-2.28:

```
sed -i 's/IO_ftrylockfile/IO_EOF_SEEN/' lib/*.c
echo "#define _IO_IN_BACKUP 0x100" >> lib/stdio-impl.h
```

Prepare M4 for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

### 6.14.2. 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.]

## 6.15. Bc-2.1.3

The Bc package contains an arbitrary precision numeric processing language.

Approximate build time: 0.1 SBU

Required disk space: 2.8 MB

### 6.15.1. Installation of Bc

Prepare Bc for compilation:

```
PREFIX=/usr CC=gcc CFLAGS="-std=c99" ./configure.sh -G -O3
```

The meaning of the configure options:

*CC=gcc CFLAGS="-std=c99"*

These parameters specify the compiler and C standard to use.

*-O3*

Specify the optimization to use.

*-G*

Omit parts of the test suite that won't work without a GNU bc present.

Compile the package:

```
make
```

To test bc, run:

```
make test
```

Install the package:

```
make install
```

### 6.15.2. Contents of Bc

Installed programs: bc and dc

#### Short Descriptions

bc A command line calculator

dc A reverse-polish command line calculator

## 6.16. Binutils-2.32

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

Approximate build time: 7.4 SBU

Required disk space: 5.1 GB

### 6.16.1. 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.
```

Now remove one test that prevents the tests from running to completion:

```
sed -i '/@t\incremental_copy/d' gold/testsuite/Makefile.in
```

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

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

Prepare Binutils for compilation:

```
../configure --prefix=/usr \
             --enable-gold \
             --enable-ld=default \
             --enable-plugins \
             --enable-shared \
             --disable-werror \
             --enable-64-bit-bfd \
             --with-system-zlib
```

The meaning of the configure parameters:

*--enable-gold*

Build the gold linker and install it as ld.gold (along side the default linker).

*--enable-ld=default*

Build the original bdf linker and install it as both ld (the default linker) and ld.bfd.

*--enable-plugins*

Enables plugin support for the linker.

*--enable-64-bit-bfd*

Enables 64-bit support (on hosts with narrower word sizes). May not be needed on 64-bit systems, but does no harm.

*--with-system-zlib*

Use the installed zlib library rather than building the included version.

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
```

The PC-relative offset test and the debug\_msg.sh test may fail in the LFS environment.

Install the package:

```
make tooldir=/usr install
```

## 6.16.2. Contents of Binutils

Installed programs:	addr2line, ar, as, c++filt, dwp, elfedit, gprof, ld, ld.bfd, ld.gold, 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
dwp	The DWARF packaging utility
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.gold	A cut down version of ld that only supports the elf object file format
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

## 6.17. GMP-6.1.2

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

Approximate build time: 1.2 SBU

Required disk space: 61 MB

### 6.17.1. 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 ...
```

#### Note

The default settings of GMP produce libraries optimized for the host processor. If libraries suitable for processors less capable than the host's CPU are desired, generic libraries can be created by running the following:

```
cp -v configfsf.guess config.guess
cp -v configfsf.sub config.sub
```

Prepare GMP for compilation:

```
./configure --prefix=/usr \
            --enable-cxx \
            --disable-static \
            --docdir=/usr/share/doc/gmp-6.1.2
```

The meaning of the new configure options:

`--enable-cxx`

This parameter enables C++ support

`--docdir=/usr/share/doc/gmp-6.1.2`

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
```

## 6.17.2. Contents of GMP

Installed Libraries:	libgmp.so and libgmpxx.so
Installed directory:	/usr/share/doc/gmp-6.1.2

### Short Descriptions

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

## 6.18. MPFR-4.0.2

The MPFR package contains functions for multiple precision math.

Approximate build time: 0.9 SBU

Required disk space: 37 MB

### 6.18.1. Installation of MPFR

Prepare MPFR for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --enable-thread-safe \
            --docdir=/usr/share/doc/mpfr-4.0.2
```

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
```

### 6.18.2. Contents of MPFR

Installed Libraries: libmpfr.so

Installed directory: /usr/share/doc/mpfr-4.0.2

#### Short Descriptions

`libmpfr` Contains multiple-precision math functions

## 6.19. MPC-1.1.0

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: 22 MB

### 6.19.1. Installation of MPC

Prepare MPC for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/mpc-1.1.0
```

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
```

### 6.19.2. Contents of MPC

Installed Libraries: libmpc.so

Installed Directory: /usr/share/doc/mpc-1.1.0

#### Short Descriptions

`libmpc` Contains complex math functions

## 6.20. Shadow-4.7

The Shadow package contains programs for handling passwords in a secure way.

Approximate build time: 0.2 SBU

Required disk space: 46 MB

### 6.20.1. Installation of Shadow

#### Note

If you would like to enforce the use of strong passwords, refer to <http://www.linuxfromscratch.org/blfs/view/9.0/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 in Section#6.8, “Man-pages-5.02”

```
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 first group number generated by useradd 1000:

```
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
```

## 6.20.2. 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
```

## 6.20.3. Setting the root password

Choose a password for user root and set it by running:

```
passwd root
```

## 6.20.4. Contents of Shadow

Installed programs:	<code>chage</code> , <code>chfn</code> , <code>chgpaswd</code> , <code>chpasswd</code> , <code>chsh</code> , <code>expiry</code> , <code>faillog</code> , <code>gpaswd</code> , <code>groupadd</code> , <code>groupdel</code> , <code>groupmems</code> , <code>groupmod</code> , <code>grpck</code> , <code>grpconv</code> , <code>grpunconv</code> , <code>lastlog</code> , <code>login</code> , <code>logoutd</code> , <code>newgidmap</code> , <code>newgrp</code> , <code>newuidmap</code> , <code>newusers</code> , <code>nologin</code> , <code>passwd</code> , <code>pwck</code> , <code>pwconv</code> , <code>pwunconv</code> , <code>sg</code> (link to <code>newgrp</code> ), <code>su</code> , <code>useradd</code> , <code>userdel</code> , <code>usermod</code> , <code>vigr</code> (link to <code>vipw</code> ), and <code>vipw</code>
Installed directory:	<code>/etc/default</code>

### Short Descriptions

<code>chage</code>	Used to change the maximum number of days between obligatory password changes
<code>chfn</code>	Used to change a user's full name and other information
<code>chgpaswd</code>	Used to update group passwords in batch mode
<code>chpasswd</code>	Used to update user passwords in batch mode
<code>chsh</code>	Used to change a user's default login shell
<code>expiry</code>	Checks and enforces the current password expiration policy

<code>faillog</code>	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
<code>gpasswd</code>	Is used to add and delete members and administrators to groups
<code>groupadd</code>	Creates a group with the given name
<code>groupdel</code>	Deletes the group with the given name
<code>groupmems</code>	Allows a user to administer his/her own group membership list without the requirement of super user privileges.
<code>groupmod</code>	Is used to modify the given group's name or GID
<code>grpck</code>	Verifies the integrity of the group files <code>/etc/group</code> and <code>/etc/gshadow</code>
<code>grpconv</code>	Creates or updates the shadow group file from the normal group file
<code>grpunconv</code>	Updates <code>/etc/group</code> from <code>/etc/gshadow</code> and then deletes the latter
<code>lastlog</code>	Reports the most recent login of all users or of a given user
<code>login</code>	Is used by the system to let users sign on
<code>logoutd</code>	Is a daemon used to enforce restrictions on log-on time and ports
<code>newgidmap</code>	Is used to set the gid mapping of a user namespace
<code>newgrp</code>	Is used to change the current GID during a login session
<code>newuidmap</code>	Is used to set the uid mapping of a user namespace
<code>newusers</code>	Is used to create or update an entire series of user accounts
<code>nologin</code>	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
<code>passwd</code>	Is used to change the password for a user or group account
<code>pwck</code>	Verifies the integrity of the password files <code>/etc/passwd</code> and <code>/etc/shadow</code>
<code>pwconv</code>	Creates or updates the shadow password file from the normal password file
<code>pwunconv</code>	Updates <code>/etc/passwd</code> from <code>/etc/shadow</code> and then deletes the latter
<code>sg</code>	Executes a given command while the user's GID is set to that of the given group
<code>su</code>	Runs a shell with substitute user and group IDs
<code>useradd</code>	Creates a new user with the given name, or updates the default new-user information
<code>userdel</code>	Deletes the given user account
<code>usermod</code>	Is used to modify the given user's login name, User Identification (UID), shell, initial group, home directory, etc.
<code>vigr</code>	Edits the <code>/etc/group</code> or <code>/etc/gshadow</code> files
<code>vipw</code>	Edits the <code>/etc/passwd</code> or <code>/etc/shadow</code> files



## 6.21. GCC-9.2.0

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

Approximate build time: 95 SBU (with tests)

Required disk space: 4.2 GB

### 6.21.1. Installation of GCC

If building on x86\_64, change the default directory name for 64-bit libraries to “lib”:

```
case $(uname -m) in
  x86_64)
    sed -e '/m64=/s/lib64/lib/' \
        -i.orig gcc/config/i386/t-linux64
    ;;
esac
```

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 parameters:

`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 as a non-privileged user, but do not stop at errors:

```
chown -Rv nobody .
su nobody -s /bin/bash -c "PATH=$PATH 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/9.0/> and <https://gcc.gnu.org/ml/gcc-testresults/>.

Six tests related to `get_time` are known to fail. These are apparently related to the `en_HK` locale.

Two tests named `lookup.cc` and `reverse.cc` in `experimental/net` are known to fail in LFS chroot environment because they require `/etc/hosts` and `iana-etc`.

Two tests named `pr57193.c` and `pr90178.c` are known to fail.

A few unexpected failures cannot always be avoided. The GCC developers are usually aware of these issues, but have not resolved them yet. Unless the test results are vastly different from those at the above URL, it is safe to continue.

Install the package and remove an unneeded directory:

```
make install
rm -rf /usr/lib/gcc/$(gcc -dumpmachine)/9.2.0/include-fixed/bits/
```

The GCC build directory is owned by `nobody` now and the ownership of the installed header directory (and its content) will be incorrect. Change the ownership to `root` user and group:

```
chown -v -R root:root \
    /usr/lib/gcc/*linux-gnu/9.2.0/include{,-fixed}
```

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)/9.2.0/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: /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/gcc/x86_64-pc-linux-gnu/9.2.0/../../../../lib/crt1.o succeeded
/usr/lib/gcc/x86_64-pc-linux-gnu/9.2.0/../../../../lib/crti.o succeeded
/usr/lib/gcc/x86_64-pc-linux-gnu/9.2.0/../../../../lib/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`. 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/x86_64-pc-linux-gnu/9.2.0/include
 /usr/local/include
 /usr/lib/gcc/x86_64-pc-linux-gnu/9.2.0/include-fixed
 /usr/include
```

Again, note that the directory named after your target triplet may be different than the above, depending on your architecture.

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/x86_64-pc-linux-gnu/lib64")
SEARCH_DIR("/usr/local/lib64")
SEARCH_DIR("/lib64")
SEARCH_DIR("/usr/lib64")
SEARCH_DIR("/usr/x86_64-pc-linux-gnu/lib")
SEARCH_DIR("/usr/local/lib")
SEARCH_DIR("/lib")
SEARCH_DIR("/usr/lib");
```

A 32-bit system may see a few different directories. For example, here is the output from an i686 machine:

```
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");
```

Next make sure that we're using the correct libc:

```
grep "/lib.*/libc.so.6 " dummy.log
```

The output of the last command 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):

```
found ld-linux-x86-64.so.2 at /lib/ld-linux-x86-64.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 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
```

## 6.21.2. Contents of GCC

Installed programs:	c++, cc (link to gcc), cpp, g++, gcc, gcc-ar, gcc-nm, gcc-ranlib, gcov, gcov-dump, and gcov-tool
Installed libraries:	libasan.{a,so}, libatomic.{a,so}, libgcc1.so, libgcc.a, libgcc_eh.a, libgcc_s.so, libgcov.a, libgomp.{a,so}, libitm.{a,so}, liblsan.{a,so}, liblto_plugin.so, libquadmath.{a,so}, libssp.{a,so}, libssp_nonshared.a, libstdc++.a, libstdc++-fs.a, libsupc++.a, libtsan.{a,so}, and libubsan.{a,so}
Installed directories:	/usr/include/c++, /usr/lib/gcc, /usr/libexec/gcc, and /usr/share/gcc-9.2.0

## Short Descriptions

c++	The C++ compiler
cc	The C compiler

<code>cpp</code>	The C preprocessor; it is used by the compiler to expand the <code>#include</code> , <code>#define</code> , and similar statements in the source files
<code>g++</code>	The C++ compiler
<code>gcc</code>	The C compiler
<code>gcc-ar</code>	A wrapper around <code>ar</code> 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
<code>gcc-nm</code>	A wrapper around <code>nm</code> 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
<code>gcc-ranlib</code>	A wrapper around <code>ranlib</code> 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
<code>gcov</code>	A coverage testing tool; it is used to analyze programs to determine where optimizations will have the most effect
<code>gcov-dump</code>	Offline <code>gcda</code> and <code>gcn</code> profile dump tool
<code>gcov-tool</code>	Offline <code>gcda</code> profile processing tool
<code>libasan</code>	The Address Sanitizer runtime library
<code>libatomic</code>	GCC atomic built-in runtime library
<code>libcc1</code>	The C preprocessing library
<code>libgcc</code>	Contains run-time support for <code>gcc</code>
<code>libgcov</code>	This library is linked in to a program when GCC is instructed to enable profiling
<code>libgomp</code>	GNU implementation of the OpenMP API for multi-platform shared-memory parallel programming in C/C++ and Fortran
<code>liblsan</code>	The Leak Sanitizer runtime library
<code>liblto_plugin</code>	GCC's Link Time Optimization (LTO) plugin allows GCC to perform optimizations across compilation units
<code>libquadmath</code>	GCC Quad Precision Math Library API
<code>libssp</code>	Contains routines supporting GCC's stack-smashing protection functionality
<code>libstdc++</code>	The standard C++ library
<code>libstdc++fs</code>	ISO/IEC TS 18822:2015 Filesystem library
<code>libsupc++</code>	Provides supporting routines for the C++ programming language
<code>libtsan</code>	The Thread Sanitizer runtime library
<code>libubsan</code>	The Undefined Behavior Sanitizer runtime library

## 6.22. Bzip2-1.0.8

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: 7.7 MB

### 6.22.1. Installation of Bzip2

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

```
patch -Np1 -i ../bzip2-1.0.8-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
```

### 6.22.2. 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/bzip2-1.0.8

### 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
libbz2	The library implementing lossless, block-sorting data compression, using the Burrows-Wheeler algorithm

## 6.23. Pkg-config-0.29.2

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: 0.4 SBU

Required disk space: 30 MB

### 6.23.1. Installation of Pkg-config

Prepare Pkg-config for compilation:

```
./configure --prefix=/usr \
            --with-internal-glib \
            --disable-host-tool \
            --docdir=/usr/share/doc/pkg-config-0.29.2
```

The meaning of the new configure options:

*--with-internal-glib*

This will allow pkg-config to use its internal version of Glib because an external version is not available in LFS.

*--disable-host-tool*

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

### 6.23.2. Contents of Pkg-config

Installed program: pkg-config

Installed directory: /usr/share/doc/pkg-config-0.29.2

### Short Descriptions

pkg-config Returns meta information for the specified library or package

## 6.24. Ncurses-6.1

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

Approximate build time: 0.4 SBU

Required disk space: 42 MB

### 6.24.1. Installation of Ncurses

Don't install a static library that is not handled by configure:

```
sed -i '/LIBTOOL_INSTALL/d' c++/Makefile.in
```

Prepare Ncurses for compilation:

```
./configure --prefix=/usr \
            --mandir=/usr/share/man \
            --with-shared \
            --without-debug \
            --without-normal \
            --enable-pc-files \
            --enable-widec
```

The meaning of the new configure options:

*--enable-widec*

This switch causes wide-character libraries (e.g., `libncursesw.so.6.1`) to be built instead of normal ones (e.g., `libncurses.so.6.1`). 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 `-lcurses` 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-6.1
cp -v -R doc/* /usr/share/doc/ncurses-6.1
```



## 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
```

## 6.24.2. 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-6.1

## 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
libcursesw	A link to libncursesw
libncursesw	Contains functions to display text in many complex ways on a terminal screen; a good example of the use of these functions is the menu displayed during the kernel's make menuconfig
libformw	Contains functions to implement forms
libmenuw	Contains functions to implement menus
libpanelw	Contains functions to implement panels

## 6.25. Attr-2.4.48

The attr package contains utilities to administer the extended attributes on filesystem objects.

Approximate build time: less than 0.1 SBU

Required disk space: 4.2 MB

### 6.25.1. Installation of Attr

Prepare Attr for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --sysconfdir=/etc \
            --docdir=/usr/share/doc/attr-2.4.48
```

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. 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/libattr.so.* /lib
ln -sfv ../../lib/$(readlink /usr/lib/libattr.so) /usr/lib/libattr.so
```

### 6.25.2. Contents of Attr

Installed programs: attr, getfattr, and setfattr

Installed library: libattr.so

Installed directories: /usr/include/attr and /usr/share/doc/attr-2.4.48

### Short Descriptions

attr	Extends attributes on filesystem objects
getfattr	Gets the extended attributes of filesystem objects
setfattr	Sets the extended attributes of filesystem objects
libattr	Contains the library functions for manipulating extended attributes

## 6.26. Acl-2.2.53

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: 6.4 MB

### 6.26.1. Installation of Acl

Prepare Acl for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --libexecdir=/usr/lib \
            --docdir=/usr/share/doc/acl-2.2.53
```

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 check` after Coreutils has been built later in this chapter.

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/libacl.so.* /lib
ln -sfv ../../lib/$(readlink /usr/lib/libacl.so) /usr/lib/libacl.so
```

### 6.26.2. Contents of Acl

Installed programs: `chacl`, `getfacl`, and `setfacl`

Installed library: `libacl.so`

Installed directories: `/usr/include/acl` and `/usr/share/doc/acl-2.2.53`

### Short Descriptions

<code>chacl</code>	Changes the access control list of a file or directory
<code>getfacl</code>	Gets file access control lists
<code>setfacl</code>	Sets file access control lists
<code>libacl</code>	Contains the library functions for manipulating Access Control Lists

## 6.27. Libcap-2.27

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: 1.5 MB

### 6.27.1. 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 lib=lib prefix=/usr install  
chmod -v 755 /usr/lib/libcap.so.2.27
```

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.

*lib=lib*

This parameter installs the library in `$prefix/lib` rather than `$prefix/lib64` on `x86_64`. It has no effect on `x86`.

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
```

### 6.27.2. 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)
setcap	Sets file capabilities
libcap	Contains the library functions for manipulating POSIX 1003.1e capabilities

## 6.28. Sed-4.7

The Sed package contains a stream editor.

Approximate build time: 0.4 SBU

Required disk space: 32 MB

### 6.28.1. Installation of Sed

First fix an issue in the LFS environment and remove a failing test:

```
sed -i 's/usr/tools/' build-aux/help2man
sed -i 's/testsuite.panic-tests.sh/' Makefile.in
```

Prepare Sed for compilation:

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

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
install -d -m755 /usr/share/doc/sed-4.7
install -m644 doc/sed.html /usr/share/doc/sed-4.7
```

### 6.28.2. Contents of Sed

Installed program: sed

Installed directory: /usr/share/doc/sed-4.7

### Short Descriptions

sed Filters and transforms text files in a single pass

## 6.29. Psmisc-23.2

The Psmisc package contains programs for displaying information about running processes.

Approximate build time: less than 0.1 SBU

Required disk space: 4.6 MB

### 6.29.1. 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
```

### 6.29.2. Contents of Psmisc

Installed programs: fuser, killall, peekfd, prtstat, pslog, 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
pslog	Reports current logs path of a process
pstree	Displays running processes as a tree
pstree.x11	Same as pstree, except that it waits for confirmation before exiting

## 6.30. 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

### 6.30.1. 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
```

### 6.30.2. 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

## 6.31. Bison-3.4.1

The Bison package contains a parser generator.

Approximate build time: 0.3 SBU

Required disk space: 39 MB

### 6.31.1. Installation of Bison

First, fix a build problem with the current version:

```
sed -i '6855 s/mv/cp/' Makefile.in
```

Prepare Bison for compilation:

```
./configure --prefix=/usr --docdir=/usr/share/doc/bison-3.4.1
```

Compile the package, but work around a race condition in the current version:

```
make -j1
```

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 package can be rebuilt and the bison checks can be run with `make check`.

Install the package:

```
make install
```

### 6.31.2. 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 <code>-y</code> option
liby	The Yacc library containing implementations of Yacc-compatible <code>yyerror</code> and <code>main</code> functions; this library is normally not very useful, but POSIX requires it



## 6.32. Flex-2.6.4

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

Approximate build time: 0.5 SBU

Required disk space: 36 MB

### 6.32.1. Installation of Flex

First, fix a problem introduced with glibc-2.26:

```
sed -i "/math.h/a #include <malloc.h>" src/flexdef.h
```

The build procedure assumes the help2man program is available to create a man page from the executable `--help` option. This is not present, so we use an environment variable to skip this process. Now, prepare Flex for compilation:

```
HELP2MAN=/tools/bin/true \  
./configure --prefix=/usr --docdir=/usr/share/doc/flex-2.6.4
```

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
```

### 6.32.2. Contents of Flex

Installed programs: flex, flex++ (link to flex), and lex (link to flex)

Installed libraries: libfl.so

Installed directory: /usr/share/doc/flex-2.6.4

### 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 symbolic link that runs flex in lex emulation mode
libfl	The flex library

## 6.33. Grep-3.3

The Grep package contains programs for searching through files.

Approximate build time: 0.5 SBU

Required disk space: 37 MB

### 6.33.1. Installation of Grep

Prepare Grep for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make -k check
```

Install the package:

```
make install
```

### 6.33.2. 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

## 6.34. Bash-5.0

The Bash package contains the Bourne-Again SHell.

Approximate build time: 2.1 SBU

Required disk space: 62 MB

### 6.34.1. Installation of Bash

Prepare Bash for compilation:

```
./configure --prefix=/usr \
            --docdir=/usr/share/doc/bash-5.0 \
            --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 HOME=/home 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.

### 6.34.2. Contents of Bash

Installed programs: bash, bashbug, and sh (link to bash)

Installed directory: /usr/include/bash, /usr/lib/bash, and /usr/share/doc/bash-5.0

#### 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

## 6.35. 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: 1.9 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, issue:

```
make check
```

#### Note

The test time for libtool can be reduced significantly on a system with multiple cores. To do this, append TESTSUITEFLAGS=-j<N> to the line above. For instance, using -j4 can reduce the test time by over 60 percent.

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-1.18.1

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: 11 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

<code>gdbm_dump</code>	Dumps a GDBM database to a file
<code>gdbm_load</code>	Recreates a GDBM database from a dump file
<code>gdbmtool</code>	Tests and modifies a GDBM database
<code>libgdbm</code>	Contains functions to manipulate a hashed database
<code>libgdbm_compat</code>	Compatibility library containing older DBM functions

## 6.37. Gperf-3.1

Gperf generates a perfect hash function from a key set.

Approximate build time: less than 0.1 SBU

Required disk space: 6.3 MB

### 6.37.1. Installation of Gperf

Prepare Gperf for compilation:

```
./configure --prefix=/usr --docdir=/usr/share/doc/gperf-3.1
```

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-3.1

### Short Descriptions

**gperf** Generates a perfect hash from a key set

## 6.38. Expat-2.2.7

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

Approximate build time: 0.1 SBU

Required disk space: 11 MB

### 6.38.1. Installation of Expat

First fix a problem with the regression tests in the LFS environment:

```
sed -i 's|usr/bin/env |bin/|' run.sh.in
```

Prepare Expat for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/expat-2.2.7
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

If desired, install the documentation:

```
install -v -m644 doc/*.{html,png,css} /usr/share/doc/expat-2.2.7
```

### 6.38.2. Contents of Expat

Installed program: xmlwf

Installed libraries: libexpat.so

Installed directory: /usr/share/doc/expat-2.2.7

### 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: 0.3 SBU

Required disk space: 29 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
```

#### Note

One test, libls.sh, may fail in the initial chroot environment but will pass if the test is rerun after the LFS system is complete. One test, ping-localhost.sh, will fail if the host system does not have ipv6 capability.

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

<code>dnsdomainname</code>	Show the system's DNS domain name
<code>ftp</code>	Is the file transfer protocol program
<code>hostname</code>	Reports or sets the name of the host
<code>ifconfig</code>	Manages network interfaces
<code>ping</code>	Sends echo-request packets and reports how long the replies take
<code>ping6</code>	A version of ping for IPv6 networks
<code>talk</code>	Is used to chat with another user
<code>telnet</code>	An interface to the TELNET protocol
<code>tftp</code>	A trivial file transfer program
<code>traceroute</code>	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-5.30.0

The Perl package contains the Practical Extraction and Report Language.

Approximate build time: 9.9 SBU

Required disk space: 272 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 \
               -Dusethreads
```

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.

`-Dusethreads`

Build perl with support for threads.

Compile the package:

```
make
```

To test the results (approximately 11 SBU), issue:

```
make -k test
```

#### Note

One test fails due to using the most recent version of gdbm.

Install the package and clean up:

```
make install
unset BUILD_ZLIB BUILD_BZIP2
```

## 6.40.2. Contents of Perl

Installed programs:	corelist, cpan, enc2xs, encguess, h2ph, h2xs, instmodsh, json_pp, libnetcfg, perl, perl5.30.0 (hard link to perl), perlbug, perldoc, perlvp, perlthanks (hard link to perlbug), piconv, pl2pm, pod2html, pod2man, pod2text, pod2usage, podchecker, podselect, prove, ptar, ptardiff, ptargrep, shasum, splain, xsubpp, and zipdetails
Installed libraries:	Many which cannot all be listed here
Installed directory:	/usr/lib/perl5

### Short Descriptions

corelist	A commandline frontend to Module::CoreList
cpan	Interact with the Comprehensive Perl Archive Network (CPAN) from the command line
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
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 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
perl5.30.0	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
perlvp	The Perl Installation Verification Procedure; it can be used to verify that Perl and its libraries have been installed correctly
perlthanks	Used to generate thank you messages to mail to the Perl developers
piconv	A Perl version of the character encoding converter iconv
pl2pm	A rough tool for converting Perl4 .pl files to Perl5 .pm modules
pod2html	Converts files from pod format to HTML format
pod2man	Converts pod data to formatted *roff input
pod2text	Converts pod data to formatted ASCII text
pod2usage	Prints usage messages from embedded pod docs in files
podchecker	Checks the syntax of pod format documentation files
podselect	Displays selected sections of pod documentation
prove	Command line tool for running tests against the Test::Harness module
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
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: 2.3 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 3.4 SBU with tests)

Required disk space: 79 MB

### 6.43.1. Installation of Autoconf

First, fix a bug generated by Perl 5.28.

```
sed '361 s/{/\\{/ -i bin/autoscan.in
```

Prepare Autoconf for compilation:

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

Compile the package:

```
make
```

The test suite is currently broken by bash-5 and libtool-2.4.3. To run the tests anyway, issue:

```
make check
```

Install the package:

```
make install
```

### 6.43.2. Contents of Autoconf

Installed programs: autoconf, autoheader, autom4te, autoreconf, autoscan, autoupdate, and ifnames

Installed directory: /usr/share/autoconf

### Short Descriptions

autoconf	Produces shell scripts that automatically configure software source code packages to adapt to many kinds of Unix-like systems; the configuration scripts it produces are independent—running them does not require the autoconf program
autoheader	A tool for creating template files of C #define statements for configure to use
autom4te	A wrapper for the M4 macro processor
autoreconf	Automatically runs autoconf, autoheader, aclocal, automake, gettextize, and libtoolize in the correct order to save time when changes are made to autoconf and automake template files
autoscan	Helps to create a <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 <code>configure.in</code> file generated by autoscan.]

## 6.44. Automake-1.16.1

The Automake package contains programs for generating Makefiles for use with Autoconf.

Approximate build time: less than 0.1 SBU (about 8.7 SBU with tests)

Required disk space: 107 MB

### 6.44.1. Installation of Automake

Prepare Automake for compilation:

```
./configure --prefix=/usr --docdir=/usr/share/doc/automake-1.16.1
```

Compile the package:

```
make
```

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:

```
make -j4 check
```

One test is known to fail in the LFS environment: `subobj.sh`.

Install the package:

```
make install
```

### 6.44.2. Contents of Automake

Installed programs: `aclocal`, `aclocal-1.16` (hard linked with `aclocal`), `automake`, and `automake-1.16` (hard linked with `automake`)

Installed directories: `/usr/share/aclocal-1.16`, `/usr/share/automake-1.16`, and `/usr/share/doc/automake-1.16.1`

### Short Descriptions

<code>aclocal</code>	Generates <code>aclocal.m4</code> files based on the contents of <code>configure.in</code> files
<code>aclocal-1.16</code>	A hard link to <code>aclocal</code>
<code>automake</code>	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.]
<code>automake-1.16</code>	A hard link to <code>automake</code>

## 6.45. Xz-5.2.4

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

### 6.45.1. Installation of Xz

Prepare Xz for compilation with:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/xz-5.2.4
```

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-5.2.4

### Short Descriptions

lzcat	Decompresses to standard output
lzcmp	Runs cmp on LZMA compressed files
lzdiff	Runs diff on LZMA compressed files
lzegrep	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
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-26

The Kmod package contains libraries and utilities for loading kernel modules

Approximate build time: 0.1 SBU

Required disk space: 13 MB

### 6.46.1. Installation of Kmod

Prepare Kmod for compilation:

```
./configure --prefix=/usr      \
            --bindir=/bin      \
            --sysconfdir=/etc   \
            --with-rootlibdir=/lib \
            --with-xz           \
            --with-zlib
```

The meaning of the configure options:

`--with-xz`, `--with-zlib`

These options enable Kmod to handle compressed kernel modules.

`--with-rootlibdir=/lib`

This option ensures different library related files are placed in the correct directories.

Compile the package:

```
make
```

This package does not come with a test suite that can be run in the LFS chroot environment. At a minimum the git program is required and several tests will not run outside of a git repository.

Install the package, and create symlinks for compatibility with Module-Init-Tools (the package that previously handled Linux kernel modules):

```
make install

for target in depmod insmod lsmod modinfo modprobe rmmod; do
    ln -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 rmmod (link to kmod)

Installed library: libkmod.so

### Short Descriptions

depmod	Creates a dependency file based on the symbols it finds in the existing set of modules; this dependency file is used by modprobe to automatically load the required modules
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-0.20.1

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: 2.9 SBU  
Required disk space: 249 MB

### 6.47.1. Installation of Gettext

Prepare Gettext for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/gettext-0.20.1
```

Compile the package:

```
make
```

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

```
make check
```

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, 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-0.20.1, /usr/share/gettext, and /usr/share/gettext-0.19.8

### 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
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

<code>msginit</code>	Creates a new <code>.po</code> file, initializing the meta information with values from the user's environment
<code>msgmerge</code>	Combines two raw translations into a single file
<code>msgunfmt</code>	Decompiles a binary message catalog into raw translation text
<code>msguniq</code>	Unifies duplicate translations in a translation catalog
<code>ngettext</code>	Displays native language translations of a textual message whose grammatical form depends on a number
<code>recode-sr-latin</code>	Recodes Serbian text from Cyrillic to Latin script
<code>xgettext</code>	Extracts the translatable message lines from the given source files to make the first translation template
<code>libasprintf</code>	defines the <code>asprintf</code> class, which makes C formatted output routines usable in C++ programs, for use with the <code>&lt;string&gt;</code> strings and the <code>&lt;iostream&gt;</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 <code>.po</code> files; this library is used when the standard applications shipped with Gettext (such as <code>msgcomm</code> , <code>msgcmp</code> , <code>msgattrib</code> , and <code>msgen</code> ) 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 <code>LD_PRELOAD</code> that assists <code>libintl</code> in logging untranslated messages

## 6.48. Libelf from Elfutils-0.177

Libelf is a library for handling ELF (Executable and Linkable Format) files.

Approximate build time: 1.1 SBU

Required disk space: 95 MB

### 6.48.1. Installation of Libelf

Libelf is part of elfutils-0.177 package. Use the elfutils-0.177.tar.bz2 as the source tarball.

Prepare Libelf for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install only Libelf:

```
make -C libelf install  
install -vm644 config/libelf.pc /usr/lib/pkgconfig
```

### 6.48.2. Contents of Libelf

Installed Library: libelf.so

Installed Directory: /usr/include/elfutils

## 6.49. Libffi-3.2.1

The Libffi library provides a portable, high level programming interface to various calling conventions. This allows a programmer to call any function specified by a call interface description at run time.

Approximate build time: 0.4 SBU

Required disk space: 7.6 MB

### 6.49.1. Installation of Libffi

#### Note

Similar to GMP, libffi builds with optimizations specific to the processor in use. If building for another system, export CFLAGS and CXXFLAGS to specify a generic build for your architecture. If this is not done, all applications that link to libffi will trigger Illegal Operation Errors.

Modify the Makefile to install headers into the standard `/usr/include` directory instead of `/usr/lib/libffi-3.2.1/include`.

```
sed -e '/^includesdir/ s/${libdir}.*${includedir}/' \
    -i include/Makefile.in

sed -e '/^includedir/ s/=.*$/=@includedir/' \
    -e 's/^Cflags: -I${includedir}/Cflags:/' \
    -i libffi.pc.in
```

Prepare libffi for compilation:

```
./configure --prefix=/usr --disable-static --with-gcc-arch=native
```

The meaning of the configure option:

*--with-gcc-arch=native*

Ensure gcc optimizes for the current system. If this is not specified, the system is guessed and the code generated may not be correct for some systems. If the generated code will be copied from the native system to a less capable system, use the less capable system as a parameter. For details about alternative system types, see the x86 options in the gcc manual.

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

### 6.49.2. Contents of Libffi

Installed library: libffi.so

#### Short Descriptions

`libffi` contains the libffi API functions.

## 6.50. OpenSSL-1.1.1c

The OpenSSL package contains management tools and libraries relating to cryptography. These are useful for providing cryptographic functions to other packages, such as OpenSSH, email applications and web browsers (for accessing HTTPS sites).

Approximate build time: 2.3 SBU  
Required disk space: 147 MB

### 6.50.1. Installation of OpenSSL

First, fix a problem identified upstream:

```
sed -i '/\} data/s/ =.*$/;\n    memset(&data, 0, sizeof(data));/' \
    crypto/rand/rand_lib.c
```

Prepare OpenSSL for compilation:

```
./config --prefix=/usr \
        --openssldir=/etc/ssl \
        --libdir=lib \
        shared \
        zlib-dynamic
```

Compile the package:

```
make
```

To test the results, issue:

```
make test
```

Install the package:

```
sed -i '/INSTALL_LIBS/s/libcrypto.a libssl.a/' Makefile
make MANSUFFIX=ssl install
```

If desired, install the documentation:

```
mv -v /usr/share/doc/openssl /usr/share/doc/openssl-1.1.1c
cp -vfr doc/* /usr/share/doc/openssl-1.1.1c
```

### 6.50.2. Contents of OpenSSL

Installed programs:	c_rehash and openssl
Installed libraries:	libcrypto.{so,a} and libssl.{so,a}
Installed directories:	/etc/ssl, /usr/include/openssl, /usr/lib/engines and /usr/share/doc/openssl-1.1.1c

### Short Descriptions

c_rehash	is a Perl script that scans all files in a directory and adds symbolic links to their hash values.
openssl	is a command-line tool for using the various cryptography functions of OpenSSL's crypto library from the shell. It can be used for various functions which are documented in man 1 openssl.
libcrypto.so	implements a wide range of cryptographic algorithms used in various Internet standards. The services provided by this library are used by the OpenSSL implementations of SSL, TLS and S/MIME, and they have also been used to implement OpenSSH, OpenPGP, and other cryptographic standards.
libssl.so	implements the Transport Layer Security (TLS v1) protocol. It provides a rich API, documentation on which can be found by running man 3 ssl.

## 6.51. Python-3.7.4

The Python 3 package contains the Python development environment. It is useful for object-oriented programming, writing scripts, prototyping large programs or developing entire applications.

Approximate build time: 1.3 SBU

Required disk space: 399 MB

### 6.51.1. Installation of Python 3

Prepare Python for compilation:

```
./configure --prefix=/usr \
            --enable-shared \
            --with-system-expat \
            --with-system-ffi \
            --with-ensurepip=yes
```

The meaning of the configure options:

*--with-system-expat*

This switch enables linking against system version of Expat.

*--with-system-ffi*

This switch enables linking against system version of libffi.

*--with-ensurepip=yes*

This switch enables building pip and setuptools packaging programs.

Compile the package:

```
make
```

The test suite requires TK and an X Windows session and cannot be run until Python 3 is reinstalled in BLFS.

Install the package:

```
make install
chmod -v 755 /usr/lib/libpython3.7m.so
chmod -v 755 /usr/lib/libpython3.so
ln -sfv pip3.7 /usr/bin/pip3
```

The meaning of the install commands:

`chmod -v 755 /usr/lib/libpython3.{7m,}.so`

Fix permissions for libraries to be consistent with other libraries.

If desired, install the preformatted documentation:

```
install -v -dm755 /usr/share/doc/python-3.7.4/html

tar --strip-components=1 \
    --no-same-owner \
    --no-same-permissions \
    -C /usr/share/doc/python-3.7.4/html \
    -xvf ../python-3.7.4-docs-html.tar.bz2
```

The meaning of the documentation install commands:

*--no-same-owner* and *--no-same-permissions*

Ensure the installed files have the correct ownership and permissions. Without these options, using tar will install the package files with the upstream creator's values.

### 6.51.2. Contents of Python 3

Installed Programs: 2to3, idle3, pip3, pydoc3, python3, python3-config, and pyvenv

Installed Library: libpython3.7m.so and libpython3.so

Installed Directories: /usr/include/python3.7m, /usr/lib/python3 and /usr/share/doc/python-3.7.4



## Short Descriptions

2to3	is a Python program that reads Python 2.x source code and applies a series of fixes to transform it into valid Python 3.x code.
idle3	is a wrapper script that opens a Python aware GUI editor. For this script to run, you must have installed Tk before Python so that the Tkinter Python module is built.
pip3	The package installer for Python. You can use pip to install packages from Python Package Index and other indexes.
pydoc3	is the Python documentation tool.
python3	is an interpreted, interactive, object-oriented programming language.
pyenv	creates virtual Python environments in one or more target directories.

## 6.52. Ninja-1.9.0

Ninja is a small build system with a focus on speed.

Approximate build time: 0.2 SBU

Required disk space: 69 MB

### 6.52.1. Installation of Ninja

When run, ninja normally runs a maximum number of processes in parallel. By default this is the number of cores on the system plus two. In some cases this can overheat a CPU or run a system out of memory. If run from the command line, passing a `-jN` parameter will limit the number of parallel processes, but some packages embed the execution of ninja and do not pass a `-j` parameter.

Using the optional procedure below allows a user to limit the number of parallel processes via an environment variable, `NINJAJOBS`. For example, setting:

```
export NINJAJOBS=4
```

will limit ninja to four parallel processes.

If desired, add the capability to use the environment variable `NINJAJOBS` by running:

```
sed -i '/int Guess/a \
int    j = 0;\
char*  jobs = getenv( "NINJAJOBS" );\
if ( jobs != NULL ) j = atoi( jobs );\
if ( j > 0 ) return j;\
' src/ninja.cc
```

Build Ninja with:

```
python3 configure.py --bootstrap
```

The meaning of the build option:

`--bootstrap`

This parameter forces ninja to rebuild itself for the current system.

To test the results, issue:

```
./ninja ninja_test
./ninja_test --gtest_filter=-SubprocessTest.SetWithLots
```

Install the package:

```
install -vm755 ninja /usr/bin/
install -vDm644 misc/bash-completion /usr/share/bash-completion/completions/ninja
install -vDm644 misc/zsh-completion /usr/share/zsh/site-functions/_ninja
```

### 6.52.2. Contents of Ninja

Installed programs:       ninja

#### Short Descriptions

ninja     is the Ninja build system.

## 6.53. Meson-0.51.1

Meson is an open source build system meant to be both extremely fast, and, even more importantly, as user friendly as possible.

Approximate build time:   less than 0.1 SBU

Required disk space:     28 MB

### 6.53.1. Installation of Meson

Compile Meson with the following command:

```
python3 setup.py build
```

This package does not come with a test suite.

Install the package:

```
python3 setup.py install --root=dest
cp -rv dest/* /
```

The meaning of the install parameters:

*--root=dest*

By default python3 setup.py install installs various files (such as man pages) into Python Eggs. With a specified root location, setup.py installs these files into a standard hierarchy. Then we can just copy the hierarchy so the files will be in the standard location.

### 6.53.2. Contents of Meson

Installed programs:       meson

Installed directory:     /usr/lib/python3.7/site-packages/meson-0.51.1-py3.7.egg-info and /usr/lib/python3.7/site-packages/mesonbuild

### Short Descriptions

meson   A high productivity build system

## 6.54. Coreutils-8.31

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

Approximate build time: 2.5 SBU

Required disk space: 202 MB

### 6.54.1. 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-8.31-i18n-1.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.

Suppress a test which on some machines can loop forever:

```
sed -i '/test.lock/s/^/#/' gnulib-tests/gnulib.mk
```

Now prepare Coreutils for compilation:

```
autoreconf -fiv
FORCE_UNSAFE_CONFIGURE=1 ./configure \
    --prefix=/usr \
    --enable-no-install-program=kill,uptime
```

The meaning of the configure options:

**autoreconf**

This command updates generated configuration files consistent with the latest version of automake.

**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:

```
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 test program **test-getlogin** is known to fail in a partially built system environment like the chroot environment here, but passes if run at the end of this chapter. The test program **tty.sh** is also known to fail.

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,chmod,cp,date,dd,df,echo} /bin
mv -v /usr/bin/{false,ln,ls,mkdir,mknod,mv,pwd,rm} /bin
mv -v /usr/bin/{rmdir,stat,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
```

```
mv -v /usr/bin/{head,nice,sleep,touch} /bin
```

## 6.54.2. Contents of Coreutils

Installed programs: [ , b2sum, base32, base64, basename, basenc, 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 (in /usr/libexec/coreutils)

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)
b2sum	Prints or checks BLAKE2 (512-bit) checksums
basename	Strips any path and a given suffix from a file name
basenc	Encodes or decodes data using various algorithms
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)

<code>dircolors</code>	Outputs commands to set the <code>LS_COLOR</code> environment variable to change the color scheme used by <code>ls</code>
<code>dirname</code>	Strips the non-directory suffix from a file name
<code>du</code>	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
<code>echo</code>	Displays the given strings
<code>env</code>	Runs a command in a modified environment
<code>expand</code>	Converts tabs to spaces
<code>expr</code>	Evaluates expressions
<code>factor</code>	Prints the prime factors of all specified integer numbers
<code>false</code>	Does nothing, unsuccessfully; it always exits with a status code indicating failure
<code>fmt</code>	Reformats the paragraphs in the given files
<code>fold</code>	Wraps the lines in the given files
<code>groups</code>	Reports a user's group memberships
<code>head</code>	Prints the first ten lines (or the given number of lines) of each given file
<code>hostid</code>	Reports the numeric identifier (in hexadecimal) of the host
<code>id</code>	Reports the effective user ID, group ID, and group memberships of the current user or specified user
<code>install</code>	Copies files while setting their permission modes and, if possible, their owner and group
<code>join</code>	Joins the lines that have identical join fields from two separate files
<code>link</code>	Creates a hard link with the given name to a file
<code>ln</code>	Makes hard links or soft (symbolic) links between files
<code>logname</code>	Reports the current user's login name
<code>ls</code>	Lists the contents of each given directory
<code>md5sum</code>	Reports or checks Message Digest 5 (MD5) checksums
<code>mkdir</code>	Creates directories with the given names
<code>mkfifo</code>	Creates First-In, First-Outs (FIFOs), a "named pipe" in UNIX parlance, with the given names
<code>mknod</code>	Creates device nodes with the given names; a device node is a character special file, a block special file, or a FIFO
<code>mktemp</code>	Creates temporary files in a secure manner; it is used in scripts
<code>mv</code>	Moves or renames files or directories
<code>nice</code>	Runs a program with modified scheduling priority
<code>nl</code>	Numbers the lines from the given files
<code>nohup</code>	Runs a command immune to hangups, with its output redirected to a log file
<code>nproc</code>	Prints the number of processing units available to a process
<code>numfmt</code>	Converts numbers to or from human-readable strings
<code>od</code>	Dumps files in octal and other formats
<code>paste</code>	Merges the given files, joining sequentially corresponding lines side by side, separated by tab characters
<code>pathchk</code>	Checks if file names are valid or portable
<code>pinky</code>	Is a lightweight finger client; it reports some information about the given users
<code>pr</code>	Paginates and columnates files for printing
<code>printenv</code>	Prints the environment
<code>printf</code>	Prints the given arguments according to the given format, much like the C <code>printf</code> function
<code>ptx</code>	Produces a permuted index from the contents of the given files, with each keyword in its context
<code>pwd</code>	Reports the name of the current working directory
<code>readlink</code>	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

## 6.55. Check-0.12.0

Check is a unit testing framework for C.

Approximate build time: 0.1 SBU (about 3.7 SBU with tests)

Required disk space: 12 MB

### 6.55.1. Installation of Check

Prepare Check for compilation:

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

Build the package:

```
make
```

Compilation is now complete. To run the Check test suite, 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 and fix a script:

```
make docdir=/usr/share/doc/check-0.12.0 install
sed -i '1 s/tools/usr/' /usr/bin/checkmk
```

### 6.55.2. 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



## 6.56. Diffutils-3.7

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

Approximate build time: 0.4 SBU

Required disk space: 36 MB

### 6.56.1. Installation of Diffutils

Prepare Diffutils for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

### 6.56.2. 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

## 6.57. Gawk-5.0.1

The Gawk package contains programs for manipulating text files.

Approximate build time: 0.4 SBU

Required disk space: 47 MB

### 6.57.1. Installation of Gawk

First, ensure some unneeded files are not installed:

```
sed -i 's/extras//' Makefile.in
```

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-5.0.1
cp -v doc/{awkforai.txt,*.eps,pdf,jpg} /usr/share/doc/gawk-5.0.1
```

### 6.57.2. Contents of Gawk

Installed programs: awk (link to gawk), gawk, and awk-5.0.1

Installed libraries: filefuncs.so, fnmatch.so, fork.so, inplace.so, intdiv.so, ordchr.so, readdir.so, readfile.so, revoutput.so, revtwoway.so, rvarray.so, and time.so (all in /usr/lib/gawk)

Installed directories: /usr/lib/gawk, /usr/libexec/awk, /usr/share/awk, and /usr/share/doc/gawk-5.0.1

### Short Descriptions

awk	A link to gawk
gawk	A program for manipulating text files; it is the GNU implementation of awk
gawk-5.0.1	A hard link to gawk

## 6.58. Findutils-4.6.0

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

Approximate build time: 0.7 SBU  
Required disk space: 52 MB

### 6.58.1. Installation of Findutils

First, suppress a test which on some machines can loop forever:

```
sed -i 's/test-lock..EXEXT.//' tests/Makefile.in
```

Next, make some fixes required by glibc-2.28 and later:

```
sed -i 's/IO_ftrylockfile/IO_EOF_SEEN/' gl/lib/*.c
sed -i '/unistd/a #include <sys/sysmacros.h>' gl/lib/mountlist.c
echo "#define _IO_IN_BACKUP 0x100" >> gl/lib/stdio-impl.h
```

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
```

### 6.58.2. Contents of Findutils

Installed programs: find, locate, updatedb, and xargs  
Installed directory: /var/lib/locate

#### Short Descriptions

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
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

## 6.59. Groff-1.22.4

The Groff package contains programs for processing and formatting text.

Approximate build time: 0.5 SBU

Required disk space: 95 MB

### 6.59.1. 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
```

This package does not support parallel build. Compile the package:

```
make -j1
```

This package does not come with a test suite.

Install the package:

```
make install
```

### 6.59.2. 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, hptodit, 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-1.22.4, /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 .pfb format to ASCII
pic	Compiles descriptions of pictures embedded within troff or TeX input files into commands understood by TeX or troff
pic2graph	Converts a PIC diagram into a cropped image
post-grohtml	Translates the output of GNU troff to HTML
preconv	Converts encoding of input files to something GNU troff understands
pre-grohtml	Translates the output of GNU troff to HTML
refer	Copies the contents of a file to the standard output, except that lines between .[ and .] are interpreted as citations, and lines between .R1 and .R2 are interpreted as commands for how citations are to be processed
roff2dvi	Transforms roff files into DVI format
roff2html	Transforms roff files into HTML format
roff2pdf	Transforms roff files into PDFs
roff2ps	Transforms roff files into ps files
roff2text	Transforms roff files into text files
roff2x	Transforms roff files into other formats
soelim	Reads files and replaces lines of the form .so file by the contents of the mentioned file
tbl	Compiles descriptions of tables embedded within troff input files into commands that are understood by troff
tfmtoedit	Creates a font file for use with groff -Tdvi
troff	Is highly compatible with Unix troff; it should usually be invoked using the groff command, which will also run preprocessors and post-processors in the appropriate order and with the appropriate options

## 6.60. GRUB-2.04

The GRUB package contains the GRand Unified Bootloader.

Approximate build time: 0.8 SBU

Required disk space: 161 MB

### 6.60.1. 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
mv -v /etc/bash_completion.d/grub /usr/share/bash-completion/completions
```

Using GRUB to make your LFS system bootable will be discussed in Section#8.4, “Using GRUB to Set Up the Boot Process”.

### 6.60.2. 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-mkreldpath, 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

<code>grub-mklayout</code>	Generates a GRUB keyboard layout file
<code>grub-mknetdir</code>	Prepares a GRUB netboot directory
<code>grub-mkpasswd-pbkdf2</code>	Generates an encrypted PBKDF2 password for use in the boot menu
<code>grub-mkrelpath</code>	Makes a system pathname relative to its root
<code>grub-mkrescue</code>	Make a bootable image of GRUB suitable for a floppy disk or CDROM/DVD
<code>grub-mkstandalone</code>	Generates a standalone image
<code>grub-ofpathname</code>	Is a helper program that prints the path of a GRUB device
<code>grub-probe</code>	Probe device information for a given path or device
<code>grub-reboot</code>	Sets the default boot entry for GRUB for the next boot only
<code>grub-render-label</code>	Render Apple .disk_label for Apple Macs
<code>grub-script-check</code>	Checks GRUB configuration script for syntax errors
<code>grub-set-default</code>	Sets the default boot entry for GRUB
<code>grub-sparc64-setup</code>	Is a helper program for grub-setup
<code>grub-syslinux2cfg</code>	Transform a syslinux config file into grub.cfg format

## 6.61. Less-551

The Less package contains a text file viewer.

Approximate build time: less than 0.1 SBU

Required disk space: 4.1 MB

### 6.61.1. 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
```

### 6.61.2. 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



## 6.62. Gzip-1.10

The Gzip package contains programs for compressing and decompressing files.

Approximate build time: 0.1 SBU

Required disk space: 20 MB

### 6.62.1. Installation of Gzip

Prepare Gzip for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Two tests are known to fail in the LFS environment: help-version and zmore.

Install the package:

```
make install
```

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

```
mv -v /usr/bin/gzip /bin
```

### 6.62.2. 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

## 6.63. IPRoute2-5.2.0

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

Approximate build time: 0.2 SBU

Required disk space: 13 MB

### 6.63.1. 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, a directory for arpd and a man page 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/9.0/server/databases.html#db>.

```
sed -i /ARPD/d Makefile
rm -fv man/man8/arpd.8
```

It is also necessary to disable building two modules that requires <http://www.linuxfromscratch.org/blfs/view/9.0/postlfs/iptables.html>.

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

Compile the package:

```
make
```

This package does not have a working test suite.

Install the package:

```
make DOCDIR=/usr/share/doc/iproute2-5.2.0 install
```

### 6.63.2. Contents of IPRoute2

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

Installed directories: /etc/iproute2, /usr/lib/tc, and /usr/share/doc/iproute2-5.2.0,

### Short Descriptions

bridge	Configures network bridges
ctstat	Connection status utility
genl	Generic netlink utility frontend
ifcfg	A shell script wrapper for the ip command [Note that it requires the arping and rdisk programs from the iputils package found at <a href="http://www.skbuff.net/iputils/">http://www.skbuff.net/iputils/</a> .]
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
lstat	Provides Linux network statistics; it is a generalized and more feature-complete replacement for the old rtstat program
nstat	Shows network statistics
route	A component of ip route. This is for flushing the routing tables

route	A component of ip route. This is for listing the routing tables
rtacct	Displays the contents of <code>/proc/net/rt_acct</code>
rtmon	Route monitoring utility
rtpr	Converts the output of <code>ip -o</code> back into a readable form
rtstat	Route status utility
ss	Similar to the <code>netstat</code> command; shows active connections
tc	Traffic Controlling Executable; this is for Quality Of Service (QOS) and Class Of Service (COS) implementations <ul style="list-style-type: none"><li><code>tc qdisc</code> allows users to setup the queueing discipline</li><li><code>tc class</code> allows users to setup classes based on the queueing discipline scheduling</li><li><code>tc estimator</code> allows users to estimate the network flow into a network</li><li><code>tc filter</code> allows users to setup the QOS/COS packet filtering</li><li><code>tc policy</code> allows users to setup the QOS/COS policies</li></ul>

## 6.64. Kbd-2.2.0

The Kbd package contains key-table files, console fonts, and keyboard utilities.

Approximate build time: 0.2 SBU

Required disk space: 36 MB

### 6.64.1. 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-2.2.0-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-2.2.0
cp -R -v docs/doc/* /usr/share/doc/kbd-2.2.0
```

### 6.64.2. Contents of Kbd

Installed programs:	chvt, deallocvt, dumpkeys, fgconsole, getkeycodes, kbdinfo, kbd_mode, kbdrate, loadkeys, loadunimap, mapscrn, openvt, psfaddtable (link to psfxtable), psfgettable (link to psfxtable), psfstriptable (link to psfxtable), psfxtable, setfont, setkeycodes, setleds, setmetamode, setvtrgb, showconsolefont, showkey, unicode_start, and unicode_stop
Installed directories:	/usr/share/consolefonts, /usr/share/consoletrans, /usr/share/keymaps, /usr/share/doc/kbd-2.2.0, and /usr/share/unimaps

### Short Descriptions

chvt	Changes the foreground virtual terminal
------	---

<code>deallocvt</code>	Deallocates unused virtual terminals
<code>dumpkeys</code>	Dumps the keyboard translation tables
<code>fgconsole</code>	Prints the number of the active virtual terminal
<code>getkeycodes</code>	Prints the kernel scancode-to-keycode mapping table
<code>kbdinfo</code>	Obtains information about the status of a console
<code>kbd_mode</code>	Reports or sets the keyboard mode
<code>kbdrate</code>	Sets the keyboard repeat and delay rates
<code>loadkeys</code>	Loads the keyboard translation tables
<code>loadunimap</code>	Loads the kernel unicode-to-font mapping table
<code>mapscrn</code>	An obsolete program that used to load a user-defined output character mapping table into the console driver; this is now done by <code>setfont</code>
<code>openvt</code>	Starts a program on a new virtual terminal (VT)
<code>psfaddtable</code>	Adds a Unicode character table to a console font
<code>psfgettable</code>	Extracts the embedded Unicode character table from a console font
<code>psfstriptime</code>	Removes the embedded Unicode character table from a console font
<code>psfxtable</code>	Handles Unicode character tables for console fonts
<code>setfont</code>	Changes the Enhanced Graphic Adapter (EGA) and Video Graphics Array (VGA) fonts on the console
<code>setkeycodes</code>	Loads kernel scancode-to-keycode mapping table entries; this is useful if there are unusual keys on the keyboard
<code>setleds</code>	Sets the keyboard flags and Light Emitting Diodes (LEDs)
<code>setmetamode</code>	Defines the keyboard meta-key handling
<code>setvtrgb</code>	Sets the console color map in all virtual terminals
<code>showconsolefont</code>	Shows the current EGA/VGA console screen font
<code>showkey</code>	Reports the scancodes, keycodes, and ASCII codes of the keys pressed on the keyboard
<code>unicode_start</code>	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.]
<code>unicode_stop</code>	Reverts keyboard and console from UNICODE mode

## 6.65. Libpipeline-1.5.1

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: 9.0 MB

### 6.65.1. Installation of Libpipeline

Prepare Libpipeline for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

### 6.65.2. Contents of Libpipeline

Installed library: libpipeline.so

#### Short Descriptions

`libpipeline` This library is used to safely construct pipelines between subprocesses

## 6.66. Make-4.2.1

The Make package contains a program for compiling packages.

Approximate build time: 0.6 SBU

Required disk space: 13 MB

### 6.66.1. Installation of Make

Again, work around an error caused by glibc-2.27 and later:

```
sed -i '211,217 d; 219,229 d; 232 d' glob/glob.c
```

Prepare Make for compilation:

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

Compile the package:

```
make
```

The test suite needs to know where supporting perl files are located. We use an environment variable to accomplish this. To test the results, issue:

```
make PERL5LIB=$PWD/tests/ check
```

Install the package:

```
make install
```

### 6.66.2. 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

## 6.67. Patch-2.7.6

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: 13 MB

### 6.67.1. 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
```

### 6.67.2. 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.]
-------	--



## 6.68. Man-DB-2.8.6.1

The Man-DB package contains programs for finding and viewing man pages.

Approximate build time: 0.4 SBU

Required disk space: 38 MB

### 6.68.1. Installation of Man-DB

Prepare Man-DB for compilation:

```
sed -i '/find/s@/usr@@' init/systemd/man-db.service.in

./configure --prefix=/usr \
            --docdir=/usr/share/doc/man-db-2.8.6.1 \
            --sysconfdir=/etc \
            --disable-setuid \
            --enable-cache-owner=bin \
            --with-browser=/usr/bin/lynx \
            --with-vgrind=/usr/bin/vgrind \
            --with-grap=/usr/bin/grap
```

The meaning of the configure options:

`sed -i '/find/s@/usr@@' init/systemd/man-db.service.in`

This changes a hardcoded path to the find utility, which we install in `/bin`.

`--disable-setuid`

This disables making the man program setuid to user man.

`--enable-cache-owner=bin`

This makes the system-wide cache files be owned by user bin.

`--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
```

### 6.68.2. Non-English Manual Pages in LFS

The following table shows the character set that Man-DB assumes manual pages installed under `/usr/share/man/<ll>` will be encoded with. In addition to this, Man-DB correctly determines if manual pages installed in that directory are UTF-8 encoded.

Table#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
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

Language (code)	Encoding	Language (code)	Encoding
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.

## 6.68.3. 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 (both in /usr/lib/man-db)  
 Installed directories: /usr/lib/man-db, /usr/libexec/man-db, and /usr/share/doc/man-db-2.8.6.1

## 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

## 6.69. Tar-1.32

The Tar package contains an archiving program.

Approximate build time: 2.2 SBU

Required disk space: 45 MB

### 6.69.1. 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 3 SBU), issue:

```
make check
```

Install the package:

```
make install
make -C doc install-html docdir=/usr/share/doc/tar-1.32
```

### 6.69.2. Contents of Tar

Installed programs: tar

Installed directory: /usr/share/doc/tar-1.32

### Short Descriptions

**tar** Creates, extracts files from, and lists the contents of archives, also known as tarballs

## 6.70. Texinfo-6.6

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

Approximate build time: 0.8 SBU

Required disk space: 122 MB

### 6.70.1. 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
```

### 6.70.2. Contents of Texinfo

Installed programs: info, install-info, makeinfo (link to texi2any), pdftexi2dvi, pod2texi, texi2any, texi2dvi, texi2pdf, and texindex

Installed library: MiscXS.so, Parsetexi.so, and XSParagraph.so (all in /usr/lib/texinfo)

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

## 6.71. Vim-8.1.1846

The Vim package contains a powerful text editor.

Approximate build time: 2.2 SBU

Required disk space: 190 MB

### Alternatives to Vim

If you prefer another editor—such as Emacs, Joe, or Nano—please refer to <http://www.linuxfromscratch.org/blfs/view/9.0/postlfs/editors.html> for suggested installation instructions.

### 6.71.1. 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 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 "LANG=en_US.UTF-8 make -j1 test" &> vim-test.log
```

The test suite outputs a lot of binary data to the screen. This can cause issues with the settings of the current terminal. The problem can be avoided by redirecting the output to a log file as shown above. A successful test will result in the words "ALL DONE" in the log file 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-8.1.1846`, making it consistent with the location of documentation for other packages:

```
ln -sv ../vim/vim81/doc /usr/share/doc/vim-8.1.1846
```

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/9.0/postlfs/vim.html>.

## 6.71.2. 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

" Ensure defaults are set before customizing settings, not after
source $VIMRUNTIME/defaults.vim
let skip_defaults_vim=1

set nocompatible
set backspace=2
set mouse=
syntax on
if (&term == "xterm") || (&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. The *set mouse=* setting enables proper pasting of text with the mouse when working in chroot or over a remote connection. 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/vim81/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.

## 6.71.3. Contents of Vim

Installed programs:	ex (link to vim), rview (link to vim), rvim (link to vim), vi (link to vim), view (link to vim), vim, vimdiff (link to vim), 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 shows 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



## 6.72. Systemd-241

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

Approximate build time: 0.4 SBU

Required disk space: 227 MB

### 6.72.1. Installation of systemd

First, apply a patch to fix issues with systemd-networkd on Linux 5.2+ kernels, as well as with AMD Ryzen CPUs:

```
patch -Np1 -i ../systemd-241-networkd_and_rdrand_fixes-1.patch
```

Create a symlink to work around missing xsltproc:

```
ln -sf /tools/bin/true /usr/bin/xsltproc
```

Because we have not yet installed the final version of Util-Linux, create links to the libraries in the appropriate location:

```
for file in /tools/lib/lib{blkid,mount,uuid}.so*; do
    ln -sf $file /usr/lib/
done
```

Set up the man pages:

```
tar -xf ../systemd-man-pages-241.tar.xz
```

Remove tests that cannot be built in chroot:

```
sed '177,$ d' -i src/resolve/meson.build
```

Remove an unneeded group, render, from the default udev rules:

```
sed -i 's/GROUP="render", //' rules/50-udev-default.rules.in
```

Prepare systemd for compilation:

```
mkdir -p build
cd      build

PKG_CONFIG_PATH="/usr/lib/pkgconfig:/tools/lib/pkgconfig" \
LANG=en_US.UTF-8 \
CFLAGS+="-Wno-format-overflow" \
meson --prefix=/usr \
      --sysconfdir=/etc \
      --localstatedir=/var \
      -Dblkid=true \
      -Dbuildtype=release \
      -Ddefault-dnssec=no \
      -Dfirstboot=false \
      -Dinstall-tests=false \
      -Dkmod-path=/bin/kmod \
      -Dldconfig=false \
      -Dmount-path=/bin/mount \
      -Drootprefix= \
      -Drootlibdir=/lib \
      -Dsplit-usr=true \
      -Dsulogin-path=/sbin/sulogin \
      -Dsusers=false \
      -Dumount-path=/bin/umount \
      -Db_lto=false \
      -Drpmmacrosdir=no \
      ..
```

The meaning of the meson options:

*-D\*-path=\**

These switches provide location of binaries needed by systemd at runtime that have not yet been installed, or who's pkgconfig files are currently only in /tools/lib/pkgconfig.

*-Ddefault-dnssec=no*

This switch turns off the experimental DNSSEC support.

*-Dfirstboot=false*

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.

*-Dinstall-tests=false*

This switch prevents installation of the compiled tests.

*-Dldconfig=false*

This switch prevents installation of a systemd unit that runs ldconfig at boot, which is not useful for source distributions such as LFS and makes the boot time longer. Remove it if the described feature is desired.

*-Droot\**

These switches ensure that core programs and shared libraries are installed in the subdirectories of the root partition.

*-Dsplit-usr=true*

This switch ensures that systemd will work on systems where /bin, /lib and /sbin directories are not symlinks to their /usr counterparts.

*-Dsysusers=false*

This switch prevents installation of systemd services responsible for setting up the /etc/group and /etc/passwd files. Both files were created earlier in this chapter.

*-Drpmmacromdir=no*

This switch disables installation of RPM Macros for use with systemd because LFS does not support RPM.

Compile the package:

```
LANG=en_US.UTF-8 ninja
```

Install the package:

```
LANG=en_US.UTF-8 ninja install
```

Remove an unnecessary symbolic link:

```
rm -f /usr/bin/xsltproc
```

Create the /etc/machine-id file needed by systemd-journald:

```
systemd-machine-id-setup
```

Remove symbolic links to Util-Linux libraries:

```
rm -fv /usr/lib/lib{blkid,uuid,mount}.so*
```

Prevent systemd from creating /run/nologin to allow unprivileged user logins without systemd-logind:

```
rm -f /usr/lib/tmpfiles.d/systemd-nologin.conf
```

## 6.72.2. Contents of systemd

Installed programs:	bootctl, busctl, coredumpctl, halt (symlink to systemctl), hostnamectl, init, journalctl, kernel-install, localectl, loginctl, machinectl, networkctl, portablectl, poweroff (symlink to systemctl), reboot (symlink to systemctl), resolvconf (symlink to resolvectl), resolvectl, runlevel (symlink to systemctl), shutdown (symlink to systemctl), systemctl, systemd-analyze, systemd-ask-password, systemd-cat, systemd-cgls, systemd-cgtop, systemd-delta, systemd-detect-virt, systemd-escape, systemd-hwdb, systemd-id128, systemd-inhibit, systemd-machine-id-setup, systemd-mount, systemd-notify, systemd-nspawn, systemd-path, systemd-resolve (symlink to resolvectl), systemd-run, systemd-socket-activate, systemd-stdio-bridge, systemd-tmpfiles, systemd-tty-ask-password-agent, systemd-umount (symlink to systemd-mount), telinit (symlink to systemctl), timedatectl, and udevadm
Installed libraries:	libnss_myhostname.so.2, libnss_mymachines.so.2, libnss_resolve.so.2, libnss_systemd.so.2, libsystemd.so, libsystemd-shared-241.so (in /lib/systemd), and libudev.so
Installed directories:	/etc/binfmt.d, /etc/init.d, /etc/kernel, /etc/modules-load.d, /etc/sysctl.d, /etc/systemd, /etc/tmpfiles.d, /etc/udev, /etc/xdg/systemd, /lib/systemd, /lib/udev, /usr/include/systemd, /usr/lib/binfmt.d, /usr/lib/kernel, /usr/lib/modules-load.d, /usr/lib/sysctl.d, /usr/lib/systemd, /usr/lib/tmpfiles.d, /usr/share/doc/systemd-241, /usr/share/factory, /usr/share/systemd, /var/lib/systemd, and /var/log/journal

### 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 processes according to its configuration files
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>
portablectl	Used to attach or detach portable services from the local system
poweroff	Tells the kernel to halt the system and switch off the computer (see <code>halt</code> )
reboot	Tells the kernel to reboot the system (see <code>halt</code> )
resolvconf	Register DNS server and domain configuration with <code>systemd-resolved</code>

resolvectl	Send control commands to the network name resolution manager, or resolve domain names, IPv4 and IPv6 addresses, DNS records, and services.
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 STDOUT and STDERR of a process with the Journal
systemd-cgls	Recursively shows the contents of the selected Linux control group hierarchy in a tree
systemd-cgtop	Shows the top control groups of the local Linux control group hierarchy, ordered by their CPU, memory and disk I/O load
systemd-delta	Used to identify and compare configuration files in <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 (hwdb)
systemd-id128	Generate and print id128 strings
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-mount	A tool to temporarily mount or auto-mount a drive.
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-socket-activate	A tool to listen on socket devices and launch a process upon connection.
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-umount	Unmount mount points
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

libsystemd

The main systemd utility library

libudev

A library to access Udev device information

## 6.73. D-Bus-1.12.16

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: 0.1 SBU

Required disk space: 18 MB

### 6.73.1. 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-1.12.16 \
            --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/9.0/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
```

### 6.73.2. Contents of D-Bus

Installed programs:	dbus-cleanup-sockets, dbus-daemon, dbus-launch, dbus-monitor, dbus-run-session, dbus-send, dbus-test-tool, dbus-update-activation-environment, 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-1.12.16, 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

<code>dbus-send</code>	Sends a message to a D-Bus message bus
<code>dbus-test-tool</code>	A tool to help packages test D-Bus
<code>dbus-update-activation-environment</code>	Updates environment variables that will be set for D-Bus session services
<code>dbus-uuidgen</code>	Generates a universally unique ID
<code>libdbus-1</code>	Contains API functions used to communicate with the D-Bus message bus

## 6.74. Procps-ng-3.3.15

The Procps-ng package contains programs for monitoring processes.

Approximate build time: 0.2 SBU

Required disk space: 17 MB

### 6.74.1. Installation of Procps-ng

Prepare procps-ng for compilation:

```
./configure --prefix=/usr          \
            --exec-prefix=         \
            --libdir=/usr/lib       \
            --docdir=/usr/share/doc/procps-ng-3.3.15 \
            --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 a test that fails when scripting does not use a tty device and fix two others. To run the test suite, run the following commands:

```
sed -i -r 's|(pmap_initname)\\$|\\1|' testsuite/pmap.test/pmap.exp
sed -i 's|/set tty/d|' testsuite/pkill.test/pkill.exp
rm testsuite/pgrep.test/pgrep.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
```

### 6.74.2. 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-3.3.15

### 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
tload	Prints a graph of the current system load average
top	Displays a list of the most CPU intensive processes; it provides an ongoing look at processor activity in real time



uptime	Reports how long the system has been running, how many users are logged on, and the system load averages
vmstat	Reports virtual memory statistics, giving information about processes, memory, paging, block Input/Output (IO), traps, and CPU activity
w	Shows which users are currently logged on, where, and since when
watch	Runs a given command repeatedly, displaying the first screen-full of its output; this allows a user to watch the output change over time
libprocps	Contains the functions used by most programs in this package

## 6.75. Util-linux-2.34

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

Approximate build time: 1.2 SBU  
Required disk space: 283 MB

### 6.75.1. 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
```

### 6.75.2. Installation of Util-linux

Remove the earlier created symlinks:

```
rm -vf /usr/include/{blkid,libmount,uuid}
```

Prepare Util-linux for compilation:

```
./configure ADJTIME_PATH=/var/lib/hwclock/adjtime \
--docdir=/usr/share/doc/util-linux-2.34 \
--disable-chfn-chsh \
--disable-login \
--disable-nologin \
--disable-su \
--disable-setpriv \
--disable-runuser \
--disable-pylibmount \
--disable-static \
--without-python
```

The `--disable` and `--without` options prevent warnings about building components that require packages not in LFS or are inconsistent with programs installed by other packages.

Compile the package:

```
make
```

If desired, run the test suite as a non-root user:

#### Warning

Running the test suite as the root user can be harmful to your system. To run it, the `CONFIG_SCSI_DEBUG` option for the kernel must be available in the currently running system, and must be built as a module. Building it into the kernel will prevent booting. For complete coverage, other BLFS packages must be installed. If desired, this test can be run after rebooting into the completed LFS system and running:

```
bash tests/run.sh --srcdir=$PWD --builddir=$PWD
```

```
chown -Rv nobody .
su nobody -s /bin/bash -c "PATH=$PATH make -k check"
```

Install the package:

```
make install
```

## 6.75.3. Contents of Util-linux

Installed programs:	addpart, agetty, blkdiscard, blkid, blkzone, blockdev, cal, cfdisk, chcpu, chmem, choom, chrt, col, colcrt, colrm, column, ctrlaltdel, delpart, dmesg, eject, fallocate, fdformat, fdisk, fincore, 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, lsmem, lsns, mcookie, mesg, mkfs, mkfs.bfs, mkfs.cramfs, mkfs.minix, mkswap, more, mount, mountpoint, namei, nsenter, partx, pivot_root, prlimit, raw, readprofile, rename, renice, resizepart, rev, rkill, rtcwake, script, scriptreplay, setarch, setsid, setterm, sfdisk, sulogin, swapon, switch_root, taskset, ul, umount, unshare, utmpdump, uuid, uuidgen, uuidparse, 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-2.34, 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
blkzone	Runs zone command on the given block device
blockdev	Allows users to call block device ioctls from the command line
cal	Displays a simple calendar
cfdisk	Manipulates the partition table of the given device
chcpu	Modifies the state of CPUs
chmem	Configures memory
choom	Displays and adjusts OOM-killer score
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
fincore	Counts pages of file contents in core
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

<code>fsck.minix</code>	Performs a consistency check on the Minix file system on the given device
<code>fsfreeze</code>	Is a very simple wrapper around FIFREEZE/FITHAW ioctl kernel driver operations
<code>fstrim</code>	Discards unused blocks on a mounted filesystem
<code>getopt</code>	Parses options in the given command line
<code>hexdump</code>	Dumps the given file in hexadecimal or in another given format
<code>hwclock</code>	Reads or sets the system's hardware clock, also called the Real-Time Clock (RTC) or Basic Input-Output System (BIOS) clock
<code>i386</code>	A symbolic link to <code>setarch</code>
<code>ionice</code>	Gets or sets the io scheduling class and priority for a program
<code>ipcmk</code>	Creates various IPC resources
<code>ipcrm</code>	Removes the given Inter-Process Communication (IPC) resource
<code>ipcs</code>	Provides IPC status information
<code>isozsize</code>	Reports the size of an iso9660 file system
<code>kill</code>	Sends signals to processes
<code>last</code>	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
<code>lastb</code>	Shows the failed login attempts, as logged in <code>/var/log/btmp</code>
<code>ldattach</code>	Attaches a line discipline to a serial line
<code>linux32</code>	A symbolic link to <code>setarch</code>
<code>linux64</code>	A symbolic link to <code>setarch</code>
<code>logger</code>	Enters the given message into the system log
<code>look</code>	Displays lines that begin with the given string
<code>losetup</code>	Sets up and controls loop devices
<code>lsblk</code>	Lists information about all or selected block devices in a tree-like format
<code>lscpu</code>	Prints CPU architecture information
<code>lsipc</code>	Prints information on IPC facilities currently employed in the system
<code>lslocks</code>	Lists local system locks
<code>lslogins</code>	Lists information about users, groups and system accounts
<code>lsmem</code>	Lists the ranges of available memory with their online status
<code>lsns</code>	Lists namespaces
<code>mcookie</code>	Generates magic cookies (128-bit random hexadecimal numbers) for xauth
<code>mesg</code>	Controls whether other users can send messages to the current user's terminal
<code>mkfs</code>	Builds a file system on a device (usually a hard disk partition)
<code>mkfs.bfs</code>	Creates a Santa Cruz Operations (SCO) bfs file system
<code>mkfs.cramfs</code>	Creates a cramfs file system
<code>mkfs.minix</code>	Creates a Minix file system
<code>mkswap</code>	Initializes the given device or file to be used as a swap area
<code>more</code>	A filter for paging through text one screen at a time
<code>mount</code>	Attaches the file system on the given device to a specified directory in the file-system tree
<code>mountpoint</code>	Checks if the directory is a mountpoint
<code>namei</code>	Shows the symbolic links in the given pathnames
<code>nsenter</code>	Runs a program with namespaces of other processes
<code>partx</code>	Tells the kernel about the presence and numbering of on-disk partitions
<code>pivot_root</code>	Makes the given file system the new root file system of the current process
<code>prlimit</code>	Get and set a process' resource limits
<code>raw</code>	Bind a Linux raw character device to a block device
<code>readprofile</code>	Reads kernel profiling information

<code>rename</code>	Renames the given files, replacing a given string with another
<code>renice</code>	Alters the priority of running processes
<code>resizepart</code>	Asks the Linux kernel to resize a partition
<code>rev</code>	Reverses the lines of a given file
<code>rkfill</code>	Tool for enabling and disabling wireless devices
<code>rtcwake</code>	Used to enter a system sleep state until specified wakeup time
<code>script</code>	Makes a typescript of a terminal session
<code>scriptreplay</code>	Plays back typescripts using timing information
<code>setarch</code>	Changes reported architecture in a new program environment and sets personality flags
<code>setsid</code>	Runs the given program in a new session
<code>setterm</code>	Sets terminal attributes
<code>sfdisk</code>	A disk partition table manipulator
<code>sulogin</code>	Allows <code>root</code> to log in; it is normally invoked by <code>init</code> when the system goes into single user mode
<code>swapon</code>	Enables devices and files for paging and swapping and lists the devices and files currently in use
<code>swaplabel</code>	Allows to change swaparea UUID and label
<code>swapoff</code>	Disables devices and files for paging and swapping
<code>switch_root</code>	Switches to another filesystem as the root of the mount tree
<code>tailf</code>	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
<code>taskset</code>	Retrieves or sets a process' CPU affinity
<code>ul</code>	A filter for translating underscores into escape sequences indicating underlining for the terminal in use
<code>umount</code>	Disconnects a file system from the system's file tree
<code>uname26</code>	A symbolic link to <code>setarch</code>
<code>unshare</code>	Runs a program with some namespaces unshared from parent
<code>utmpdump</code>	Displays the content of the given login file in a more user-friendly format
<code>uuid</code>	A daemon used by the UUID library to generate time-based UUIDs in a secure and guaranteed-unique fashion
<code>uuidgen</code>	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
<code>uuidparse</code>	An utility to parse unique identifiers
<code>wall</code>	Displays the contents of a file or, by default, its standard input, on the terminals of all currently logged in users
<code>wdctl</code>	Shows hardware watchdog status
<code>whereis</code>	Reports the location of the binary, source, and man page for the given command
<code>wipefs</code>	Wipes a filesystem signature from a device
<code>x86_64</code>	A symbolic link to <code>setarch</code>
<code>zramctl</code>	A program to set up and control zram (compressed ram disk) devices
<code>libblkid</code>	Contains routines for device identification and token extraction
<code>libfdisk</code>	Contains routines for manipulating partition tables
<code>libmount</code>	Contains routines for block device mounting and unmounting
<code>libsmartcols</code>	Contains routines for aiding screen output in tabular form
<code>libuuid</code>	Contains routines for generating unique identifiers for objects that may be accessible beyond the local system

## 6.76. E2fsprogs-1.45.3

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: 3.1 SBU

Required disk space: 108 MB

### 6.76.1. Installation of E2fsprogs

The E2fsprogs documentation recommends that the package be built in a subdirectory of the source tree:

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

Prepare E2fsprogs for compilation:

```
../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:

`--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 run the tests, issue:

```
make 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
```

## 6.76.2. Contents of E2fsprogs

Installed programs:      badblocks, chatter, compile\_et, debugfs, dumpe2fs, e2freefrag, e2fsck, e2image, e2label, e2mmpstatus, e2scrub, e2scrub\_all, e2undo, e4crypt, e4defrag, filefrag, fsck.ext2, fsck.ext3, fsck.ext4, logsave, lsattr, mk\_cmds, mke2fs, mkfs.ext2, mkfs.ext3, mkfs.ext4, 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/lib/e2fsprogs, /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
e2mmpstatus	Checks MMP status of an <code>ext4</code> filesystem
e2scrub	Checks the contents of a mounted <code>ext[234]</code> filesystem
e2scrub_all	Checks all mounted <code>ext[234]</code> filesystems for errors
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.]
e4crypt	<code>Ext4</code> filesystem encryption utility
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 <code>e2fsck</code>
fsck.ext3	By default checks <code>ext3</code> file systems and is a hard link to <code>e2fsck</code>
fsck.ext4	By default checks <code>ext4</code> file systems and is a hard link to <code>e2fsck</code>
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 <code>mke2fs</code>
mkfs.ext3	By default creates <code>ext3</code> file systems and is a hard link to <code>mke2fs</code>
mkfs.ext4	By default creates <code>ext4</code> file systems and is a hard link to <code>mke2fs</code>
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 <code>e2fsck</code>
resize2fs	Can be used to enlarge or shrink an <code>ext2</code> file system

<code>tune2fs</code>	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 <code>dumpe2fs</code> , <code>chattr</code> , and <code>lsattr</code>
<code>libext2fs</code>	Contains routines to enable user-level programs to manipulate an <code>ext2</code> file system
<code>libss</code>	Used by <code>debugfs</code>



## 6.77. 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.

## 6.78. Stripping Again

This section is optional. 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 commands 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 commands, it is a good idea to make a backup of the LFS system in its current state.

First place the debugging symbols for selected libraries in separate files. This debugging information is needed if running regression tests that use `valgrind` or `gdb` later in BLFS.

```
save_lib="ld-2.30.so libc-2.30.so libpthread-2.30.so libthread_db-1.0.so"

cd /lib

for LIB in $save_lib; do
    objcopy --only-keep-debug $LIB $LIB.dbg
    strip --strip-unneeded $LIB
    objcopy --add-gnu-debuglink=$LIB.dbg $LIB
done

save_usrlib="libquadmath.so.0.0.0 libstdc++.so.6.0.27
            libitm.so.1.0.0 libatomic.so.1.2.0"

cd /usr/lib

for LIB in $save_usrlib; do
    objcopy --only-keep-debug $LIB $LIB.dbg
    strip --strip-unneeded $LIB
    objcopy --add-gnu-debuglink=$LIB.dbg $LIB
done

unset LIB save_lib save_usrlib
```

Before performing the stripping, take special care to ensure that none of the binaries that are about to be stripped are running:

```
exec /tools/bin/bash
```

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 \(-name \*.so* -a ! -name \*dbg\) \
-exec /tools/bin/strip --strip-unneeded {} ';'

/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.

## 6.79. Cleaning Up

Finally, clean up some extra files left around from running tests:

```
rm -rf /tmp/*
```

Now log out and reenter the chroot environment with an updated chroot command. From now on, use this updated chroot command any time you need to reenter the chroot environment after exiting:

```
logout

chroot "$LFS" /usr/bin/env -i \
    HOME=/root TERM="$TERM" \
    PS1='(lfs chroot) \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. For this reason you can delete the `/tools` directory if so desired.

### Note

Removing `/tools` will also remove the temporary copies of Tcl, Expect, and DejaGNU which were used for running the toolchain tests. If you need these programs later on, they will need to be recompiled and re-installed. The BLFS book has instructions for this (see <http://www.linuxfromscratch.org/blfs/>).

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".

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/libz.a

```

There are also several files installed in the `/usr/lib` and `/usr/libexec` directories with a file name extension of `.la`. These are "libtool archive" files and generally unneeded on a linux system. None of these are necessary at this point. To remove them, run:

```
find /usr/lib /usr/libexec -name \*.la -delete
```

For more information about libtool archive files, see the BLFS section "About Libtool Archive (`.la`) files".

# 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.

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.

#### 7.2.1.1. Network Device Naming

Udev normally assigns 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.

For most systems, there is only one network interface for each type of connection. For example, the classic interface name for a wired connection is `eth0`. A wireless connection will usually have the name `wifi0` or `wlan0`.

If you prefer to use the classic or customized network interface names, there are three alternative ways to do that:

- Mask udev's `.link` file for the default policy:

```
ln -s /dev/null /etc/systemd/network/99-default.link
```

- Create a manual naming scheme, for example by naming the interfaces something like "internet0", "dmz0", or "lan0". For that, create .link files in /etc/systemd/network/, that choose an explicit name or a better naming scheme for one, some, or all of your interfaces. For example:

```
cat > /etc/systemd/network/10-ether0.link << "EOF"
[Match]
# Change the MAC address as appropriate for your network device
MACAddress=12:34:45:78:90:AB

[Link]
Name=ether0
EOF
```

See the man page `systemd.link(5)` for more information.

- In `/boot/grub/grub.cfg`, pass the option `net.ifnames=0` on the kernel command line.

### 7.2.1.2. 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-eth-static.network << "EOF"
[Match]
Name=<network-device-name>

[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.

### 7.2.1.3. DHCP Configuration

The command below creates a basic configuration file for an IPv4 DHCP setup:

```
cat > /etc/systemd/network/10-eth-dhcp.network << "EOF"
[Match]
Name=<network-device-name>

[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 creates the file `/run/systemd/resolve/resolv.conf`. Create a symlink in `/etc` to use the generated file:

```
ln -sfv /run/systemd/resolve/resolv.conf /etc/resolv.conf
```

### 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 localhost
127.0.1.1 <FQDN> <HOSTNAME>
::1      localhost ip6-localhost ip6-loopback
ff02::1  ip6-allnodes
ff02::2  ip6-allrouters

# End /etc/hosts
EOF
```

The `::1` entry is the IPv6 counterpart of `127.0.0.1` and represents the IPv6 loopback interface. `127.0.1.1` is a loopback entry reserved specifically for the FQDN.

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
127.0.1.1 <FQDN> <HOSTNAME>
<192.168.0.2> <FQDN> <HOSTNAME> [alias1] [alias2] ...
::1      localhost ip6-localhost ip6-loopback
ff02::1  ip6-allnodes
ff02::2  ip6-allrouters

# End /etc/hosts
EOF
```

The `<192.168.0.2>`, `<FQDN>`, 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-5.2.8, `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-5.2.8, 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 to the corresponding `/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](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+="tvrtuner"

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 a list of available time zones by running:

```
timedatectl list-timezones
```

## Note

Please note that the `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 the `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 the 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, “UTF-8” 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 the `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 the `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/9.0/introduction/locale-issues.html>.

## 7.8. Creating the /etc/inputrc File

The inputrc file is the configuration file for the Readline library, which provides editing capabilities while the user is entering a line from the terminal. It works by translating keyboard inputs into specific actions. Readline is used by Bash and most other shells as well as many other applications.

Most people do not need user-specific functionality 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 the `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 reviewed by using the `journalctl -b` command as the root user.

### 7.10.3. Disabling tmpfs for /tmp

By default, `/tmp` is created as a tmpfs. If this is not desired, it can be overridden by the following:

```
ln -sfv /dev/null /etc/systemd/system/tmp.mount
```

Alternatively, if a separate partition for `/tmp` is desired, specify that partition in an `/etc/fstab` entry.

#### Warning

Do not create the symbolic link above if a separate partition is used for `/tmp`. This will prevent the root file system (/) from being remounted r/w and make the system unusable when booted.

### 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.

Note that the syntax for the `/usr/lib/tmpfiles.d/*.conf` files can be confusing. For example, the default deletion of files in the `/tmp` directory is located in `/usr/lib/tmpfiles.d/tmp.conf` with the line:

```
q /tmp 1777 root root 10d
```

The type field, `q`, discusses creating a subvolume with quotas which is really only applicable to btrfs filesystems. It references type `v` which in turn references type `d` (directory). This then creates the specified directory if it is not present and adjusts the permissions and ownership as specified. Contents of the directory will be subject to time based cleanup if the age argument is specified.

If the default parameters are not desired, then the file should be copied to `/etc/tmpfiles.d` and edited as desired. For example:

```
mkdir -p /etc/tmpfiles.d
cp /usr/lib/tmpfiles.d/tmp.conf /etc/tmpfiles.d
```

## 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 `journalctl` is provided. Here are some examples of frequently used commands:

- `journalctl -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 the `daemon()` or `setsid()` functions. 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 selected 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 `-Ddefault-kill-user-processes=no` to the `meson` 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 a special option, `utf8`, in order for non-ASCII characters in file names to be interpreted properly. For non-UTF-8 locales, the value of `iocharset` should be set to be the same as the character set of the 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 when configuring the kernel) has been compiled into the kernel or built as a module. However, if the character set of the locale is UTF-8, the corresponding option `iocharset=utf8` would make the file system case sensitive. To fix this, use the special option `utf8` instead of `iocharset=utf8`, for UTF-8 locales. 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. For example, 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,codepage=866,iocharset=koi8r
```

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

```
noauto,user,quiet,showexec,codepage=866,utf8
```

Note that using `iocharset` is the default for `iso8859-1` (which keeps the file system case insensitive), and the `utf8` option tells the kernel to convert the file names using UTF-8 so they can be interpreted in the UTF-8 locale.

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-5.2.8

The Linux package contains the Linux kernel.

Approximate build time: 4.4 - 66.0 SBU (typically about 6 SBU)

Required disk space: 960 - 4250 MB (typically about 1100 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/9.0/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/disable/set the following features or the system might not work correctly or boot at all:

```
General setup -->
  [ ] Enable deprecated sysfs features to support old userspace tools [CONFIG_SYSFS_DEPRECATED]
  [ ] Enable deprecated sysfs features by default [CONFIG_SYSFS_DEPRECATED_V2]
  [*] 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_LOADER_USER_HELPER]
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_AUTOFS4_FS]
Pseudo filesystems --->
  [*] Tmpfs POSIX Access Control Lists [CONFIG_TMPFS_POSIX_ACL]
  [*] Tmpfs extended attributes [CONFIG_TMPFS_XATTR]
Kernel hacking --->
  Choose kernel unwinder (Frame pointer unwinder) ---> [CONFIG_UNWINDER_FRAME_POINTER]
```

#### Note

While "The IPv6 Protocol" is not strictly required, it is highly recommended by the systemd developers.

## Note

If your host hardware is using UEFI, then the 'make defconfig' above should automatically add in some EFI-related kernel options.

In order to allow your LFS kernel to be booted from within your host's UEFI boot environment, your kernel must have this option selected:

```
Processor type and features --->
[*]   EFI stub support   [CONFIG_EFI_STUB]
```

A fuller description of managing UEFI environments from within LFS is covered by the lfs-uefi.txt hint at <http://www.linuxfromscratch.org/hints/downloads/files/lfs-uefi.txt>.

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-5.2.8 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-5.2.8/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 (outside chroot) to /mnt/lfs/boot before proceeding. As the root user in the host system:

```
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 -iv arch/x86/boot/bzImage /boot/vmlinuz-5.2.8-lfs-9.0-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 -iv System.map /boot/System.map-5.2.8
```

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 -iv .config /boot/config-5.2.8
```

Install the documentation for the Linux kernel:

```
install -d /usr/share/doc/linux-5.2.8
cp -r Documentation/* /usr/share/doc/linux-5.2.8
```

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-5.2.8` 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-5.2.8 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-5.2.8`, `vmlinuz-5.2.8-lfs-9.0-systemd`, and `System.map-5.2.8`  
 Installed directories: `/lib/modules`, `/usr/share/doc/linux-5.2.8`

#### Short Descriptions

<code>config-5.2.8</code>	Contains all the configuration selections for the kernel
<code>vmlinuz-5.2.8-lfs-9.0-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-5.2.8</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

To boot LFS on host systems that have UEFI enabled, the kernel needs to have been built with the `CONFIG_EFI_STUB` capability described in the previous section. However, LFS can be booted using GRUB2 without such an addition. To do this, the UEFI Mode and Secure Boot capabilities in the host system's BIOS need to be turned off. 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 `(hdm)`, 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
```

## Note

If the system has been booted using UEFI, grub-install will try to install files for the x86\_64-efi target, but those files have not been installed in chapter 6. If this is the case, add `--target i386-pc` to the command above.

## 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 5.2.8-lfs-9.0-systemd" {
    linux /boot/vmlinuz-5.2.8-lfs-9.0-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="9.0-systemd"
ID=lfs
PRETTY_NAME="Linux From Scratch 9.0-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 9.0-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="9.0-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`.
- 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 9.0 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. 附录

# 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
- Bruce Dubbs <bdubbs@linuxfromscratch.org> – LFS Managing Editor
- Jim Gifford <jim@linuxfromscratch.org> – CLFS Project Co-Leader
- Pierre Labastie <pierre@linuxfromscratch.org> – BLFS Editor and ALFS Lead
- DJ Lucas <dj@linuxfromscratch.org> – LFS and BLFS Editor
- Ken Moffat <ken@linuxfromscratch.org> – BLFS Editor
- 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 2008-2016
- Julien Lepiller <jlepiller@linuxfromscratch.org> – French LFS translation project 2017-present
- Anderson Lizardo <lizardo@linuxfromscratch.org> – Portuguese LFS translation project
- Thomas Reitelbach <tr@erdfunkstelle.de> – German LFS translation project
- Anton Maisak <info@linuxfromscratch.org.ru> – Russian LFS translation project
- Elena Shevcova <helen@linuxfromscratch.org.ru> – Russian 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
- Anton Maisak <info@linuxfromscratch.org.ru> – linuxfromscratch.org.ru mirror

## Asian Mirrors

- Satit Phermasawang <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
- Matthew Burgess <matthew@linuxfromscratch.org> – LFS Project Leader, LFS Technical Writer/Editor
- 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
- Bryan Kadzban <bryan@linuxfromscratch.org> – LFS Technical Writer
- Mark Hymers
- Seth W. Klein – FAQ maintainer
- Nicholas Leippe <nicholas@linuxfromscratch.org> – Wiki Maintainer
- Anderson Lizardo <lizardo@linuxfromscratch.org> – Website Backend-Scripts Maintainer
- Randy McMurchy <randy@linuxfromscratch.org> – BLFS Project Leader, LFS Editor
- 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
- Douglas R. Reno <renodr@linuxfromscratch.org> – Systemd Editor
- Ryan Oliver <ryan@linuxfromscratch.org> – CLFS Project Co-Leader
- 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 Utlej <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, and 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 and 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, Perl, 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, Eudev, Findutils, and Man-DB  
 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: Perl  
 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 and Psmisc  
 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

## 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, Expect, and Shadow  
 Must be installed before: None  
 Optional dependencies: GNAT and ISL

## 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, Python, 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 and GCC  
 Optional dependencies: None

## Gperf

Installation depends on: Bash, Binutils, Coreutils, GCC, Glibc, and Make  
 Test suite depends on: Diffutils and 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 and Less  
 Must be installed before: Man-DB  
 Optional dependencies: None

## Iana-Etc

Installation depends on: Coreutils, Gawk, and Make  
 Test suite depends on: No test suite available  
 Must be installed before: Perl  
 Optional dependencies: None

## Inetutils

Installation depends on: Bash, Binutils, Coreutils, GCC, Glibc, Grep, Make, Ncurses, Patch, Sed, Texinfo, and Zlib  
 Test suite depends on: No test suite available  
 Must be installed before: Tar  
 Optional dependencies: None

## Intltool

Installation depends on: Bash, Gawk, Glibc, Make, Perl, Sed, and XML::Parser  
 Test suite depends on: Perl  
 Must be installed before: None  
 Optional dependencies: None

## IProute2

Installation depends on: Bash, Bison, Coreutils, Flex, GCC, Glibc, Make, and Linux API Headers  
 Test suite depends on: No test suite available  
 Must be installed before: None  
 Optional dependencies: None

## Kbd

Installation depends on: Bash, Binutils, Bison, Check, Coreutils, Flex, GCC, Gettext, Glibc, Gzip, Make, Patch, and Sed  
 Test suite depends on: No test suite available  
 Must be installed before: None  
 Optional dependencies: None

## Kmod

Installation depends on: Bash, Binutils, Bison, Coreutils, Flex, GCC, Gettext, Glibc, Gzip, Make, Pkg-config, 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

## Libelf

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

## Libffi

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

## 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, and 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, Libelf, Make, Ncurses, OpenSSL, Perl, and Sed  
 Test suite depends on: No test suite available  
 Must be installed before: None  
 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 Procs-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

## Meson

Installation depends on: Ninja and Python

Test suite depends on: No test suite available

Must be installed before: Systemd

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 and 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

## Ninja

Installation depends on: Binutils, Coreutils, Gcc, and Python

Test suite depends on: None

Must be installed before: Meson

Optional dependencies: AsciiDoc, Doxygen, Emacs, and re2c

## Openssl

Installation depends on: Binutils, Coreutils, Gcc, Make, and Perl

Test suite depends on: None

Must be installed before: Linux

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, and 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

## Python

Installation depends on: Bash, Binutils, Coreutils, GCC, Gdbm, Gettext, Glibc, Grep, Libffi, Make, Ncurses, and Sed  
 Test suite depends on: GDB and Valgrind  
 Must be installed before: Ninja  
 Optional dependencies: Berkeley DB, OpenSSL, SQLite, and Tk

## 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 and 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: None

## Shadow

Installation depends on: Bash, Binutils, Coreutils, Diffutils, Findutils, Gawk, GCC, Gettext, Glibc, Grep, Make, and Sed  
 Test suite depends on: No test suite available  
 Must be installed before: Coreutils  
 Optional dependencies: Acl, Attr, Cracklib, and PAM

## Syslogd

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

## Systemd

Installation depends on: Acl, Attr, Bash, Binutils, Coreutils, Diffutils, Expat, Gawk, GCC, Glibc, Gperf, Grep, Intltool, Libcap, Meson, Sed, and Util-linux  
 Test suite depends on: None  
 Must be installed before: None  
 Optional dependencies: Many, see BLFS systemd page

## 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, Eudev, Findutils, Gawk, GCC, Gettext, Glibc, Grep, Make, Ncurses, Sed, and Zlib

Test suite depends on: None

Must be installed before: None

Optional dependencies: Libcap-ng

## Vim

Installation depends on: Acl, Attr, Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, Grep, Make, Ncurses, and Sed

Test suite depends on: None

Must be installed before: None

Optional dependencies: Xorg, GTK+2, LessTif, Python, Tcl, Ruby, and GPM

## XML::Parser

Installation depends on: Bash, Binutils, Coreutils, Expat, GCC, Glibc, Make, and Perl

Test suite depends on: Perl

Must be installed before: Intltool

Optional dependencies: None

## Xz

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

Test suite depends on: None

Must be installed before: Eudev, GRUB, Kmod, and Man-DB

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.
- 6. 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.
- 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, MERCHANTIBILITY, FITNESS FOR A PARTICULAR PURPOSE, NONINFRINGEMENT, 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 © 1999-2019 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: 116  
 Attr: 115  
 Autoconf: 135  
 Automake: 136  
 Bash: 124  
   tools: 51  
 Bash: 124  
   tools: 51  
 Bc: 96  
 Binutils: 97  
   tools, pass 1: 33  
   tools, pass 2: 42  
 Binutils: 97  
   tools, pass 1: 33  
   tools, pass 2: 42  
 Binutils: 97  
   tools, pass 1: 33  
   tools, pass 2: 42  
 Bison: 121  
   tools: 52  
 Bison: 121  
   tools: 52  
 Bzip2: 110  
   tools: 53  
 Bzip2: 110  
   tools: 53  
 Check: 153  
 Coreutils: 149  
   tools: 54  
 Coreutils: 149  
   tools: 54  
 D-Bus: 183  
 DejaGNU: 48  
 Diffutils: 154  
   tools: 55  
 Diffutils: 154  
   tools: 55  
 E2fsprogs: 191  
 Expat: 128  
 Expect: 47  
 File: 93  
   tools: 56  
 File: 93  
   tools: 56  
 Findutils: 156  
   tools: 57  
 Findutils: 156  
   tools: 57  
 Flex: 122  
 Gawk: 155  
   tools: 58  
 Gawk: 155  
   tools: 58  
 GCC: 106  
   tools, libstdc++: 41  
   tools, pass 1: 35  
   tools, pass 2: 43  
 GCC: 106  
   tools, libstdc++: 41  
   tools, pass 1: 35  
   tools, pass 2: 43  
 GCC: 106  
   tools, libstdc++: 41  
   tools, pass 1: 35  
   tools, pass 2: 43  
 GDBM: 126  
 Gettext: 140  
   tools: 59  
 Gettext: 140  
   tools: 59  
 Glibc: 84  
   tools: 39  
 Glibc: 84  
   tools: 39  
 GMP: 99  
 Gperf: 127  
 Grep: 123  
   tools: 60  
 Grep: 123  
   tools: 60  
 Groff: 157  
 GRUB: 159  
 Gzip: 162  
   tools: 61  
 Gzip: 162  
   tools: 61  
 Iana-Etc: 120  
 Inetutils: 129  
 Intltool: 134  
 IPRoute2: 163  
 Kbd: 165  
 Kmod: 139  
 Less: 161  
 Libcap: 117  
 Libelf: 142  
 libffi: 143  
 Libpipeline: 167  
 Libtool: 125  
 Linux: 211  
   API headers: 82  
   tools, API headers: 38  
 Linux: 211  
   API headers: 82  
   tools, API headers: 38  
 Linux: 211  
   API headers: 82  
   tools, API headers: 38  
 M4: 95  
   tools: 49  
 M4: 95  
   tools: 49  
 Make: 168

tools: 62  
 Make: 168  
   tools: 62  
 Man-DB: 170  
 Man-pages: 83  
 Meson: 148  
 MPC: 102  
 MPFR: 101  
 Ncurses: 113  
   tools: 50  
 Ncurses: 113  
   tools: 50  
 Ninja: 147  
 OpenSSL: 144  
 Patch: 169  
   tools: 63  
 Patch: 169  
   tools: 63  
 Perl: 131  
   tools: 64  
 Perl: 131  
   tools: 64  
 Pkgconfig: 112  
 Procps-ng: 185  
 Psmisc: 119  
 Python  
   tools: 65  
 python: 145  
 Readline: 94  
 Sed: 118  
   tools: 66  
 Sed: 118  
   tools: 66  
 Shadow: 103  
   configuring: 104  
 Shadow: 103  
   configuring: 104  
 systemd: 178  
 Tar: 172  
   tools: 67  
 Tar: 172  
   tools: 67  
 Tcl: 46  
 Texinfo: 173  
   tools: 68  
 Texinfo: 173  
   tools: 68  
 Udev  
   usage: 199  
 Util-linux: 187  
   tools: 69  
 Util-linux: 187  
   tools: 69  
 Vim: 175  
 XML::Parser: 133  
 Xz: 137  
   tools: 70  
 Xz: 137  
   tools: 70  
 Zlib: 92

## Programs

2to3: 145  
 accessdb: 170, 171  
 aclocal: 136, 136  
 aclocal-1.16: 136, 136  
 addftinfo: 157, 157  
 addpart: 187, 188  
 addr2line: 97, 98  
 afmtodit: 157, 157  
 agetty: 187, 188  
 apropos: 170, 171  
 ar: 97, 98  
 as: 97, 98  
 attr: 115, 115  
 autoconf: 135, 135  
 autoheader: 135, 135  
 autom4te: 135, 135  
 automake: 136, 136  
 automake-1.16: 136, 136  
 autopoint: 140, 140  
 autoreconf: 135, 135  
 autoscan: 135, 135  
 autoupdate: 135, 135  
 awk: 155, 155  
 b2sum: 149, 150  
 badblocks: 191, 192  
 base64: 149, 150, 149, 150  
 base64: 149, 150, 149, 150  
 basename: 149, 150  
 basenc: 149, 150  
 bash: 124, 124  
 bashbug: 124, 124  
 bc: 96, 96  
 bison: 121, 121  
 blkdiscard: 187, 188  
 blkid: 187, 188  
 blkzone: 187, 188  
 blockdev: 187, 188  
 bootctl: 178, 180  
 bridge: 163, 163  
 bunzip2: 110, 110  
 busctl: 178, 180  
 bzipcat: 110, 110  
 bzipcmp: 110, 110  
 bzdiff: 110, 110  
 bzegrep: 110, 110  
 bzfgrep: 110, 110  
 bzgrep: 110, 110  
 bzip2: 110, 111  
 bzip2recover: 110, 111  
 bzless: 110, 111  
 bzipmore: 110, 111  
 c++: 106, 108  
 c++filt: 97, 98  
 cal: 187, 188  
 capsh: 117, 117  
 captinfo: 113, 114  
 cat: 149, 150  
 catchsegv: 84, 88  
 catman: 170, 171

cc: 106, 108  
 cfdisk: 187, 188  
 chacl: 116, 116  
 chage: 103, 104  
 chattr: 191, 192  
 chcon: 149, 150  
 chcpu: 187, 188  
 checkmk: 153, 153  
 chem: 157, 157  
 chfn: 103, 104  
 chgpasswd: 103, 104  
 chgrp: 149, 150  
 chmem: 187, 188  
 chmod: 149, 150  
 choom: 187, 188  
 chown: 149, 150  
 chpasswd: 103, 104  
 chroot: 149, 150  
 chrt: 187, 188  
 chsh: 103, 104  
 chvt: 165, 165  
 cksum: 149, 150  
 clear: 113, 114  
 cmp: 154, 154  
 col: 187, 188  
 colcrt: 187, 188  
 colrm: 187, 188  
 column: 187, 188  
 comm: 149, 150  
 compile\_et: 191, 192  
 coredumpctl: 178, 180  
 corelist: 131, 132  
 cp: 149, 150  
 cpan: 131, 132  
 cpp: 106, 109  
 csplit: 149, 150  
 ctrlaltdel: 187, 188  
 ctstat: 163, 163  
 cut: 149, 150  
 c\_rehash: 144, 144  
 date: 149, 150  
 dbus-cleanup-sockets: 183, 183  
 dbus-daemon: 183, 183  
 dbus-launch: 183, 183  
 dbus-monitor: 183, 183  
 dbus-run-session: 183, 183  
 dbus-send: 183, 184  
 dbus-test-tool: 183, 184  
 dbus-update-activation-environment: 183, 184  
 dbus-uuidgen: 183, 184  
 dc: 96, 96  
 dd: 149, 150  
 dealloct: 165, 166  
 debugfs: 191, 192  
 delpart: 187, 188  
 depmod: 139, 139  
 df: 149, 150  
 diff: 154, 154  
 diff3: 154, 154  
 dir: 149, 150  
 dircolors: 149, 151  
 dirname: 149, 151  
 dmesg: 187, 188  
 dnsdomainname: 129, 130  
 du: 149, 151  
 dumpe2fs: 191, 192  
 dumpkeys: 165, 166  
 e2freefrag: 191, 192  
 e2fsck: 191, 192  
 e2image: 191, 192  
 e2label: 191, 192  
 e2mmpstatus: 191, 192  
 e2scrub: 191, 192  
 e2scrub\_all: 191, 192  
 e2undo: 191, 192  
 e4crypt: 191, 192  
 e4defrag: 191, 192  
 echo: 149, 151  
 egrep: 123, 123  
 eject: 187, 188  
 elfedit: 97, 98  
 enc2xs: 131, 132  
 encguess: 131, 132  
 env: 149, 151  
 envsubst: 140, 140  
 eqn: 157, 157  
 eqn2graph: 157, 157  
 ex: 175, 176  
 expand: 149, 151  
 expect: 47, 47  
 expiry: 103, 104  
 expr: 149, 151  
 factor: 149, 151  
 faillog: 103, 105  
 fallocate: 187, 188  
 false: 149, 151  
 fdformat: 187, 188  
 fdisk: 187, 188  
 fgconsole: 165, 166  
 fgrep: 123, 123  
 file: 93, 93  
 filefrag: 191, 192  
 fincore: 187, 188  
 find: 156, 156  
 findfs: 187, 188  
 findmnt: 187, 188  
 flex: 122, 122  
 flex++: 122, 122  
 flock: 187, 188  
 fmt: 149, 151  
 fold: 149, 151  
 free: 185, 185  
 fsck: 187, 188  
 fsck.cramfs: 187, 188  
 fsck.ext2: 191, 192  
 fsck.ext3: 191, 192  
 fsck.ext4: 191, 192  
 fsck.minix: 187, 189  
 fsfreeze: 187, 189  
 fstrim: 187, 189  
 ftp: 129, 130  
 fuser: 119, 119



g++: 106, 109  
 gawk: 155, 155  
 gawk-5.0.1: 155, 155  
 gcc: 106, 109  
 gc-ar: 106, 109  
 gc-nm: 106, 109  
 gc-ranlib: 106, 109  
 gcov: 106, 109  
 gcov-dump: 106, 109  
 gcov-tool: 106, 109  
 gdbmtool: 126, 126  
 gdbm\_dump: 126, 126  
 gdbm\_load: 126, 126  
 gdiffmk: 157, 157  
 gencat: 84, 88  
 genl: 163, 163  
 getcap: 117, 117  
 getconf: 84, 88  
 getent: 84, 88  
 getfacl: 116, 116  
 getfattr: 115, 115  
 getkeycodes: 165, 166  
 getopt: 187, 189  
 getpcaps: 117, 117  
 gettext: 140, 140  
 gettext.sh: 140, 140  
 gettextize: 140, 140  
 glilypond: 157, 157  
 gpasswd: 103, 105  
 gperf: 127, 127  
 gperl: 157, 157  
 gpinyin: 157, 157  
 gprof: 97, 98  
 grap2graph: 157, 157  
 grep: 123, 123  
 grn: 157, 157  
 grodvi: 157, 157  
 groff: 157, 157  
 groffer: 157, 157  
 grog: 157, 157  
 grolbp: 157, 157  
 grolj4: 157, 158  
 gropdf: 157, 158  
 grops: 157, 158  
 grotty: 157, 158  
 groupadd: 103, 105  
 groupdel: 103, 105  
 groupmems: 103, 105  
 groupmod: 103, 105  
 groups: 149, 151  
 grpck: 103, 105  
 grpconv: 103, 105  
 grpunconv: 103, 105  
 grub-bios-setup: 159, 159  
 grub-editenv: 159, 159  
 grub-file: 159, 159  
 grub-fstest: 159, 159  
 grub-glue-efi: 159, 159  
 grub-install: 159, 159  
 grub-kbdcomp: 159, 159  
 grub-macbless: 159, 159

grub-menulst2cfg: 159, 159  
 grub-mkconfig: 159, 159  
 grub-mkimage: 159, 159  
 grub-mklayout: 159, 160  
 grub-mknetdir: 159, 160  
 grub-mkpasswd-pbkdf2: 159, 160  
 grub-mkrelpath: 159, 160  
 grub-mkrescue: 159, 160  
 grub-mkstandalone: 159, 160  
 grub-ofpathname: 159, 160  
 grub-probe: 159, 160  
 grub-reboot: 159, 160  
 grub-render-label: 159, 160  
 grub-script-check: 159, 160  
 grub-set-default: 159, 160  
 grub-setup: 159, 160  
 grub-syslinux2cfg: 159, 160  
 gunzip: 162, 162  
 gzexe: 162, 162  
 gzip: 162, 162  
 h2ph: 131, 132  
 h2xs: 131, 132  
 halt: 178, 180  
 head: 149, 151  
 hexdump: 187, 189  
 hostid: 149, 151  
 hostname: 129, 130  
 hostnamectl: 178, 180  
 hpftodit: 157, 158  
 hwclock: 187, 189  
 i386: 187, 189  
 iconv: 84, 88  
 iconvconfig: 84, 88  
 id: 149, 151  
 idle3: 145  
 ifcfg: 163, 163  
 ifconfig: 129, 130  
 ifnames: 135, 135  
 ifstat: 163, 163  
 indxbib: 157, 158  
 info: 173, 173  
 infocmp: 113, 114  
 infotocap: 113, 114  
 init: 178, 180  
 insmod: 139, 139  
 install: 149, 151  
 install-info: 173, 173  
 instmodsh: 131, 132  
 intltool-extract: 134, 134  
 intltool-merge: 134, 134  
 intltool-prepare: 134, 134  
 intltool-update: 134, 134  
 intltoolize: 134, 134  
 ionice: 187, 189  
 ip: 163, 163  
 ipcmk: 187, 189  
 ipcrm: 187, 189  
 ipcs: 187, 189  
 isosize: 187, 189  
 join: 149, 151  
 journalctl: 178, 180

json_pp: 131, 132	lzcat: 137, 137
kbdinfo: 165, 166	lzcmp: 137, 137
kbdrate: 165, 166	lzdiff: 137, 137
kbd_mode: 165, 166	lzegrep: 137, 137
kernel-install: 178, 180	lzfgrep: 137, 137
kill: 187, 189	lzgrep: 137, 137
killall: 119, 119	lzless: 137, 137
kmod: 139, 139	lzma: 137, 137
last: 187, 189	lzmadec: 137, 137
lastb: 187, 189	lzmainfo: 137, 137
lastlog: 103, 105	lzmore: 137, 137
ld: 97, 98	m4: 95, 95
ld.bfd: 97, 98	machinectl: 178, 180
ld.gold: 97, 98	make: 168, 168
ldattach: 187, 189	makedb: 84, 88
ldconfig: 84, 88	makeinfo: 173, 173
ldd: 84, 88	man: 170, 171
lddlibc4: 84, 88	mandb: 170, 171
less: 161, 161	manpath: 170, 171
lessecho: 161, 161	mapscrn: 165, 166
lesskey: 161, 161	mcookie: 187, 189
lex: 122, 122	md5sum: 149, 151
lexgrog: 170, 171	mesg: 187, 189
lfskernel-5.2.8: 211, 214	meson: 148, 148
libasan: 106, 109	mkdir: 149, 151
libatomic: 106, 109	mke2fs: 191, 192
libcc1: 106, 109	mkfifo: 149, 151
libnetcfg: 131, 132	mkfs: 187, 189
libtool: 125, 125	mkfs.bfs: 187, 189
libtoolize: 125, 125	mkfs.cramfs: 187, 189
link: 149, 151	mkfs.ext2: 191, 192
linux32: 187, 189	mkfs.ext3: 191, 192
linux64: 187, 189	mkfs.ext4: 191, 192
lkbib: 157, 158	mkfs.minix: 187, 189
ln: 149, 151	mklost+found: 191, 192
lnstat: 163, 163	mknod: 149, 151
loadkeys: 165, 166	mkswap: 187, 189
loadunimap: 165, 166	mktemp: 149, 151
locale: 84, 88	mk_cmds: 191, 192
localectl: 178, 180	mmroff: 157, 158
localedef: 84, 88	modinfo: 139, 139
locate: 156, 156	modprobe: 139, 139
logger: 187, 189	more: 187, 189
login: 103, 105	mount: 187, 189
loginctl: 178, 180	mountpoint: 187, 189
logname: 149, 151	msgattrib: 140, 140
logoutd: 103, 105	msgcat: 140, 140
logsave: 191, 192	msgcmp: 140, 140
look: 187, 189	msgcomm: 140, 140
lookbib: 157, 158	msgconv: 140, 140
losetup: 187, 189	msgen: 140, 140
ls: 149, 151	msgexec: 140, 140
lsattr: 191, 192	msgfilter: 140, 140
lsblk: 187, 189	msgfmt: 140, 140
lscpu: 187, 189	msggrep: 140, 140
lsipc: 187, 189	msginit: 140, 141
lslocks: 187, 189	msgmerge: 140, 141
lslogins: 187, 189	msgunfmt: 140, 141
lsmem: 187, 189	msguniq: 140, 141
lsmod: 139, 139	mtrace: 84, 89
lsns: 187, 189	mv: 149, 151

namei: 187, 189  
 ncursesw6-config: 113, 114  
 neqn: 157, 158  
 networkctl: 178, 180  
 newgidmap: 103, 105  
 newgrp: 103, 105  
 newuidmap: 103, 105  
 newusers: 103, 105  
 ngettext: 140, 141  
 nice: 149, 151  
 ninja: 147, 147  
 nl: 149, 151  
 nm: 97, 98  
 nohup: 149, 151  
 nologin: 103, 105  
 nproc: 149, 151  
 nroff: 157, 158  
 nscd: 84, 89  
 nsenter: 187, 189  
 nstat: 163, 163  
 numfmt: 149, 151  
 objcopy: 97, 98  
 objdump: 97, 98  
 od: 149, 151  
 openssl: 144, 144  
 openvt: 165, 166  
 partx: 187, 189  
 passwd: 103, 105  
 paste: 149, 151  
 patch: 169, 169  
 pathchk: 149, 151  
 pcprofiledump: 84, 89  
 pdfmom: 157, 158  
 pdfroff: 157, 158  
 pdftexi2dvi: 173, 174  
 peekfd: 119, 119  
 perl: 131, 132  
 perl5.30.0: 131, 132  
 perlbug: 131, 132  
 perldoc: 131, 132  
 perlvp: 131, 132  
 perlthanks: 131, 132  
 pfbtops: 157, 158  
 pgrep: 185, 185  
 pic: 157, 158  
 pic2graph: 157, 158  
 piconv: 131, 132  
 pidof: 185, 185  
 ping: 129, 130  
 ping6: 129, 130  
 pinky: 149, 151  
 pip3: 145  
 pivot\_root: 187, 189  
 pkg-config: 112, 112  
 pkill: 185, 185  
 pl2pm: 131, 132  
 pldd: 84, 89  
 pmap: 185, 185  
 pod2html: 131, 132  
 pod2man: 131, 132  
 pod2texi: 173, 174  
 pod2text: 131, 132  
 pod2usage: 131, 132  
 podchecker: 131, 132  
 podselect: 131, 132  
 portablectl: 178, 180  
 post-grohtml: 157, 158  
 poweroff: 178, 180  
 pr: 149, 151  
 pre-grohtml: 157, 158  
 preconv: 157, 158  
 printenv: 149, 151  
 printf: 149, 151  
 prlimit: 187, 189  
 prove: 131, 132  
 prtstat: 119, 119  
 ps: 185, 185  
 psfaddtable: 165, 166  
 psfgettable: 165, 166  
 psfstriptime: 165, 166  
 psfxtable: 165, 166  
 pslog: 119, 119  
 pstree: 119, 119  
 pstree.x11: 119, 119  
 ptar: 131, 132  
 ptardiff: 131, 132  
 ptargrep: 131, 132  
 ptx: 149, 151  
 pwck: 103, 105  
 pwconv: 103, 105  
 pwd: 149, 151  
 pwdx: 185, 185  
 pwunconv: 103, 105  
 pydoc3: 145  
 python3: 145  
 pyvenv: 145  
 ranlib: 97, 98  
 raw: 187, 189  
 readelf: 97, 98  
 readlink: 149, 151  
 readprofile: 187, 189  
 realpath: 149, 152  
 reboot: 178, 180  
 recode-sr-latin: 140, 141  
 refer: 157, 158  
 rename: 187, 190  
 renice: 187, 190  
 reset: 113, 114  
 resize2fs: 191, 192  
 resizepart: 187, 190  
 resolvconf: 178, 180  
 resolvectl: 178, 181  
 rev: 187, 190  
 rkfill: 187, 190  
 rm: 149, 152  
 rmdir: 149, 152  
 rmmod: 139, 139  
 roff2dvi: 157, 158  
 roff2html: 157, 158  
 roff2pdf: 157, 158  
 roff2ps: 157, 158  
 roff2text: 157, 158

roff2x: 157, 158  
 routef: 163, 163  
 routel: 163, 164  
 rtacct: 163, 164  
 rtcwake: 187, 190  
 rtmon: 163, 164  
 rtpr: 163, 164  
 rtstat: 163, 164  
 runcon: 149, 152  
 runlevel: 178, 181  
 runtest: 48, 48  
 rview: 175, 176  
 rvim: 175, 176  
 script: 187, 190  
 scriptreplay: 187, 190  
 sdiff: 154, 154  
 sed: 118, 118  
 seq: 149, 152  
 setarch: 187, 190  
 setcap: 117, 117  
 setfacl: 116, 116  
 setfattr: 115, 115  
 setfont: 165, 166  
 setkeycodes: 165, 166  
 settled: 165, 166  
 setmetamode: 165, 166  
 setsid: 187, 190  
 setterm: 187, 190  
 setvtrgb: 165, 166  
 sfdisk: 187, 190  
 sg: 103, 105  
 sh: 124, 124  
 sha1sum: 149, 152  
 sha224sum: 149, 152  
 sha256sum: 149, 152  
 sha384sum: 149, 152  
 sha512sum: 149, 152  
 shasum: 131, 132  
 showconsolefont: 165, 166  
 showkey: 165, 166  
 shred: 149, 152  
 shuf: 149, 152  
 shutdown: 178, 181  
 size: 97, 98  
 slabtop: 185, 185  
 sleep: 149, 152  
 sln: 84, 89  
 soelim: 157, 158  
 sort: 149, 152  
 sotruss: 84, 89  
 splain: 131, 132  
 split: 149, 152  
 sprof: 84, 89  
 ss: 163, 164  
 stat: 149, 152  
 stdbuf: 149, 152  
 strings: 97, 98  
 strip: 97, 98  
 stty: 149, 152  
 su: 103, 105  
 sulogin: 187, 190  
 sum: 149, 152  
 swapon: 187, 190  
 swapon: 187, 190  
 switch\_root: 187, 190  
 sync: 149, 152  
 sysctl: 185, 185  
 systemctl: 178, 181  
 systemd-analyze: 178, 181  
 systemd-ask-password: 178, 181  
 systemd-cat: 178, 181  
 systemd-cgls: 178, 181  
 systemd-cgtop: 178, 181  
 systemd-delta: 178, 181  
 systemd-detect-virt: 178, 181  
 systemd-escape: 178, 181  
 systemd-hwdb: 178, 181  
 systemd-id128: 178, 181  
 systemd-inhibit: 178, 181  
 systemd-machine-id-setup: 178, 181  
 systemd-mount: 178, 181  
 systemd-notify: 178, 181  
 systemd-nspawn: 178, 181  
 systemd-path: 178, 181  
 systemd-resolve: 178, 181  
 systemd-run: 178, 181  
 systemd-socket-activate: 178, 181  
 systemd-tmpfiles: 178, 181  
 systemd-tty-ask-password-agent: 178, 181  
 systemd-umount: 178, 181  
 tabs: 113, 114  
 tac: 149, 152  
 tail: 149, 152  
 tailf: 187, 190  
 talk: 129, 130  
 tar: 172, 172  
 taskset: 187, 190  
 tbl: 157, 158  
 tc: 163, 164  
 tcsh: 46, 46  
 tcsh8.6: 46, 46  
 tee: 149, 152  
 telinit: 178, 181  
 telnet: 129, 130  
 test: 149, 152  
 texi2dvi: 173, 174  
 texi2pdf: 173, 174  
 texi2any: 173, 174  
 texindex: 173, 174  
 tfmtodit: 157, 158  
 tftp: 129, 130  
 tic: 113, 114  
 timedatectl: 178, 181  
 timeout: 149, 152  
 tload: 185, 185  
 toe: 113, 114  
 top: 185, 185  
 touch: 149, 152  
 tput: 113, 114  
 tr: 149, 152  
 traceroute: 129, 130

troff: 157, 158  
 true: 149, 152  
 truncate: 149, 152  
 tset: 113, 114  
 tsort: 149, 152  
 tty: 149, 152  
 tune2fs: 191, 193  
 tzselect: 84, 89  
 udevadm: 178, 181  
 ul: 187, 190  
 umount: 187, 190  
 uname: 149, 152  
 uname26: 187, 190  
 uncompress: 162, 162  
 unexpand: 149, 152  
 unicode\_start: 165, 166  
 unicode\_stop: 165, 166  
 uniq: 149, 152  
 unlink: 149, 152  
 unlzma: 137, 137  
 unshare: 187, 190  
 unxz: 137, 137  
 updatedb: 156, 156  
 uptime: 185, 186  
 useradd: 103, 105  
 userdel: 103, 105  
 usermod: 103, 105  
 users: 149, 152  
 utmpdump: 187, 190  
 uuid: 187, 190  
 uuidgen: 187, 190  
 uuidparse: 187, 190  
 vdir: 149, 152  
 vi: 175, 176  
 view: 175, 177  
 vigr: 103, 105  
 vim: 175, 177  
 vimdiff: 175, 177  
 vimtutor: 175, 177  
 vipw: 103, 105  
 vmstat: 185, 186  
 w: 185, 186  
 wall: 187, 190  
 watch: 185, 186  
 wc: 149, 152  
 wdctl: 187, 190  
 whatis: 170, 171  
 whereis: 187, 190  
 who: 149, 152  
 whoami: 149, 152  
 wipefs: 187, 190  
 x86\_64: 187, 190  
 xargs: 156, 156  
 xgettext: 140, 141  
 xmlwf: 128, 128  
 xsubpp: 131, 132  
 xtrace: 84, 89  
 xxd: 175, 177  
 xz: 137, 137  
 xzcat: 137, 137  
 xzcmp: 137, 137

xzdec: 137, 137  
 xzdiff: 137, 138  
 xzegrep: 137, 138  
 xzfgrep: 137, 138  
 xzgrep: 137, 138  
 xzless: 137, 138  
 xzmore: 137, 138  
 yacc: 121, 121  
 yes: 149, 152  
 zcat: 162, 162  
 zcmp: 162, 162  
 zdiff: 162, 162  
 zdump: 84, 89  
 zegrep: 162, 162  
 zfgrep: 162, 162  
 zforce: 162, 162  
 zgrep: 162, 162  
 zic: 84, 89  
 zipdetails: 131, 132  
 zless: 162, 162  
 zmore: 162, 162  
 znew: 162, 162  
 zramctl: 187, 190

## Libraries

Expat: 133, 133  
 ld-2.30.so: 84, 89  
 libacl: 116, 116  
 libanl: 84, 89  
 libasprintf: 140, 141  
 libattr: 115, 115  
 libbdf: 97, 98  
 libblkid: 187, 190  
 libBrokenLocale: 84, 89  
 libbz2: 110, 111  
 libc: 84, 89  
 libcap: 117, 117  
 libcheck: 153, 153  
 libcom\_err: 191, 193  
 libcrypt: 84, 89  
 libcrypto.so: 144, 144  
 libcurl: 113, 114  
 libdbus-1: 183, 184  
 libdl: 84, 89  
 libe2p: 191, 193  
 libexpat: 128, 128  
 libexpect-5.45: 47, 47  
 libext2fs: 191, 193  
 libfdisk: 187, 190  
 libffi: 143  
 libfl: 122, 122  
 libformw: 113, 114  
 libg: 84, 89  
 libgcc: 106, 109  
 libgcov: 106, 109  
 libgdbm: 126, 126  
 libgdbm\_compat: 126, 126  
 libgettextlib: 140, 141  
 libgettextpo: 140, 141  
 libgettextsrc: 140, 141

- libgmp: 99, 100
- libgmpxx: 99, 100
- libgomp: 106, 109
- libhistory: 94, 94
- libkmod: 139
- liblsan: 106, 109
- libltdl: 125, 125
- liblto\_plugin: 106, 109
- liblzma: 137, 138
- libm: 84, 89
- libmagic: 93, 93
- libman: 170, 171
- libmandb: 170, 171
- libmcheck: 84, 89
- libmemusage: 84, 89
- libmenuw: 113, 114
- libmount: 187, 190
- libmpc: 102, 102
- libmpfr: 101, 101
- libncursesw: 113, 114
- libnsl: 84, 89
- libnss: 84, 89
- libopcodes: 97, 98
- libpanelw: 113, 114
- libpcprofile: 84, 89
- libpipeline: 167
- libprocps: 185, 186
- libpthread: 84, 89
- libquadmath: 106, 109
- libreadline: 94, 94
- libresolv: 84, 89
- librt: 84, 89
- libSegFault: 84, 89
- libsmartcols: 187, 190
- libss: 191, 193
- libssl.so: 144, 144
- libssp: 106, 109
- libstdbuf: 149, 152
- libstdc++: 106, 109
- libstdc++fs: 106, 109
- libsupc++: 106, 109
- libsystemd: 178, 182
- libtcl8.6.so: 46, 46
- libtclstub8.6.a: 46, 46
- libthread\_db: 84, 89
- libtsan: 106, 109
- libubsan: 106, 109
- libudev: 178, 182
- libutil: 84, 89
- libuuid: 187, 190
- liby: 121, 121
- libz: 92, 92
- preloadable\_libintl: 140, 141

- configuring: 198
- localnet
  - /etc/hosts: 198
- network
  - /etc/hosts: 198
  - configuring: 196
- network
  - /etc/hosts: 198
  - configuring: 196
- dwp: 97, 98

## Others

- /boot/config-5.2.8: 211, 214
- /boot/System.map-5.2.8: 211, 214
- /dev/\*: 73
- /etc/fstab: 210
- /etc/group: 78
- /etc/hosts: 198
- /etc/inputrc: 206
- /etc/ld.so.conf: 88
- /etc/lfs-release: 217
- /etc/localtime: 86
- /etc/lsb-release: 217
- /etc/modprobe.d/usb.conf: 213
- /etc/nsswitch.conf: 86
- /etc/os-release: 217
- /etc/passwd: 78
- /etc/protocols: 120
- /etc/resolv.conf: 197
- /etc/services: 120
- /etc/vimrc: 176
- /usr/include/asm-generic/\*.h: 82, 82
- /usr/include/asm/\*.h: 82, 82
- /usr/include/drm/\*.h: 82, 82
- /usr/include/linux/\*.h: 82, 82
- /usr/include/misc/\*.h: 82, 82
- /usr/include/mtd/\*.h: 82, 82
- /usr/include/rdma/\*.h: 82, 82
- /usr/include/scsi/\*.h: 82, 82
- /usr/include/sound/\*.h: 82, 82
- /usr/include/video/\*.h: 82, 82
- /usr/include/xen/\*.h: 82, 82
- /var/log/btmp: 78
- /var/log/lastlog: 78
- /var/log/wtmp: 78
- /var/run/utmp: 78
- /etc/locale.conf: 204
- /etc/shells: 207
- man pages: 83, 83
- Systemd Customization: 207

## Scripts

- clock
  - configuring: 202
- console
  - configuring: 203
- hostname