

**Linux From Scratch**  
**Version 10.1-systemd**  
**Published March 1st, 2021**

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

# **Linux From Scratch: Version 10.1-systemd: Published March 1st, 2021**

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

Copyright © 1999-2021 Gerard Beekmans

Copyright © 1999-2021, 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 .....	viii
i. Foreword .....	viii
ii. Audience .....	viii
iii. LFS Target Architectures .....	ix
iv. Prerequisites .....	x
v. LFS and Standards .....	x
vi. Rationale for Packages in the Book .....	xi
vii. Typography .....	xvii
viii. Structure .....	xviii
ix. Errata .....	xviii
I. Introduction .....	1
1. Introduction .....	2
1.1. How to Build an LFS System .....	2
1.2. What's new since the last release .....	2
1.3. Changelog .....	4
1.4. Resources .....	8
1.5. Help .....	9
II. Preparing for the Build .....	11
2. Preparing the Host System .....	12
2.1. Introduction .....	12
2.2. Host System Requirements .....	12
2.3. Building LFS in Stages .....	14
2.4. Creating a New Partition .....	15
2.5. Creating a File System on the Partition .....	17
2.6. Setting The \$LFS Variable .....	17
2.7. Mounting the New Partition .....	18
3. Packages and Patches .....	20
3.1. Introduction .....	20
3.2. All Packages .....	20
3.3. Needed Patches .....	28
4. Final Preparations .....	30
4.1. Introduction .....	30
4.2. Creating a limited directory layout in LFS filesystem .....	30
4.3. Adding the LFS User .....	30
4.4. Setting Up the Environment .....	31
4.5. About SBUs .....	33
4.6. About the Test Suites .....	34
III. Building the LFS Cross Toolchain and Temporary Tools .....	35
Important Preliminary Material .....	xxxvi
i. Introduction .....	xxxvi
ii. Toolchain Technical Notes .....	xxxvi
iii. General Compilation Instructions .....	xl
5. Compiling a Cross-Toolchain .....	42
5.1. Introduction .....	42
5.2. Binutils-2.36.1 - Pass 1 .....	43

5.3. GCC-10.2.0 - Pass 1 .....	45
5.4. Linux-5.10.17 API Headers .....	48
5.5. Glibc-2.33 .....	49
5.6. Libstdc++ from GCC-10.2.0, Pass 1 .....	52
6. Cross Compiling Temporary Tools .....	53
6.1. Introduction .....	53
6.2. M4-1.4.18 .....	54
6.3. Ncurses-6.2 .....	55
6.4. Bash-5.1 .....	57
6.5. Coreutils-8.32 .....	58
6.6. Diffutils-3.7 .....	59
6.7. File-5.39 .....	60
6.8. Findutils-4.8.0 .....	61
6.9. Gawk-5.1.0 .....	62
6.10. Grep-3.6 .....	63
6.11. Gzip-1.10 .....	64
6.12. Make-4.3 .....	65
6.13. Patch-2.7.6 .....	66
6.14. Sed-4.8 .....	67
6.15. Tar-1.34 .....	68
6.16. Xz-5.2.5 .....	69
6.17. Binutils-2.36.1 - Pass 2 .....	70
6.18. GCC-10.2.0 - Pass 2 .....	71
7. Entering Chroot and Building Additional Temporary Tools .....	73
7.1. Introduction .....	73
7.2. Changing Ownership .....	73
7.3. Preparing Virtual Kernel File Systems .....	73
7.4. Entering the Chroot Environment .....	74
7.5. Creating Directories .....	75
7.6. Creating Essential Files and Symlinks .....	76
7.7. Libstdc++ from GCC-10.2.0, Pass 2 .....	80
7.8. Gettext-0.21 .....	82
7.9. Bison-3.7.5 .....	83
7.10. Perl-5.32.1 .....	84
7.11. Python-3.9.2 .....	85
7.12. Texinfo-6.7 .....	86
7.13. Util-linux-2.36.2 .....	87
7.14. Cleaning up and Saving the Temporary System .....	88
IV. Building the LFS System .....	90
8. Installing Basic System Software .....	91
8.1. Introduction .....	91
8.2. Package Management .....	91
8.3. Man-pages-5.10 .....	95
8.4. Iana-Etc-20210202 .....	96
8.5. Glibc-2.33 .....	97
8.6. Zlib-1.2.11 .....	104
8.7. Bzip2-1.0.8 .....	105

8.8. Xz-5.2.5 .....	107
8.9. Zstd-1.4.8 .....	109
8.10. File-5.39 .....	110
8.11. Readline-8.1 .....	111
8.12. M4-1.4.18 .....	113
8.13. Bc-3.3.0 .....	114
8.14. Flex-2.6.4 .....	115
8.15. Tcl-8.6.11 .....	116
8.16. Expect-5.45.4 .....	118
8.17. DejaGNU-1.6.2 .....	119
8.18. Binutils-2.36.1 .....	120
8.19. GMP-6.2.1 .....	123
8.20. MPFR-4.1.0 .....	125
8.21. MPC-1.2.1 .....	126
8.22. Attr-2.4.48 .....	127
8.23. Acl-2.2.53 .....	128
8.24. Libcap-2.48 .....	129
8.25. Shadow-4.8.1 .....	130
8.26. GCC-10.2.0 .....	134
8.27. Pkg-config-0.29.2 .....	139
8.28. Ncurses-6.2 .....	140
8.29. Sed-4.8 .....	143
8.30. Psmisc-23.4 .....	144
8.31. Gettext-0.21 .....	145
8.32. Bison-3.7.5 .....	147
8.33. Grep-3.6 .....	148
8.34. Bash-5.1 .....	149
8.35. Libtool-2.4.6 .....	151
8.36. GDBM-1.19 .....	152
8.37. Gperf-3.1 .....	153
8.38. Expat-2.2.10 .....	154
8.39. Inetutils-2.0 .....	155
8.40. Perl-5.32.1 .....	157
8.41. XML::Parser-2.46 .....	160
8.42. Intltool-0.51.0 .....	161
8.43. Autoconf-2.71 .....	162
8.44. Automake-1.16.3 .....	163
8.45. Kmod-28 .....	164
8.46. Libelf from Elfutils-0.183 .....	166
8.47. Libffi-3.3 .....	167
8.48. OpenSSL-1.1.1j .....	168
8.49. Python-3.9.2 .....	170
8.50. Ninja-1.10.2 .....	172
8.51. Meson-0.57.1 .....	174
8.52. Coreutils-8.32 .....	175
8.53. Check-0.15.2 .....	181
8.54. Diffutils-3.7 .....	182

8.55. Gawk-5.1.0 .....	183
8.56. Findutils-4.8.0 .....	184
8.57. Groff-1.22.4 .....	185
8.58. GRUB-2.04 .....	188
8.59. Less-563 .....	190
8.60. Gzip-1.10 .....	191
8.61. IPRoute2-5.10.0 .....	193
8.62. Kbd-2.4.0 .....	195
8.63. Libpipeline-1.5.3 .....	197
8.64. Make-4.3 .....	198
8.65. Patch-2.7.6 .....	199
8.66. Man-DB-2.9.4 .....	200
8.67. Tar-1.34 .....	203
8.68. Texinfo-6.7 .....	204
8.69. Vim-8.2.2433 .....	206
8.70. Systemd-247 .....	209
8.71. D-Bus-1.12.20 .....	215
8.72. Procs-ng-3.3.17 .....	217
8.73. Util-linux-2.36.2 .....	219
8.74. E2fsprogs-1.46.1 .....	224
8.75. About Debugging Symbols .....	227
8.76. Stripping Again .....	227
8.77. Cleaning Up .....	228
9. System Configuration .....	230
9.1. Introduction .....	230
9.2. General Network Configuration .....	230
9.3. Overview of Device and Module Handling .....	234
9.4. Managing Devices .....	237
9.5. Configuring the system clock .....	238
9.6. Configuring the Linux Console .....	239
9.7. Configuring the System Locale .....	240
9.8. Creating the /etc/inputrc File .....	242
9.9. Creating the /etc/shells File .....	244
9.10. Systemd Usage and Configuration .....	244
10. Making the LFS System Bootable .....	248
10.1. Introduction .....	248
10.2. Creating the /etc/fstab File .....	248
10.3. Linux-5.10.17 .....	250
10.4. Using GRUB to Set Up the Boot Process .....	255
11. The End .....	257
11.1. The End .....	257
11.2. Get Counted .....	257
11.3. Rebooting the System .....	258
11.4. What Now? .....	259
V. Appendices .....	260
A. Acronyms and Terms .....	261
B. Acknowledgments .....	264

C. Dependencies .....	267
D. LFS Licenses .....	279
D.1. Creative Commons License .....	279
D.2. The MIT License .....	283
Index .....	284

# 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 page, 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.

For building LFS, the gain of building on a 64-bit system compared to a 32-bit system is minimal. For example, in a test build of LFS-9.1 on a Core i7-4790 CPU based system, using 4 cores, the following statistics were measured:

Architecture	Build Time	Build Size
32-bit	239.9 minutes	3.6 GB
64-bit	233.2 minutes	4.4 GB

As you can see, on the same hardware, the 64-bit build is only 3% faster and is 22% larger than the 32-bit build. If you plan to use LFS as a LAMP server, or a firewall, a 32-bit CPU may be largely sufficient. On the other hand, several packages in BLFS now need more than 4GB of RAM to be built and/or to run, so that if you plan to use LFS as a desktop, the LFS authors recommend building on a 64-bit system.

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. Some LFS/BLFS editors maintain a fork of LFS for multilib, which is accessible at <http://www.linuxfromscratch.org/~thomas/multilib/index.html>. But it is an advanced topic.

## 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.

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



### Note

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

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

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

*LSB Core:*

Bash, Bc, Binutils, Coreutils, Diffutils, File, Findutils, Gawk, Grep, Gzip, M4, Man-DB, Ncurses, Procps, Psmisc, Sed, Shadow, Tar, Util-linux, Zlib

*LSB Desktop:*

None

<i>LSB Runtime Languages:</i>	Perl
<i>LSB Imaging:</i>	None
<i>LSB Gtk3 and LSB Graphics (Trial Use):</i>	None

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

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

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

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

## Rationale for Packages in the Book

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

- Acl
 

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

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

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

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

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

- Bc

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

- Binutils

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

- Bison

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

- Bzip2

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

- Check

This package contains a test harness for other programs.

- Coreutils

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

- D-Bus

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

- DejaGNU

This package contains a framework for testing other programs.

- 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 in their build scripts.

- 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 will 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 that returns 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.

- 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.

- Zstd

This package contains compression and decompression routines used by some programs. It provide high compression ratios and a very wide range of compression / speed trade-offs.

## 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 page being specified. Note 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 Cross Toolchain and Temporary Tools

Part III provides instructions for building the tools needed for constructing the final LFS system.

### Part IV - Building the LFS System

Part IV 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.

### Part V - Appendices

Part V provides information about the book itself including acronyms and terms, acknowledgments, package dependencies, a listing of LFS boot scripts, licenses for the distribution of the book, and a comprehensive index of packages, programs, libraries, and scripts.

## Errata

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

# Part I. Introduction

# Chapter 1. Introduction

## 1.1. How to Build an LFS System

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

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

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

Chapter 5, explains the installation of the initial tool chain, (binutils, gcc, and glibc) using cross compilation techniques to isolate the new tools from the host system.

Chapter 6 shows you how to cross-compile basic utilities using the just built cross-toolchain.

Chapter 7 then enters a "chroot" environment and uses the previously built tools to build the additional tools needed to build and test the final system.

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 Toolchain Technical Notes.

In Chapter 8, The full LFS system is built. Another advantage provided by the chroot environment is that it 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 9, and the kernel and boot loader are set up in Chapter 10. Chapter 11 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

In this version of LFS, there has been a major reorganization of the book using techniques that avoid changing the host system and provides a more straight forward build process.

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

### Upgraded to:

- 
- Autoconf-2.71

- Automake-1.16.3
- Bash 5.1
- Bc 3.3.0
- Binutils-2.36.1
- Bison-3.7.5
- E2fsprogs-1.46.1
- Expat-2.2.10
- Findutils-4.8.0
- GDBM-1.19
- Glibc-2.33
- GMP-6.2.1
- Grep-3.6
- IANA-Etc-20210202
- Inetutils-2.0
- IPRoute2-5.10.0
- Kbd-2.4.0
- Kmod-28
- Less-563
- Libcap-2.48
- Libelf-0.183 (from elfutils)
- Linux-5.10.17
- Man-DB-2.9.4
- Man-pages-5.10
- Meson-0.57.1
- MPC-1.2.1
- Ninja-1.10.2
- Openssl-1.1.1j
- Perl-5.32.1
- Procps-ng-3.3.17
- Psmisc-23.4
- Python-3.9.2
- Systemd-247
- Tar-1.34
- Tcl-8.6.11

- Tzdata-2021a
- Util-Linux-2.36.2
- Vim-8.2.2433
- Zstd-1.4.8

**Added:**

- 
- systemd-247-upstream\_fixes-1.patch

**Removed:**

- 
- bash-5.0-upstream\_fixes-1.patch

## 1.3. Changelog

This is version 10.1-systemd of the Linux From Scratch book, dated March 1st, 2021. 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:**

- 2021-03-01
  - [bdubbs] - LFS-10.1 released.
- 2021-02-20
  - [bdubbs] - Update to meson-0.57.1. Fixes #4821.
  - [bdubbs] - Update to Python-3.9.2. Fixes #4820.
  - [pierre] - Fix grub to prevent generation of a huge binary blob for lzma compression. Reported on the lfs-support mailing list by Frans de Boer.
- 2021-02-18
  - [bdubbs] - Fix a glibc bug that causes issues with chrooted applications. Fixes #4817.
  - [bdubbs] - Update to bc-3.3.0. Fixes #4819.
  - [bdubbs] - Update to openssl-1.1.1j. Fixes #4816.
  - [bdubbs] - Update to meson-0.57.0. Fixes #4815.
  - [bdubbs] - Update to linux-5.10.17. Fixes #4807.
- 2021-02-14
  - [renodr] - Add a command explanation for 'pwait'.
  - [bdubbs] - Update to util-linux-2.36.2. Fixes #4812.
  - [bdubbs] - Update to tar-1.34. Fixes #4813.
  - [bdubbs] - Update to psmisc-23.4. Fixes #4805.

- [bdubbs] - Update to procps-ng-3.3.17. Fixes #4811.
- [bdubbs] - Update to man-db-2.9.4. Fixes #4808.
- [bdubbs] - Update to eudev-3.2.10. Fixes #4810.
- [bdubbs] - Update to elfutils-0.183. Fixes #4806.
- [bdubbs] - Update to e2fsprogs-1.46.1. Fixes #4809.
- [bdubbs] - Update to bc-3.2.7. Fixes #4814.
- 2021-02-01
  - [bdubbs] - Update to iana-etc-20210202. Addresses #4722.
  - [bdubbs] - Update to inetutils-2.0. Fixes #4803.
  - [bdubbs] - Update to libcap-2.48. Fixes #4802.
  - [bdubbs] - Update to binutils-2.36.1. Fixes #4804.
  - [bdubbs] - Update to linux-5.10.13. Fixes #4801.
- 2021-02-02
  - [pierre] - Move tcl, expect, and dejagnu just before binutils in chapter 8: this allows to build them against chapter 8 glibc.
  - [pierre] - To allow building with newer version of glibc than the host distribution, build a "file" executable for the host before cross-compiling it.
  - [pierre] - Replace the relinked libctf (which may incorrectly link against libz from the host distribution) with the one that was linked during "make" in binutils-pass2. Thanks to Xi Ruoyao for the fix.
  - [bdubbs] - Update to bc-3.2.6. Fixes #4800.
  - [bdubbs] - Update to glibc-2.33. Fixes #4799.
  - [bdubbs] - Minor change to mountfs boot script. Fixes #4798.
- 2021-02-01
  - [bdubbs] - Update to vim-8.2.2433. Addresses #4500.
  - [bdubbs] - Update to iana-etc-20210115. Addresses #4722.
  - [bdubbs] - Update to bc-3.2.5. Fixes #4797.
  - [bdubbs] - Update to e2fsprogs-1.46.0. Fixes #4796.
  - [bdubbs] - Update to autoconf-2.71. Fixes #4795.
  - [bdubbs] - Update to tzdata-2021a. Fixes #4793.
  - [bdubbs] - Update to perl-5.32.1. Fixes #4792.
  - [bdubbs] - Update to libcap-2.47. Fixes #4791.
  - [bdubbs] - Update to bison-3.7.5. Fixes #4790.
  - [bdubbs] - Update to binutils-2.36. Fixes #4789.
  - [bdubbs] - Update to linux-5.10.12. Fixes #4786.
- 2020-01-16
  - [renodr] - Update to findutils-4.8.0. Fixes #4785.

- [renodr] - Update to kmod-28. Fixes #4784.
- [renodr] - Update to tar-1.33. Fixes #4783.
- [renodr] - Update to linux-5.10.7. Fixes #4782.
- [renodr] - Update to meson-0.56.2. Fixes #4781.
- [renodr] - Update to tcl-8.6.11. Fixes #4780.
- 2021-01-13
  - [xry111] - Fix util-linux uuidd socket path.
  - [xry111] - Remove various references to deprecated /var/run, use /run instead.
- 2021-01-01
  - [bdubbs] - Update to vim-8.2.2253. Addresses #4500.
  - [bdubbs] - Update to iana-etc-20201229. Addresses #4722.
  - [bdubbs] - Update to gdbm-1.19. Fixes #4779.
  - [bdubbs] - Update to tzdata-2020f. Fixes #4777.
  - [bdubbs] - Update to man-pages-5.10. Fixes #4776.
  - [bdubbs] - Update to iproute2-5.10.0. Fixes #4775.
  - [bdubbs] - Update to zstd-1.4.8. Fixes #4774.
  - [bdubbs] - Update to kbd-2.4.0. Fixes #4773.
  - [bdubbs] - Update to linux-5.10.4. Fixes #4772.
- 2020-12-15
  - [bdubbs] - Update to libcap-2.46. Fixes #4771.
  - [bdubbs] - Update to bc-3.2.4. Fixes #4770.
  - [bdubbs] - Update to autoconf-2.70. Fixes #4769.
  - [bdubbs] - Update to openssl-1.1.1i. Fixes #4768.
  - [bdubbs] - Update to Python3-3.9.1. Fixes #4767.
  - [bdubbs] - Update to linux-5.9.14. Fixes #4766.
  - [bdubbs] - Update to bash-5.1 and readline-8.1. Fixes #4764.
- 2020-12-07
  - [ken] - Patch meson-0.56.0 to correctly create pkgconfig files re static libraries (re sysprof in BLFS) . Fixes #4675.
- 2020-12-03
  - [renodr] - Update to linux-5.9.12. Fixes #4673.
  - [renodr] - Update to bc-3.2.3. Fixes #4672.
  - [renodr] - Update to systemd-247. Fixes #4745.
- 2020-12-01
  - [bdubbs] - Update to ninja-1.10.2. Fixes #4760.
  - [bdubbs] - Update to bc-3.2.1. Fixes #4759.

- [bdubbs] - Update to linux-5.9.11. Fixes #4758.
- [bdubbs] - Update to automake-1.16.3. Fixes #4757.
- [bdubbs] - Update to util-linux-2.36.1. Fixes #4755.
- [bdubbs] - Update to iana-etc-20201124. Addresses #4722.
- [bdubbs] - Update to vim-8.2.2070. Addresses #4500.
- 2020-11-15
  - [bdubbs] - Update to gmp-6.2.1. Fixes #4754.
  - [bdubbs] - Update to iana-etc-20201110. Addresses #4722.
  - [bdubbs] - Update to man-pages-5.09. Fixes #4750.
  - [bdubbs] - Update to linux-5.9.8. Fixes #4749.
  - [bdubbs] - Update to libcap-2.45. Fixes #4751.
  - [bdubbs] - Update to grep-3.6. Fixes #4752.
  - [bdubbs] - Update to bison-3.7.4. Fixes #4753.
- 2020-11-01
  - [bdubbs] - Update to elfutils-0.182. Fixes #4748.
  - [bdubbs] - Update to meson-0.56.0. Fixes #4747.
  - [bdubbs] - Update to linux-5.9.2. Fixes #4746.
  - [bdubbs] - Update to mpc-1.2.1. Fixes #4744.
  - [bdubbs] - Update to less-563. Fixes #4743.
  - [bdubbs] - Update to tzdata-2020d. Fixes #4742.
- 2020-10-20
  - [bdubbs] - Update to iproute2-5.9.0. Fixes #4739.
  - [bdubbs] - Update to tzdata-2020c. Fixes #4741.
  - [bdubbs] - Update to linux-5.9.1. Fixes #4740.
- 2020-10-15
  - [bdubbs] - Update to iana-etc-20201012. Addresses #4722.
  - [bdubbs] - Update to vim-8.2.1845. Addresses #4500.
  - [bdubbs] - Update to bison-3.7.3. Fixes #4738.
  - [bdubbs] - Update to tzdata-2020b. Fixes #4737.
  - [bdubbs] - Update to libcap-2.44. Fixes #4735.
  - [bdubbs] - Update to Python-3.9. Fixes #4736.
  - [bdubbs] - Update to expat-2.2.10. Fixes #4734.
  - [bdubbs] - Update to bc-3.1.6. Fixes #4732.
  - [bdubbs] - Update to linux-5.9. Fixes #4733.
- 2020-10-01
  - [bdubbs] - Update to grep-3.5. Fixes #4731.

- [bdubbs] - Update to Python-3.8.6. Fixes #4730.
- [bdubbs] - Update to openssl-1.1.1h. Fixes #4729.
- [bdubbs] - Update to binutils-2.35.1. Fixes #4728.
- [bdubbs] - Update to linux-5.8.12. Fixes #4727.
- 2020-09-27
  - [bdubbs] - Add autoconf-2.69-consolidated\_fixes-1.patch which allows autoconf tests to pass.
- 2020-09-15
  - [bdubbs] - Update to linux-5.8.9. Fixes #4723.
  - [bdubbs] - Update to bison-3.7.2. Fixes #4724.
  - [bdubbs] - Update to elfutils-0.181. Fixes #4725.
  - [bdubbs] - Update to meson-0.55.3. Fixes #4726.
- 2020-09-02
  - [bdubbs] - Update to linux-5.8.5. Fixes #4721.
  - [bdubbs] - Update to ninja-1.10.1. Fixes #4719.
  - [bdubbs] - Update to mpc-1.2.0. Fixes #4717.
  - [bdubbs] - Update to meson-0.55.1. Fixes #4716.
  - [bdubbs] - Update to libcap-2.43. Fixes #4715.
- 2020-09-01
  - [bdubbs] - LFS-10.0 released.

## 1.4. Resources

### 1.4.1. FAQ

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

### 1.4.2. Mailing Lists

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

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

### 1.4.3. IRC

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

## 1.4.4. Mirror Sites

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

## 1.4.5. Contact Information

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

## 1.5. Help

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

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

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

### 1.5.1. Things to Mention

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

- The version of the book being used (in this case 10.1-systemd)
- The host distribution and version being used to create LFS
- The output from the Host System Requirements script
- The package or section the problem was encountered in
- The exact error message or symptom being received
- Note whether you have deviated from the book at all



#### Note

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

### 1.5.2. Configure Script Problems

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

### 1.5.3. Compilation Problems

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

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

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

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

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

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

## **Part II. Preparing for the Build**

# Chapter 2. Preparing the Host System

## 2.1. Introduction

In this chapter, the host tools needed for building LFS are checked and, if necessary, installed. Then a partition which will host the LFS system is prepared. We will create the partition itself, create a file system on it, and mount it.

## 2.2. Host System Requirements

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

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

- **Bash-3.2** (/bin/sh should be a symbolic or hard link to bash)
- **Binutils-2.25** (Versions greater than 2.36.1 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 10.2.0 are not recommended as they have not been tested)
- **Glibc-2.11** (Versions greater than 2.33 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 10.

- **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 5–6

- The `/mnt/lfs` partition must be mounted.
- These two chapters *must* be done as user `lfs`. A `su - lfs` needs to be done before any task in these chapters. Failing to do that, you are at risk of installing packages to the host, and potentially rendering it unusable.
- The procedures in General Compilation Instructions are critical. If there is any doubt about installing a package, ensure any previously expanded tarballs are removed, then re-extract the package files, and complete all instructions in that section.

### 2.3.3. Chapter 7–10

- The `/mnt/lfs` partition must be mounted.

- A few operations, from “Changing Ownership” to “Entering the Chroot Environment” must be done as the `root` user, with the `LFS` environment variable set for the `root` user.
- When entering `chroot`, the `LFS` environment variable must be set for `root`. The `LFS` variable is not used afterwards.
- 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 7.3.2, “Mounting and Populating `/dev`” and Section 7.3.3, “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 10 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 30 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 twenty 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.

If you want to use the hibernation feature (suspend-to-disk) of Linux, it writes out the contents of RAM to the swap partition before turning off the machine. In this case the size of the swap partition should be at least as large as the system's installed RAM.

Swapping is never good. For mechanical hard drives you can generally tell if a system is swapping by just listening to disk activity and observing how the system reacts to commands. For an SSD drive you will not be able to hear swapping but you can tell how much swap space is being used by the **top** or **free** programs. Use of an SSD drive for a swap partition should be avoided if possible. 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 200 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 ten 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 10.2, “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>
```

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

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
```

There are several ways to obtain all the necessary packages and patches to build LFS:

- The files can be downloaded individually as described in the next two sections.
- For stable versions of the book, a tarball of all the needed files can be downloaded from one of the LFS files mirrors listed at <http://www.linuxfromscratch.org/mirrors.html#files>.
- The files can be downloaded using **wget** and a `wget-list` as described below.

To download all of the packages and patches by using `wget-list` as an input to the **wget** command, use:

```
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
```

This check can be used after retrieving the needed files with any of the methods listed above.

### 3.2. All Packages

Download or otherwise obtain the following packages:

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

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

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

MD5 sum: 007aabf1dbb550bcddde52a244cd1070

- **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 (2.71) - 1,263 KB:**

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

Download: <http://ftp.gnu.org/gnu/autoconf/autoconf-2.71.tar.xz>

MD5 sum: 12cfa1687ffa2606337efe1a64416106

- **Automake (1.16.3) - 1,554 KB:**

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

Download: <http://ftp.gnu.org/gnu/automake/automake-1.16.3.tar.xz>

MD5 sum: c27f608a4e1f302ec7ce42f1251c184e

- **Bash (5.1) - 10,214 KB:**

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

Download: <http://ftp.gnu.org/gnu/bash/bash-5.1.tar.gz>

MD5 sum: bb91a17fd6c9032c26d0b2b78b50aff5

- **Bc (3.3.0) - 225 KB:**

Home page: <https://git.yzena.com/gavin/bc>

Download: <https://github.com/gavinhoward/bc/releases/download/3.3.0/bc-3.3.0.tar.xz>

MD5 sum: 452ae2d467b1d7212bb7896c0c689825

- **Binutils (2.36.1) - 22,239 KB:**

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

Download: <http://ftp.gnu.org/gnu/binutils/binutils-2.36.1.tar.xz>

MD5 sum: 628d490d976d8957279bbbf06cf29d4

- **Bison (3.7.5) - 2,561 KB:**

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

Download: <http://ftp.gnu.org/gnu/bison/bison-3.7.5.tar.xz>

MD5 sum: 9b762dc24a6723f86d14d957d3deeb90

- **Bzip2 (1.0.8) - 792 KB:**

Download: <https://www.sourceware.org/pub/bzip2/bzip2-1.0.8.tar.gz>

MD5 sum: 67e051268d0c475ea773822f7500d0e5

- **Check (0.15.2) - 760 KB:**

Home page: <https://libcheck.github.io/check>

Download: <https://github.com/libcheck/check/releases/download/0.15.2/check-0.15.2.tar.gz>

MD5 sum: 50fcacfcecd5a380415b12e9c574e0b2

- **Coreutils (8.32) - 5,418 KB:**

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

Download: <http://ftp.gnu.org/gnu/coreutils/coreutils-8.32.tar.xz>

MD5 sum: 022042695b7d5bcf1a93559a9735e668

- **D-Bus (1.12.20) - 2,048 KB:**

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

Download: <https://dbus.freedesktop.org/releases/dbus/dbus-1.12.20.tar.gz>

MD5 sum: dfe8a71f412e0b53be26ed4fbfdc91c4

- **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 (1.46.1) - 9,269 KB:**

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

Download: <https://downloads.sourceforge.net/project/e2fsprogs/e2fsprogs/v1.46.1/e2fsprogs-1.46.1.tar.gz>

MD5 sum: 8c52585522b7ca6bdae2bdecba27b3a4

- **Elfutils (0.183) - 8,896 KB:**

Home page: <https://sourceware.org/ftp/elfutils/>

Download: <https://sourceware.org/ftp/elfutils/0.183/elfutils-0.183.tar.bz2>

MD5 sum: 6f58aa1b9af1a5681b1cbf63e0da2d67

- **Expat (2.2.10) - 416 KB:**

Home page: <https://libexpat.github.io/>

Download: <https://prdownloads.sourceforge.net/expat/expat-2.2.10.tar.xz>

MD5 sum: e0fe49a6b3480827c9455e4cfc799133

- **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 (5.39) - 932 KB:**

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

Download: <http://ftp.astron.com/pub/file/file-5.39.tar.gz>

MD5 sum: 1c450306053622803a25647d88f80f25



### Note

File (5.39) 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 (4.8.0) - 1,940 KB:**

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

Download: <http://ftp.gnu.org/gnu/findutils/findutils-4.8.0.tar.xz>

MD5 sum: eeefe2e6380931a77dfa6d9350b43186

• **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 (5.1.0) - 3,081 KB:**

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

Download: <http://ftp.gnu.org/gnu/gawk/gawk-5.1.0.tar.xz>

MD5 sum: 8470c34eeecc41c1aa0c5d89e630df50

• **GCC (10.2.0) - 73,247 KB:**

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

Download: <http://ftp.gnu.org/gnu/gcc/gcc-10.2.0/gcc-10.2.0.tar.xz>

MD5 sum: e9fd9b1789155ad09bcf3ae747596b50

• **GDBM (1.19) - 946 KB:**

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

Download: <http://ftp.gnu.org/gnu/gdbm/gdbm-1.19.tar.gz>

MD5 sum: aeb29c6a90350a4c959cd1df38cd0a7e

• **Gettext (0.21) - 9,487 KB:**

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

Download: <http://ftp.gnu.org/gnu/gettext/gettext-0.21.tar.xz>

MD5 sum: 40996bbaf7d1356d3c22e33a8b255b31

• **Glibc (2.33) - 16,663 KB:**

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

Download: <http://ftp.gnu.org/gnu/glibc/glibc-2.33.tar.xz>

MD5 sum: 390bbd889c7e8e8a7041564cb6b27cca

• **GMP (6.2.1) - 1,980 KB:**

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

Download: <http://ftp.gnu.org/gnu/gmp/gmp-6.2.1.tar.xz>

MD5 sum: 0b82665c4a92fd2ade7440c13fcaa42b

• **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 (3.6) - 1,553 KB:**

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

Download: <http://ftp.gnu.org/gnu/grep/grep-3.6.tar.xz>

MD5 sum: f47fe27049510b2249dba7f862ac1b51

• **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 (20210202) - 578 KB:**

Home page: <https://www.iana.org/protocols>

Download: <https://github.com/Mic92/iana-etc/releases/download/20210202/iana-etc-20210202.tar.gz>

MD5 sum: 1c193a4d6ca36274570d1505140a7bee

• **Inetutils (2.0) - 1,462 KB:**

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

Download: <http://ftp.gnu.org/gnu/inetutils/inetutils-2.0.tar.xz>

MD5 sum: 5e1018502cd131ed8e42339f6b5c98aa

• **Intltool (0.51.0) - 159 KB:**

Home page: <https://freedesktop.org/wiki/Software/intltool>

Download: <https://launchpad.net/intltool/trunk/0.51.0/+download/intltool-0.51.0.tar.gz>

MD5 sum: 12e517cac2b57a0121cda351570f1e63

• **IPRoute2 (5.10.0) - 781 KB:**

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

Download: <https://www.kernel.org/pub/linux/utils/net/iproute2/iproute2-5.10.0.tar.xz>

MD5 sum: 19ffea480a21e600453776b7225f3319

• **Kbd (2.4.0) - 1,095 KB:**

Home page: <http://ftp.altlinux.org/pub/people/legion/kbd>

Download: <https://www.kernel.org/pub/linux/utils/kbd/kbd-2.4.0.tar.xz>

MD5 sum: 3cac5be0096fcf7b32dcbd3c53831380

• **Kmod (28) - 540 KB:**

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

MD5 sum: 0a2b887b1b3dfb8c0b3f41f598203e56

• **Less (563) - 328 KB:**

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

Download: <http://www.greenwoodsoftware.com/less/less-563.tar.gz>

MD5 sum: 1ee44fa71447a845f6eef5b3f38d2781

• **Libcap (2.48) - 130 KB:**

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

Download: <https://www.kernel.org/pub/linux/libs/security/linux-privs/libcap2/libcap-2.48.tar.xz>

MD5 sum: ca71693a9abe4e0ad9cc33a755ee47e0

• **Libffi (3.3) - 1,275 KB:**

Home page: <https://sourceware.org/libffi/>

Download: <https://sourceware.org/pub/libffi/libffi-3.3.tar.gz>

MD5 sum: 6313289e32f1d38a9df4770b014a2ca7

- **Libpipeline (1.5.3) - 972 KB:**

Home page: <http://libpipeline.nongnu.org/>

Download: <http://download.savannah.gnu.org/releases/libpipeline/libpipeline-1.5.3.tar.gz>

MD5 sum: dad443d0911cf9f0f1bd90a334bc9004

- **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 (5.10.17) - 113,548 KB:**

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

Download: <https://www.kernel.org/pub/linux/kernel/v5.x/linux-5.10.17.tar.xz>

MD5 sum: 4908707ed841923d8d1814130d5c380f



### Note

The Linux kernel is updated relatively often, many times due to discoveries of security vulnerabilities. The latest available stable kernel version may 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 (4.3) - 2,263 KB:**

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

Download: <http://ftp.gnu.org/gnu/make/make-4.3.tar.gz>

MD5 sum: fc7a67ea86ace13195b0bce683fd4469

- **Man-DB (2.9.4) - 1,865 KB:**

Home page: <https://www.nongnu.org/man-db/>

Download: <http://download.savannah.gnu.org/releases/man-db/man-db-2.9.4.tar.xz>

MD5 sum: 6e233a555f7b9ae91ce7cd0faa322bce

- **Man-pages (5.10) - 1,707 KB:**

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

Download: <https://www.kernel.org/pub/linux/docs/man-pages/man-pages-5.10.tar.xz>

MD5 sum: 4ae3f74a1beddd919936e1058642644c

- **Meson (0.57.1) - 1,806 KB:**

Home page: <https://mesonbuild.com>

Download: <https://github.com/mesonbuild/meson/releases/download/0.57.1/meson-0.57.1.tar.gz>

MD5 sum: fbd744560351491892478a36a1586815

- **MPC (1.2.1) - 820 KB:**

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

Download: <https://ftp.gnu.org/gnu/mpc/mpc-1.2.1.tar.gz>

MD5 sum: 9f16c976c25bb0f76b50be749cd7a3a8

- **MPFR (4.1.0) - 1,490 KB:**

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

Download: <http://www.mpfr.org/mpfr-4.1.0/mpfr-4.1.0.tar.xz>

MD5 sum: bdd3d5efba9c17da8d83a35ec552baef

- **Ncurses (6.2) - 3,346 KB:**

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

Download: <http://ftp.gnu.org/gnu/ncurses/ncurses-6.2.tar.gz>

MD5 sum: e812da327b1c2214ac1aed440ea3ae8d

- **Ninja (1.10.2) - 209 KB:**

Home page: <https://ninja-build.org/>

Download: <https://github.com/ninja-build/ninja/archive/v1.10.2/ninja-1.10.2.tar.gz>

MD5 sum: 639f75bc2e3b19ab893eaf2c810d4eb4

- **OpenSSL (1.1.1j) - 9,593 KB:**

Home page: <https://www.openssl.org/>

Download: <https://www.openssl.org/source/openssl-1.1.1j.tar.gz>

MD5 sum: cccaa064ed860a2b4d1303811bf5c682

- **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 (5.32.1) - 12,316 KB:**

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

Download: <https://www.cpan.org/src/5.0/perl-5.32.1.tar.xz>

MD5 sum: 7f104064b906ad8c7329ca5e409a32d7

- **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: f6e931e319531b736fad017f470e68a

- **Procps (3.3.17) - 985 KB:**

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

Download: <https://sourceforge.net/projects/procps-ng/files/Production/procps-ng-3.3.17.tar.xz>

MD5 sum: d60613e88c2f442ebd462b5a75313d56

- **Psmisc (23.4) - 362 KB:**

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

Download: <https://sourceforge.net/projects/psmisc/files/psmisc/psmisc-23.4.tar.xz>

MD5 sum: 8114cd4489b95308efe2509c3a406bbf

- **Python (3.9.2) - 18,477 KB:**

Home page: <https://www.python.org/>

Download: <https://www.python.org/ftp/python/3.9.2/Python-3.9.2.tar.xz>

MD5 sum: f0dc9000312abeb16de4eccce9a870ab

- **Python Documentation (3.9.2) - 6,659 KB:**

Download: <https://www.python.org/ftp/python/doc/3.9.2/python-3.9.2-docs-html.tar.bz2>

MD5 sum: 719cd64a4c5768b646b716df20229400

- **Readline (8.1) - 2,924 KB:**

Home page: <https://tiswww.case.edu/php/chet/readline/rltop.html>

Download: <http://ftp.gnu.org/gnu/readline/readline-8.1.tar.gz>

MD5 sum: e9557dd5b1409f5d7b37ef717c64518e

- **Sed (4.8) - 1,317 KB:**

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

Download: <http://ftp.gnu.org/gnu/sed/sed-4.8.tar.xz>

MD5 sum: 6d906edfdb3202304059233f51f9a71d

- **Shadow (4.8.1) - 1,574 KB:**

Download: <https://github.com/shadow-maint/shadow/releases/download/4.8.1/shadow-4.8.1.tar.xz>

MD5 sum: 4b05efff8a427cf50e615bda324b5bc45

- **Systemd (247) - 9,656 KB:**

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

Download: <https://github.com/systemd/systemd/archive/v247/systemd-247.tar.gz>

MD5 sum: b0d6e603b814908acc69db29bbfb023c

- **Systemd Man Pages(247) - 612 KB:**

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

Download: <http://anduin.linuxfromscratch.org/LFS/systemd-man-pages-247.tar.xz>

MD5 sum: 438c98be200e1c3b308e58a3399d4465



### 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 (1.34) - 2,174 KB:**

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

Download: <http://ftp.gnu.org/gnu/tar/tar-1.34.tar.xz>

MD5 sum: 9a08d29a9ac4727130b5708347c0f5cf

- **Tcl (8.6.11) - 10,020 KB:**

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

Download: <https://downloads.sourceforge.net/tcl/tcl8.6.11-src.tar.gz>

MD5 sum: 8a4c004f48984a03a7747e9ba06e4da4

- **Tcl Documentation (8.6.11) - 1,172 KB:**

Download: <https://downloads.sourceforge.net/tcl/tcl8.6.11-html.tar.gz>

MD5 sum: e358a9140c3a171e42f18c8a7f6a36ea

- **Texinfo (6.7) - 4,237 KB:**

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

Download: <http://ftp.gnu.org/gnu/texinfo/texinfo-6.7.tar.xz>

MD5 sum: d4c5d8cc84438c5993ec5163a59522a6

- **Time Zone Data (2021a) - 403 KB:**

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

Download: <https://www.iana.org/time-zones/repository/releases/tzdata2021a.tar.gz>

MD5 sum: 20eae7d1da671c6eac56339c8df85bbd

- **Util-linux (2.36.2) - 5,223 KB:**

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

Download: <https://www.kernel.org/pub/linux/utils/util-linux/v2.36/util-linux-2.36.2.tar.xz>

MD5 sum: f78419af679ac9678190ad961eb3cf27

- **Vim (8.2.2433) - 15,051 KB:**

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

Download: <http://andu.in.linuxfromscratch.org/LFS/vim-8.2.2433.tar.gz>

MD5 sum: a26555c8919cf40938d2428d834bf913



### Note

The version of vim changes daily. To get the latest version, go to <https://github.com/vim/vim/releases>.

- **XML::Parser (2.46) - 249 KB:**

Home page: <https://github.com/chorny/XML-Parser>

Download: <https://cpan.metacpan.org/authors/id/T/TO/TODDR/XML-Parser-2.46.tar.gz>

MD5 sum: 80bb18a8e6240fcf7ec2f7b57601c170

- **Xz Utils (5.2.5) - 1,122 KB:**

Home page: <https://tukaani.org/xz>

Download: <https://tukaani.org/xz/xz-5.2.5.tar.xz>

MD5 sum: aa1621ec7013a19abab52a8aff04fe5b

- **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

- **Zstd (1.4.8) - 1,762 KB:**

Home page: <https://facebook.github.io/zstd/>

Download: <https://github.com/facebook/zstd/releases/download/v1.4.8/zstd-1.4.8.tar.gz>

MD5 sum: e873db7cfa5ef05832e6d55a5a572840

Total size of these packages: about 428 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/10.1/bzip2-1.0.8-install\\_docs-1.patch](http://www.linuxfromscratch.org/patches/lfs/10.1/bzip2-1.0.8-install_docs-1.patch)

MD5 sum: 6a5ac7e89b791aae556de0f745916f7f

- **Coreutils Internationalization Fixes Patch - 166 KB:**

Download: <http://www.linuxfromscratch.org/patches/lfs/10.1/coreutils-8.32-i18n-1.patch>

MD5 sum: cd8ebed2a67fff2e231026df91af6776

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

Download: <http://www.linuxfromscratch.org/patches/lfs/10.1/glibc-2.33-fhs-1.patch>

MD5 sum: 9a5997c3452909b1769918c759eff8a2

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

Download: <http://www.linuxfromscratch.org/patches/lfs/10.1/kbd-2.4.0-backspace-1.patch>

MD5 sum: f75cca16a38da6caa7d52151f7136895

- **Systemd Upstream Fixes Patch - 8 KB:**

Download: [http://www.linuxfromscratch.org/patches/lfs/10.1/systemd-247-upstream\\_fixes-1.patch](http://www.linuxfromscratch.org/patches/lfs/10.1/systemd-247-upstream_fixes-1.patch)

MD5 sum: 573a166f3620875208f78bf4dc431c8b

Total size of these patches: about 190.4 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 set of directories 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 a limited directory layout in LFS filesystem

The first task performed in the LFS partition is to create a limited directory hierarchy so that programs compiled in Chapter 6 may be installed in their final location. This is needed so that those temporary programs be overwritten when rebuilding them in Chapter 8.

Create the required directory layout by running the following as `root`:

```
mkdir -pv $LFS/{bin,etc,lib,sbin,usr,var}
case $(uname -m) in
  x86_64) mkdir -pv $LFS/lib64 ;;
esac
```

Programs in Chapter 6 will be compiled with a cross-compiler (more details in section Toolchain Technical Notes). In order to separate this cross-compiler from the other programs, it will be installed in a special directory. Create this directory with:

```
mkdir -pv $LFS/tools
```

## 4.3. Adding the LFS User

When logged in as user `root`, making a single mistake can damage or destroy a system. Therefore, the packages in the next two chapters are built 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 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 all directories under `$LFS` by making `lfs` the directory owner:

```
chown -v lfs $LFS/{usr,lib,var,etc,bin,sbin,tools}
case $(uname -m) in
  x86_64) chown -v lfs $LFS/lib64 ;;
esac
```

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

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



### Note

In some host systems, the following command does not complete properly and suspends the login to the `lfs` user to the background. If the prompt "`lfs:~$`" does not appear immediately, entering the `fg` command will fix the issue.

Next, login as user `lfs`. This can be done via a virtual console, through a display manager, or with the following substitute/switch 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, and execute, the contents of `/etc/profile` or `.bash_profile` files, but rather reads, and executes, the `.bashrc` file instead. Create the `.bashrc` file now:

```
cat > ~/.bashrc << "EOF"
set +h
umask 022
LFS=/mnt/lfs
LC_ALL=POSIX
LFS_TGT=$(uname -m)-lfs-linux-gnu
PATH=/usr/bin
if [ ! -L /bin ]; then PATH=/bin:$PATH; fi
PATH=$LFS/tools/bin:$PATH
CONFIG_SITE=$LFS/usr/share/config.site
export LFS LC_ALL LFS_TGT PATH CONFIG_SITE
EOF
```

### The meaning of the settings in `.bashrc`

```
set +h
```

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.

```
umask 022
```

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).

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

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

```
LC_ALL=POSIX
```

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.

```
LFS_TGT=$(uname -m)-lfs-linux-gnu
```

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 Toolchain Technical Notes.

```
PATH=/usr/bin
```

Many modern linux distributions have merged `/bin` and `/usr/bin`. When this is the case, the standard `PATH` variable needs just to be set to `/usr/bin/` for the Chapter 6 environment. When this is not the case, the following line adds `/bin` to the path.

```
if [ ! -L /bin ]; then PATH=/bin:$PATH; fi
```

If `/bin` is not a symbolic link, then it has to be added to the `PATH` variable.

```
PATH=$LFS/tools/bin:$PATH
```

By putting `$LFS/tools/bin` ahead of the standard `PATH`, the cross-compiler installed at the beginning of Chapter 5 is picked up by the shell immediately after its installation. This, combined with turning off hashing, limits the risk that the compiler from the host be used instead of the cross-compiler.

```
CONFIG_SITE=$LFS/usr/share/config.site
```

In Chapter 5 and Chapter 6, if this variable is not set, **configure** scripts may attempt to load configuration items specific to some distributions from `/usr/share/config.site` on the host system. Override it to prevent potential contamination from the host.

```
export ...
```

While the above commands have set some variables, in order to make them visible within any sub-shells, we export them.



### Important

Several commercial distributions add a non-documented instantiation of `/etc/bash.bashrc` to the initialization of **bash**. This file has the potential to modify the `lfs` user's environment in ways that can affect the building of critical LFS packages. To make sure the `lfs` user's environment is clean, check for the presence of `/etc/bash.bashrc` and, if present, move it out of the way. As the `root` user, run:

```
[ ! -e /etc/bash.bashrc ] || mv -v /etc/bash.bashrc /etc/bash.bashrc.NOUSE
```

After use of the `lfs` user is finished at the beginning of Chapter 7, you can restore `/etc/bash.bashrc` (if desired).

Note that the LFS Bash package we will build in Section 8.34, “Bash-5.1” is not configured to load or execute `/etc/bash.bashrc`, so this file is useless on a completed LFS system.

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, an Intel i5-6500 CPU can support four simultaneous processes with:

```
export MAKEFLAGS='-j4'
```

or just building with:

```
make -j4
```

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**

Running the test suites in Chapter 5 and Chapter 6 is impossible, since the programs are compiled with a cross-compiler, so are not supposed to be able to run on the build host.

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/10.1/> to verify whether or not these failures are expected. This site is valid for all tests throughout this book.

## **Part III. Building the LFS Cross Toolchain and Temporary Tools**

# Important Preliminary Material

## Introduction

This part is divided into three stages: first building a cross compiler and its associated libraries; second, use this cross toolchain to build several utilities in a way that isolates them from the host distribution; third, enter the chroot environment, which further improves host isolation, and build the remaining tools needed to build the final system.



### Important

With this part begins the real work of building a new system. It requires much care in ensuring that the instructions are followed exactly as the book shows them. You should try to understand what they do, and whatever your eagerness to finish your build, you should refrain from blindly type them as shown, but rather read documentation when there is something you do not understand. Also, keep track of your typing and of the output of commands, by sending them to a file, using the `tee` utility. This allows for better diagnosing if something gets wrong.

The next section gives a technical introduction to the build process, while the following one contains **very important** general instructions.

## 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 and Chapter 6 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.

The build process is based on the process of *cross-compilation*. Cross-compilation is normally used for building a compiler and its toolchain for a machine different from the one that is used for the build. This is not strictly needed for LFS, since the machine where the new system will run is the same as the one used for the build. But cross-compilation has the great advantage that anything that is cross-compiled cannot depend on the host environment.

## About Cross-Compilation

Cross-compilation involves some concepts that deserve a section on their own. Although this section may be omitted in a first reading, it is strongly suggested to come back to it later in order to get a full grasp of the build process.

Let us first define some terms used in this context:

build

is the machine where we build programs. Note that this machine is referred to as the “host” in other sections.

host

is the machine/system where the built programs will run. Note that this use of “host” is not the same as in other sections.

target

is only used for compilers. It is the machine the compiler produces code for. It may be different from both build and host.

As an example, let us imagine the following scenario (sometimes referred to as “Canadian Cross”): we may have a compiler on a slow machine only, let's call the machine A, and the compiler ccA. We may have also a fast machine (B), but with no compiler, and we may want to produce code for another slow machine (C). To build a compiler for machine C, we would have three stages:

Stage	Build	Host	Target	Action
1	A	A	B	build cross-compiler cc1 using ccA on machine A
2	A	B	C	build cross-compiler cc2 using cc1 on machine A
3	B	C	C	build compiler ccC using cc2 on machine B

Then, all the other programs needed by machine C can be compiled using cc2 on the fast machine B. Note that unless B can run programs produced for C, there is no way to test the built programs until machine C itself is running. For example, for testing ccC, we may want to add a fourth stage:

Stage	Build	Host	Target	Action
4	C	C	C	rebuild and test ccC using itself on machine C

In the example above, only cc1 and cc2 are cross-compilers, that is, they produce code for a machine different from the one they are run on. The other compilers ccA and ccC produce code for the machine they are run on. Such compilers are called *native* compilers.

## Implementation of Cross-Compilation for LFS



### Note

Almost all the build systems use names of the form `cpu-vendor-kernel-os` referred to as the machine triplet. An astute reader may wonder why a “triplet” refers to a four component name. The reason is history: initially, three component names were enough to designate unambiguously a machine, but with new machines and systems appearing, that proved insufficient. The word “triplet” remained. A simple way to determine your machine 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.

In order to fake a cross compilation, the name of the host triplet is slightly adjusted by changing the “vendor” field in the `LFS_TGT` variable. We also use the `--with-sysroot` option when building the cross linker and cross compiler to tell them where to find the needed host files. This ensures that none of the other programs built in Chapter 6 can link to libraries on the build machine. Only two stages are mandatory, and one more for tests:

Stage	Build	Host	Target	Action
1	pc	pc	lfs	build cross-compiler <code>cc1</code> using <code>cc-pc</code> on <code>pc</code>
2	pc	lfs	lfs	build compiler <code>cc-lfs</code> using <code>cc1</code> on <code>pc</code>
3	lfs	lfs	lfs	rebuild and test <code>cc-lfs</code> using itself on <code>lfs</code>

In the above table, “on `pc`” means the commands are run on a machine using the already installed distribution. “On `lfs`” means the commands are run in a chrooted environment.

Now, there is more about cross-compiling: the C language is not just a compiler, but also defines a standard library. In this book, the GNU C library, named `glibc`, is used. This library must be compiled for the `lfs` machine, that is, using the cross compiler `cc1`. But the compiler itself uses an internal library implementing complex instructions not available in the assembler instruction set. This internal library is named `libgcc`, and must be linked to the `glibc` library to be fully functional! Furthermore, the standard library for C++ (`libstdc++`) also needs being linked to `glibc`. The solution to this chicken and egg problem is to first build a degraded `cc1` based `libgcc`, lacking some functionalities such as threads and exception handling, then build `glibc` using this degraded compiler (`glibc` itself is not degraded), then build `libstdc++`. But this last library will lack the same functionalities as `libgcc`.

This is not the end of the story: the conclusion of the preceding paragraph is that `cc1` is unable to build a fully functional `libstdc++`, but this is the only compiler available for building the C/C++ libraries during stage 2! Of course, the compiler built during stage 2, `cc-lfs`, would be able to build those libraries, but (1) the build system of GCC does not know that it is usable on `pc`, and (2) using it on `pc` would be at risk of linking to the `pc` libraries, since `cc-lfs` is a native compiler. So we have to build `libstdc++` later, in `chroot`.

## Other procedural details

The cross-compiler will be installed in a separate `$LFS/tools` directory, since it will not be part of the final system.

`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, `$LFS/tools/bin` and `$LFS/tools/$LFS_TGT/bin`. The tools in one location are hard linked to the other. An important facet of the linker is its library search order. Detailed information can be obtained from `ld` by passing it the `--verbose` flag. For example, `$LFS_TGT-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, `$LFS_TGT-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... /mnt/lfs/tools/i686-lfs-linux-gnu/bin/as
checking what linker to use... /mnt/lfs/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: `$LFS_TGT-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 `$LFS_TGT-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 `build`

directory for all important details. Note the use of `CC="$LFS_TGT-gcc"` (with `$LFS_TGT` expanded) 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.

As said above, the standard C++ library is compiled next, followed in Chapter 6 by all the programs that need themselves to be built. The install step of all those packages uses the `DESTDIR` variable to have the programs land into the LFS filesystem.

At the end of Chapter 6 the native lfs compiler is installed. First `binutils-pass2` is built, with the same `DESTDIR` install as the other programs, then the second pass of GCC is constructed, omitting `libstdc++` and other non-important libraries. Due to some weird logic in GCC's configure script, `CC_FOR_TARGET` ends up as `cc` when the host is the same as the target, but is different from the build system. This is why `CC_FOR_TARGET=$LFS_TGT-gcc` is put explicitly into the configure options.

Upon entering the chroot environment in Chapter 7, the first task is to install `libstdc++`. Then temporary installations of programs needed for the proper operation of the toolchain are performed. From this point onwards, the core toolchain is self-contained and self-hosted. In Chapter 8, final versions of all the packages needed for a fully functional system are built, tested and installed.

## 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 following chapters, but sometimes in only one location. 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/`.
2. Change to the sources directory.
3. For each package:
  - a. Using the **tar** program, extract the package to be built. In Chapter 5 and Chapter 6, ensure you are the *lfs* user when extracting the package.
  - b. Change to the directory created when the package was extracted.
  - c. Follow the book's instructions for building the package.
  - d. Change back to the sources directory.
  - e. Delete the extracted source directory unless instructed otherwise.

# Chapter 5. Compiling a Cross-Toolchain

## 5.1. Introduction

This chapter shows how to build a cross-compiler and its associated tools. Although here cross-compilation is faked, the principles are the same as for a real cross-toolchain.

The programs compiled in this chapter will be installed under the `$LFS/tools` directory to keep them separate from the files installed in the following chapters. The libraries, on the other hand, are installed into their final place, since they pertain to the system we want to build.

## 5.2. Binutils-2.36.1 - 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:** 640 MB

### 5.2.1. Installation of Cross Binutils



#### Note

Go back and re-read the notes in the section titled General Compilation Instructions. Understanding the notes labeled important can 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 && make install; }**.

Now prepare Binutils for compilation:

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

#### The meaning of the configure options:

*--prefix=\$LFS/tools*

This tells the configure script to prepare to install the binutils programs in the `$LFS/tools` directory.

*--with-sysroot=\$LFS*

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

*--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
```

Install the package:

```
make install
```

Details on this package are located in Section 8.18.2, “Contents of Binutils.”

## 5.3. GCC-10.2.0 - Pass 1

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

**Approximate build time:** 11 SBU

**Required disk space:** 3.7 GB

### 5.3.1. Installation of Cross GCC

GCC 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-4.1.0.tar.xz
mv -v mpfr-4.1.0 mpfr
tar -xf ../gmp-6.2.1.tar.xz
mv -v gmp-6.2.1 gmp
tar -xf ../mpc-1.2.1.tar.gz
mv -v mpc-1.2.1 mpc
```

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=$LFS_TGT \
  --prefix=$LFS/tools \
  --with-glibc-version=2.11 \
  --with-sysroot=$LFS \
  --with-newlib \
  --without-headers \
  --enable-initfini-array \
  --disable-nls \
  --disable-shared \
  --disable-multilib \
  --disable-decimal-float \
  --disable-threads \
  --disable-libatomic \
  --disable-libgomp \
  --disable-libquadmath \
  --disable-libssp \
  --disable-libvtv \
  --disable-libstdcxx \
  --enable-languages=c,c++

```

**The meaning of the configure options:**

*--with-glibc-version=2.11*

This option ensures the package will be compatible with the host's version of glibc. It is set to the minimum glibc requirement specified in the Host System Requirements.

*--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.

*--enable-initfini-array*

This switch forces the use of some internal data structures that are needed but cannot be detected when building a cross compiler.

*--disable-shared*

This switch forces GCC to link its internal libraries statically. We need this because the shared libraries require `glibc`, which is not yet installed on the target system.

*--disable-multilib*

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

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

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`.

```
--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
```

Install the package:

```
make install
```

This build of GCC has installed a couple of internal system headers. Normally one of them, `limits.h`, would in turn include the corresponding system `limits.h` header, in this case, `$LFS/usr/include/limits.h`. However, at the time of this build of GCC `$LFS/usr/include/limits.h` does not exist, so the internal header that has just been installed is a partial, self-contained file and does not include the extended features of the system header. This is adequate for building glibc, but the full internal header will be needed later. Create a full version of the internal header using a command that is identical to what the GCC build system does in normal circumstances:

```
cd ..
cat gcc/limitx.h gcc/glimits.h gcc/limity.h > \
  `dirname $($LFS_TGT-gcc -print-libgcc-file-name)~/install-tools/include/limits.h
```

Details on this package are located in Section 8.26.2, “Contents of GCC.”

## 5.4. Linux-5.10.17 API Headers

The Linux API Headers (in linux-5.10.17.tar.xz) expose the kernel's API for use by Glibc.

**Approximate build time:** 0.1 SBU

**Required disk space:** 1.1 GB

### 5.4.1. 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. The recommended make target “headers\_install” cannot be used, because it requires rsync, which may not be available. The headers are first placed in `./usr`, then copied to the needed location.

```
make headers
find usr/include -name '*.h' -delete
rm usr/include/Makefile
cp -rv usr/include $LFS/usr
```

### 5.4.2. 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

<code>/usr/include/asm/*.h</code>	The Linux API ASM Headers
<code>/usr/include/asm-generic/*.h</code>	The Linux API ASM Generic Headers
<code>/usr/include/drm/*.h</code>	The Linux API DRM Headers
<code>/usr/include/linux/*.h</code>	The Linux API Linux Headers
<code>/usr/include/misc/*.h</code>	The Linux API Miscellaneous Headers
<code>/usr/include/mtd/*.h</code>	The Linux API MTD Headers
<code>/usr/include/rdma/*.h</code>	The Linux API RDMA Headers
<code>/usr/include/scsi/*.h</code>	The Linux API SCSI Headers
<code>/usr/include/sound/*.h</code>	The Linux API Sound Headers
<code>/usr/include/video/*.h</code>	The Linux API Video Headers
<code>/usr/include/xen/*.h</code>	The Linux API Xen Headers

## 5.5. Glibc-2.33

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:** 4.2 SBU

**Required disk space:** 770 MB

### 5.5.1. Installation of Glibc

First, create a symbolic link for LSB compliance. Additionally, for `x86_64`, create a compatibility symbolic link required for proper operation of the dynamic library loader:

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

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-2.33-fhs-1.patch
```

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

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

Next, prepare Glibc for compilation:

```
../configure \
  --prefix=/usr \
  --host=$LFS_TGT \
  --build=$(../scripts/config.guess) \
  --enable-kernel=3.2 \
  --with-headers=$LFS/usr/include \
  libc_cv_slibdir=/lib
```

**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 be cross-compiled, using the cross-linker and cross-compiler in `$LFS/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=$LFS/usr/include
```

This tells Glibc to compile itself against the headers recently installed to the `$LFS/usr/include` directory, so that it knows exactly what features the kernel has and can optimize itself accordingly.

```
libc_cv_slibdir=/lib
```

This ensures that the library is installed in `/lib` instead of the default `/lib64` on 64 bit machines.

```
libc_cv_include_x86_isa_level=no
```

This disables “x86 ISA needed” property in Glibc libraries. Use it **if** you are building Glibc with `-march` option in `CFLAGS`, to workaround an issue in Glibc-2.33 breaking it.

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:



### Warning

If `LFS` is not properly set, and despite the recommendations, you are building as `root`, the next command will install the newly built `glibc` to your host system, which most likely will render it unusable. So double check that the environment is correctly set, before running the following command.

```
make DESTDIR=$LFS install
```

**The meaning of the make install option:**

```
DESTDIR=$LFS
```

The `DESTDIR` make variable is used by almost all packages to define the location where the package should be installed. If it is not set, it defaults to the root (`/`) directory. Here we specify that the package be installed in `$LFS`, which will become the root after Section 7.4, “Entering the Chroot Environment”.



## 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 '/ld-linux'
```

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

Note that for 32-bit machines, the interpreter name will be `/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 packages in the next chapter will serve as an additional check that the toolchain has been built properly. If some package, especially `binutils-pass2` or `gcc-pass2`, fails to build, it is an indication that something has gone wrong with the previous Binutils, GCC, or Glibc installations.

Now that our cross-toolchain is complete, finalize the installation of the `limits.h` header. For doing so, run a utility provided by the GCC developers:

```
$LFS/tools/libexec/gcc/$LFS_TGT/10.2.0/install-tools/mkheaders
```

Details on this package are located in Section 8.5.3, “Contents of Glibc.”

## 5.6. Libstdc++ from GCC-10.2.0, Pass 1

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 the target directory.

**Approximate build time:** 0.4 SBU

**Required disk space:** 953 MB

### 5.6.1. Installation of Target Libstdc++



#### Note

Libstdc++ is part of the GCC sources. You should first unpack the GCC tarball and change to the `gcc-10.2.0` directory.

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

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

Prepare libstdc++ for compilation:

```
../libstdc++-v3/configure \
  --host=$LFS_TGT          \
  --build=$(../config.guess) \
  --prefix=/usr            \
  --disable-multilib       \
  --disable-nls            \
  --disable-libstdcxx-pch  \
  --with-gxx-include-dir=/tools/$LFS_TGT/include/c++/10.2.0
```

The meaning of the configure options:

`--host=...`

Specifies the use the cross compiler we have just built instead of the one in `/usr/bin`.

`--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++/10.2.0`

This is the location where the C++ compiler should search for the standard include files. 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 DESTDIR=$LFS install
```

Details on this package are located in Section 8.26.2, “Contents of GCC.”

# Chapter 6. Cross Compiling Temporary Tools

## 6.1. Introduction

This chapter shows how to cross-compile basic utilities using the just built cross-toolchain. Those utilities are installed into their final location, but cannot be used yet. Basic tasks still rely on the host's tools. Nevertheless, the installed libraries are used when linking.

Using the utilities will be possible in next chapter after entering the “chroot” environment. But all the packages built in the present chapter need to be built before we do that. Therefore we cannot be independent of the host system yet.

Once again, let us recall that improper setting of `LFS` together with building as `root`, may render your computer unusable. This whole chapter must be done as user `lfs`, with the environment as described in Section 4.4, “Setting Up the Environment”.

## 6.2. M4-1.4.18

The M4 package contains a macro processor.

**Approximate build time:** 0.1 SBU

**Required disk space:** 22 MB

### 6.2.1. Installation of M4

First, make some fixes introduced 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 \
            --host=$LFS_TGT \
            --build=$(build-aux/config.guess)
```

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

Details on this package are located in Section 8.12.2, “Contents of M4.”

## 6.3. Ncurses-6.2

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

**Approximate build time:** 0.7 SBU

**Required disk space:** 48 MB

### 6.3.1. Installation of Ncurses

First, ensure that **gawk** is found first during configuration:

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

Then, run the following commands to build the “tic” program on the build host:

```
mkdir build
pushd build
  ./configure
  make -C include
  make -C progs tic
popd
```

Prepare Ncurses for compilation:

```
./configure --prefix=/usr \
            --host=$LFS_TGT \
            --build=$(./config.guess) \
            --mandir=/usr/share/man \
            --with-manpage-format=normal \
            --with-shared \
            --without-debug \
            --without-ada \
            --without-normal \
            --enable-widenc
```

**The meaning of the new configure options:**

*--with-manpage-format=normal*

This prevents Ncurses installing compressed manual pages, which may happen if the host distribution itself has compressed manual pages.

*--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-widenc*

This switch causes wide-character libraries (e.g., `libncursesw.so.6.2`) to be built instead of normal ones (e.g., `libncurses.so.6.2`). 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.

*--without-normal*

This switch disables building and installing most static libraries.

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS TIC_PATH=$(pwd)/build/progs/tic install  
echo "INPUT(-lncursesw)" > $LFS/usr/lib/libncurses.so
```

**The meaning of the install options:**

```
TIC_PATH=$(pwd)/build/progs/tic
```

We need to pass the path of the just built `tic` able to run on the building machine, so that the terminal database can be created without errors.

```
echo "INPUT(-lncursesw)" > $LFS/usr/lib/libncurses.so
```

The `libncurses.so` library is needed by a few packages we will build soon. We create this small linker script, as this is what is done in Chapter 8.

Move the shared libraries to the `/lib` directory, where they are expected to reside:

```
mv -v $LFS/usr/lib/libncursesw.so.6* $LFS/lib
```

Because the libraries have been moved, one symlink points to a non-existent file. Recreate it:

```
ln -sfv ../../lib/$(readlink $LFS/usr/lib/libncursesw.so) $LFS/usr/lib/libncursesw.so
```

Details on this package are located in Section 8.28.2, “Contents of Ncurses.”

## 6.4. Bash-5.1

The Bash package contains the Bourne-Again SHell.

**Approximate build time:** 0.4 SBU

**Required disk space:** 66 MB

### 6.4.1. Installation of Bash

Prepare Bash for compilation:

```
./configure --prefix=/usr          \
            --build=$(support/config.guess) \
            --host=$LFS_TGT        \
            --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
```

Install the package:

```
make DESTDIR=$LFS install
```

Move the executable to where it is expected:

```
mv $LFS/usr/bin/bash $LFS/bin/bash
```

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

```
ln -sv bash $LFS/bin/sh
```

Details on this package are located in Section 8.34.2, “Contents of Bash.”

## 6.5. Coreutils-8.32

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

**Approximate build time:** 0.5 SBU

**Required disk space:** 170 MB

### 6.5.1. Installation of Coreutils

Prepare Coreutils for compilation:

```
./configure --prefix=/usr \
            --host=$LFS_TGT \
            --build=$(build-aux/config.guess) \
            --enable-install-program=hostname \
            --enable-no-install-program=kill,uptime
```

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
```

Install the package:

```
make DESTDIR=$LFS install
```

Move programs to their final expected locations. Although this is not necessary in this temporary environment, we must do so because some programs hardcode executable locations:

```
mv -v $LFS/usr/bin/{cat,chgrp,chmod,chown,cp,date,dd,df,echo} $LFS/bin
mv -v $LFS/usr/bin/{false,ln,ls,mkdir,mknod,mv,pwd,rm} $LFS/bin
mv -v $LFS/usr/bin/{rmdir,stty,sync,true,uname} $LFS/bin
mv -v $LFS/usr/bin/{head,nice,sleep,touch} $LFS/bin
mv -v $LFS/usr/bin/chroot $LFS/usr/sbin
mkdir -pv $LFS/usr/share/man/man8
mv -v $LFS/usr/share/man/man1/chroot.1 $LFS/usr/share/man/m
sed -i 's/"1"/"8"/'
```

Details on this package are located in Section 8.52.2, “Contents of Coreutils.”

## 6.6. Diffutils-3.7

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

**Approximate build time:** 0.1 SBU

**Required disk space:** 26 MB

### 6.6.1. Installation of Diffutils

Prepare Diffutils for compilation:

```
./configure --prefix=/usr --host=$LFS_TGT
```

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

Details on this package are located in Section 8.54.2, “Contents of Diffutils.”

## 6.7. File-5.39

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

**Approximate build time:** 0.2 SBU

**Required disk space:** 31 MB

### 6.7.1. Installation of File

The `file` command on the build host needs to be same version as the one we are building in order to create the signature file. Run the following commands to build it:

```
mkdir build
pushd build
  ./configure --disable-bzlib      \
              --disable-libseccomp \
              --disable-xzlib     \
              --disable-zlib
  make
popd
```

The meaning of the new configure option:

`--disable-*`

The configuration script attempts to use some packages from the host distribution if the corresponding library files exist. It may cause compilation failure if a library file exists, but the corresponding header files do not. These options prevent using these unneeded capabilities from the host.

Prepare File for compilation:

```
./configure --prefix=/usr --host=$LFS_TGT --build=$(./config.guess)
```

Compile the package:

```
make FILE_COMPILE=$(pwd)/build/src/file
```

Install the package:

```
make DESTDIR=$LFS install
```

Details on this package are located in Section 8.10.2, “Contents of File.”

## 6.8. Findutils-4.8.0

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 is unreliable if the database has not been recently updated).

**Approximate build time:** 0.2 SBU

**Required disk space:** 42 MB

### 6.8.1. Installation of Findutils

Prepare Findutils for compilation:

```
./configure --prefix=/usr \
            --host=$LFS_TGT \
            --build=$(build-aux/config.guess)
```

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

Move the executable to its final expected location:

```
mv -v $LFS/usr/bin/find $LFS/bin
sed -i 's|find:=${BINDIR}|find:=/bin|' $LFS/usr/bin/updatedb
```

Details on this package are located in Section 8.56.2, “Contents of Findutils.”

## 6.9. Gawk-5.1.0

The Gawk package contains programs for manipulating text files.

**Approximate build time:** 0.2 SBU

**Required disk space:** 46 MB

### 6.9.1. Installation of Gawk

First, ensure some unneeded files are not installed:

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

Prepare Gawk for compilation:

```
./configure --prefix=/usr \
            --host=$LFS_TGT \
            --build=$(./config.guess)
```

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

Details on this package are located in Section 8.55.2, “Contents of Gawk.”

## 6.10. Grep-3.6

The Grep package contains programs for searching through the contents of files.

**Approximate build time:** 0.2 SBU

**Required disk space:** 26 MB

### 6.10.1. Installation of Grep

Prepare Grep for compilation:

```
./configure --prefix=/usr \
            --host=$LFS_TGT \
            --bindir=/bin
```

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

Details on this package are located in Section 8.33.2, “Contents of Grep.”

## 6.11. Gzip-1.10

The Gzip package contains programs for compressing and decompressing files.

**Approximate build time:** 0.1 SBU

**Required disk space:** 10 MB

### 6.11.1. Installation of Gzip

Prepare Gzip for compilation:

```
./configure --prefix=/usr --host=$LFS_TGT
```

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

Move the executable to its final expected location:

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

Details on this package are located in Section 8.60.2, “Contents of Gzip.”

## 6.12. Make-4.3

The Make package contains a program for controlling the generation of executables and other non-source files of a package from source files.

**Approximate build time:** 0.1 SBU

**Required disk space:** 16 MB

### 6.12.1. Installation of Make

Prepare Make for compilation:

```
./configure --prefix=/usr \
            --without-guile \
            --host=$LFS_TGT \
            --build=$(build-aux/config.guess)
```

**The meaning of the new configure option:**

*--without-guile*

Although we are cross-compiling, configure tries to use guile from the build host if it finds it. This makes compilation fail, so this switch prevents using it.

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

Details on this package are located in Section 8.64.2, “Contents of Make.”

## 6.13. 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:** 0.1 SBU

**Required disk space:** 13 MB

### 6.13.1. Installation of Patch

Prepare Patch for compilation:

```
./configure --prefix=/usr \
            --host=$LFS_TGT \
            --build=$(build-aux/config.guess)
```

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

Details on this package are located in Section 8.65.2, “Contents of Patch.”

## 6.14. Sed-4.8

The Sed package contains a stream editor.

**Approximate build time:** 0.1 SBU

**Required disk space:** 21 MB

### 6.14.1. Installation of Sed

Prepare Sed for compilation:

```
./configure --prefix=/usr \
            --host=$LFS_TGT \
            --bindir=/bin
```

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

Details on this package are located in Section 8.29.2, “Contents of Sed.”

## 6.15. Tar-1.34

The Tar package provides the ability to create tar archives as well as perform various other kinds of archive manipulation. Tar can be used on previously created archives to extract files, to store additional files, or to update or list files which were already stored.

**Approximate build time:** 0.2 SBU

**Required disk space:** 40 MB

### 6.15.1. Installation of Tar

Prepare Tar for compilation:

```
./configure --prefix=/usr          \  
            --host=$LFS_TGT        \  
            --build=$(build-aux/config.guess) \  
            --bindir=/bin
```

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

Details on this package are located in Section 8.67.2, “Contents of Tar.”

## 6.16. Xz-5.2.5

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:** 0.1 SBU

**Required disk space:** 16 MB

### 6.16.1. Installation of Xz

Prepare Xz for compilation:

```
./configure --prefix=/usr          \
            --host=$LFS_TGT        \
            --build=$(build-aux/config.guess) \
            --disable-static       \
            --docdir=/usr/share/doc/xz-5.2.5
```

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

Make sure that all essential files are in the correct directory:

```
mv -v $LFS/usr/bin/{lzma,unlzma,lzcat,xz,unxz,xzcat} $LFS/bin
mv -v $LFS/usr/lib/liblzma.so.*                    $LFS/lib
ln -svf ../../lib/$(readlink $LFS/usr/lib/liblzma.so) $LFS/usr/lib/liblzma.so
```

Details on this package are located in Section 8.8.2, “Contents of Xz.”

## 6.17. Binutils-2.36.1 - Pass 2

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

**Approximate build time:** 1.3 SBU

**Required disk space:** 517 MB

### 6.17.1. Installation of Binutils

Create a separate build directory again:

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

Prepare Binutils for compilation:

```
../configure \
  --prefix=/usr \
  --build=$(../config.guess) \
  --host=$LFS_TGT \
  --disable-nls \
  --enable-shared \
  --disable-werror \
  --enable-64-bit-bfd
```

The meaning of the new configure options:

*--enable-shared*

Builds `libbfd` as a shared library.

*--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.

Compile the package:

```
make
```

Install the package, and workaround an issue causing `libctf.so` to link against `zlib` from the host distribution:

```
make DESTDIR=$LFS install
install -vm755 libctf/.libs/libctf.so.0.0.0 $LFS/usr/lib
```

Details on this package are located in Section 8.18.2, “Contents of Binutils.”

## 6.18. GCC-10.2.0 - Pass 2

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

**Approximate build time:** 11 SBU

**Required disk space:** 3.7 GB

### 6.18.1. Installation of GCC

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

```
tar -xf ../mpfr-4.1.0.tar.xz
mv -v mpfr-4.1.0 mpfr
tar -xf ../gmp-6.2.1.tar.xz
mv -v gmp-6.2.1 gmp
tar -xf ../mpc-1.2.1.tar.gz
mv -v mpc-1.2.1 mpc
```

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
```

Create a separate build directory again:

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

Create a symlink that allows libgcc to be built with posix threads support:

```
mkdir -pv $LFS_TGT/libgcc
ln -s ../../../../libgcc/gthr-posix.h $LFS_TGT/libgcc/gthr-default.h
```

Before starting to build GCC, remember to unset any environment variables that override the default optimization flags.

Now prepare GCC for compilation:

```

./configure \
  --build=$(./config.guess) \
  --host=$LFS_TGT \
  --prefix=/usr \
  CC_FOR_TARGET=$LFS_TGT-gcc \
  --with-build-sysroot=$LFS \
  --enable-initfini-array \
  --disable-nls \
  --disable-multilib \
  --disable-decimal-float \
  --disable-libatomic \
  --disable-libgomp \
  --disable-libquadmath \
  --disable-libssp \
  --disable-libvtv \
  --disable-libstdcxx \
  --enable-languages=c,c++

```

The meaning of the new configure options:

*--with-build-sysroot=\$LFS*

Normally, using *--host* ensures that a cross-compiler is used for building GCC, and that compiler knows that it has to look for headers and libraries in *\$LFS*. But the build system of GCC uses other tools, which are not aware of this location. This switch is needed to have them find the needed files in *\$LFS*, and not on the host.

*--enable-initfini-array*

This option is automatically enabled when building a native compiler with a native compiler on x86. But here, we build with a cross compiler, so we need to explicitly set this option.

Compile the package:

```
make
```

Install the package:

```
make DESTDIR=$LFS install
```

As a finishing touch, create a utility 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 $LFS/usr/bin/cc
```

Details on this package are located in Section 8.26.2, “Contents of GCC.”

# Chapter 7. Entering Chroot and Building Additional Temporary Tools

## 7.1. Introduction

This chapter shows how to build the last missing bits of the temporary system: first, the tools needed by the build machinery of various packages, then three packages needed to run tests. Now that all circular dependencies have been resolved, we can use a “chroot” environment, completely isolated the host operating system used for the build, except for the running kernel.

For proper operation of the isolated environment, some communication with the running kernel must be established. This is done through the so-called *Virtual Kernel File Systems*, which must be mounted when entering the chroot environment. You may want to check that they are mounted by issuing **findmnt**.

Until Section 7.4, “Entering the Chroot Environment”, the commands must be run as `root`, with the `LFS` variable set. After entering chroot, all commands are run as `root`, fortunately without access to the OS of the computer you built LFS on. Be careful anyway, as it is easy to destroy the whole LFS system with badly formed commands.

## 7.2. 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 whole directory hierarchy in `$LFS` is owned by the user `lfs`, a user that exists only on the host system. If the directories and files under `$LFS` are kept as they are, they will be 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 all the files under `$LFS`, thus exposing these files to possible malicious manipulation.

To address this issue, change the ownership of the `$LFS/*` directories to user `root` by running the following command:

```
chown -R root:root $LFS/{usr,lib,var,etc,bin,sbin,tools}
case $(uname -m) in
  x86_64) chown -R root:root $LFS/lib64 ;;
esac
```

## 7.3. 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}
```

### 7.3.1. 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 the kernel populates `/dev`, 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
```

### 7.3.2. 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
```

### 7.3.3. Mounting Virtual Kernel File Systems

Now mount the remaining virtual kernel filesystems:

```
mount -v --bind /dev/pts $LFS/dev/pts
mount -vt proc proc $LFS/proc
mount -vt sysfs sysfs $LFS/sys
mount -vt tmpfs tmpfs $LFS/run
```

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
```

## 7.4. Entering the Chroot Environment

Now that all the packages which are required to build the rest of the needed tools are on the system, it is time to enter the `chroot` environment to finish installing the remaining temporary tools. This environment will be in use also for installing the final system. As user `root`, run the following command to enter the environment that is, at the moment, populated with only the temporary tools:

```
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 +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 desired, 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` is not in the `PATH`. This means that the cross toolchain will no longer be used in the chroot environment. 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 7.3.2, “Mounting and Populating `/dev`” and Section 7.3.3, “Mounting Virtual Kernel File Systems” and enter chroot again before continuing with the installation.

## 7.5. Creating Directories

It is time to create the full structure in the `LFS` file system.

Create some root-level directories that are not in the limited set required in the previous chapters by issuing the following command:



### Note

Some of the directories below have already been created earlier with explicit instructions or when installing some packages. They are repeated below for completeness.

```
mkdir -pv /{boot,home,mnt,opt,srv}
```

Create the required set of subdirectories below the root-level by issuing the following commands:

```
mkdir -pv /etc/{opt,sysconfig}
mkdir -pv /lib/firmware
mkdir -pv /media/{floppy,cdrom}
mkdir -pv /usr/{,local/}{bin,include,lib,sbin,src}
mkdir -pv /usr/{,local/}share/{color,dict,doc,info,locale,man}
mkdir -pv /usr/{,local/}share/{misc,terminfo,zoneinfo}
mkdir -pv /usr/{,local/}share/man/man{1..8}
mkdir -pv /var/{cache,local,log,mail,opt,spool}
mkdir -pv /var/lib/{color,misc,locate}

ln -sfv /run /var/run
ln -sfv /run/lock /var/lock

install -dv -m 0750 /root
install -dv -m 1777 /tmp /var/tmp
```

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.

### 7.5.1. 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.

## 7.6. Creating Essential Files and Symlinks

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
```

Create a basic `/etc/hosts` file to be referenced in some test suites, and in one of Perl's configuration files as well:

```
echo "127.0.0.1 localhost $(hostname)" > /etc/hosts
```

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:/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
uidd:x:80:80:UUID Generation Daemon User:/dev/null:/bin/false
nobody:x:99:99:Unprivileged User:/dev/null:/bin/false
EOF
```

The actual password for `root` 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:
uudd:x:80:
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 Chapter 9, 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://refspecs.linuxfoundation.org/lsb.shtml>) only recommends 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.

Some tests in Chapter 8 need a regular user. We add this user here and delete this account at the end of that chapter.

```
echo "tester:x:${ls -n $(tty) | cut -d" " -f3):101:~/home/tester:/bin/bash" >> /etc/passwd
echo "tester:x:101:" >> /etc/group
install -o tester -d /home/tester
```

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

```
exec /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 and the next 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.

## 7.7. Libstdc++ from GCC-10.2.0, Pass 2

When building gcc-pass2 we had to defer the installation of the C++ standard library because no suitable compiler was available to compile it. We could not use the compiler built in that section because it is a native compiler and should not be used outside of chroot and risks polluting the libraries with some host components.

**Approximate build time:** 0.8 SBU

**Required disk space:** 1.1 GB

### 7.7.1. Installation of Target Libstdc++



#### Note

Libstdc++ is part of the GCC sources. You should first unpack the GCC tarball and change to the `gcc-10.2.0` directory.

Create a link which exists when building libstdc++ in the gcc tree:

```
ln -s gthr-posix.h libgcc/gthr-default.h
```

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

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

Prepare libstdc++ for compilation:

```
../libstdc++-v3/configure \
  CXXFLAGS="-g -O2 -D_GNU_SOURCE" \
  --prefix=/usr \
  --disable-multilib \
  --disable-nls \
  --host=$(uname -m)-lfs-linux-gnu \
  --disable-libstdcxx-pch
```

The meaning of the configure options:

```
CXXFLAGS="-g -O2 -D_GNU_SOURCE"
```

These flags are passed by the top level Makefile when doing a full build of GCC.

```
--host=$(uname -m)-lfs-linux-gnu
```

We have to mimic what would happen if this package were built as part of a full compiler build. This switch would be passed to configure by GCC's build machinery.

```
--disable-libstdcxx-pch
```

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

Compile libstdc++ by running:

```
make
```

Install the library:

```
make install
```

Details on this package are located in Section 8.26.2, “Contents of GCC.”

## 7.8. Gettext-0.21

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:** 310 MB

### 7.8.1. 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
```

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

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

Details on this package are located in Section 8.31.2, “Contents of Gettext.”

## 7.9. Bison-3.7.5

The Bison package contains a parser generator.

**Approximate build time:** 0.3 SBU

**Required disk space:** 52 MB

### 7.9.1. Installation of Bison

Prepare Bison for compilation:

```
./configure --prefix=/usr \  
            --docdir=/usr/share/doc/bison-3.7.5
```

**The meaning of the new configure option:**

```
--docdir=/usr/share/doc/bison-3.7.5
```

This tells the build system to install bison documentation into a versioned directory.

Compile the package:

```
make
```

Install the package:

```
make install
```

Details on this package are located in Section 8.32.2, “Contents of Bison.”

## 7.10. Perl-5.32.1

The Perl package contains the Practical Extraction and Report Language.

**Approximate build time:** 1.7 SBU

**Required disk space:** 268 MB

### 7.10.1. Installation of Perl

Prepare Perl for compilation:

```
sh Configure -des \
-Dprefix=/usr \
-Dvendorprefix=/usr \
-Dprivlib=/usr/lib/perl5/5.32/core_perl \
-Darchlib=/usr/lib/perl5/5.32/core_perl \
-Dsitelib=/usr/lib/perl5/5.32/site_perl \
-Dsitearch=/usr/lib/perl5/5.32/site_perl \
-Dvendorlib=/usr/lib/perl5/5.32/vendor_perl \
-Dvendorarch=/usr/lib/perl5/5.32/vendor_perl
```

The meaning of the new 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.

Compile the package:

```
make
```

Install the package:

```
make install
```

Details on this package are located in Section 8.40.2, “Contents of Perl.”

## 7.11. Python-3.9.2

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:** 0.9 SBU

**Required disk space:** 374 MB

### 7.11.1. Installation of Python



#### Note

There are two package files whose name starts with “python”. The one to extract from is `Python-3.9.2.tar.xz` (notice the uppercase first letter).

Prepare Python for compilation:

```
./configure --prefix=/usr \
            --enable-shared \
            --without-ensurepip
```

The meaning of the `configure` option:

`--enable-shared`

This switch prevents installation of static libraries.

`--without-ensurepip`

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

Compile the package:

```
make
```

Install the package:

```
make install
```

Details on this package are located in Section 8.49.2, “Contents of Python 3.”

## 7.12. Texinfo-6.7

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

**Approximate build time:** 0.3 SBU

**Required disk space:** 105 MB

### 7.12.1. Installation of Texinfo

Prepare Texinfo for compilation:

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



#### 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
```

Install the package:

```
make install
```

Details on this package are located in Section 8.68.2, “Contents of Texinfo.”

## 7.13. Util-linux-2.36.2

The Util-linux package contains miscellaneous utility programs.

**Approximate build time:** 0.7 SBU

**Required disk space:** 134 MB

### 7.13.1. Installation of Util-linux

The FHS recommends using the `/var/lib/hwclock` directory instead of the usual `/etc` directory as the location for the `adjtime` file. Create this directory with:

```
mkdir -pv /var/lib/hwclock
```

Prepare Util-linux for compilation:

```
./configure ADJTIME_PATH=/var/lib/hwclock/adjtime \
  --docdir=/usr/share/doc/util-linux-2.36.2 \
  --disable-chfn-chsh \
  --disable-login \
  --disable-nologin \
  --disable-su \
  --disable-setpriv \
  --disable-runuser \
  --disable-pylibmount \
  --disable-static \
  --without-python \
  runstatedir=/run
```

**The meaning of the configure options:**

*ADJTIME\_PATH=/var/lib/hwclock/adjtime*

This sets the location of the file recording information about the hardware clock in accordance to the FHS. This is not strictly needed for this temporary tool, but it prevents creating a file at another location, which would not be overwritten or removed when building the final util-linux package.

*--disable-\**

These switches prevent warnings about building components that require packages not in LFS or not installed yet.

*--without-python*

This switch disables using Python. It avoids trying to build unneeded bindings.

*runstatedir=/run*

This switch sets the location of the socket used by **uuid** and `libuuid` correctly.

Compile the package:

```
make
```

Install the package:

```
make install
```

Details on this package are located in Section 8.73.2, “Contents of Util-linux.”

## 7.14. Cleaning up and Saving the Temporary System

The libtool `.la` files are only useful when linking with static libraries. They are unneeded, and potentially harmful, when using dynamic shared libraries, specially when using non-autotools build systems. While still in chroot, remove those files now:

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

Remove the documentation of the temporary tools, to prevent them from ending up in the final system, and save about 35 MB:

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



### Note

All the remaining steps in this section are optional. Nevertheless, as soon as you begin installing packages in Chapter 8, the temporary tools will be overwritten. So it may be a good idea to do a backup of the temporary tools as described below. The other steps are only needed if you are really short on disk space.

The following steps are performed from outside the chroot environment. That means, you have to leave the chroot environment first before continuing. The reason for that is to:

- make sure that objects are not in use while they are manipulated.
- get access to file system locations outside of the chroot environment to store/read the backup archive which should not be placed within the `$LFS` hierarchy for safety reasons.

Leave the chroot environment and unmount the kernel virtual file systems:



### Note

All of the following instructions are executed by `root`. Take extra care about the commands you're going to run as mistakes here can modify your host system. Be aware that the environment variable `LFS` is set for user `lfs` by default but it might *not* be set for `root`. Whenever commands are to be executed by `root`, make sure you have set `LFS` accordingly. This has been discussed in Section 2.6, “Setting The `$LFS` Variable”.

```
exit
umount $LFS/dev{/pts,}
umount $LFS/{sys,proc,run}
```

### 7.14.1. Stripping

If the `LFS` partition is rather small, it is good to know that unnecessary items can be removed. The executables and libraries built so far contain a little over 90 MB of unneeded debugging symbols.

Strip off debugging symbols from binaries:

```
strip --strip-debug $LFS/usr/lib/*
strip --strip-unnneeded $LFS/usr/{,s}bin/*
strip --strip-unnneeded $LFS/tools/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.

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

At this point, you should have at least 5 GB of free space on the chroot partition 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. You can check the free disk space with the command `df -h $LFS`.

## 7.14.2. Backup

Now that the essential tools have been created, its time to think about a backup. When every check has passed successfully in the previously built packages, your temporary tools are in a good state and might be backed up for later reuse. In case of fatal failures in the subsequent chapters, it often turns out that removing everything and starting over (more carefully) is the best option to recover. Unfortunately, all the temporary tools will be removed, too. To avoid spending extra time to redo something which has been built successfully, prepare a backup.

Make sure you have at least 600 MB free disk space (the source tarballs will be included in the backup archive) in the home directory of user `root`.

Create the backup archive by running the following command:

```
cd $LFS &&
tar -cJpf $HOME/lfs-temp-tools-10.1-systemd.tar.xz .
```

Replace `$HOME` by a directory of your choice if you do not want to have the backup stored in `root`'s home directory.

## 7.14.3. Restore

In case some mistakes have been made and you need to start over, you can use this backup to restore the temporary tools and save some recovery time. Since the sources are located under `$LFS`, they are included in the backup archive as well, so they do not need to be downloaded again. After checking that `$LFS` is set properly, restore the backup by executing the following commands:

```
cd $LFS &&
rm -rf ./ * &&
tar -xpf $HOME/lfs-temp-tools-10.1-systemd.tar.xz
```

Again, double check that the environment has been setup properly and continue building the rest of the system.



### Important

If you left the chroot environment either to strip off debug symbols, create a backup, or restart building using a restore, remember to mount the kernel virtual filesystems now again as described in Section 7.3, “Preparing Virtual Kernel File Systems” and re-enter the chroot environment (see Section 7.4, “Entering the Chroot Environment”) again before continuing.

## **Part IV. Building the LFS System**

# Chapter 8. Installing Basic System Software

## 8.1. Introduction

In this chapter, we start constructing the LFS system in earnest.

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.

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) that the package installs.



### Note

The SBU values and required disk space includes test suite data for all applicable packages in Chapter 8. SBU values have been calculated using a single CPU core (-j1) for all operations.

### 8.1.1. 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 this chapter, 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.

## 8.2. 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.

### 8.2.1. 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 books 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-2.31 to glibc-2.32), 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 any the packages dynamically linked to the library need to be recompiled in order 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`. If 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, any packages that are dynamically linked to `libfoo.so.1` need to be recompiled to link against `libfoo.so.2` in order to use the new library version. You should not remove the previous libraries unless all the dependent packages are recompiled.

### 8.2.2. 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.

#### 8.2.2.1. 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.

#### 8.2.2.2. 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.

### 8.2.2.3. 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`.

### 8.2.2.4. 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.

### 8.2.2.5. 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.

### 8.2.2.6. 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>.

### 8.2.2.7. 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).

## 8.2.3. 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 10.4, “Using GRUB to Set Up the Boot Process”.

## 8.3. Man-pages-5.10

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

**Approximate build time:** less than 0.1 SBU

**Required disk space:** 4.7 MB

### 8.3.1. Installation of Man-pages

Install Man-pages by running:

```
make install
```

### 8.3.2. 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

## 8.4. Iana-Etc-20210202

The Iana-Etc package provides data for network services and protocols.

**Approximate build time:** less than 0.1 SBU

**Required disk space:** 4.7 MB

### 8.4.1. Installation of Iana-Etc

For this package, we only need to copy the files into place:

```
cp services protocols /etc
```

### 8.4.2. Contents of Iana-Etc

**Installed files:** */etc/protocols* and */etc/services*

#### Short Descriptions

*/etc/protocols* Describes the various DARPA Internet protocols that are available from the TCP/IP subsystem

*/etc/services* Provides a mapping between friendly textual names for internet services, and their underlying assigned port numbers and protocol types

## 8.5. Glibc-2.33

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:** 19 SBU

**Required disk space:** 2.5 GB

### 8.5.1. Installation of Glibc

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-2.33-fhs-1.patch
```

Fix a bug that causes issues with chrooted applications:

```
sed -e '402a\         *result = local->data.services[database_index];' \  
-i nss/nss_database.c
```

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

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

Prepare Glibc for compilation:

```
../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 configure options:**

*--disable-werror*

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

*--enable-kernel=3.2*

This option tells the build system that this glibc may be used with kernels as old as 3.2. This means generating workarounds in case a system call introduced in a later version cannot be used.

*--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.

*libc\_cv\_slibdir=/lib*

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

```
libc_cv_include_x86_isa_level=no
```

This disables “x86 ISA needed” property in Glibc libraries. Use it **if** you are building Glibc with `-march` option in `CFLAGS`, to workaround an issue in Glibc-2.33 breaking it.

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.

```
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:

- `io/tst-lchmod` is known to fail in the LFS chroot environment.
- `misc/tst-tynname` is known to fail in the LFS chroot environment.
- `elf/tst-cpu-features-cpuinfo` 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-2.33/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-2.33/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*.

## 8.5.2. Configuring Glibc

### 8.5.2.1. 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
```

### 8.5.2.2. Adding time zone data

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

```
tar -xf ../../tzdata2021a.tar.gz

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

for tz in etcetera southamerica northamerica europe africa antarctica \
        asia australasia backward; 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 1.9 MB 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*).

**8.5.2.3. 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
```

### 8.5.3. Contents of Glibc

**Installed programs:** catchsegv, gencat, getconf, getent, iconv, iconvconfig, ldconfig, ldd, lddlibc4, locale, localedef, makedb, mtrace, nscd, pcpfiledump, pldd, sln, sotruss, sprof, tzselect, xtrace, zdump, and zic

**Installed libraries:** ld-2.33.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

<b>catchsegv</b>	Can be used to create a stack trace when a program terminates with a segmentation fault
<b>gencat</b>	Generates message catalogues
<b>getconf</b>	Displays the system configuration values for file system specific variables
<b>getent</b>	Gets entries from an administrative database
<b>iconv</b>	Performs character set conversion
<b>iconvconfig</b>	Creates fastloading <b>iconv</b> module configuration files
<b>ldconfig</b>	Configures the dynamic linker runtime bindings
<b>ldd</b>	Reports which shared libraries are required by each given program or shared library
<b>lddlibc4</b>	Assists <b>ldd</b> with object files
<b>locale</b>	Prints various information about the current locale
<b>localedef</b>	Compiles locale specifications
<b>makedb</b>	Creates a simple database from textual input
<b>mtrace</b>	Reads and interprets a memory trace file and displays a summary in human-readable format
<b>nscd</b>	A daemon that provides a cache for the most common name service requests

<b>pcprofiledump</b>	Dump information generated by PC profiling
<b>pldd</b>	Lists dynamic shared objects used by running processes
<b>sln</b>	A statically linked <b>ln</b> program
<b>sotrust</b>	Traces shared library procedure calls of a specified command
<b>sprof</b>	Reads and displays shared object profiling data
<b>tzselect</b>	Asks the user about the location of the system and reports the corresponding time zone description
<b>xtrace</b>	Traces the execution of a program by printing the currently executed function
<b>zdump</b>	The time zone dumper
<b>zic</b>	The time zone compiler
ld-2.33.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-2.33/locale/broken_cur_max.c</code> for more information
libSegFault	The segmentation fault signal handler, used by <b>catchsegv</b>
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 <b>g++</b>
libm	The mathematical library
libmcheck	Turns on memory allocation checking when linked to
libmemusage	Used by <b>memusage</b> 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

## 8.6. 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:** 5.0 MB

### 8.6.1. 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
```

Remove an useless static library:

```
rm -fv /usr/lib/libz.a
```

### 8.6.2. Contents of Zlib

**Installed libraries:** libz.so

#### Short Descriptions

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

## 8.7. 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:** 7.5 MB

### 8.7.1. 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
```

Remove an useless static library:

```
rm -fv /usr/lib/libbz2.a
```



## 8.8. Xz-5.2.5

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

**Approximate build time:** 0.2 SBU

**Required disk space:** 15 MB

### 8.8.1. Installation of Xz

Prepare Xz for compilation with:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/xz-5.2.5
```

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
```

### 8.8.2. 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-5.2.5

### Short Descriptions

<b>lzcat</b>	Decompresses to standard output
<b>lzcmp</b>	Runs <b>cmp</b> on LZMA compressed files
<b>lzdiff</b>	Runs <b>diff</b> on LZMA compressed files
<b>lzegrep</b>	Runs <b>egrep</b> on LZMA compressed files
<b>lzfgrep</b>	Runs <b>fgrep</b> on LZMA compressed files
<b>lzgrep</b>	Runs <b>grep</b> on LZMA compressed files

<b>lzless</b>	Runs <b>less</b> on LZMA compressed files
<b>lzma</b>	Compresses or decompresses files using the LZMA format
<b>lzmadec</b>	A small and fast decoder for LZMA compressed files
<b>lzmainfo</b>	Shows information stored in the LZMA compressed file header
<b>lzmore</b>	Runs <b>more</b> on LZMA compressed files
<b>unlzma</b>	Decompresses files using the LZMA format
<b>unxz</b>	Decompresses files using the XZ format
<b>xz</b>	Compresses or decompresses files using the XZ format
<b>xzcat</b>	Decompresses to standard output
<b>xzcmp</b>	Runs <b>cmp</b> on XZ compressed files
<b>xzdec</b>	A small and fast decoder for XZ compressed files
<b>xzdiff</b>	Runs <b>diff</b> on XZ compressed files
<b>xzegrep</b>	Runs <b>egrep</b> on XZ compressed files
<b>xzfgrep</b>	Runs <b>fgrep</b> on XZ compressed files
<b>xzgrep</b>	Runs <b>grep</b> on XZ compressed files
<b>xzless</b>	Runs <b>less</b> on XZ compressed files
<b>xzmore</b>	Runs <b>more</b> on XZ compressed files
<b>liblzma</b>	The library implementing lossless, block-sorting data compression, using the Lempel-Ziv-Markov chain algorithm

## 8.9. Zstd-1.4.8

Zstandard is a real-time compression algorithm, providing high compression ratios. It offers a very wide range of compression / speed trade-offs, while being backed by a very fast decoder.

**Approximate build time:** 1.1 SBU

**Required disk space:** 59 MB

### 8.9.1. Installation of Zstd

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make prefix=/usr install
```

Remove the static library and move the shared library to `/lib`. Also, the `.so` file in `/usr/lib` will need to be recreated:

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

### 8.9.2. Contents of Zstd

**Installed programs:** zstd, zstdcat (link to zstd), zstdgrep, zstdless, zstdmt (link to zstd), and unzstd (link to zstd)

**Installed library:** libzstd.so

### Short Descriptions

**zstd** Compresses or decompresses files using the ZSTD format

**zstdgrep** Runs **grep** on ZSTD compressed files

**zstdless** Runs **less** on ZSTD compressed files

**libzstd** The library implementing lossless data compression, using the ZSTD algorithm

## 8.10. File-5.39

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:** 14 MB

### 8.10.1. 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
```

### 8.10.2. 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

## 8.11. Readline-8.1

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:** 16 MB

### 8.11.1. 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 '{/OLD_SUFFIX}/c:' support/shlib-install
```

Prepare Readline for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --with-curses \
            --docdir=/usr/share/doc/readline-8.1
```

**The meaning of the configure option:**

*--with-curses*

This option tells Readline that it can find the termcap library functions in the curses library, rather than a separate termcap library. It allows generating a correct `readline.pc` file.

Compile the package:

```
make SHLIB_LIBS="-lncursesw"
```

**The meaning of the make option:**

*SHLIB\_LIBS="-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="-lncursesw" install
```

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

```
mv -v /usr/lib/lib{readline,history}.so.* /lib
ln -sfv ../../lib/$(readlink /usr/lib/libreadline.so) /usr/lib/libreadline.so
ln -sfv ../../lib/$(readlink /usr/lib/libhistory.so) /usr/lib/libhistory.so
```

If desired, install the documentation:

```
install -v -m644 doc/*.{ps,pdf,html,dvi} /usr/share/doc/readline-8.1
```

### 8.11.2. Contents of Readline

**Installed libraries:** libhistory.so and libreadline.so

**Installed directories:** /usr/include/readline and /usr/share/doc/readline-8.1

## 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

## 8.12. M4-1.4.18

The M4 package contains a macro processor.

**Approximate build time:** 0.4 SBU

**Required disk space:** 32 MB

### 8.12.1. Installation of M4

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

```
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
```

### 8.12.2. 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

## 8.13. Bc-3.3.0

The Bc package contains an arbitrary precision numeric processing language.

**Approximate build time:** less than 0.1 SBU

**Required disk space:** 6.7 MB

### 8.13.1. Installation of Bc

Prepare Bc for compilation:

```
PREFIX=/usr CC=gcc ./configure.sh -G -O3
```

**The meaning of the configure options:**

*CC=gcc*

These parameters specify the compiler 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
```

### 8.13.2. Contents of Bc

**Installed programs:** bc and dc

#### Short Descriptions

**bc** A command line calculator

**dc** A reverse-polish command line calculator

## 8.14. Flex-2.6.4

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

**Approximate build time:** 0.4 SBU

**Required disk space:** 36 MB

### 8.14.1. Installation of Flex

Prepare Flex for compilation:

```
./configure --prefix=/usr \
            --docdir=/usr/share/doc/flex-2.6.4 \
            --disable-static
```

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
```

### 8.14.2. 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

## 8.15. Tcl-8.6.11

The Tcl package contains the Tool Command Language, a robust general-purpose scripting language. The Expect package is written in the Tcl language.

**Approximate build time:** 3.8 SBU

**Required disk space:** 80 MB

### 8.15.1. Installation of Tcl

This package and the next two (Expect and DejaGNU) are installed to support running the test suites for binutils and GCC 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.

First, unpack the documentation by issuing the following command:

```
tar -xf ../tcl8.6.11-html.tar.gz --strip-components=1
```

Prepare Tcl for compilation:

```
SRCDIR=$(pwd)
cd unix
./configure --prefix=/usr          \
            --mandir=/usr/share/man \
            $([ "$(uname -m)" = x86_64 ] && echo --enable-64bit)
```

The meaning of the configure options:

```
$([ "$(uname -m)" = x86_64 ] && echo --enable-64bit)
```

The construct `$(<shell command>)` is replaced by the output of the shell command. Here this output is empty if running on a 32 bit machine, and is `--enable-64bit` if running on a 64 bit machine.

Build the package:

```
make

sed -e "s|${SRCDIR}/unix|/usr/lib|" \
    -e "s|${SRCDIR}|/usr/include|" \
    -i tclConfig.sh

sed -e "s|${SRCDIR}/unix/pkgs/tdbc1.1.2|/usr/lib/tdbc1.1.2|" \
    -e "s|${SRCDIR}/pkgs/tdbc1.1.2/generic|/usr/include|" \
    -e "s|${SRCDIR}/pkgs/tdbc1.1.2/library|/usr/lib/tcl8.6|" \
    -e "s|${SRCDIR}/pkgs/tdbc1.1.2|/usr/include|" \
    -i pkgs/tdbc1.1.2/tdbcConfig.sh

sed -e "s|${SRCDIR}/unix/pkgs/itcl4.2.1|/usr/lib/itcl4.2.1|" \
    -e "s|${SRCDIR}/pkgs/itcl4.2.1/generic|/usr/include|" \
    -e "s|${SRCDIR}/pkgs/itcl4.2.1|/usr/include|" \
    -i pkgs/itcl4.2.1/itclConfig.sh

unset SRCDIR
```

The various “sed” instructions after the “make” command removes references to the build directory from the configuration files and replaces them with the install directory. This is not mandatory for the remainder of LFS, but may be needed in case a package built later uses Tcl.

To test the results, issue:

```
make test
```



### Note

In the test results there are several places associated with clock.test that indicate a failure, but the summary at the end indicates no failures. clock.test passes on a complete LFS system.

Install the package:

```
make install
```

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

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

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

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

Now make a necessary symbolic link:

```
ln -sfv tclsh8.6 /usr/bin/tclsh
```

Finally, rename a man page that conflicts with a Perl man page:

```
mv /usr/share/man/man3/{Thread,Tcl_Thread}.3
```

## 8.15.2. Contents of Tcl

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

### Short Descriptions

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

## 8.16. Expect-5.45.4

The Expect package contains tools for automating, via scripted dialogues, interactive applications such as **telnet**, **ftp**, **passwd**, **fsck**, **rlogin**, and **tip**. Expect is also useful for testing these same applications as well as easing all sorts of tasks that are prohibitively difficult with anything else. The DejaGnu framework is written in Expect.

**Approximate build time:** 0.2 SBU

**Required disk space:** 3.9 MB

### 8.16.1. Installation of Expect

Prepare Expect for compilation:

```
./configure --prefix=/usr          \
            --with-tcl=/usr/lib    \
            --enable-shared        \
            --mandir=/usr/share/man \
            --with-tclinclude=/usr/include
```

The meaning of the configure options:

*--with-tcl=/usr/lib*

This parameter is needed to tell **configure** where the **tclConfig.sh** script is located.

*--with-tclinclude=/usr/include*

This explicitly tells Expect where to find Tcl's internal headers.

Build the package:

```
make
```

To test the results, issue:

```
make test
```

Install the package:

```
make install
ln -svf expect5.45.4/libexpect5.45.4.so /usr/lib
```

### 8.16.2. Contents of Expect

**Installed program:** expect

**Installed library:** libexpect-5.45.so

#### Short Descriptions

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

## 8.17. DejaGNU-1.6.2

The DejaGnu package contains a framework for running test suites on GNU tools. It is written in **expect**, which itself uses Tcl (Tool Command Language).

**Approximate build time:** less than 0.1 SBU

**Required disk space:** 4.6 MB

### 8.17.1. Installation of DejaGNU

Prepare DejaGNU for compilation:

```
./configure --prefix=/usr
makeinfo --html --no-split -o doc/dejagnu.html doc/dejagnu.texi
makeinfo --plaintext -o doc/dejagnu.txt doc/dejagnu.texi
```

Build and install the package:

```
make install
install -v -dm755 /usr/share/doc/dejagnu-1.6.2
install -v -m644 doc/dejagnu.{html,txt} /usr/share/doc/dejagnu-1.6.2
```

To test the results, issue:

```
make check
```

### 8.17.2. Contents of DejaGNU

**Installed program:** runtest

#### Short Descriptions

**runtest** A wrapper script that locates the proper **expect** shell and then runs DejaGNU

## 8.18. Binutils-2.36.1

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

**Approximate build time:** 6.2 SBU

**Required disk space:** 4.9 GB

### 8.18.1. 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 '/@\tincremental_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 bfd 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
```

Four tests named “Run property ...” are known to fail.

Install the package:

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

Remove useless static libraries:

```
rm -fv /usr/lib/lib{bfd,ctf,ctf-nobfd,opcodes}.a
```

## 8.18.2. Contents of Binutils

<b>Installed programs:</b>	addr2line, ar, as, c++filt, dwp, elfedit, gprof, ld, ld.bfd, ld.gold, nm, objcopy, objdump, ranlib, readelf, size, strings, and strip
<b>Installed libraries:</b>	libbfd.so, libctf.so, libctf-nobfd.so, and libopcodes.so
<b>Installed directory:</b>	/usr/lib/ldscripts

### Short Descriptions

<b>addr2line</b>	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
<b>ar</b>	Creates, modifies, and extracts from archives
<b>as</b>	An assembler that assembles the output of <b>gcc</b> into object files

<b>c++filt</b>	Used by the linker to de-mangle C++ and Java symbols and to keep overloaded functions from clashing
<b>dwp</b>	The DWARF packaging utility
<b>elfedit</b>	Updates the ELF header of ELF files
<b>gprof</b>	Displays call graph profile data
<b>ld</b>	A linker that combines a number of object and archive files into a single file, relocating their data and tying up symbol references
<b>ld.gold</b>	A cut down version of ld that only supports the elf object file format
<b>ld.bfd</b>	Hard link to <b>ld</b>
<b>nm</b>	Lists the symbols occurring in a given object file
<b>objcopy</b>	Translates one type of object file into another
<b>objdump</b>	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
<b>ranlib</b>	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
<b>readelf</b>	Displays information about ELF type binaries
<b>size</b>	Lists the section sizes and the total size for the given object files
<b>strings</b>	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
<b>strip</b>	Discards symbols from object files
<b>libbfd</b>	The Binary File Descriptor library
<b>libctf</b>	The Compat ANSI-C Type Format debugging support library
<b>libctf-nobfd</b>	A libctf variant which does not use libbfd functionality
<b>libopcodes</b>	A library for dealing with opcodes—the “readable text” versions of instructions for the processor; it is used for building utilities like <b>objdump</b>

## 8.19. GMP-6.2.1

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

**Approximate build time:** 1.0 SBU

**Required disk space:** 52 MB

### 8.19.1. 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-6.2.1
```

The meaning of the new configure options:

`--enable-cxx`

This parameter enables C++ support

`--docdir=/usr/share/doc/gmp-6.2.1`

This variable specifies the correct place for the documentation.

Compile the package and generate the HTML documentation:

```
make
make html
```



#### Important

The test suite for GMP in this section is considered critical. Do not skip it under any circumstances.

Test the results:

```
make check 2>&1 | tee gmp-check-log
```

**Caution**

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

Ensure that all 197 tests in the test suite passed. Check the results by issuing the following command:

```
awk '/# PASS:/{total+=$3} ; END{print total}' gmp-check-log
```

Install the package and its documentation:

```
make install
make install-html
```

## 8.19.2. Contents of GMP

**Installed Libraries:** libgmp.so and libgmpxx.so  
**Installed directory:** /usr/share/doc/gmp-6.2.1

### Short Descriptions

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

## 8.20. MPFR-4.1.0

The MPFR package contains functions for multiple precision math.

**Approximate build time:** 0.8 SBU

**Required disk space:** 38 MB

### 8.20.1. Installation of MPFR

Prepare MPFR for compilation:

```
./configure --prefix=/usr      \  
            --disable-static   \  
            --enable-thread-safe \  
            --docdir=/usr/share/doc/mpfr-4.1.0
```

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
```

### 8.20.2. Contents of MPFR

**Installed Libraries:** libmpfr.so

**Installed directory:** /usr/share/doc/mpfr-4.1.0

#### Short Descriptions

`libmpfr` Contains multiple-precision math functions

## 8.21. MPC-1.2.1

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

### 8.21.1. Installation of MPC

Prepare MPC for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/mpc-1.2.1
```

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
```

### 8.21.2. Contents of MPC

**Installed Libraries:** libmpc.so

**Installed Directory:** /usr/share/doc/mpc-1.2.1

#### Short Descriptions

libmpc Contains complex math functions

## 8.22. 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

### 8.22.1. 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
```

### 8.22.2. 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

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

## 8.23. 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:** 0.1 SBU

**Required disk space:** 2.8 MB

### 8.23.1. 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
```

### 8.23.2. 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

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

## 8.24. Libcap-2.48

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:** 45 MB

### 8.24.1. Installation of Libcap

Prevent static libraries from being installed:

```
sed -i '/install -m.*STA/d' libcap/Makefile
```

Compile the package:

```
make prefix=/usr lib=lib
```

The meaning of the make option:

```
lib=lib
```

This parameter sets the library directory to `/usr/lib` rather than `/usr/lib64` on `x86_64`. It has no effect on `x86`.

To test the results, issue:

```
make test
```

Install the package and make sure the essential libraries are in the correct directory:

```
make prefix=/usr lib=lib install
for libname in cap psx; do
    mv -v /usr/lib/lib${libname}.so.* /lib
    ln -sfv ../../lib/lib${libname}.so.2 /usr/lib/lib${libname}.so
    chmod -v 755 /lib/lib${libname}.so.2.48
done
```

### 8.24.2. Contents of Libcap

**Installed programs:** capsh, getcap, getpcaps, and setcap  
**Installed library:** libcap.so and libpsx.so

#### Short Descriptions

<b>capsh</b>	A shell wrapper to explore and constrain capability support
<b>getcap</b>	Examines file capabilities
<b>getpcaps</b>	Displays the capabilities on the queried process(es)
<b>setcap</b>	Sets file capabilities
<b>libcap</b>	Contains the library functions for manipulating POSIX 1003.1e capabilities
<b>libpsx</b>	Contains functions to support POSIX semantics for syscalls associated with the pthread library

## 8.25. Shadow-4.8.1

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

**Approximate build time:** 0.2 SBU

**Required disk space:** 45 MB

### 8.25.1. Installation of Shadow



#### Note

If you would like to enforce the use of strong passwords, refer to <http://www.linuxfromscratch.org/blfs/view/10.1/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 8.3, “Man-pages-5.10”:

```
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 -e 's:#ENCRYPT_METHOD DES:ENCRYPT_METHOD SHA512:' \
    -e 's:/var/spool/mail:/var/mail:' \
    -i 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:

```
touch /usr/bin/passwd
./configure --sysconfdir=/etc \
            --with-group-name-max-length=32
```

**The meaning of the configure option:**

**touch /usr/bin/passwd**

The file `/usr/bin/passwd` needs to exist because its location is hardcoded in some programs, and the default location if it does not exist is not right.

```
--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
```

## 8.25.2. Configuring Shadow

This package contains utilities to add, modify, and delete users and groups; set and change their passwords; and perform other administrative tasks. For a full explanation of what *password shadowing* means, see the `doc/HOWTO` file within the unpacked source tree. If using Shadow support, keep in mind that programs which need to verify passwords (display managers, FTP programs, pop3 daemons, etc.) must be Shadow-compliant. That is, they need to be able to work with shadowed passwords.

To enable shadowed passwords, run the following command:

```
pwconv
```

To enable shadowed group passwords, run:

```
grpconv
```

Shadow's stock configuration for the **useradd** utility has a few caveats that need some explanation. First, the default action for the **useradd** utility is to create the user and a group of the same name as the user. By default the user ID (UID) and group ID (GID) numbers will begin with 1000. This means if you don't pass parameters to **useradd**, each user will be a member of a unique group on the system. If this behavior is undesirable, you'll need to pass the `-g` parameter to **useradd**. The default parameters are stored in the `/etc/default/useradd` file. You may need to modify two parameters in this file to suit your particular needs.

### `/etc/default/useradd` Parameter Explanations

```
GROUP=1000
```

This parameter sets the beginning of the group numbers used in the `/etc/group` file. You can modify it to anything you desire. Note that **useradd** will never reuse a UID or GID. If the number identified in this parameter is used, it will use the next available number after this. Note also that if you don't have a group 1000 on your system the first time you use **useradd** without the `-g` parameter, you'll get a message displayed on the terminal that says: `useradd: unknown GID 1000`. You may disregard this message and group number 1000 will be used.

```
CREATE_MAIL_SPOOL=yes
```

This parameter causes **useradd** to create a mailbox file for the newly created user. **useradd** will make the group ownership of this file to the `mail` group with 0660 permissions. If you would prefer that these mailbox files are not created by **useradd**, issue the following command:

```
sed -i 's/yes/no/' /etc/default/useradd
```

### 8.25.3. Setting the root password

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

```
passwd root
```

### 8.25.4. Contents of Shadow

**Installed programs:** chage, chfn, chgpasswd, chpasswd, chsh, expiry, faillog, gpasswd, groupadd, groupdel, groupmems, groupmod, grpck, grpconv, grpunconv, lastlog, login, logoutd, newgidmap, newgrp, newuidmap, newusers, nologin, passwd, pwck, pwconv, pwunconv, sg (link to newgrp), su, useradd, userdel, usermod, vigr (link to vipw), and vipw

**Installed directory:** /etc/default

#### Short Descriptions

**chage** Used to change the maximum number of days between obligatory password changes

**chfn** Used to change a user's full name and other information

**chgpasswd** Used to update group passwords in batch mode

**chpasswd** Used to update user passwords in batch mode

**chsh** Used to change a user's default login shell

**expiry** Checks and enforces the current password expiration policy

**faillog** Is used to examine the log of login failures, to set a maximum number of failures before an account is blocked, or to reset the failure count

**gpasswd** Is used to add and delete members and administrators to groups

**groupadd** Creates a group with the given name

**groupdel** Deletes the group with the given name

**groupmems** Allows a user to administer his/her own group membership list without the requirement of super user privileges.

**groupmod** Is used to modify the given group's name or GID

**grpck** Verifies the integrity of the group files */etc/group* and */etc/gshadow*

**grpconv** Creates or updates the shadow group file from the normal group file

**grpunconv** Updates */etc/group* from */etc/gshadow* and then deletes the latter

**lastlog** Reports the most recent login of all users or of a given user

**login** Is used by the system to let users sign on

**logoutd** Is a daemon used to enforce restrictions on log-on time and ports

**newgidmap** Is used to set the gid mapping of a user namespace

**newgrp** Is used to change the current GID during a login session

**newuidmap** Is used to set the uid mapping of a user namespace

**newusers** Is used to create or update an entire series of user accounts

**nologin** Displays a message that an account is not available; it is designed to be used as the default shell for accounts that have been disabled

<b>passwd</b>	Is used to change the password for a user or group account
<b>pwck</b>	Verifies the integrity of the password files <code>/etc/passwd</code> and <code>/etc/shadow</code>
<b>pwconv</b>	Creates or updates the shadow password file from the normal password file
<b>pwunconv</b>	Updates <code>/etc/passwd</code> from <code>/etc/shadow</code> and then deletes the latter
<b>sg</b>	Executes a given command while the user's GID is set to that of the given group
<b>su</b>	Runs a shell with substitute user and group IDs
<b>useradd</b>	Creates a new user with the given name, or updates the default new-user information
<b>userdel</b>	Deletes the given user account
<b>usermod</b>	Is used to modify the given user's login name, User Identification (UID), shell, initial group, home directory, etc.
<b>vigr</b>	Edits the <code>/etc/group</code> or <code>/etc/gshadow</code> files
<b>vipw</b>	Edits the <code>/etc/passwd</code> or <code>/etc/shadow</code> files

## 8.26. GCC-10.2.0

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:** 4.6 GB

### 8.26.1. 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:

```
../configure --prefix=/usr \
             LD=ld \
             --enable-languages=c,c++ \
             --disable-multilib \
             --disable-bootstrap \
             --with-system-zlib
```

Note that for other programming languages there are some prerequisites that are not yet available. See the *BLFS Book GCC page* for instructions on how to build all of GCC's supported languages.

**The meaning of the new configure parameters:**

*LD=ld*

This parameter makes the configure script use the ld installed by the binutils built earlier in this chapter, rather than the cross-built version which would otherwise be used.

*--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 default 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 tester .
su tester -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/10.1/> 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.

Additionally the following tests related to the following files are known to fail with `glibc-2.33`: `asan_test.C`, `co-ret-17-void-ret-coro.C`, `pr95519-05-gro.C`, `pr80166.c`.

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)/10.2.0/include-fixed/bits/
```

The GCC build directory is owned by `tester` 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/10.2.0/include{,-fixed}
```

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

```
ln -sv ../usr/bin/cpp /lib
```

Add a compatibility symlink to enable building programs with Link Time Optimization (LTO):

```
ln -sfv ../../libexec/gcc/$(gcc -dumpmachine)/10.2.0/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 some 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 the 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/10.2.0/../../../../lib/crt1.o succeeded
/usr/lib/gcc/x86_64-pc-linux-gnu/10.2.0/../../../../lib/crti.o succeeded
/usr/lib/gcc/x86_64-pc-linux-gnu/10.2.0/../../../../lib/crtn.o succeeded
```

Depending on your machine architecture, the above may differ slightly. The difference will be 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/10.2.0/include
 /usr/local/include
 /usr/lib/gcc/x86_64-pc-linux-gnu/10.2.0/include-fixed
 /usr/include
```

Again, the directory named after your target triplet may be different than the above, depending on your system 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
```

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. 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
```

## 8.26.2. Contents of GCC

<b>Installed programs:</b>	c++, cc (link to gcc), cpp, g++, gcc, gcc-ar, gcc-nm, gcc-ranlib, gcov, gcov-dump, and gcov-tool
<b>Installed libraries:</b>	libasan.{a,so}, libatomic.{a,so}, libcc1.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}
<b>Installed directories:</b>	/usr/include/c++, /usr/lib/gcc, /usr/libexec/gcc, and /usr/share/gcc-10.2.0

### Short Descriptions

<b>c++</b>	The C++ compiler
<b>cc</b>	The C compiler
<b>cpp</b>	The C preprocessor; it is used by the compiler to expand the #include, #define, and similar statements in the source files
<b>g++</b>	The C++ compiler
<b>gcc</b>	The C compiler
<b>gcc-ar</b>	A wrapper around <b>ar</b> 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
<b>gcc-nm</b>	A wrapper around <b>nm</b> 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

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

## 8.27. 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 phases of package installations.

**Approximate build time:** 0.3 SBU

**Required disk space:** 30 MB

### 8.27.1. 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
```

### 8.27.2. 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

## 8.28. Ncurses-6.2

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

**Approximate build time:** 0.4 SBU

**Required disk space:** 34 MB

### 8.28.1. Installation of Ncurses

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.6.2`) to be built instead of normal ones (e.g., `libncurses.so.6.2`). These wide-character libraries are usable in both multibyte and traditional 8-bit locales, while normal libraries work properly only in 8-bit locales. Wide-character and normal libraries are source-compatible, but not binary-compatible.

*--enable-pc-files*

This switch generates and installs `.pc` files for `pkg-config`.

*--without-normal*

This switch disables building and installing most static libraries.

Compile the package:

```
make
```

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

Install the package:

```
make install
```

Move the shared libraries to the `/lib` directory, where they are expected to reside:

```
mv -v /usr/lib/libncursesw.so.6* /lib
```

Because the libraries have been moved, one symlink points to a non-existent file. Recreate it:

```
ln -sfv ../../lib/${readlink /usr/lib/libncursesw.so} /usr/lib/libncursesw.so
```

Many applications still expect the linker to be able to find non-wide-character Ncurses libraries. Trick such applications into linking with wide-character libraries by means of symlinks and linker scripts:

```
for lib in ncurses form panel menu ; do
  rm -vf /usr/lib/lib${lib}.so
  echo "INPUT(-l${lib}w)" > /usr/lib/lib${lib}.so
  ln -sfv ${lib}w.pc /usr/lib/pkgconfig/${lib}.pc
done
```

Finally, make sure that old applications that look for `-lncurses` at build time are still buildable:

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

Remove a static library that is not handled by configure:

```
rm -fv /usr/lib/libncurses++w.a
```

If desired, install the Ncurses documentation:

```
mkdir -v /usr/share/doc/ncurses-6.2
cp -v -R doc/* /usr/share/doc/ncurses-6.2
```



## 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
```

## 8.28.2. 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`, `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-6.2`

## Short Descriptions

<b>captoinfo</b>	Converts a termcap description into a terminfo description
<b>clear</b>	Clears the screen, if possible
<b>infocmp</b>	Compares or prints out terminfo descriptions
<b>infotocap</b>	Converts a terminfo description into a termcap description
<b>ncursesw6-config</b>	Provides configuration information for ncurses
<b>reset</b>	Reinitializes a terminal to its default values
<b>tabs</b>	Clears and sets tab stops on a terminal
<b>tic</b>	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.]
<b>toe</b>	Lists all available terminal types, giving the primary name and description for each
<b>tput</b>	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
<b>tset</b>	Can be used to initialize terminals
<code>libcursesw</code>	A link to <code>libncursesw</code>
<code>libncursesw</code>	Contains functions to display text in many complex ways on a terminal screen; a good example of the use of these functions is the menu displayed during the kernel's <b>make menuconfig</b>
<code>libformw</code>	Contains functions to implement forms
<code>libmenuw</code>	Contains functions to implement menus
<code>libpanelw</code>	Contains functions to implement panels

## 8.29. Sed-4.8

The Sed package contains a stream editor.

**Approximate build time:** 0.5 SBU

**Required disk space:** 32 MB

### 8.29.1. Installation of Sed

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:

```
chown -Rv tester .
su tester -c "PATH=$PATH make check"
```

Install the package and its documentation:

```
make install
install -d -m755          /usr/share/doc/sed-4.8
install -m644 doc/sed.html /usr/share/doc/sed-4.8
```

### 8.29.2. Contents of Sed

**Installed program:** sed

**Installed directory:** /usr/share/doc/sed-4.8

#### Short Descriptions

**sed** Filters and transforms text files in a single pass

## 8.30. Psmisc-23.4

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

**Approximate build time:** less than 0.1 SBU

**Required disk space:** 5.7 MB

### 8.30.1. 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
```

### 8.30.2. Contents of Psmisc

**Installed programs:** fuser, killall, peekfd, prtstat, pslog, pstree, and pstree.x11 (link to pstree)

#### Short Descriptions

<b>fuser</b>	Reports the Process IDs (PIDs) of processes that use the given files or file systems
<b>killall</b>	Kills processes by name; it sends a signal to all processes running any of the given commands
<b>peekfd</b>	Peek at file descriptors of a running process, given its PID
<b>prtstat</b>	Prints information about a process
<b>pslog</b>	Reports current logs path of a process
<b>pstree</b>	Displays running processes as a tree
<b>pstree.x11</b>	Same as <b>pstree</b> , except that it waits for confirmation before exiting

## 8.31. Gettext-0.21

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:** 240 MB

### 8.31.1. Installation of Gettext

Prepare Gettext for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/gettext-0.21
```

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
```

### 8.31.2. Contents of Gettext

<b>Installed programs:</b>	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
<b>Installed libraries:</b>	libasprintf.so, libgettextlib.so, libgettextpo.so, libgettextsrc.so, libtextstyle.so, and preloadable_libintl.so
<b>Installed directories:</b>	/usr/lib/gettext, /usr/share/doc/gettext-0.21, /usr/share/gettext, and /usr/share/gettext-0.19.8

### Short Descriptions

<b>autopoint</b>	Copies standard Gettext infrastructure files into a source package
<b>envsubst</b>	Substitutes environment variables in shell format strings
<b>gettext</b>	Translates a natural language message into the user's language by looking up the translation in a message catalog
<b>gettext.sh</b>	Primarily serves as a shell function library for gettext
<b>gettextize</b>	Copies all standard Gettext files into the given top-level directory of a package to begin internationalizing it
<b>msgattrib</b>	Filters the messages of a translation catalog according to their attributes and manipulates the attributes

<b>msgcat</b>	Concatenates and merges the given .po files
<b>msgcmp</b>	Compares two .po files to check that both contain the same set of msgid strings
<b>msgcomm</b>	Finds the messages that are common to the given .po files
<b>msgconv</b>	Converts a translation catalog to a different character encoding
<b>msgen</b>	Creates an English translation catalog
<b>msgexec</b>	Applies a command to all translations of a translation catalog
<b>msgfilter</b>	Applies a filter to all translations of a translation catalog
<b>msgfmt</b>	Generates a binary message catalog from a translation catalog
<b>msggrep</b>	Extracts all messages of a translation catalog that match a given pattern or belong to some given source files
<b>msginit</b>	Creates a new .po file, initializing the meta information with values from the user's environment
<b>msgmerge</b>	Combines two raw translations into a single file
<b>msgunfmt</b>	Decompiles a binary message catalog into raw translation text
<b>msguniq</b>	Unifies duplicate translations in a translation catalog
<b>ngettext</b>	Displays native language translations of a textual message whose grammatical form depends on a number
<b>recode-sr-latin</b>	Recodes Serbian text from Cyrillic to Latin script
<b>xgettext</b>	Extracts the translatable message lines from the given source files to make the first translation template
libasprintf	defines the <i>autosprintf</i> class, which makes C formatted output routines usable in C++ programs, for use with the <i>&lt;string&gt;</i> strings and the <i>&lt;iostream&gt;</i> streams
libgettextlib	a private library containing common routines used by the various Gettext programs; these are not intended for general use
libgettextpo	Used to write specialized programs that process .po files; this library is used when the standard applications shipped with Gettext (such as <b>msgcomm</b> , <b>msgcmp</b> , <b>msgattrib</b> , and <b>msgen</b> ) will not suffice
libgettextsrc	A private library containing common routines used by the various Gettext programs; these are not intended for general use
libtextstyle	Text styling library
preloadable_libintl	A library, intended to be used by LD_PRELOAD that assists libintl in logging untranslated messages

## 8.32. Bison-3.7.5

The Bison package contains a parser generator.

**Approximate build time:** 6.4 SBU

**Required disk space:** 56 MB

### 8.32.1. Installation of Bison

Prepare Bison for compilation:

```
./configure --prefix=/usr --docdir=/usr/share/doc/bison-3.7.5
```

Compile the package:

```
make
```

To test the results (about 5.5 SBU), issue:

```
make check
```

Install the package:

```
make install
```

### 8.32.2. Contents of Bison

**Installed programs:** bison and yacc

**Installed library:** liby.a

**Installed directory:** /usr/share/bison

### Short Descriptions

- bison** Generates, from a series of rules, a program for analyzing the structure of text files; Bison is a replacement for Yacc (Yet Another Compiler Compiler)
- yacc** A wrapper for **bison**, meant for programs that still call **yacc** instead of **bison**; it calls **bison** with the `-y` option
- liby** The Yacc library containing implementations of Yacc-compatible `yyerror` and `main` functions; this library is normally not very useful, but POSIX requires it

## 8.33. Grep-3.6

The Grep package contains programs for searching through the contents of files.

**Approximate build time:** 0.8 SBU

**Required disk space:** 38 MB

### 8.33.1. Installation of Grep

Prepare Grep for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

### 8.33.2. 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

## 8.34. Bash-5.1

The Bash package contains the Bourne-Again SHell.

**Approximate build time:** 1.6 SBU

**Required disk space:** 51 MB

### 8.34.1. Installation of Bash

First, fix a race condition if using multiple cores:

```
sed -i '/^bashline.o:.*shmbchar.h/a bashline.o: ${DEFDIR}/builtext.h' Makefile.in
```

Prepare Bash for compilation:

```
./configure --prefix=/usr \
            --docdir=/usr/share/doc/bash-5.1 \
            --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 `tester` user can write to the sources tree:

```
chown -Rv tester .
```

Now, run the tests as the `tester` user:

```
su tester << EOF
PATH=$PATH make tests < $(tty)
EOF
```

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 continues to disable hashing so that new programs are found as they become available.

## 8.34.2. 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-5.1

### 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

## 8.35. 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:** 1.6 SBU  
**Required disk space:** 43 MB

### 8.35.1. 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
```

Remove an useless static library:

```
rm -fv /usr/lib/libltdl.a
```

### 8.35.2. 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

## 8.36. GDBM-1.19

The GDBM package contains the GNU Database Manager. It is a library of database functions that use extensible hashing and works 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:** 0.2 SBU

**Required disk space:** 11 MB

### 8.36.1. 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 building the libgdbm compatibility library. Some packages outside of LFS may require the older DBM routines it provides.

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

One test, `VERSION`, is known to fail.

Install the package:

```
make install
```

### 8.36.2. Contents of GDBM

**Installed programs:** gdbm\_dump, gdbm\_load, and gdbmtool

**Installed libraries:** libgdbm.so and libgdbm\_compat.so

#### Short Descriptions

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

## 8.37. Gperf-3.1

Gperf generates a perfect hash function from a key set.

**Approximate build time:** less than 0.1 SBU

**Required disk space:** 6.4 MB

### 8.37.1. 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
```

### 8.37.2. 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

## 8.38. Expat-2.2.10

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

**Approximate build time:** 0.1 SBU

**Required disk space:** 14 MB

### 8.38.1. Installation of Expat

Prepare Expat for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/expat-2.2.10
```

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-2.2.10
```

### 8.38.2. Contents of Expat

<b>Installed program:</b>	xmlwf
<b>Installed libraries:</b>	libexpat.so
<b>Installed directory:</b>	/usr/share/doc/expat-2.2.10

### 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

## 8.39. Inetutils-2.0

The Inetutils package contains programs for basic networking.

**Approximate build time:** 0.3 SBU

**Required disk space:** 31 MB

### 8.39.1. Installation of Inetutils

Prepare Inetutils for compilation:

```
./configure --prefix=/usr \
            --localstatedir=/var \
            --disable-logger \
            --disable-whois \
            --disable-rpc \
            --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
```

## 8.39.2. Contents of Inetutils

**Installed programs:**            `dnsdomainname`, `ftp`, `ifconfig`, `hostname`, `ping`, `ping6`, `talk`, `telnet`, `tftp`, and `traceroute`

### Short Descriptions

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

## 8.40. Perl-5.32.1

The Perl package contains the Practical Extraction and Report Language.

**Approximate build time:** 10 SBU

**Required disk space:** 222 MB

### 8.40.1. Installation of Perl

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 \
-Dprivlib=/usr/lib/perl5/5.32/core_perl \
-Darchlib=/usr/lib/perl5/5.32/core_perl \
-Dsitelib=/usr/lib/perl5/5.32/site_perl \
-Dsitearch=/usr/lib/perl5/5.32/site_perl \
-Dvendorlib=/usr/lib/perl5/5.32/vendor_perl \
-Dvendorarch=/usr/lib/perl5/5.32/vendor_perl \
-Dman1dir=/usr/share/man/man1 \
-Dman3dir=/usr/share/man/man3 \
-Dpager="/usr/bin/less -isR" \
-Duseshrplib \
-Dusetthreads
```

**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.

`-Dusetthreads`

Build perl with support for threads.

```
-Dprivlib, -Darchlib, -Dsitelib, ...
```

These settings define where Perl is looking for installed modules. The LFS editors chose to put them in a directory structure based on the Major.Minor version of Perl (5.32) which allows upgrading Perl to newer Patch levels (5.32.1) without the need to reinstall all of the modules again.

Compile the package:

```
make
```

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

```
make test
```

Install the package and clean up:

```
make install  
unset BUILD_ZLIB BUILD_BZIP2
```

## 8.40.2. Contents of Perl

**Installed programs:** corelist, cpan, enc2xs, encguess, h2ph, h2xs, instmodsh, json\_pp, libnetcfg, perl, perl5.32.1 (hard link to perl), perlbug, perldoc, perlivp, 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

<b>corelist</b>	A commandline frontend to Module::CoreList
<b>cpan</b>	Interact with the Comprehensive Perl Archive Network (CPAN) from the command line
<b>enc2xs</b>	Builds a Perl extension for the Encode module from either Unicode Character Mappings or Tcl Encoding Files
<b>encguess</b>	Guess the encoding type of one or several files
<b>h2ph</b>	Converts .h C header files to .ph Perl header files
<b>h2xs</b>	Converts .h C header files to Perl extensions
<b>instmodsh</b>	Shell script for examining installed Perl modules, and can create a tarball from an installed module
<b>json_pp</b>	Converts data between certain input and output formats
<b>libnetcfg</b>	Can be used to configure the libnet Perl module
<b>perl</b>	Combines some of the best features of C, <b>sed</b> , <b>awk</b> and <b>sh</b> into a single swiss-army language
<b>perl5.32.1</b>	A hard link to <b>perl</b>
<b>perlbug</b>	Used to generate bug reports about Perl, or the modules that come with it, and mail them
<b>perldoc</b>	Displays a piece of documentation in pod format that is embedded in the Perl installation tree or in a Perl script
<b>perlivp</b>	The Perl Installation Verification Procedure; it can be used to verify that Perl and its libraries have been installed correctly

<b>perlthanks</b>	Used to generate thank you messages to mail to the Perl developers
<b>piconv</b>	A Perl version of the character encoding converter <b>iconv</b>
<b>pl2pm</b>	A rough tool for converting Perl4 .pl files to Perl5 .pm modules
<b>pod2html</b>	Converts files from pod format to HTML format
<b>pod2man</b>	Converts pod data to formatted *roff input
<b>pod2text</b>	Converts pod data to formatted ASCII text
<b>pod2usage</b>	Prints usage messages from embedded pod docs in files
<b>podchecker</b>	Checks the syntax of pod format documentation files
<b>podselect</b>	Displays selected sections of pod documentation
<b>prove</b>	Command line tool for running tests against the Test::Harness module
<b>ptar</b>	A <b>tar</b> -like program written in Perl
<b>ptardiff</b>	A Perl program that compares an extracted archive with an unextracted one
<b>ptargrep</b>	A Perl program that applies pattern matching to the contents of files in a tar archive
<b>shasum</b>	Prints or checks SHA checksums
<b>splain</b>	Is used to force verbose warning diagnostics in Perl
<b>xsubpp</b>	Converts Perl XS code into C code
<b>zipdetails</b>	Displays details about the internal structure of a Zip file

## 8.41. XML::Parser-2.46

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:** 2.4 MB

### 8.41.1. 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
```

### 8.41.2. Contents of XML::Parser

**Installed module:** Expat.so

#### Short Descriptions

Expat provides the Perl Expat interface

## 8.42. 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

### 8.42.1. Installation of Intltool

First fix a warning that is caused by perl-5.22 and later:

```
sed -i 's:\\\\${:\\\\$\\{:' intltool-update.in
```



#### Note

The above regular expression looks unusual because of all the backslashes. What it does is add a backslash before the right brace character in the sequence '\${' resulting 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
```

### 8.42.2. 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

<b>intltoolize</b>	Prepares a package to use intltool
<b>intltool-extract</b>	Generates header files that can be read by <b>gettext</b>
<b>intltool-merge</b>	Merges translated strings into various file types
<b>intltool-prepare</b>	Updates pot files and merges them with translation files
<b>intltool-update</b>	Updates the po template files and merges them with the translations

## 8.43. Autoconf-2.71

The Autoconf package contains programs for producing shell scripts that can automatically configure source code.

**Approximate build time:** less than 0.1 SBU (about 7.2 SBU with tests)

**Required disk space:** 24 MB

### 8.43.1. Installation of Autoconf

Prepare Autoconf for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

### 8.43.2. Contents of Autoconf

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

**Installed directory:** /usr/share/autoconf

#### Short Descriptions

<b>autoconf</b>	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 <b>autoconf</b> program
<b>autoheader</b>	A tool for creating template files of C <i>#define</i> statements for configure to use
<b>autom4te</b>	A wrapper for the M4 macro processor
<b>autoreconf</b>	Automatically runs <b>autoconf</b> , <b>autoheader</b> , <b>aclocal</b> , <b>automake</b> , <b>gettextize</b> , and <b>libtoolize</b> in the correct order to save time when changes are made to <b>autoconf</b> and <b>automake</b> template files
<b>autoscan</b>	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 as a preliminary <code>configure.in</code> file for the package
<b>autoupdate</b>	Modifies a <code>configure.in</code> file that still calls <b>autoconf</b> macros by their old names to use the current macro names
<b>ifnames</b>	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 <b>configure</b> needs to check for. It can also fill in gaps in a <code>configure.in</code> file generated by <b>autoscan</b> .]

## 8.44. Automake-1.16.3

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

**Approximate build time:** less than 0.1 SBU (about 9.1 SBU with tests)

**Required disk space:** 115 MB

### 8.44.1. Installation of Automake

Fix a failing test:

```
sed -i "s/'/etags/" t/tags-lisp-space.sh
```

Prepare Automake for compilation:

```
./configure --prefix=/usr --docdir=/usr/share/doc/automake-1.16.3
```

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
```

The tests `t/subobj.sh`, `t/deprecated-acinit.sh`, and `t/init.sh` are known to fail in the LFS environment.

Install the package:

```
make install
```

### 8.44.2. 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-1.16.3`

### Short Descriptions

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

## 8.45. Kmod-28

The Kmod package contains libraries and utilities for loading kernel modules

**Approximate build time:** 0.1 SBU

**Required disk space:** 13 MB

### 8.45.1. Installation of Kmod

Prepare Kmod for compilation:

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

**The meaning of the configure options:**

*--with-xz, --with-zlib, --with-zstd*

These options enable Kmod to handle compressed kernel modules.

*--with-rootlibdir=/lib*

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

Compile the package:

```
make
```

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

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

```
make install

for target in depmod insmod lsmod modinfo modprobe rmmmod; do
  ln -sfv ../bin/kmod /sbin/$target
done

ln -sfv kmod /bin/lsmod
```

### 8.45.2. Contents of Kmod

**Installed programs:** depmod (link to kmod), insmod (link to kmod), kmod, lsmod (link to kmod), modinfo (link to kmod), modprobe (link to kmod), and rmmmod (link to kmod)

**Installed library:** libkmod.so

### Short Descriptions

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

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

## 8.46. Libelf from Elfutils-0.183

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

**Approximate build time:** 0.9 SBU

**Required disk space:** 121 MB

### 8.46.1. Installation of Libelf

Libelf is part of elfutils-0.183 package. Use the elfutils-0.183.tar.bz2 as the source tarball.

Prepare Libelf for compilation:

```
./configure --prefix=/usr          \
            --disable-debuginfod   \
            --enable-libdebuginfod=dummy \
            --libdir=/lib
```

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
rm /lib/libelf.a
```

### 8.46.2. Contents of Libelf

**Installed Library:** libelf.so (symlink) and libelf-0.183.so

**Installed Directory:** /usr/include/elfutils

### Short Descriptions

`libelf` Contains API functions to handle ELF object files

## 8.47. Libffi-3.3

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:** 1.9 SBU

**Required disk space:** 10 MB

### 8.47.1. 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.

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
```

### 8.47.2. Contents of Libffi

**Installed library:** libffi.so

#### Short Descriptions

`libffi` contains the foreign function interface API functions

## 8.48. OpenSSL-1.1.1j

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:** 2.2 SBU

**Required disk space:** 154 MB

### 8.48.1. Installation of OpenSSL

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
```

One test 30-test\_afalg.t is known to fail on some kernel configurations (it apparently assumes certain unspecified crypto options have been selected).

Install the package:

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

Add the version to the documentation directory name, to be consistent with other packages:

```
mv -v /usr/share/doc/openssl /usr/share/doc/openssl-1.1.1j
```

If desired, install some additional documentation:

```
cp -vfr doc/* /usr/share/doc/openssl-1.1.1j
```

### 8.48.2. Contents of OpenSSL

**Installed programs:** c\_rehash and openssl

**Installed libraries:** libcrypto.so and libssl.so

**Installed directories:** /etc/ssl, /usr/include/openssl, /usr/lib/engines and /usr/share/doc/openssl-1.1.1j

#### 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**

## 8.49. Python-3.9.2

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:** 2.8 SBU

**Required disk space:** 294 MB

### 8.49.1. 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
```

To test the results, issue:

```
make test
```

Some tests requiring a network connection or additional packages are skipped. The test named `test_normalization` is known to fail. For more comprehensive results, the tests can be rerun when Python 3 is reinstalled in BLFS.

Install the package:

```
make install
```

If desired, install the preformatted documentation:

```
install -v -dm755 /usr/share/doc/python-3.9.2/html

tar --strip-components=1 \
    --no-same-owner \
    --no-same-permissions \
    -C /usr/share/doc/python-3.9.2/html \
    -xvf ../python-3.9.2-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.

**8.49.2. Contents of Python 3**

**Installed Programs:** 2to3, idle3, pip3, pydoc3, python3, and python3-config  
**Installed Library:** libpython3.9.so and libpython3.so  
**Installed Directories:** /usr/include/python3.9, /usr/lib/python3, and /usr/share/doc/python-3.9.2

**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

## 8.50. Ninja-1.10.2

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

**Approximate build time:** 0.2 SBU

**Required disk space:** 79 MB

### 8.50.1. 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
```

### 8.50.2. Contents of Ninja

**Installed programs:**       ninja

## Short Descriptions

**ninja** is the Ninja build system

## 8.51. Meson-0.57.1

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

**Approximate build time:** less than 0.1 SBU

**Required disk space:** 37 MB

### 8.51.1. 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 the hierarchy can just be copied to the standard location.

### 8.51.2. Contents of Meson

**Installed programs:** meson

**Installed directory:** /usr/lib/python3.9/site-packages/meson-0.57.1-py3.9.egg-info and /usr/lib/python3.9/site-packages/mesonbuild

### Short Descriptions

**meson** A high productivity build system

## 8.52. Coreutils-8.32

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

**Approximate build time:** 2.5 SBU

**Required disk space:** 164 MB

### 8.52.1. 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-8.32-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

The patch for internationalization has modified the building system of the package, so the configuration files have to be regenerated.

`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=tester check-root
```

We're going to run the remainder of the tests as the `tester` user. Certain tests require that the user be a member of more than one group. So that these tests are not skipped, add a temporary group and make the user `tester` a part of it:

```
echo "dummy:x:102:tester" >> /etc/group
```

Fix some of the permissions so that the non-root user can compile and run the tests:

```
chown -Rv tester .
```

Now run the tests:

```
su tester -c "PATH=$PATH make RUN_EXPENSIVE_TESTS=yes check"
```

The `test-getlogin` test is known to fail in the LFS chroot environment.

Remove the temporary group:

```
sed -i '/dummy/d' /etc/group
```

Install the package:

```
make install
```

Move programs to the locations specified by the FHS:

```
mv -v /usr/bin/{cat,chgrp,chmod,chown,cp,date,dd,df,echo} /bin
mv -v /usr/bin/{false,ln,ls,mkdir,mknod,mv,pwd,rm} /bin
mv -v /usr/bin/{rmdir,stty,sync,true,uname} /bin
mv -v /usr/bin/chroot /usr/sbin
mv -v /usr/share/man/man1/chroot.1 /usr/share/man/man8/chroot.8
sed -i 's/"1"/"8"/' /usr/share/man/man8/chroot.8
```

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

## 8.52.2. 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

`[` Is an actual command, `/usr/bin/[`, that is a synonym for the `test` command.

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

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

<b>b2sum</b>	Prints or checks BLAKE2 (512-bit) checksums
<b>basename</b>	Strips any path and a given suffix from a file name
<b>basenc</b>	Encodes or decodes data using various algorithms
<b>cat</b>	Concatenates files to standard output
<b>chcon</b>	Changes security context for files and directories
<b>chgrp</b>	Changes the group ownership of files and directories
<b>chmod</b>	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
<b>chown</b>	Changes the user and/or group ownership of files and directories
<b>chroot</b>	Runs a command with the specified directory as the / directory
<b>cksum</b>	Prints the Cyclic Redundancy Check (CRC) checksum and the byte counts of each specified file
<b>comm</b>	Compares two sorted files, outputting in three columns the lines that are unique and the lines that are common
<b>cp</b>	Copies files
<b>csplit</b>	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
<b>cut</b>	Prints sections of lines, selecting the parts according to given fields or positions
<b>date</b>	Displays the current time in the given format, or sets the system date
<b>dd</b>	Copies a file using the given block size and count, while optionally performing conversions on it
<b>df</b>	Reports the amount of disk space available (and used) on all mounted file systems, or only on the file systems holding the selected files
<b>dir</b>	Lists the contents of each given directory (the same as the <b>ls</b> command)
<b>dircolors</b>	Outputs commands to set the <code>LS_COLOR</code> environment variable to change the color scheme used by <b>ls</b>
<b>dirname</b>	Strips the non-directory suffix from a file name
<b>du</b>	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
<b>echo</b>	Displays the given strings
<b>env</b>	Runs a command in a modified environment
<b>expand</b>	Converts tabs to spaces
<b>expr</b>	Evaluates expressions
<b>factor</b>	Prints the prime factors of all specified integer numbers
<b>false</b>	Does nothing, unsuccessfully; it always exits with a status code indicating failure
<b>fmt</b>	Reformats the paragraphs in the given files
<b>fold</b>	Wraps the lines in the given files
<b>groups</b>	Reports a user's group memberships
<b>head</b>	Prints the first ten lines (or the given number of lines) of each given file
<b>hostid</b>	Reports the numeric identifier (in hexadecimal) of the host

<b>id</b>	Reports the effective user ID, group ID, and group memberships of the current user or specified user
<b>install</b>	Copies files while setting their permission modes and, if possible, their owner and group
<b>join</b>	Joins the lines that have identical join fields from two separate files
<b>link</b>	Creates a hard link with the given name to a file
<b>ln</b>	Makes hard links or soft (symbolic) links between files
<b>logname</b>	Reports the current user's login name
<b>ls</b>	Lists the contents of each given directory
<b>md5sum</b>	Reports or checks Message Digest 5 (MD5) checksums
<b>mkdir</b>	Creates directories with the given names
<b>mkfifo</b>	Creates First-In, First-Outs (FIFOs), a "named pipe" in UNIX parlance, with the given names
<b>mknod</b>	Creates device nodes with the given names; a device node is a character special file, a block special file, or a FIFO
<b>mktemp</b>	Creates temporary files in a secure manner; it is used in scripts
<b>mv</b>	Moves or renames files or directories
<b>nice</b>	Runs a program with modified scheduling priority
<b>nl</b>	Numbers the lines from the given files
<b>nohup</b>	Runs a command immune to hangups, with its output redirected to a log file
<b>nproc</b>	Prints the number of processing units available to a process
<b>numfmt</b>	Converts numbers to or from human-readable strings
<b>od</b>	Dumps files in octal and other formats
<b>paste</b>	Merges the given files, joining sequentially corresponding lines side by side, separated by tab characters
<b>pathchk</b>	Checks if file names are valid or portable
<b>pinky</b>	Is a lightweight finger client; it reports some information about the given users
<b>pr</b>	Paginates and columnates files for printing
<b>printenv</b>	Prints the environment
<b>printf</b>	Prints the given arguments according to the given format, much like the C printf function
<b>ptx</b>	Produces a permuted index from the contents of the given files, with each keyword in its context
<b>pwd</b>	Reports the name of the current working directory
<b>readlink</b>	Reports the value of the given symbolic link
<b>realpath</b>	Prints the resolved path
<b>rm</b>	Removes files or directories
<b>rmdir</b>	Removes directories if they are empty
<b>runcon</b>	Runs a command with specified security context
<b>seq</b>	Prints a sequence of numbers within a given range and with a given increment
<b>sha1sum</b>	Prints or checks 160-bit Secure Hash Algorithm 1 (SHA1) checksums
<b>sha224sum</b>	Prints or checks 224-bit Secure Hash Algorithm checksums

<b>sha256sum</b>	Prints or checks 256-bit Secure Hash Algorithm checksums
<b>sha384sum</b>	Prints or checks 384-bit Secure Hash Algorithm checksums
<b>sha512sum</b>	Prints or checks 512-bit Secure Hash Algorithm checksums
<b>shred</b>	Overwrites the given files repeatedly with complex patterns, making it difficult to recover the data
<b>shuf</b>	Shuffles lines of text
<b>sleep</b>	Pauses for the given amount of time
<b>sort</b>	Sorts the lines from the given files
<b>split</b>	Splits the given file into pieces, by size or by number of lines
<b>stat</b>	Displays file or filesystem status
<b>stdbuf</b>	Runs commands with altered buffering operations for its standard streams
<b>stty</b>	Sets or reports terminal line settings
<b>sum</b>	Prints checksum and block counts for each given file
<b>sync</b>	Flushes file system buffers; it forces changed blocks to disk and updates the super block
<b>tac</b>	Concatenates the given files in reverse
<b>tail</b>	Prints the last ten lines (or the given number of lines) of each given file
<b>tee</b>	Reads from standard input while writing both to standard output and to the given files
<b>test</b>	Compares values and checks file types
<b>timeout</b>	Runs a command with a time limit
<b>touch</b>	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
<b>tr</b>	Translates, squeezes, and deletes the given characters from standard input
<b>true</b>	Does nothing, successfully; it always exits with a status code indicating success
<b>truncate</b>	Shrinks or expands a file to the specified size
<b>tsort</b>	Performs a topological sort; it writes a completely ordered list according to the partial ordering in a given file
<b>tty</b>	Reports the file name of the terminal connected to standard input
<b>uname</b>	Reports system information
<b>unexpand</b>	Converts spaces to tabs
<b>uniq</b>	Discards all but one of successive identical lines
<b>unlink</b>	Removes the given file
<b>users</b>	Reports the names of the users currently logged on
<b>vdir</b>	Is the same as <b>ls -l</b>
<b>wc</b>	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
<b>who</b>	Reports who is logged on
<b>whoami</b>	Reports the user name associated with the current effective user ID
<b>yes</b>	Repeatedly outputs “y” or a given string until killed

`libstdbuf` Library used by **stdbuf**

## 8.53. Check-0.15.2

Check is a unit testing framework for C.

**Approximate build time:** 0.1 SBU (about 4.2 SBU with tests)

**Required disk space:** 12 MB

### 8.53.1. Installation of Check

Prepare Check for compilation:

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

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:

```
make docdir=/usr/share/doc/check-0.15.2 install
```

### 8.53.2. Contents of Check

**Installed program:** checkmk

**Installed library:** libcheck.so

#### Short Descriptions

<b>checkmk</b>	Awk script for generating C unit tests for use with the Check unit testing framework
<b>libcheck.{a,so}</b>	Contains functions that allow Check to be called from a test program

## 8.54. 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:** 33 MB

### 8.54.1. 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
```

### 8.54.2. 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

## 8.55. Gawk-5.1.0

The Gawk package contains programs for manipulating text files.

**Approximate build time:** 0.4 SBU

**Required disk space:** 45 MB

### 8.55.1. 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-5.1.0
cp -v doc/{awkforai.txt,*.{eps,pdf,jpg}} /usr/share/doc/gawk-5.1.0
```

### 8.55.2. Contents of Gawk

**Installed programs:** awk (link to gawk), gawk, and awk-5.1.0

**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-5.1.0

### Short Descriptions

<b>awk</b>	A link to <b>gawk</b>
<b>gawk</b>	A program for manipulating text files; it is the GNU implementation of <b>awk</b>
<b>gawk-5.1.0</b>	A hard link to <b>gawk</b>

## 8.56. Findutils-4.8.0

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 is unreliable if the database has not been recently updated).

**Approximate build time:** 0.9 SBU

**Required disk space:** 55 MB

### 8.56.1. Installation of Findutils

Prepare Findutils for compilation:

```
./configure --prefix=/usr --localstatedir=/var/lib/locate
```

The meaning of the configure options:

*--localstatedir*

This option changes the location of the **locate** database to be in `/var/lib/locate`, which is FHS-compliant.

Compile the package:

```
make
```

To test the results, issue:

```
chown -Rv tester .
su tester -c "PATH=$PATH 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
```

### 8.56.2. 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

## 8.57. Groff-1.22.4

The Groff package contains programs for processing and formatting text.

**Approximate build time:** 0.5 SBU

**Required disk space:** 96 MB

### 8.57.1. 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
```

### 8.57.2. Contents of Groff

**Installed programs:** addftinfo, afmtodit, chem, eqn, eqn2graph, gdiffmk, glilypond, gperl, gpinyin, grap2graph, grn, grodvi, groff, groffer, grog, grolbp, grolj4, gropdf, grops, grotty, hpftodit, indxbib, lkbib, lookbib, mmroff, neqn, nroff, pdfmom, pdfroff, pfbtops, pic, pic2graph, post-grohtml, preconv, pre-grohtml, refer, roff2dvi, roff2html, roff2pdf, roff2ps, roff2text, roff2x, soelim, tbl, tfmtodit, and troff

**Installed directories:** /usr/lib/groff and /usr/share/doc/groff-1.22.4, /usr/share/groff

### Short Descriptions

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

<b>grap2graph</b>	Converts a grap diagram into a cropped bitmap image
<b>grn</b>	A <b>groff</b> preprocessor for gremlin files
<b>grodvi</b>	A driver for <b>groff</b> that produces TeX dvi format
<b>groff</b>	A front-end to the groff document formatting system; normally, it runs the <b>troff</b> program and a post-processor appropriate for the selected device
<b>groffer</b>	Displays groff files and man pages on X and tty terminals
<b>grog</b>	Reads files and guesses which of the <b>groff</b> 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 <b>groff</b> command including those options
<b>grolbp</b>	Is a <b>groff</b> driver for Canon CAPSL printers (LBP-4 and LBP-8 series laser printers)
<b>grolj4</b>	Is a driver for <b>groff</b> that produces output in PCL5 format suitable for an HP LaserJet 4 printer
<b>gropdf</b>	Translates the output of GNU <b>troff</b> to PDF
<b>grops</b>	Translates the output of GNU <b>troff</b> to PostScript
<b>grotty</b>	Translates the output of GNU <b>troff</b> into a form suitable for typewriter-like devices
<b>hpftodit</b>	Creates a font file for use with <b>groff -Tlj4</b> from an HP-tagged font metric file
<b>indxbib</b>	Creates an inverted index for the bibliographic databases with a specified file for use with <b>refer</b> , <b>lookbib</b> , and <b>lkbib</b>
<b>lkbib</b>	Searches bibliographic databases for references that contain specified keys and reports any references found
<b>lookbib</b>	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
<b>mmroff</b>	A simple preprocessor for <b>groff</b>
<b>neqn</b>	Formats equations for American Standard Code for Information Interchange (ASCII) output
<b>nroff</b>	A script that emulates the <b>nroff</b> command using <b>groff</b>
<b>pdfmom</b>	Is a wrapper around groff that facilitates the production of PDF documents from files formatted with the mom macros.
<b>pdfroff</b>	Creates pdf documents using groff
<b>pfbtops</b>	Translates a PostScript font in <code>.pfb</code> format to ASCII
<b>pic</b>	Compiles descriptions of pictures embedded within troff or TeX input files into commands understood by TeX or <b>troff</b>
<b>pic2graph</b>	Converts a PIC diagram into a cropped image
<b>post-grohtml</b>	Translates the output of GNU <b>troff</b> to HTML
<b>preconv</b>	Converts encoding of input files to something GNU <b>troff</b> understands
<b>pre-grohtml</b>	Translates the output of GNU <b>troff</b> to HTML
<b>refer</b>	Copies the contents of a file to the standard output, except that lines between <code>./</code> and <code>./</code> are interpreted as citations, and lines between <code>.R1</code> and <code>.R2</code> are interpreted as commands for how citations are to be processed
<b>roff2dvi</b>	Transforms roff files into DVI format

<b>roff2html</b>	Transforms roff files into HTML format
<b>roff2pdf</b>	Transforms roff files into PDFs
<b>roff2ps</b>	Transforms roff files into ps files
<b>roff2text</b>	Transforms roff files into text files
<b>roff2x</b>	Transforms roff files into other formats
<b>soelim</b>	Reads files and replaces lines of the form <i>.so file</i> by the contents of the mentioned <i>file</i>
<b>tbl</b>	Compiles descriptions of tables embedded within troff input files into commands that are understood by <b>troff</b>
<b>tfmtofit</b>	Creates a font file for use with <b>groff -Tdvi</b>
<b>troff</b>	Is highly compatible with Unix <b>troff</b> ; it should usually be invoked using the <b>groff</b> command, which will also run preprocessors and post-processors in the appropriate order and with the appropriate options

## 8.58. GRUB-2.04

The GRUB package contains the GRand Unified Bootloader.

**Approximate build time:** 0.7 SBU

**Required disk space:** 154 MB

### 8.58.1. Installation of GRUB

First, fix an issue introduced by binutils-2.36:

```
sed "s/gold-version/& -R .note.gnu.property/" \
-i Makefile.in grub-core/Makefile.in
```

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 10.4, “Using GRUB to Set Up the Boot Process”.

### 8.58.2. Contents of GRUB

**Installed programs:** grub-bios-setup, grub-editenv, grub-file, grub-fstest, grub-glue-efi, grub-install, grub-kbdcomp, grub-macbless, grub-menulst2cfg, grub-mkconfig, grub-mkimage, grub-mklayout, grub-mknetdir, grub-mkpasswd-pbkdf2, grub-mkrelpath, grub-mkrescue, grub-mkstandalone, grub-ofpathname, grub-probe, grub-reboot, grub-render-label, grub-script-check, grub-set-default, grub-sparc64-setup, and grub-syslinux2cfg

**Installed directories:** /usr/lib/grub, /etc/grub.d, /usr/share/grub, and /boot/grub (when grub-install is first run)

#### Short Descriptions

**grub-bios-setup** Is a helper program for grub-install

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

## 8.59. Less-563

The Less package contains a text file viewer.

**Approximate build time:** less than 0.1 SBU

**Required disk space:** 4.1 MB

### 8.59.1. 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
```

### 8.59.2. Contents of Less

**Installed programs:** less, lessecho, and lesskey

#### Short Descriptions

- |                 |  |
|-----------------|--|
| <b>less</b>     | A file viewer or pager; it displays the contents of the given file, letting the user scroll, find strings, and jump to marks |
| <b>lessecho</b> | Needed to expand meta-characters, such as <code>*</code> and <code>?</code> , in filenames on Unix systems                   |
| <b>lesskey</b>  | Used to specify the key bindings for <b>less</b>   |

## 8.60. Gzip-1.10

The Gzip package contains programs for compressing and decompressing files.

**Approximate build time:** 0.1 SBU

**Required disk space:** 19 MB

### 8.60.1. Installation of Gzip

Prepare Gzip for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

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

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

### 8.60.2. 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

<b>gunzip</b>	Decompresses gzipped files
<b>gzexe</b>	Creates self-decompressing executable files
<b>gzip</b>	Compresses the given files using Lempel-Ziv (LZ77) coding
<b>uncompress</b>	Decompresses compressed files
<b>zcat</b>	Decompresses the given gzipped files to standard output
<b>zcmp</b>	Runs <b>cmp</b> on gzipped files
<b>zdiff</b>	Runs <b>diff</b> on gzipped files
<b>zegrep</b>	Runs <b>egrep</b> on gzipped files
<b>zfgrep</b>	Runs <b>fgrep</b> on gzipped files
<b>zforce</b>	Forces a <b>.gz</b> extension on all given files that are gzipped files, so that <b>gzip</b> will not compress them again; this can be useful when file names were truncated during a file transfer
<b>zgrep</b>	Runs <b>grep</b> on gzipped files
<b>zless</b>	Runs <b>less</b> on gzipped files

**zmore**       Runs **more** on gzipped files

**znew**        Re-compresses files from **compress** format to **gzip** format— .Z to .gz

## 8.61. IPRoute2-5.10.0

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

**Approximate build time:** 0.2 SBU

**Required disk space:** 15 MB

### 8.61.1. 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/10.1/server/db.html>.

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

It is also necessary to disable building two modules that require <http://www.linuxfromscratch.org/blfs/view/10.1/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/iproute2-5.10.0 install
```

### 8.61.2. Contents of IPRoute2

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

**Installed directories:** /etc/iproute2, /usr/lib/tc, and /usr/share/doc/iproute2-5.10.0

### 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 <http://www.skbuff.net/iputils/>]

**ifstat** Shows the interface statistics, including the amount of transmitted and received packets by interface

**ip** The main executable. It has several different functions:  
**ip link <device>** allows users to look at the state of devices and to make changes  
**ip addr** allows users to look at addresses and their properties, add new addresses, and delete old ones  
**ip neighbor** allows users to look at neighbor bindings and their properties, add new neighbor entries, and delete old ones

**ip rule** allows users to look at the routing policies and change them

**ip route** allows users to look at the routing table and change routing table rules

**ip tunnel** allows users to look at the IP tunnels and their properties, and change them

**ip maddr** allows users to look at the multicast addresses and their properties, and change them

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

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

<b>lnstat</b>	Provides Linux network statistics; it is a generalized and more feature-complete replacement for the old <b>rtstat</b> program
<b>nstat</b>	Shows network statistics
<b>routef</b>	A component of <b>ip route</b> . This is for flushing the routing tables
<b>routel</b>	A component of <b>ip route</b> . This is for listing the routing tables
<b>rtacct</b>	Displays the contents of <code>/proc/net/rt_acct</code>
<b>rtmon</b>	Route monitoring utility
<b>rtpr</b>	Converts the output of <b>ip -o</b> back into a readable form
<b>rtstat</b>	Route status utility
<b>ss</b>	Similar to the <b>netstat</b> command; shows active connections
<b>tc</b>	Traffic Controlling Executable; this is for Quality Of Service (QOS) and Class Of Service (COS) implementations
	<b>tc qdisc</b> allows users to setup the queueing discipline
	<b>tc class</b> allows users to setup classes based on the queueing discipline scheduling
	<b>tc estimator</b> allows users to estimate the network flow into a network
	<b>tc filter</b> allows users to setup the QOS/COS packet filtering
	<b>tc policy</b> allows users to setup the QOS/COS policies

## 8.62. Kbd-2.4.0

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

**Approximate build time:** 0.1 SBU

**Required disk space:** 33 MB

### 8.62.1. 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-2.4.0-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 '/RESIZECONS_PROGS=/s/yes/no/' configure
sed -i 's/resizecons.8 //' docs/man/man8/Makefile.in
```

Prepare Kbd for compilation:

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

**The meaning of the configure option:**

*--disable-vlock*

This option prevents the vlock utility from being built because 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-2.4.0
cp -R -v docs/doc/* /usr/share/doc/kbd-2.4.0
```

## 8.62.2. Contents of Kbd

<b>Installed programs:</b>	chvt, deallocvt, dumpkeys, fgconsole, getkeycodes, kbinfo, kbd_mode, kbdrate, loadkeys, loadunimap, mapscrn, openvt, psfaddtable (link to psfxtable), psfgettable (link to psfxtable), psfstrietable (link to psfxtable), psfxtable, setfont, setkeycodes, settled, setmetamode, setvtrgb, showconsolefont, showkey, unicode_start, and unicode_stop
<b>Installed directories:</b>	/usr/share/consolefonts, /usr/share/consoletrans, /usr/share/keymaps, /usr/share/doc/kbd-2.4.0, and /usr/share/unimaps

### Short Descriptions

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

## 8.63. Libpipeline-1.5.3

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:** 9.3 MB

### 8.63.1. 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
```

### 8.63.2. Contents of Libpipeline

**Installed library:** libpipeline.so

#### Short Descriptions

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

## 8.64. Make-4.3

The Make package contains a program for controlling the generation of executables and other non-source files of a package from source files.

**Approximate build time:** 0.6 SBU

**Required disk space:** 14 MB

### 8.64.1. Installation of Make

Prepare Make for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

### 8.64.2. 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

## 8.65. 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:** 12 MB

### 8.65.1. 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
```

### 8.65.2. 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.)

## 8.66. Man-DB-2.9.4

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

**Approximate build time:** 0.4 SBU

**Required disk space:** 40 MB

### 8.66.1. 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-2.9.4 \
            --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
```

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

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

**Table 8.1. 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
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.

**8.66.3. Contents of Man-DB**

**Installed programs:** accessdb, apropos (link to whatis), catman, leygrog, 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-2.9.4

**Short Descriptions**

**accessdb** Dumps the **whatis** database contents in human-readable form

<b>apropos</b>	Searches the <b>whatis</b> database and displays the short descriptions of system commands that contain a given string
<b>catman</b>	Creates or updates the pre-formatted manual pages
<b>lexgrog</b>	Displays one-line summary information about a given manual page
<b>man</b>	Formats and displays the requested manual page
<b>mandb</b>	Creates or updates the <b>whatis</b> database
<b>manpath</b>	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
<b>whatis</b>	Searches the <b>whatis</b> database and displays the short descriptions of system commands that contain the given keyword as a separate word
libman	Contains run-time support for <b>man</b>
libmandb	Contains run-time support for <b>man</b>

## 8.67. Tar-1.34

The Tar package provides the ability to create tar archives as well as perform various other kinds of archive manipulation. Tar can be used on previously created archives to extract files, to store additional files, or to update or list files which were already stored.

**Approximate build time:** 2.0 SBU

**Required disk space:** 41 MB

### 8.67.1. Installation of Tar

Prepare Tar for compilation:

```
FORCE_UNSAFE_CONFIGURE=1 \
./configure --prefix=/usr \
            --bindir=/bin
```

**The meaning of the configure option:**

```
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
```

One test, capabilities: binary store/restore, is known to fail.

Install the package:

```
make install
make -C doc install-html docdir=/usr/share/doc/tar-1.34
```

### 8.67.2. Contents of Tar

**Installed programs:** tar

**Installed directory:** /usr/share/doc/tar-1.34

### Short Descriptions

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

## 8.68. Texinfo-6.7

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

**Approximate build time:** 0.7 SBU

**Required disk space:** 105 MB

### 8.68.1. Installation of Texinfo

Prepare Texinfo for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

Optionally, install the components belonging in a TeX installation:

```
make TEXMF=/usr/share/texmf install-tex
```

**The meaning of the make parameter:**

*TEXMF=/usr/share/texmf*

The `TEXMF` makefile variable holds the location of the root of the TeX tree if, for example, a TeX package will be installed later.

The Info documentation system uses a plain text file to hold its list of menu entries. The file is located at `/usr/share/info/dir`. Unfortunately, due to occasional problems in the Makefiles of various packages, it can sometimes get out of sync with the info pages installed on the system. If the `/usr/share/info/dir` file ever needs to be recreated, the following optional commands will accomplish the task:

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

### 8.68.2. 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

<b>info</b>	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 <b>man bison</b> and <b>info bison</b> .]
<b>install-info</b>	Used to install info pages; it updates entries in the <b>info</b> index file
<b>makeinfo</b>	Translates the given Texinfo source documents into info pages, plain text, or HTML
<b>pdftexi2dvi</b>	Used to format the given Texinfo document into a Portable Document Format (PDF) file
<b>pod2texi</b>	Converts Pod to Texinfo format
<b>texi2any</b>	Translate Texinfo source documentation to various other formats
<b>texi2dvi</b>	Used to format the given Texinfo document into a device-independent file that can be printed
<b>texi2pdf</b>	Used to format the given Texinfo document into a Portable Document Format (PDF) file
<b>texindex</b>	Used to sort Texinfo index files

## 8.69. Vim-8.2.2433

The Vim package contains a powerful text editor.

**Approximate build time:** 2.0 SBU

**Required disk space:** 208 MB



### Alternatives to Vim

If you prefer another editor—such as Emacs, Joe, or Nano—please refer to <http://www.linuxfromscratch.org/blfs/view/10.1/postlfs/editors.html> for suggested installation instructions.

### 8.69.1. Installation of Vim

First, change the default location of the `vimrc` configuration file to `/etc`:

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

Prepare vim for compilation:

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

Compile the package:

```
make
```

To prepare the tests, ensure that user `tester` can write to the source tree:

```
chown -Rv tester .
```

Now run the tests as user `tester`:

```
su tester -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-8.2.2433`, making it consistent with the location of documentation for other packages:

```
ln -sv ../vim/vim82/doc /usr/share/doc/vim-8.2.2433
```

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/10.1/postlfs/vim.html>.

## 8.69.2. Configuring Vim

By default, **vim** runs in vi-incompatible mode. This may be new to users who have used other editors in the past. The “*nocompatible*” setting is included below to highlight the fact that a new behavior is being used. It also reminds those who would change to “*compatible*” mode that it should be the first setting in the configuration file. This is necessary because it changes other settings, and overrides must come after this setting. Create a default **vim** configuration file by running the following:

```
cat > /etc/vimrc << "EOF"
" Begin /etc/vimrc

" 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 an 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/vim82/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.

**8.69.3. Contents of Vim**

**Installed programs:** ex ([link to vim](#)), rview ([link to vim](#)), rvim ([link to vim](#)), vi ([link to vim](#)), view ([link to vim](#)), vim, vimdiff ([link to vim](#)), vimtutor, and xxd

**Installed directory:** /usr/share/vim

**Short Descriptions**

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

## 8.70. Systemd-247

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

**Approximate build time:** 1.8 SBU

**Required disk space:** 264 MB

### 8.70.1. Installation of systemd

First, apply a patch to fix some regressions:

```
patch -Np1 -i ../systemd-247-upstream_fixes-1.patch
```

Create a symlink to work around the xsltproc command not being installed:

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

Set up the man pages:

```
tar -xf ../systemd-man-pages-247.tar.xz
```

Remove tests that cannot be built in chroot:

```
sed '181,$ d' -i src/resolve/meson.build
```

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

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

Prepare systemd for compilation:

```
mkdir -p build
cd      build

LANG=en_US.UTF-8 \
meson --prefix=/usr \
      --sysconffdir=/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 \
      -Dsysusers=false \
      -Dumount-path=/bin/umount \
      -Db_lto=false \
      -Drpmmacrodir=no \
      -Dhomed=false \
      -Duserdb=false \
      -Dman=true \
      -Dmode=release \
      -Ddocdir=/usr/share/doc/systemd-247 \
      ..
```

The meaning of the meson options:

*-D\*-path=\**

These switches provide the location of binaries needed by systemd at runtime that have not yet been installed.

*-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 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.

*-D{userdb,homed}=false*

Remove two daemons that have dependencies that do not fit the scope of LFS.

*-Dmode=release*

Disable some features considered experimental by upstream.

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
```

Remove a useless directory:

```
rm -rf /usr/lib/pam.d
```

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

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

Setup the basic target structure:

```
systemctl preset-all
```

Disable a service that is known to cause problems with systems that use a network configuration other than what is provided by `systemd-networkd`:

```
systemctl disable systemd-time-wait-sync.service
```

## 8.70.2. Contents of systemd

<b>Installed programs:</b>	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-dissect, systemd-escape, systemd-hwdb, systemd-id128, systemd-inhibit, systemd-machine-id-setup, systemd-mount, systemd-notify, systemd-nspawn, systemd-path, systemd-repart, 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
<b>Installed libraries:</b>	libnss_myhostname.so.2, libnss_mymachines.so.2, libnss_resolve.so.2, libnss_systemd.so.2, libsystemd.so, libsystemd-shared-247.so (in /lib/systemd), and libudev.so
<b>Installed directories:</b>	/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/environment.d, /usr/lib/kernel, /usr/lib/modules-load.d, /usr/lib/sysctl.d, /usr/lib/systemd, /usr/lib/tmpfiles.d, /usr/share/doc/systemd-247, /usr/share/factory, /usr/share/systemd, /var/lib/systemd, and /var/log/journal

### Short Descriptions

<b>bootctl</b>	Is used to query the firmware and boot manager settings
<b>busctl</b>	Is used to introspect and monitor the D-Bus bus
<b>coredumpctl</b>	Is used to retrieve coredumps from the systemd journal
<b>halt</b>	Normally invokes <b>shutdown</b> 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
<b>hostnamectl</b>	Is used to query and change the system hostname and related settings
<b>init</b>	Is 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. In this case, it starts systemd
<b>journalctl</b>	Is used to query the contents of the systemd journal
<b>kernel-install</b>	Is used to add and remove kernel and initramfs images to and from /boot. In LFS, this is done manually
<b>localectl</b>	Is used to query and change the system locale and keyboard layout settings
<b>loginctl</b>	Is used to introspect and control the state of the systemd Login Manager
<b>machinectl</b>	Is used to introspect and control the state of the systemd Virtual Machine and Container Registration Manager
<b>networkctl</b>	Is used to introspect and configure the state of the network links configured by systemd-networkd
<b>portablectl</b>	Is used to attach or detach portable services from the local system

<b>poweroff</b>	Instructs the kernel to halt the system and switch off the computer (see <b>halt</b> )
<b>reboot</b>	Instructs the kernel to reboot the system (see <b>halt</b> )
<b>resolvconf</b>	Registers DNS server and domain configuration with <b>systemd-resolved</b>
<b>resolvectl</b>	Sends control commands to the network name resolution manager, or resolves domain names, IPv4 and IPv6 addresses, DNS records, and services
<b>runlevel</b>	Outputs the previous and the current run-level, as noted in the last run-level record in <code>/run/utmp</code>
<b>shutdown</b>	Brings the system down in a safe and secure manner, signaling all processes and notifying all logged-in users
<b>systemctl</b>	Is used to introspect and control the state of the systemd system and service manager
<b>systemd-analyze</b>	Is used to determine system startup performance of the current boot, as well as identify troublesome systemd units
<b>systemd-ask-password</b>	Is used to query a system password or passphrase from the user, using a question message specified on the command line
<b>systemd-cat</b>	Is used to connect the <code>STDOUT</code> and <code>STDERR</code> outputs of a process with the systemd journal
<b>systemd-cgls</b>	Recursively shows the contents of the selected Linux control group hierarchy in a tree
<b>systemd-cgtop</b>	Shows the top control groups of the local Linux control group hierarchy, ordered by their CPU, memory and disk I/O load
<b>systemd-delta</b>	Is used to identify and compare configuration files in <code>/etc</code> that override default counterparts in <code>/usr</code>
<b>systemd-detect-virt</b>	Detects whether the system is being run in a virtual environment, and adjusts <code>udev</code> accordingly
<b>systemd-dissect</b>	Is used to inspect OS disk images
<b>systemd-escape</b>	Is used to escape strings for inclusion in systemd unit names
<b>systemd-hwdb</b>	Is used to manage the hardware database ( <code>hwdb</code> )
<b>systemd-id128</b>	Generates and prints <code>id128</code> strings
<b>systemd-inhibit</b>	Is used to execute a program with a shutdown, sleep or idle inhibitor lock taken, preventing an action such as a system shutdown until the process is completed
<b>systemd-machine-id-setup</b>	Is 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
<b>systemd-mount</b>	Is used to temporarily mount or automount disks
<b>systemd-notify</b>	Is used by daemon scripts to notify the init system about status changes
<b>systemd-nspawn</b>	Is used to run a command or OS in a light-weight namespace container

<b>systemd-path</b>	Is used to query system and user paths
<b>systemd-repart</b>	Is used to grow and add partitions to a partition table when systemd is used in an OS image (e.g. a container)
<b>systemd-resolve</b>	Is used to resolve domain names, IPV4 and IPv6 addresses, DNS resource records, and services
<b>systemd-run</b>	Is used to create and start a transient <code>.service</code> or a <code>.scope</code> unit and run the specified command in it. This is useful for validating systemd units
<b>systemd-socket-activate</b>	Is used to listen on socket devices and launch a process upon a successful connection to the socket
<b>systemd-tmpfiles</b>	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
<b>systemd-umount</b>	Unmounts mount points
<b>systemd-tty-ask-password-agent</b>	Is used to list and/or process pending systemd password requests
<b>telinit</b>	Tells <b>init</b> which run-level to change to
<b>timedatectl</b>	Is used to query and change the system clock and its settings
<b>udevadm</b>	Is a generic udev administration tool which controls the udevd daemon, provides info from the Udev hardware database, monitors uevents, waits for uevents to finish, tests udev configuration, and triggers uevents for a given device
<code>libsystemd</code>	Is the main systemd utility library
<code>libudev</code>	Is a library to access Udev device information

## 8.71. D-Bus-1.12.20

D-Bus is a message bus system, a simple way for applications to talk to one another. D-Bus supplies both a system daemon (for events such as "new hardware device added" or "printer queue changed") and a per-user-login-session daemon (for general IPC needs among user applications). Also, the message bus is built on top of a general one-to-one message passing framework, which can be used by any two applications to communicate directly (without going through the message bus daemon).

**Approximate build time:** 0.2 SBU

**Required disk space:** 18 MB

### 8.71.1. 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-1.12.20 \
            --with-console-auth-dir=/run/console \
            --with-system-pid-file=/run/dbus/pid \
            --with-system-socket=/run/dbus/system_bus_socket
```

The meaning of the configure options:

*--with-console-auth-dir=/run/console*

This specifies the location of the ConsoleKit authorization directory.

*--with-system-pid-file=/run/dbus/pid* and *--with-system-socket=/run/dbus/system\_bus\_socket*

These set the location of the PID file and the system bus socket to be in /run, instead of deprecated /var/run.

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/10.1/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
```

## 8.71.2. Contents of D-Bus

<b>Installed programs:</b>	dbus-cleanup-sockets, dbus-daemon, dbus-launch, dbus-monitor, dbus-run-session, dbus-send, dbus-test-tool, dbus-update-activation-environment, and dbus-uuidgen
<b>Installed libraries:</b>	libdbus-1.{a,so}
<b>Installed directories:</b>	/etc/dbus-1, /usr/include/dbus-1.0, /usr/lib/dbus-1.0, /usr/share/dbus-1, /usr/share/doc/dbus-1.12.20, and /var/lib/dbus

### Short Descriptions

<b>dbus-cleanup-sockets</b>	is used to remove leftover sockets in a directory
<b>dbus-daemon</b>	Is the D-Bus message bus daemon
<b>dbus-launch</b>	Starts <b>dbus-daemon</b> from a shell script
<b>dbus-monitor</b>	Monitors messages passing through a D-Bus message bus
<b>dbus-run-session</b>	Starts a session bus instance of <b>dbus-daemon</b> from a shell script and starts a specified program in that session
<b>dbus-send</b>	Sends a message to a D-Bus message bus
<b>dbus-test-tool</b>	Is a tool to help packages test D-Bus
<b>dbus-update-activation-environment</b>	Updates environment variables that will be set for D-Bus session services
<b>dbus-uuidgen</b>	Generates a universally unique ID
<b>libdbus-1</b>	Contains API functions used to communicate with the D-Bus message bus

## 8.72. Procps-ng-3.3.17

The Procps-ng package contains programs for monitoring processes.



### Note

This package extracts to the directory `procps-3.3.17`, not the expected `procps-ng-3.3.17`.

**Approximate build time:** 0.5 SBU

**Required disk space:** 20 MB

### 8.72.1. Installation of Procps-ng

Prepare `procps-ng` for compilation:

```
./configure --prefix=/usr \
            --exec-prefix= \
            --libdir=/usr/lib \
            --docdir=/usr/share/doc/procps-ng-3.3.17 \
            --disable-static \
            --disable-kill \
            --with-systemd
```

The meaning of the `configure` option:

`--disable-kill`

This switch disables building the `kill` command that will be installed by the `Util-linux` package.

Compile the package:

```
make
```

To run the test suite, run:

```
make check
```

Five tests related to `kill` are known to fail due to a problem with tests that were not updated.

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
```

### 8.72.2. Contents of Procps-ng

**Installed programs:** `free`, `pgrep`, `pidof`, `kill`, `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-3.3.17`

## Short Descriptions

<b>free</b>	Reports the amount of free and used memory (both physical and swap memory) in the system
<b>pgrep</b>	Looks up processes based on their name and other attributes
<b>pidof</b>	Reports the PIDs of the given programs
<b>pkill</b>	Signals processes based on their name and other attributes
<b>pmap</b>	Reports the memory map of the given process
<b>ps</b>	Lists the current running processes
<b>pwait</b>	Waits for a process to finish before executing.
<b>pwdx</b>	Reports the current working directory of a process
<b>slabtop</b>	Displays detailed kernel slab cache information in real time
<b>sysctl</b>	Modifies kernel parameters at run time
<b>tload</b>	Prints a graph of the current system load average
<b>top</b>	Displays a list of the most CPU intensive processes; it provides an ongoing look at processor activity in real time
<b>uptime</b>	Reports how long the system has been running, how many users are logged on, and the system load averages
<b>vmstat</b>	Reports virtual memory statistics, giving information about processes, memory, paging, block Input/Output (IO), traps, and CPU activity
<b>w</b>	Shows which users are currently logged on, where, and since when
<b>watch</b>	Runs a given command repeatedly, displaying the first screen-full of its output; this allows a user to watch the output change over time
<b>libprocps</b>	Contains the functions used by most programs in this package

## 8.73. Util-linux-2.36.2

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

**Approximate build time:** 1.1 SBU

**Required disk space:** 262 MB

### 8.73.1. Installation of Util-linux

Prepare Util-linux for compilation:

```
./configure ADJTIME_PATH=/var/lib/hwclock/adjtime \
--docdir=/usr/share/doc/util-linux-2.36.2 \
--disable-chfn-chsh \
--disable-login \
--disable-nologin \
--disable-su \
--disable-setpriv \
--disable-runuser \
--disable-pylibmount \
--disable-static \
--without-python \
runstatedir=/run
```

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 tester .
su tester -c "make -k check"
```

Install the package:

```
make install
```

## 8.73.2. Contents of Util-linux

<b>Installed programs:</b>	addpart, agetty, blkdiscard, blkid, blkzone, blockdev, cal, cfdisk, chcpu, chmem, choom, chrt, col, colcrt, colrm, column, ctrlaltdel, delpart, dmesg, eject, fallocate, fdformat, fdisk, findcore, 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, rfclock, rtcwake, script, scriptreplay, setarch, setsid, setterm, sfdisk, sulogin, swapon, swapoff (link to swapon), swapon, switch_root, taskset, ul, umount, unshare, utmpdump, uidd, uuidgen, uuidparse, wall, wdctl, whereis, wipefs, x86_64, and zramctl
<b>Installed libraries:</b>	libblkid.so, libfdisk.so, libmount.so, libsmartcols.so, and libuuid.so
<b>Installed directories:</b>	/usr/include/blkid, /usr/include/libfdisk, /usr/include/libmount, /usr/include/libsmartcols, /usr/include/uuid, /usr/share/doc/util-linux-2.36.2, and /var/lib/hwclock

### Short Descriptions

<b>addpart</b>	Notifies the Linux kernel of new partitions
<b>agetty</b>	Opens a tty port, prompts for a login name, and then invokes the <b>login</b> program
<b>blkdiscard</b>	Discards sectors on a device
<b>blkid</b>	A command line utility to locate and print block device attributes
<b>blkzone</b>	Runs zone command on the given block device
<b>blockdev</b>	Allows users to call block device ioctls from the command line
<b>cal</b>	Displays a simple calendar
<b>cfdisk</b>	Manipulates the partition table of the given device
<b>chcpu</b>	Modifies the state of CPUs
<b>chmem</b>	Configures memory
<b>choom</b>	Displays and adjusts OOM-killer score
<b>chrt</b>	Manipulates real-time attributes of a process
<b>col</b>	Filters out reverse line feeds
<b>colcrt</b>	Filters <b>nroff</b> output for terminals that lack some capabilities, such as overstriking and half-lines
<b>colrm</b>	Filters out the given columns
<b>column</b>	Formats a given file into multiple columns
<b>ctrlaltdel</b>	Sets the function of the Ctrl+Alt+Del key combination to a hard or a soft reset
<b>delpart</b>	Asks the Linux kernel to remove a partition
<b>dmesg</b>	Dumps the kernel boot messages
<b>eject</b>	Ejects removable media
<b>fallocate</b>	Preallocates space to a file
<b>fdformat</b>	Low-level formats a floppy disk

<b>fdisk</b>	Manipulates the partition table of the given device
<b>findcore</b>	Counts pages of file contents in core
<b>findfs</b>	Finds a file system by label or Universally Unique Identifier (UUID)
<b>findmnt</b>	Is a command line interface to the libmount library for work with mountinfo, fstab and mtab files
<b>flock</b>	Acquires a file lock and then executes a command with the lock held
<b>fsck</b>	Is used to check, and optionally repair, file systems
<b>fsck.cramfs</b>	Performs a consistency check on the Cramfs file system on the given device
<b>fsck.minix</b>	Performs a consistency check on the Minix file system on the given device
<b>fsfreeze</b>	Is a very simple wrapper around FIFREEZE/FITHAW ioctl kernel driver operations
<b>fstrim</b>	Discards unused blocks on a mounted filesystem
<b>getopt</b>	Parses options in the given command line
<b>hexdump</b>	Dumps the given file in hexadecimal or in another given format
<b>hwclock</b>	Reads or sets the system's hardware clock, also called the Real-Time Clock (RTC) or Basic Input-Output System (BIOS) clock
<b>i386</b>	A symbolic link to setarch
<b>ionice</b>	Gets or sets the io scheduling class and priority for a program
<b>ipcmk</b>	Creates various IPC resources
<b>ipcrm</b>	Removes the given Inter-Process Communication (IPC) resource
<b>ipcs</b>	Provides IPC status information
<b>isosize</b>	Reports the size of an iso9660 file system
<b>kill</b>	Sends signals to processes
<b>last</b>	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
<b>lastb</b>	Shows the failed login attempts, as logged in <code>/var/log/btmp</code>
<b>ldattach</b>	Attaches a line discipline to a serial line
<b>linux32</b>	A symbolic link to setarch
<b>linux64</b>	A symbolic link to setarch
<b>logger</b>	Enters the given message into the system log
<b>look</b>	Displays lines that begin with the given string
<b>losetup</b>	Sets up and controls loop devices
<b>lsblk</b>	Lists information about all or selected block devices in a tree-like format
<b>lscpu</b>	Prints CPU architecture information
<b>lsipc</b>	Prints information on IPC facilities currently employed in the system
<b>lslocks</b>	Lists local system locks
<b>lslogins</b>	Lists information about users, groups and system accounts
<b>lsmem</b>	Lists the ranges of available memory with their online status
<b>lsns</b>	Lists namespaces

<b>mcookie</b>	Generates magic cookies (128-bit random hexadecimal numbers) for <b>xauth</b>
<b>mesg</b>	Controls whether other users can send messages to the current user's terminal
<b>mkfs</b>	Builds a file system on a device (usually a hard disk partition)
<b>mkfs.bfs</b>	Creates a Santa Cruz Operations (SCO) bfs file system
<b>mkfs.cramfs</b>	Creates a cramfs file system
<b>mkfs.minix</b>	Creates a Minix file system
<b>mkswap</b>	Initializes the given device or file to be used as a swap area
<b>more</b>	A filter for paging through text one screen at a time
<b>mount</b>	Attaches the file system on the given device to a specified directory in the file-system tree
<b>mountpoint</b>	Checks if the directory is a mountpoint
<b>namei</b>	Shows the symbolic links in the given pathnames
<b>nsenter</b>	Runs a program with namespaces of other processes
<b>partx</b>	Tells the kernel about the presence and numbering of on-disk partitions
<b>pivot_root</b>	Makes the given file system the new root file system of the current process
<b>prlimit</b>	Get and set a process' resource limits
<b>raw</b>	Bind a Linux raw character device to a block device
<b>readprofile</b>	Reads kernel profiling information
<b>rename</b>	Renames the given files, replacing a given string with another
<b>renice</b>	Alters the priority of running processes
<b>resizepart</b>	Asks the Linux kernel to resize a partition
<b>rev</b>	Reverses the lines of a given file
<b>rkfill</b>	Tool for enabling and disabling wireless devices
<b>rtcwake</b>	Used to enter a system sleep state until specified wakeup time
<b>script</b>	Makes a typescript of a terminal session
<b>scriptreplay</b>	Plays back typescripts using timing information
<b>setarch</b>	Changes reported architecture in a new program environment and sets personality flags
<b>setsid</b>	Runs the given program in a new session
<b>setterm</b>	Sets terminal attributes
<b>sfdisk</b>	A disk partition table manipulator
<b>sulogin</b>	Allows <code>root</code> to log in; it is normally invoked by <b>init</b> when the system goes into single user mode
<b>swaponlabel</b>	Allows to change swaparea UUID and label
<b>swapoff</b>	Disables devices and files for paging and swapping
<b>swapon</b>	Enables devices and files for paging and swapping and lists the devices and files currently in use
<b>switch_root</b>	Switches to another filesystem as the root of the mount tree
<b>tailf</b>	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

<b>taskset</b>	Retrieves or sets a process' CPU affinity
<b>ul</b>	A filter for translating underscores into escape sequences indicating underlining for the terminal in use
<b>umount</b>	Disconnects a file system from the system's file tree
<b>uname26</b>	A symbolic link to setarch
<b>unshare</b>	Runs a program with some namespaces unshared from parent
<b>utmpdump</b>	Displays the content of the given login file in a more user-friendly format
<b>uidd</b>	A daemon used by the UUID library to generate time-based UUIDs in a secure and guaranteed-unique fashion
<b>uuidgen</b>	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
<b>uuidparse</b>	An utility to parse unique identifiers
<b>wall</b>	Displays the contents of a file or, by default, its standard input, on the terminals of all currently logged in users
<b>wdctl</b>	Shows hardware watchdog status
<b>whereis</b>	Reports the location of the binary, source, and man page for the given command
<b>wipefs</b>	Wipes a filesystem signature from a device
<b>x86_64</b>	A symbolic link to setarch
<b>zramctl</b>	A program to set up and control zram (compressed ram disk) devices
<b>libblkid</b>	Contains routines for device identification and token extraction
<b>libfdisk</b>	Contains routines for manipulating partition tables
<b>libmount</b>	Contains routines for block device mounting and unmounting
<b>libsmartcols</b>	Contains routines for aiding screen output in tabular form
<b>libuuid</b>	Contains routines for generating unique identifiers for objects that may be accessible beyond the local system

## 8.74. E2fsprogs-1.46.1

The `e2fsprogs` package contains the utilities for handling the `ext2` file system. It also supports the `ext3` and `ext4` journaling file systems.

**Approximate build time:** 4.4 SBU on a spinning disk, 1.5 SBU on an SSD

**Required disk space:** 102 MB

### 8.74.1. 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 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 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 test, `m_rootdir_acl`, is known to fail.

On a spinning disk, the tests take a little more than 4 SBUs. They can be much shorter on an SSD (down to about 1.5 SBUs).

Install the package:

```
make install
```

Remove useless static libraries:

```
rm -fv /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
```

## 8.74.2. Contents of E2fsprogs

**Installed programs:** badblocks, chattr, 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

<b>badblocks</b>	Searches a device (usually a disk partition) for bad blocks
<b>chattr</b>	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
<b>compile_et</b>	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
<b>debugfs</b>	A file system debugger; it can be used to examine and change the state of an <code>ext2</code> file system
<b>dumpe2fs</b>	Prints the super block and blocks group information for the file system present on a given device
<b>e2freefrag</b>	Reports free space fragmentation information
<b>e2fsck</b>	Is used to check, and optionally repair <code>ext2</code> file systems and <code>ext3</code> file systems
<b>e2image</b>	Is used to save critical <code>ext2</code> file system data to a file
<b>e2label</b>	Displays or changes the file system label on the <code>ext2</code> file system present on a given device
<b>e2mmpstatus</b>	Checks MMP status of an <code>ext4</code> filesystem
<b>e2scrub</b>	Checks the contents of a mounted <code>ext[234]</code> filesystem
<b>e2scrub_all</b>	Checks all mounted <code>ext[234]</code> filesystems for errors
<b>e2undo</b>	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.]
<b>e4crypt</b>	Ext4 filesystem encryption utility
<b>e4defrag</b>	Online defragmenter for <code>ext4</code> filesystems

<b>filefrag</b>	Reports on how badly fragmented a particular file might be
<b>fsck.ext2</b>	By default checks <code>ext2</code> file systems and is a hard link to <b>e2fsck</b>
<b>fsck.ext3</b>	By default checks <code>ext3</code> file systems and is a hard link to <b>e2fsck</b>
<b>fsck.ext4</b>	By default checks <code>ext4</code> file systems and is a hard link to <b>e2fsck</b>
<b>logsave</b>	Saves the output of a command in a log file
<b>lsattr</b>	Lists the attributes of files on a second extended file system
<b>mk_cmds</b>	Converts a table of command names and help messages into a C source file suitable for use with the <code>libss</code> subsystem library
<b>mke2fs</b>	Creates an <code>ext2</code> or <code>ext3</code> file system on the given device
<b>mkfs.ext2</b>	By default creates <code>ext2</code> file systems and is a hard link to <b>mke2fs</b>
<b>mkfs.ext3</b>	By default creates <code>ext3</code> file systems and is a hard link to <b>mke2fs</b>
<b>mkfs.ext4</b>	By default creates <code>ext4</code> file systems and is a hard link to <b>mke2fs</b>
<b>mklost+found</b>	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 <b>e2fsck</b>
<b>resize2fs</b>	Can be used to enlarge or shrink an <code>ext2</code> file system
<b>tune2fs</b>	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 <b>dumpe2fs</b> , <b>chattr</b> , and <b>lsattr</b>
<code>libext2fs</code>	Contains routines to enable user-level programs to manipulate an <code>ext2</code> file system
<code>libss</code>	Used by <b>debugfs</b>

## 8.75. 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, 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.

## 8.76. 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 2 GB 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-2.33.so libc-2.33.so libpthread-2.33.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.6.0.28
            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
```

Now the binaries and libraries can be stripped:

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

find /lib /usr/lib -type f -name \*.so* ! -name \*.dbg \
    -exec strip --strip-unneeded {} ';'

find /{bin,sbin} /usr/{bin,sbin,libexec} -type f \
    -exec 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.

## 8.77. 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
```

Here the `+h` option is not used anymore, since all the previous programs have been replaced: hashing is therefore possible.

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 7.3.2, “Mounting and Populating /dev” and Section 7.3.3, “Mounting Virtual Kernel File Systems”.

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. As already said, they are only useful when linking with static libraries. They are unneeded, and potentially harmful, when using dynamic shared libraries, specially when using also non-autotools build systems. 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”.

The compiler built in Chapter 6 and Chapter 7 is still partially installed and not needed anymore. Remove it with:

```
find /usr -depth -name $(uname -m)-lfs-linux-gnu\* | xargs rm -rf
```

The `/tools` directory can also be removed to further gain some space:

```
rm -rf /tools
```

Finally, remove the temporary ‘tester’ user account created at the beginning of the previous chapter.

```
userdel -r tester
```

# Chapter 9. System Configuration

## 9.1. Introduction

This chapter discusses configuration files and systemd services. First, the general configuration files needed to set up networking are presented.

- Section 9.2, “General Network Configuration.”
- Section 9.2.3, “Configuring the system hostname.”
- Section 9.2.4, “Customizing the `/etc/hosts` File.”

Second, issues that affect the proper setup of devices are discussed.

- Section 9.3, “Overview of Device and Module Handling.”
- Section 9.4, “Managing Devices.”

Third, configuring the system clock and keyboard layout is shown.

- Section 9.5, “Configuring the system clock.”
- Section 9.6, “Configuring the Linux Console.”

Fourth, a brief introduction to the scripts and configuration files used when the user logs into the system is presented.

- Section 9.7, “Configuring the System Locale.”
- Section 9.8, “Creating the `/etc/inputrc` File.”

And finally, configuring the behavior of systemd is discussed.

- Section 9.10, “Systemd Usage and Configuration.”

## 9.2. General Network Configuration

This section only applies if a network card is to be configured.

### 9.2.1. 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.

#### 9.2.1.1. Network Device Naming

Udev normally assigns network card interface names based on physical system 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". To do that, create `.link` files in `/etc/systemd/network/` that select an explicit name or a better naming scheme for your network 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.

### 9.2.1.2. 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.

### 9.2.1.3. 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
```

## 9.2.2. 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`.

### 9.2.2.1. 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, unbound, 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
```

### 9.2.2.2. 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 server most appropriate for your 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. Another option is to use the Google Public DNS service using the IP addresses below as nameservers.



### 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.

## 9.2.3. 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.

## 9.2.4. 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 IP 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, such as MTAs, to operate properly.

Create the `/etc/hosts` file using the following command:

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

127.0.0.1 localhost.localdomain 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, and the `<192.168.0.2>` line can be omitted if you are using a connection configured with DHCP or IPv6 Autoconfiguration.

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.

## 9.3. Overview of Device and Module Handling

In Chapter 8, 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.

### 9.3.1. 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.

## 9.3.2. Udev Implementation

### 9.3.2.1. 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).

### 9.3.2.2. 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.

### 9.3.2.3. 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.

### 9.3.2.4. 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.

### 9.3.3. Problems with Loading Modules and Creating Devices

There are a few possible problems when it comes to automatically creating device nodes.

#### 9.3.3.1. 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-5.10.17, 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-5.10.17, 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.

#### 9.3.3.2. 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:` dependencies. See the `modprobe.d(5)` manual page for more information on “softdep” syntax and capabilities.

#### 9.3.3.3. 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.

#### 9.3.3.4. 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.

#### 9.3.3.5. 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.

### 9.3.3.6. 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**.

### 9.3.3.7. 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 9.4, “Managing Devices” and Section 9.2, “General Network Configuration” for examples.

## 9.3.4. 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>

## 9.4. Managing Devices

### 9.4.1. Dealing with duplicate devices

As explained in Section 9.3, “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. 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 9.2, “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+="tv-tuner"

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.

## 9.5. Configuring the system clock

This section discusses how to configure the **systemd-timedated** system service, which configures the 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, 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
```

The 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.

## 9.5.1. 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.

## 9.6. 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 the output of **localectl list-keymaps** for a list of valid console keymaps. Look in the `/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`

Shows known X11 keyboard mapping models.

`list-x11-keymap-layouts`

Shows known X11 keyboard mapping layouts.

`list-x11-keymap-variants`

Shows known X11 keyboard mapping variants.

`list-x11-keymap-options`

Shows known X11 keyboard mapping options.



### Note

Using any of the parameters listed above requires the XKeyboard-Config package from BLFS.

## 9.7. Configuring the System Locale

The `/etc/locale.conf` file below sets some environment variables necessary for native language support. Setting them properly results in:

- The output of programs being translated into your native language
- The 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
- The appropriate default paper size
- The correct formatting of monetary, time, and date values

Replace `<ll>` below with the two-letter code for your 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 the safest in most cases to choose the canonical name for a particular locale. To determine the canonical name, run the following command, where `<locale name>` is the output given by **locale -a** for your preferred locale (“en\_GB.iso88591” in our example).

```
LC_ALL=<locale name> locale charmap
```

For the “en\_GB.iso88591” locale, the above command will print:

```
ISO-8859-1
```

This results in a final locale setting of “en\_GB.ISO-8859-1”. It is important that the locale found using the heuristic above is tested prior to it being added to the Bash startup files:

```
LC_ALL=<locale name> locale language
LC_ALL=<locale name> locale charmap
LC_ALL=<locale name> locale int_curr_symbol
LC_ALL=<locale name> locale int_prefix
```

The above commands should print the language name, the character encoding used by the locale, the local currency, and the prefix to dial before the telephone number in order to get into the country. If any of the commands above fail with a message similar to the one shown below, this means that your locale was either not installed in Chapter 6 or is not supported by the default installation of Glibc.

```
locale: Cannot set LC_* to default locale: No such file or directory
```

If this happens, you should either install the desired locale using the **localedef** command, or consider choosing a different locale. Further instructions assume that there are no such error messages from Glibc.

Some packages beyond LFS may also lack support for your chosen locale. One example is the X library (part of the X Window System), which outputs the following error message if the locale does not exactly match one of the character map names in its internal files:

```
Warning: locale not supported by Xlib, locale set to C
```

In several cases Xlib expects that the character map will be listed in uppercase notation with canonical dashes. For instance, “ISO-8859-1” rather than “iso88591”. It is also possible to find an appropriate specification by removing the charmap part of the locale specification. This can be checked by running the **locale charmap** command in both locales. For example, one would have to change “de\_DE.ISO-8859-15@euro” to “de\_DE@euro” in order to get this locale recognized by Xlib.

Other packages can also function incorrectly (but may not necessarily display any error messages) if the locale name does not meet their expectations. In those cases, investigating how other Linux distributions support your locale might provide some useful information.

Once the proper locale settings have been determined, create the `/etc/locale.conf` file:

```
cat > /etc/locale.conf << "EOF"
LANG=<ll>_<CC>.<charmap><@modifiers>
EOF
```

Note that you can modify `/etc/locale.conf` with 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”). It's suggested that you use the “C” locale only if you are certain that you will never need 8-bit characters.

## 9.8. 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
```

## 9.9. 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 the ability to change shells.

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
```

## 9.10. Systemd Usage and Configuration

### 9.10.1. 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.

### 9.10.2. 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.

### 9.10.3. Disabling tmpfs for `/tmp`

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

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

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

## 9.10.4. 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
```

## 9.10.5. Overriding Default Services Behavior

The parameters 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.

## 9.10.6. 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).

## 9.10.7. 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 operate 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).

## 9.10.8. Working with Core Dumps

Core dumps are useful to debug crashed programs, especially when a daemon process crashes. On systemd booted systems the core dumping is handled by **systemd-coredump**. It will log the core dump in the journal and store the core dump itself in `/var/lib/systemd/coredump`. To retrieve and process core dumps, the **coredumpctl** tool is provided. Here are some examples of frequently used commands:

- **coredumpctl -r**: lists all core dumps in reverse chronological order.
- **coredumpctl -1 info**: shows the information from the last core dump.
- **coredumpctl -1 debug**: loads the last core dump into *GDB*.

Core dumps may use a lot of disk space. The maximum disk space used by core dumps can be limited by creating a configuration file in `/etc/systemd/coredump.conf.d`. For example:

```
mkdir -pv /etc/systemd/coredump.conf.d

cat > /etc/systemd/coredump.conf.d/maxuse.conf << EOF
[CoreDump]
MaxUse=5G
EOF
```

See the `systemd-coredump(8)`, `coredumpctl(1)`, and `coredump.conf.d(5)` manual pages for more information.

### 9.10.9. 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/systemd/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 disable lingering by default while building `systemd` by adding the switch `-Ddefault-kill-user-processes=false` to the **meson** command for `systemd`. This completely disables the ability of `systemd` to kill user processes at session end.

# Chapter 10. Making the LFS System Bootable

## 10.1. Introduction

It is time to make the LFS system bootable. This chapter discusses creating the `/etc/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.

## 10.2. 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.

## 10.3. Linux-5.10.17

The Linux package contains the Linux kernel.

**Approximate build time:** 5.0 - 125.0 SBU (typically about 9 SBU)

**Required disk space:** 1200 - 6750 MB (typically about 1500 MB)

### 10.3.1. 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.

There are several ways to configure the kernel options. Usually, This is done through a menu-driven interface, for example:

```
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.

#### make menuconfig

This launches an ncurses menu-driven interface. For other (graphical) interfaces, type **make help**.

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/10.1/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 -->
  [ ] Auditing Support [CONFIG_AUDIT]
  [*] Control Group support [CONFIG_CGROUPS]
  [ ] Enable deprecated sysfs features to support old userspace tools [CONF
  [*] Configure standard kernel features (expert users) [CONFIG_EXPERT] ---
      [*] open by fhandle syscalls [CONFIG_FHANDLE]
Processor type and features --->
  [*] Enable seccomp to safely compute untrusted bytecode [CONFIG_SECCOMP]
Firmware Drivers --->
  [*] Export DMI identification via sysfs to userspace [CONFIG_DMIID]
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]
  Firmware Loader --->
    [ ] Enable the firmware sysfs fallback mechanism [CONFIG_FW_LOADER_USE
File systems --->
  [*] Inotify support for userspace [CONFIG_INOTIFY_USER]
Pseudo filesystems --->
  [*] Tmpfs POSIX Access Control Lists [CONFIG_TMPFS_POSIX_ACL]
```



## 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.

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-5.10.17` 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 9.3, “Overview of Device and Module Handling” and in the kernel documentation in the `linux-5.10.17/Documentation` directory. Also, `modprobe.d(5)` may be of interest.

Unless module support has been disabled in the kernel configuration, install the modules with:

```
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-5.10.17-lfs-10.1-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-5.10.17
```

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-5.10.17
```

Install the documentation for the Linux kernel:

```
install -d /usr/share/doc/linux-5.10.17
cp -r Documentation/* /usr/share/doc/linux-5.10.17
```

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-5.10.17` 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 5.4, “Linux-5.10.17 API Headers”. Therefore, they should *never* be replaced by either the raw kernel headers or any other kernel sanitized headers.

## 10.3.2. 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
```

### 10.3.3. Contents of Linux

**Installed files:** `config-5.10.17`, `vmlinuz-5.10.17-lfs-10.1-systemd`, and `System.map-5.10.17`  
**Installed directories:** `/lib/modules`, `/usr/share/doc/linux-5.10.17`

#### Short Descriptions

<code>config-5.10.17</code>	Contains all the configuration selections for the kernel
<code>vmlinuz-5.10.17-lfs-10.1-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-5.10.17</code>	A list of addresses and symbols; it maps the entry points and addresses of all the functions and data structures in the kernel

## 10.4. Using GRUB to Set Up the Boot Process

### 10.4.1. Introduction



#### Warning

Configuring GRUB incorrectly can render your system inoperable without an alternate boot device such as a CD-ROM or bootable USB drive. 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>.

### 10.4.2. GRUB Naming Conventions

GRUB uses its own naming structure for drives and partitions in the form of  $(hdn,m)$ , where  $n$  is the hard drive number and  $m$  is the partition number. The hard drive number starts from zero, but the partition number starts from one for normal partitions and five for extended partitions. Note that this is different from earlier versions where both numbers started from zero. For example, partition `sda1` is  $(hd0,1)$  to GRUB and `sdb3` is  $(hd1,3)$ . In contrast to Linux, GRUB does not consider CD-ROM drives to be hard drives. For example, if using a CD on `hdb` and a second hard drive on `hdc`, that second hard drive would still be  $(hd1)$ .

### 10.4.3. 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 200 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.

## 10.4.4. 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 5.10.17-lfs-10.1-systemd" {
    linux /boot/vmlinuz-5.10.17-lfs-10.1-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 11. The End

## 11.1. The End

Well done! The new LFS system is installed! We wish you much success with your shiny new custom-built Linux system.

It may be a good idea to create an `/etc/lfs-release` file. 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 10.1-systemd > /etc/lfs-release
```

Two files describing the installed system may be used by packages that can be installed on the system later, either in binary form or by building them.

The first one shows 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="10.1-systemd"
DISTRIB_CODENAME="<your name here>"
DISTRIB_DESCRIPTION="Linux From Scratch"
EOF
```

The second one contains roughly the same information, and is used by `systemd` and some graphical desktop environments. To create this file, run:

```
cat > /etc/os-release << "EOF"
NAME="Linux From Scratch"
VERSION="10.1-systemd"
ID=lfs
PRETTY_NAME="Linux From Scratch 10.1-systemd"
VERSION_CODENAME="<your name here>"
EOF
```

Be sure to put some sort of customization for the fields 'DISTRIB\_CODENAME' and 'VERSION\_CODENAME' to make the system uniquely yours.

## 11.2. 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.

## 11.3. 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 *dhcpc* 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*.
- 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
```

Unmount the LFS file system hierarchy:

```
umount -Rv $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 10.1* automatically.

When the reboot is complete, the LFS system is ready for use and more software may be added to suit your needs.

## 11.4. 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/view/10.1/>.

- 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/downloads/files/>.

- 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 V. Appendices**

# Appendix A. Acronyms and Terms

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

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

<b>UUID</b>	Universally Unique Identifier
<b>VC</b>	Virtual Console
<b>VGA</b>	Video Graphics Array
<b>VT</b>	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* <jlepillier@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 Phermawang* <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 Utley* <jeremy@linuxfromscratch.org> – LFS Technical Writer, Bugzilla Maintainer, LFS-Bootscripts Maintainer
- *Zack Winkles* <zwinkles@gmail.com> – LFS Technical Writer

# Appendix C. Dependencies

Every package built in LFS relies on one or more other packages in order to build and install properly. Some packages even participate in circular dependencies, that is, the first package depends on the second which in turn depends on the first. Because of these dependencies, the order in which packages are built in LFS is very important. The purpose of this page is to document the dependencies of each package built in LFS.

For each package we build, we have listed three, and sometimes four, types of dependencies. The first lists what other packages need to be available in order to compile and install the package in question. The second lists what packages, in addition to those on the first list, need to be available in order to run the test suites. The third list of dependencies are packages that require this package to be built and installed in its final location before they are built and installed. In most cases, this is because these packages will hard code paths to binaries within their scripts. If not built in a certain order, this could result in paths of `/tools/bin/[binary]` being placed inside scripts installed to the final system. This is obviously not desirable.

The last list of dependencies are optional packages that are not addressed in LFS, but could be useful to the user. These packages may have additional mandatory or optional dependencies of their own. For these dependencies, the recommended practice is to install them after completion of the LFS book and then go back and rebuild the LFS package. In several cases, re-installation is addressed in BLFS.

## Acl

**Installation depends on:** Attr, Bash, Binutils, Coreutils, GCC, Gettext, Grep, M4, Make, Perl, Sed, and Texinfo  
**Test suite depends on:** Automake, Diffutils, Findutils, and Libtool  
**Must be installed before:** Coreutils, Sed, Tar, 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, Coreutils, GCC, Glibc, Grep, and Make

**Test suite depends on:** Gawk

**Must be installed before:** Linux Kernel

**Optional dependencies:** None

## Binutils

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

**Test suite depends on:** DejaGNU and Expect

**Must be installed before:** None

**Optional dependencies:** Debuginfod

## 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:** File

**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, Libcap, 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, Sed, and Texinfo  
**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, Sed, and Util-linux  
**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:** Python and 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:** *tk*

## File

**Installation depends on:** Bash, Binutils, Bzip2, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, Make, Sed, Xz, 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:** Binutils, IProute2, Kbd, Kmod, 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:** libsigsegv

## GCC

**Installation depends on:** Bash, Binutils, Coreutils, Diffutils, Findutils, Gawk, GCC, Gettext, Glibc, GMP, Grep, M4, Make, MPC, MPFR, Patch, Perl, Sed, Tar, Texinfo, and Zstd  
**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, Ncurses, Sed, and Texinfo  
**Test suite depends on:** Diffutils, Perl, and Tcl  
**Must be installed before:** Automake and Bison  
**Optional dependencies:** None

## Glibc

**Installation depends on:** Bash, Binutils, Bison, 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 and libsigsegv

## 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:** 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

## lana-Etc

**Installation depends on:** Coreutils, Gawk, and Make

**Test suite depends on:** No test suite available

**Must be installed before:** Perl

**Optional dependencies:** None

## Inetutils

**Installation depends on:** Bash, Binutils, Coreutils, GCC, Glibc, Grep, Make, Ncurses, Patch, Sed, Texinfo, and Zlib

**Test suite depends on:** None

**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, Libcap, Libelf, and Linux API Headers

**Test suite depends on:** No test suite available

**Must be installed before:** None

**Optional dependencies:** Berkeley DB and Iptables

## Kbd

**Installation depends on:** Bash, Binutils, Bison, Check, Coreutils, Flex, GCC, Gettext, Glibc, Gzip, Make, Patch, and Sed

**Test suite depends on:** None

**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:** None

**Must be installed before:** IProute2 and Shadow

**Optional dependencies:** Linux-PAM

## Libelf

**Installation depends on:** Bash, Binutils, Coreutils, GCC, Glibc, and Make  
**Test suite depends on:** None  
**Must be installed before:** IProute2 and 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 Procps-ng  
**Must be installed before:** None  
**Optional dependencies:** None

## Man-DB

**Installation depends on:** Bash, Binutils, Bzip2, Coreutils, Flex, GCC, GDBM, Gettext, Glibc, Grep, Groff, Gzip, Less, Libpipeline, Make, Sed, and Xz

**Test suite depends on:** Util-linux

**Must be installed before:** None

**Optional dependencies:** None

## Man-Pages

**Installation depends on:** Bash, Coreutils, and Make

**Test suite depends on:** No test suite available

**Must be installed before:** None

**Optional dependencies:** None

## 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, Expat, GCC, Gdbm, Gettext, Glibc, Grep, Libffi, Make, Ncurses, Sed, and Util-linux
- 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:** Acl, Attr, Bash, Binutils, Coreutils, Diffutils, Findutils, Gawk, GCC, Gettext, Glibc, Grep, Libcap, Make, and Sed
- Test suite depends on:** No test suite available
- Must be installed before:** Coreutils
- Optional dependencies:** Cracklib and PAM

## Sysklogd

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

## 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

<b>Installation depends on:</b>	Acl, Attr, Bash, Binutils, Bison, Coreutils, GCC, Gettext, Glibc, Grep, Inetutils, Make, Sed, and Texinfo
<b>Test suite depends on:</b>	Autoconf, Diffutils, Findutils, Gawk, and Gzip
<b>Must be installed before:</b>	None
<b>Optional dependencies:</b>	None

## Tcl

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

## Texinfo

<b>Installation depends on:</b>	Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Ncurses, Patch, and Sed
<b>Test suite depends on:</b>	None
<b>Must be installed before:</b>	None
<b>Optional dependencies:</b>	None

## Util-linux

<b>Installation depends on:</b>	Bash, Binutils, Coreutils, Diffutils, Eudev, Findutils, Gawk, GCC, Gettext, Glibc, Grep, Make, Ncurses, Sed, and Zlib
<b>Test suite depends on:</b>	None
<b>Must be installed before:</b>	None
<b>Optional dependencies:</b>	<i>Libcap-ng</i>

## Vim

<b>Installation depends on:</b>	Acl, Attr, Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, Grep, Make, Ncurses, and Sed
<b>Test suite depends on:</b>	None
<b>Must be installed before:</b>	None
<b>Optional dependencies:</b>	Xorg, GTK+2, LessTif, Python, Tcl, Ruby, and GPM

## XML::Parser

<b>Installation depends on:</b>	Bash, Binutils, Coreutils, Expat, GCC, Glibc, Make, and Perl
<b>Test suite depends on:</b>	Perl
<b>Must be installed before:</b>	Intltool
<b>Optional dependencies:</b>	None

## Xz

<b>Installation depends on:</b>	Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, and Make
<b>Test suite depends on:</b>	None
<b>Must be installed before:</b>	Eudev, File, GRUB, Kmod, and Man-DB
<b>Optional dependencies:</b>	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

## Zstd

**Installation depends on:** Binutils, Coreutils, GCC, Glibc, Gzip, Make, and Xz  
**Test suite depends on:** None  
**Must be installed before:** GCC  
**Optional dependencies:** None

# Appendix D. LFS Licenses

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

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

## D.1. Creative Commons License

Creative Commons Legal Code

Attribution-NonCommercial-ShareAlike 2.0



### Important

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

License

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

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

### 1. Definitions

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

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

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

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

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

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

## 5. Representations, Warranties and Disclaimer

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

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



### Important

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

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

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

## D.2. The MIT License

Copyright © 1999-2021 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: 128
- Attr: 127
- Autoconf: 162
- Automake: 163
- Bash: 149
  - tools: 57
- Bash: 149
  - tools: 57
- Bc: 114
- Binutils: 120
  - tools, pass 1: 43
  - tools, pass 2: 70
- Binutils: 120
  - tools, pass 1: 43
  - tools, pass 2: 70
- Binutils: 120
  - tools, pass 1: 43
  - tools, pass 2: 70
- Bison: 147
  - tools: 83
- Bison: 147
  - tools: 83
- Bzip2: 105
- Check: 181
- Coreutils: 175
  - tools: 58
- Coreutils: 175
  - tools: 58
- D-Bus: 215
- DejaGNU: 119
- Diffutils: 182
  - tools: 59
- Diffutils: 182
  - tools: 59
- E2fsprogs: 224
- Expat: 154
- Expect: 118
- File: 110
  - tools: 60
- File: 110
  - tools: 60
- Findutils: 184
  - tools: 61
- Findutils: 184
  - tools: 61
- Flex: 115
- Gawk: 183
  - tools: 62
- Gawk: 183
  - tools: 62
- GCC: 134
  - tools, libstdc++ pass 1: 52
  - tools, libstdc++ pass 2: 80
  - tools, pass 1: 45
  - tools, pass 2: 71
- GCC: 134
  - tools, libstdc++ pass 1: 52
  - tools, libstdc++ pass 2: 80
  - tools, pass 1: 45
  - tools, pass 2: 71
- GCC: 134
  - tools, libstdc++ pass 1: 52
  - tools, libstdc++ pass 2: 80
  - tools, pass 1: 45
  - tools, pass 2: 71
- GCC: 134
  - tools, libstdc++ pass 1: 52
  - tools, libstdc++ pass 2: 80
  - tools, pass 1: 45
  - tools, pass 2: 71
- GCC: 134
  - tools, libstdc++ pass 1: 52
  - tools, libstdc++ pass 2: 80
  - tools, pass 1: 45
  - tools, pass 2: 71
- GCC: 134
  - tools, libstdc++ pass 1: 52
  - tools, libstdc++ pass 2: 80
  - tools, pass 1: 45
  - tools, pass 2: 71
- GDBM: 152
- Gettext: 145
  - tools: 82
- Gettext: 145
  - tools: 82
- Glibc: 97
  - tools: 49
- Glibc: 97
  - tools: 49
- GMP: 123
- Gperf: 153
- Grep: 148
  - tools: 63
- Grep: 148
  - tools: 63

Groff: 185  
 GRUB: 188  
 Gzip: 191  
   tools: 64  
 Gzip: 191  
   tools: 64  
 Iana-Etc: 96  
 Inetutils: 155  
 Intltool: 161  
 IPRoute2: 193  
 Kbd: 195  
 Kmod: 164  
 Less: 190  
 Libcap: 129  
 Libelf: 166  
 libffi: 167  
 Libpipeline: 197  
 Libtool: 151  
 Linux: 250  
   tools, API headers: 48  
 Linux: 250  
   tools, API headers: 48  
 M4: 113  
   tools: 54  
 M4: 113  
   tools: 54  
 Make: 198  
   tools: 65  
 Make: 198  
   tools: 65  
 Man-DB: 200  
 Man-pages: 95  
 Meson: 174  
 MPC: 126  
 MPFR: 125  
 Ncurses: 140  
   tools: 55  
 Ncurses: 140  
   tools: 55  
 Ninja: 172  
 OpenSSL: 168  
 Patch: 199  
   tools: 66  
 Patch: 199  
   tools: 66  
 Perl: 157  
   tools: 84  
 Perl: 157  
   tools: 84  
 Pkgconfig: 139  
 Procps-ng: 217  
 Psmisc: 144  
 Python: 170  
   temporary: 85  
 Python: 170  
   temporary: 85  
 Readline: 111  
 Sed: 143  
   tools: 67  
 Sed: 143  
   tools: 67  
 Shadow: 130  
   configuring: 131  
 Shadow: 130  
   configuring: 131  
 systemd: 209  
 Tar: 203  
   tools: 68  
 Tar: 203  
   tools: 68  
 Tcl: 116  
 Texinfo: 204  
   temporary: 86  
 Texinfo: 204  
   temporary: 86  
 Udev  
   usage: 234  
 Util-linux: 219  
   tools: 87  
 Util-linux: 219  
   tools: 87  
 Vim: 206  
 XML::Parser: 160  
 Xz: 107  
   tools: 69  
 Xz: 107  
   tools: 69  
 Zlib: 104  
 zstd: 109

## Programs

[: 175, 176  
 2to3: 170  
 accessdb: 200, 201

aclocal: 163, 163  
aclocal-1.16: 163, 163  
addftinfo: 185, 185  
addpart: 219, 220  
addr2line: 120, 121  
afmtodit: 185, 185  
agetty: 219, 220  
apropos: 200, 202  
ar: 120, 121  
as: 120, 121  
attr: 127, 127  
autoconf: 162, 162  
autoheader: 162, 162  
autom4te: 162, 162  
automake: 163, 163  
automake-1.16: 163, 163  
autopoint: 145, 145  
autoreconf: 162, 162  
autoscan: 162, 162  
autoupdate: 162, 162  
awk: 183, 183  
b2sum: 175, 177  
badblocks: 224, 225  
base64: 175, 176, 175, 176  
base64: 175, 176, 175, 176  
basename: 175, 177  
basenc: 175, 177  
bash: 149, 150  
bashbug: 149, 150  
bc: 114, 114  
bison: 147, 147  
blkdiscard: 219, 220  
blkid: 219, 220  
blkzone: 219, 220  
blockdev: 219, 220  
bootctl: 209, 212  
bridge: 193, 193  
bunzip2: 105, 106  
busctl: 209, 212  
bzipcat: 105, 106  
bzcmp: 105, 106  
bzdiff: 105, 106  
bzegrep: 105, 106  
bzfgrep: 105, 106  
bzgrep: 105, 106  
bzip2: 105, 106  
bzip2recover: 105, 106  
bzless: 105, 106  
bzmore: 105, 106  
c++: 134, 137  
c++filt: 120, 122  
cal: 219, 220  
capsh: 129, 129  
captain: 140, 142  
cat: 175, 177  
catchsegv: 97, 102  
catman: 200, 202  
cc: 134, 137  
cfdisk: 219, 220  
chacl: 128, 128  
chage: 130, 132  
chattr: 224, 225  
chcon: 175, 177  
chcpu: 219, 220  
checkmk: 181, 181  
chem: 185, 185  
chfn: 130, 132  
chgpasswd: 130, 132  
chgrp: 175, 177  
chmem: 219, 220  
chmod: 175, 177  
choom: 219, 220  
chown: 175, 177  
chpasswd: 130, 132  
chroot: 175, 177  
chrt: 219, 220  
chsh: 130, 132  
chvt: 195, 196  
cksum: 175, 177  
clear: 140, 142  
cmp: 182, 182  
col: 219, 220  
colcrt: 219, 220  
colrm: 219, 220  
column: 219, 220  
comm: 175, 177  
compile\_et: 224, 225  
coredumpctl: 209, 212  
corelist: 157, 158  
cp: 175, 177  
cpan: 157, 158  
cpp: 134, 137  
csplit: 175, 177  
ctrlaltdel: 219, 220

ctstat: 193, 193  
 cut: 175, 177  
 c\_rehash: 168, 168  
 date: 175, 177  
 dbus-cleanup-sockets: 215, 216  
 dbus-daemon: 215, 216  
 dbus-launch: 215, 216  
 dbus-monitor: 215, 216  
 dbus-run-session: 215, 216  
 dbus-send: 215, 216  
 dbus-test-tool: 215, 216  
 dbus-update-activation-environment: 215, 216  
 dbus-uuidgen: 215, 216  
 dc: 114, 114  
 dd: 175, 177  
 deallocvt: 195, 196  
 debugfs: 224, 225  
 delpart: 219, 220  
 depmod: 164, 164  
 df: 175, 177  
 diff: 182, 182  
 diff3: 182, 182  
 dir: 175, 177  
 dircolors: 175, 177  
 dirname: 175, 177  
 dmesg: 219, 220  
 dnsdomainname: 155, 156  
 du: 175, 177  
 dumpe2fs: 224, 225  
 dumpkeys: 195, 196  
 e2freefrag: 224, 225  
 e2fsck: 224, 225  
 e2image: 224, 225  
 e2label: 224, 225  
 e2mmpstatus: 224, 225  
 e2scrub: 224, 225  
 e2scrub\_all: 224, 225  
 e2undo: 224, 225  
 e4crypt: 224, 225  
 e4defrag: 224, 225  
 echo: 175, 177  
 egrep: 148, 148  
 eject: 219, 220  
 elfedit: 120, 122  
 enc2xs: 157, 158  
 encguess: 157, 158  
 env: 175, 177  
 envsubst: 145, 145  
 eqn: 185, 185  
 eqn2graph: 185, 185  
 ex: 206, 208  
 expand: 175, 177  
 expect: 118, 118  
 expiry: 130, 132  
 expr: 175, 177  
 factor: 175, 177  
 faillog: 130, 132  
 fallocate: 219, 220  
 false: 175, 177  
 fdformat: 219, 220  
 fdisk: 219, 221  
 fgconsole: 195, 196  
 fgrep: 148, 148  
 file: 110, 110  
 filefrag: 224, 226  
 findcore: 219, 221  
 find: 184, 184  
 findfs: 219, 221  
 findmnt: 219, 221  
 flex: 115, 115  
 flex++: 115, 115  
 flock: 219, 221  
 fmt: 175, 177  
 fold: 175, 177  
 free: 217, 218  
 fsck: 219, 221  
 fsck.cramfs: 219, 221  
 fsck.ext2: 224, 226  
 fsck.ext3: 224, 226  
 fsck.ext4: 224, 226  
 fsck.minix: 219, 221  
 fsfreeze: 219, 221  
 fstrim: 219, 221  
 ftp: 155, 156  
 fuser: 144, 144  
 g++: 134, 137  
 gawk: 183, 183  
 gawk-5.1.0: 183, 183  
 gcc: 134, 137  
 gc-ar: 134, 137  
 gc-nm: 134, 137  
 gc-ranlib: 134, 138  
 gcov: 134, 138  
 gcov-dump: 134, 138

gcov-tool: 134, 138  
 gdbmtool: 152, 152  
 gdbm\_dump: 152, 152  
 gdbm\_load: 152, 152  
 gdiffmk: 185, 185  
 gencat: 97, 102  
 genl: 193, 193  
 getcap: 129, 129  
 getconf: 97, 102  
 getent: 97, 102  
 getfacl: 128, 128  
 getfattr: 127, 127  
 getkeycodes: 195, 196  
 getopt: 219, 221  
 getpcaps: 129, 129  
 gettext: 145, 145  
 gettext.sh: 145, 145  
 gettextize: 145, 145  
 glilypond: 185, 185  
 gpasswd: 130, 132  
 gperf: 153, 153  
 gperl: 185, 185  
 gpinyin: 185, 185  
 gprof: 120, 122  
 grap2graph: 185, 186  
 grep: 148, 148  
 gm: 185, 186  
 grodvi: 185, 186  
 groff: 185, 186  
 groffer: 185, 186  
 grog: 185, 186  
 grolbp: 185, 186  
 grolj4: 185, 186  
 gropdf: 185, 186  
 grops: 185, 186  
 grotty: 185, 186  
 groupadd: 130, 132  
 groupdel: 130, 132  
 groupmems: 130, 132  
 groupmod: 130, 132  
 groups: 175, 177  
 grpck: 130, 132  
 grpconv: 130, 132  
 grpunconv: 130, 132  
 grub-bios-setup: 188, 188  
 grub-editenv: 188, 189  
 grub-file: 188, 189  
 grub-fstest: 188, 189  
 grub-glue-efi: 188, 189  
 grub-install: 188, 189  
 grub-kbdcomp: 188, 189  
 grub-macbless: 188, 189  
 grub-menulst2cfg: 188, 189  
 grub-mkconfig: 188, 189  
 grub-mkimage: 188, 189  
 grub-mklayout: 188, 189  
 grub-mknetdir: 188, 189  
 grub-mkpasswd-pbkdf2: 188, 189  
 grub-mkrelpath: 188, 189  
 grub-mkrescue: 188, 189  
 grub-mkstandalone: 188, 189  
 grub-ofpathname: 188, 189  
 grub-probe: 188, 189  
 grub-reboot: 188, 189  
 grub-render-label: 188, 189  
 grub-script-check: 188, 189  
 grub-set-default: 188, 189  
 grub-setup: 188, 189  
 grub-syslinux2cfg: 188, 189  
 gunzip: 191, 191  
 gzexe: 191, 191  
 gzip: 191, 191  
 h2ph: 157, 158  
 h2xs: 157, 158  
 halt: 209, 212  
 head: 175, 177  
 hexdump: 219, 221  
 hostid: 175, 177  
 hostname: 155, 156  
 hostnamectl: 209, 212  
 hpftodit: 185, 186  
 hwclock: 219, 221  
 i386: 219, 221  
 iconv: 97, 102  
 iconvconfig: 97, 102  
 id: 175, 178  
 idle3: 170  
 ifcfg: 193, 193  
 ifconfig: 155, 156  
 ifnames: 162, 162  
 ifstat: 193, 193  
 indxbib: 185, 186  
 info: 204, 205  
 infocmp: 140, 142

infotocap: 140, 142  
 init: 209, 212  
 insmod: 164, 165  
 install: 175, 178  
 install-info: 204, 205  
 instmodsh: 157, 158  
 intltool-extract: 161, 161  
 intltool-merge: 161, 161  
 intltool-prepare: 161, 161  
 intltool-update: 161, 161  
 intltoolize: 161, 161  
 ionice: 219, 221  
 ip: 193, 193  
 ipcmk: 219, 221  
 ipcrm: 219, 221  
 ipcs: 219, 221  
 isosize: 219, 221  
 join: 175, 178  
 journalctl: 209, 212  
 json\_pp: 157, 158  
 kbdfinfo: 195, 196  
 kbdrate: 195, 196  
 kbd\_mode: 195, 196  
 kernel-install: 209, 212  
 kill: 219, 221  
 killall: 144, 144  
 kmod: 164, 165  
 last: 219, 221  
 lastb: 219, 221  
 lastlog: 130, 132  
 ld: 120, 122  
 ld.bfd: 120, 122  
 ld.gold: 120, 122  
 ldattach: 219, 221  
 ldconfig: 97, 102  
 ldd: 97, 102  
 lddlibc4: 97, 102  
 less: 190, 190  
 lessecho: 190, 190  
 lesskey: 190, 190  
 lex: 115, 115  
 lexgrog: 200, 202  
 lfskernel-5.10.17: 250, 254  
 libasan: 134, 138  
 libatomic: 134, 138  
 libcc1: 134, 138  
 libnetcfg: 157, 158  
 libtool: 151, 151  
 libtoolize: 151, 151  
 link: 175, 178  
 linux32: 219, 221  
 linux64: 219, 221  
 lkbib: 185, 186  
 ln: 175, 178  
 lnstat: 193, 194  
 loadkeys: 195, 196  
 loadunimap: 195, 196  
 locale: 97, 102  
 localectl: 209, 212  
 localedef: 97, 102  
 locate: 184, 184  
 logger: 219, 221  
 login: 130, 132  
 loginctl: 209, 212  
 logname: 175, 178  
 logoutd: 130, 132  
 logsave: 224, 226  
 look: 219, 221  
 lookbib: 185, 186  
 losetup: 219, 221  
 ls: 175, 178  
 lsattr: 224, 226  
 lsblk: 219, 221  
 lscpu: 219, 221  
 lspic: 219, 221  
 lslocks: 219, 221  
 lslogins: 219, 221  
 lsmem: 219, 221  
 lsmod: 164, 165  
 lsns: 219, 221  
 lzcat: 107, 107  
 lzcmp: 107, 107  
 lzdiff: 107, 107  
 lzegrep: 107, 107  
 lzfgrep: 107, 107  
 lzgrep: 107, 107  
 lzless: 107, 108  
 lzma: 107, 108  
 lzmadec: 107, 108  
 lzmainfo: 107, 108  
 lzmore: 107, 108  
 m4: 113, 113  
 machinectl: 209, 212  
 make: 198, 198

makedb: 97, 102  
 makeinfo: 204, 205  
 man: 200, 202  
 mandb: 200, 202  
 manpath: 200, 202  
 mapscrn: 195, 196  
 mcookie: 219, 222  
 md5sum: 175, 178  
 mesg: 219, 222  
 meson: 174, 174  
 mkdir: 175, 178  
 mke2fs: 224, 226  
 mkfifo: 175, 178  
 mkfs: 219, 222  
 mkfs.bfs: 219, 222  
 mkfs.cramfs: 219, 222  
 mkfs.ext2: 224, 226  
 mkfs.ext3: 224, 226  
 mkfs.ext4: 224, 226  
 mkfs.minix: 219, 222  
 mklost+found: 224, 226  
 mknod: 175, 178  
 mkswap: 219, 222  
 mktemp: 175, 178  
 mk\_cmds: 224, 226  
 mmroff: 185, 186  
 modinfo: 164, 165  
 modprobe: 164, 165  
 more: 219, 222  
 mount: 219, 222  
 mountpoint: 219, 222  
 msgattrib: 145, 145  
 msgcat: 145, 146  
 msgcmp: 145, 146  
 msgcomm: 145, 146  
 msgconv: 145, 146  
 msgen: 145, 146  
 msgexec: 145, 146  
 msgfilter: 145, 146  
 msgfmt: 145, 146  
 msggrep: 145, 146  
 msginit: 145, 146  
 msgmerge: 145, 146  
 msgunfmt: 145, 146  
 msguniq: 145, 146  
 mtrace: 97, 102  
 mv: 175, 178  
 namei: 219, 222  
 ncursesw6-config: 140, 142  
 neqn: 185, 186  
 networkctl: 209, 212  
 newgidmap: 130, 132  
 newgrp: 130, 132  
 newuidmap: 130, 132  
 newusers: 130, 132  
 ngettext: 145, 146  
 nice: 175, 178  
 ninja: 172, 173  
 nl: 175, 178  
 nm: 120, 122  
 nohup: 175, 178  
 nologin: 130, 132  
 nproc: 175, 178  
 nroff: 185, 186  
 nscd: 97, 102  
 nsenter: 219, 222  
 nstat: 193, 194  
 numfmt: 175, 178  
 objcopy: 120, 122  
 objdump: 120, 122  
 od: 175, 178  
 openssl: 168, 168  
 openvt: 195, 196  
 partx: 219, 222  
 passwd: 130, 133  
 paste: 175, 178  
 patch: 199, 199  
 pathchk: 175, 178  
 pcprofiledump: 97, 103  
 pdfmom: 185, 186  
 pdfroff: 185, 186  
 pdftexi2dvi: 204, 205  
 peekfd: 144, 144  
 perl: 157, 158  
 perl5.32.1: 157, 158  
 perlbug: 157, 158  
 perldoc: 157, 158  
 perlivp: 157, 158  
 perlthanks: 157, 159  
 pfbtops: 185, 186  
 pgrep: 217, 218  
 pic: 185, 186  
 pic2graph: 185, 186  
 piconv: 157, 159

pidof: 217, 218  
 ping: 155, 156  
 ping6: 155, 156  
 pinky: 175, 178  
 pip3: 170  
 pivot\_root: 219, 222  
 pkg-config: 139, 139  
 pkill: 217, 218  
 pl2pm: 157, 159  
 pldd: 97, 103  
 pmap: 217, 218  
 pod2html: 157, 159  
 pod2man: 157, 159  
 pod2texi: 204, 205  
 pod2text: 157, 159  
 pod2usage: 157, 159  
 podchecker: 157, 159  
 podselect: 157, 159  
 portablectl: 209, 212  
 post-grohtml: 185, 186  
 poweroff: 209, 213  
 pr: 175, 178  
 pre-grohtml: 185, 186  
 preconv: 185, 186  
 printenv: 175, 178  
 printf: 175, 178  
 prlimit: 219, 222  
 prove: 157, 159  
 prtstat: 144, 144  
 ps: 217, 218  
 psfaddtable: 195, 196  
 psfgettable: 195, 196  
 psfstriutable: 195, 196  
 psfxtable: 195, 196  
 pslog: 144, 144  
 pstree: 144, 144  
 pstree.x11: 144, 144  
 ptar: 157, 159  
 ptardiff: 157, 159  
 ptargrep: 157, 159  
 ptx: 175, 178  
 pwait: 217, 218  
 pwck: 130, 133  
 pwconv: 130, 133  
 pwd: 175, 178  
 pwdx: 217, 218  
 pwunconv: 130, 133  
 pydoc3: 170  
 python3: 170  
 ranlib: 120, 122  
 raw: 219, 222  
 readelf: 120, 122  
 readlink: 175, 178  
 readprofile: 219, 222  
 realpath: 175, 178  
 reboot: 209, 213  
 recode-sr-latin: 145, 146  
 refer: 185, 186  
 rename: 219, 222  
 renice: 219, 222  
 reset: 140, 142  
 resize2fs: 224, 226  
 resizepart: 219, 222  
 resolvconf: 209, 213  
 resolvectl: 209, 213  
 rev: 219, 222  
 rkfill: 219, 222  
 rm: 175, 178  
 rmdir: 175, 178  
 rmmod: 164, 165  
 roff2dvi: 185, 186  
 roff2html: 185, 187  
 roff2pdf: 185, 187  
 roff2ps: 185, 187  
 roff2text: 185, 187  
 roff2x: 185, 187  
 routef: 193, 194  
 routel: 193, 194  
 rtacct: 193, 194  
 rtcwake: 219, 222  
 rtmon: 193, 194  
 rtp: 193, 194  
 rtstat: 193, 194  
 runcon: 175, 178  
 runlevel: 209, 213  
 runttest: 119, 119  
 rview: 206, 208  
 rvim: 206, 208  
 script: 219, 222  
 scriptreplay: 219, 222  
 sdiff: 182, 182  
 sed: 143, 143  
 seq: 175, 178  
 setarch: 219, 222

setcap: 129, 129  
 setfacl: 128, 128  
 setfattr: 127, 127  
 setfont: 195, 196  
 setkeycodes: 195, 196  
 setleds: 195, 196  
 setmetamode: 195, 196  
 setsid: 219, 222  
 setterm: 219, 222  
 setvtrgb: 195, 196  
 sfdisk: 219, 222  
 sg: 130, 133  
 sh: 149, 150  
 sha1sum: 175, 178  
 sha224sum: 175, 178  
 sha256sum: 175, 179  
 sha384sum: 175, 179  
 sha512sum: 175, 179  
 shasum: 157, 159  
 showconsolefont: 195, 196  
 showkey: 195, 196  
 shred: 175, 179  
 shuf: 175, 179  
 shutdown: 209, 213  
 size: 120, 122  
 slabtop: 217, 218  
 sleep: 175, 179  
 sln: 97, 103  
 soelim: 185, 187  
 sort: 175, 179  
 sotruss: 97, 103  
 splain: 157, 159  
 split: 175, 179  
 sprof: 97, 103  
 ss: 193, 194  
 stat: 175, 179  
 stdbuf: 175, 179  
 strings: 120, 122  
 strip: 120, 122  
 stty: 175, 179  
 su: 130, 133  
 sulogin: 219, 222  
 sum: 175, 179  
 swapon: 219, 222  
 swaponoff: 219, 222  
 swapon: 219, 222  
 switch\_root: 219, 222  
 sync: 175, 179  
 sysctl: 217, 218  
 systemctl: 209, 213  
 systemd-analyze: 209, 213  
 systemd-ask-password: 209, 213  
 systemd-cat: 209, 213  
 systemd-cgls: 209, 213  
 systemd-cgtop: 209, 213  
 systemd-delta: 209, 213  
 systemd-detect-virt: 209, 213  
 systemd-dissect: 209, 213  
 systemd-escape: 209, 213  
 systemd-hwdb: 209, 213  
 systemd-id128: 209, 213  
 systemd-inhibit: 209, 213  
 systemd-machine-id-setup: 209, 213  
 systemd-mount: 209, 213  
 systemd-notify: 209, 213  
 systemd-nspawn: 209, 213  
 systemd-path: 209, 214  
 systemd-repart: 209, 214  
 systemd-resolve: 209, 214  
 systemd-run: 209, 214  
 systemd-socket-activate: 209, 214  
 systemd-tmpfiles: 209, 214  
 systemd-tty-ask-password-agent: 209, 214  
 systemd-umount: 209, 214  
 tabs: 140, 142  
 tac: 175, 179  
 tail: 175, 179  
 tailf: 219, 222  
 talk: 155, 156  
 tar: 203, 203  
 taskset: 219, 223  
 tbl: 185, 187  
 tc: 193, 194  
 tclsh: 116, 117  
 tclsh8.6: 116, 117  
 tee: 175, 179  
 telinit: 209, 214  
 telnet: 155, 156  
 test: 175, 179  
 texi2dvi: 204, 205  
 texi2pdf: 204, 205  
 texi2any: 204, 205  
 texindex: 204, 205  
 tfmtodit: 185, 187

tftp: 155, 156  
 tic: 140, 142  
 timedatectl: 209, 214  
 timeout: 175, 179  
 tload: 217, 218  
 toe: 140, 142  
 top: 217, 218  
 touch: 175, 179  
 tput: 140, 142  
 tr: 175, 179  
 traceroute: 155, 156  
 troff: 185, 187  
 true: 175, 179  
 truncate: 175, 179  
 tset: 140, 142  
 tsort: 175, 179  
 tty: 175, 179  
 tune2fs: 224, 226  
 tzselect: 97, 103  
 udevadm: 209, 214  
 ul: 219, 223  
 umount: 219, 223  
 uname: 175, 179  
 uname26: 219, 223  
 uncompress: 191, 191  
 unexpand: 175, 179  
 unicode\_start: 195, 196  
 unicode\_stop: 195, 196  
 uniq: 175, 179  
 unlink: 175, 179  
 unlzma: 107, 108  
 unshare: 219, 223  
 unxz: 107, 108  
 updatedb: 184, 184  
 uptime: 217, 218  
 useradd: 130, 133  
 userdel: 130, 133  
 usermod: 130, 133  
 users: 175, 179  
 utmpdump: 219, 223  
 uuuid: 219, 223  
 uuidgen: 219, 223  
 uuidparse: 219, 223  
 vdir: 175, 179  
 vi: 206, 208  
 view: 206, 208  
 vigr: 130, 133  
 vim: 206, 208  
 vimdiff: 206, 208  
 vimtutor: 206, 208  
 vipw: 130, 133  
 vmstat: 217, 218  
 w: 217, 218  
 wall: 219, 223  
 watch: 217, 218  
 wc: 175, 179  
 wdctl: 219, 223  
 whatis: 200, 202  
 whereis: 219, 223  
 who: 175, 179  
 whoami: 175, 179  
 wipefs: 219, 223  
 x86\_64: 219, 223  
 xargs: 184, 184  
 xgettext: 145, 146  
 xmlwf: 154, 154  
 xsubpp: 157, 159  
 xtrace: 97, 103  
 xxd: 206, 208  
 xz: 107, 108  
 xzcat: 107, 108  
 xzcmp: 107, 108  
 xzdec: 107, 108  
 xzdiff: 107, 108  
 xzegrep: 107, 108  
 xzfgrep: 107, 108  
 xzgrep: 107, 108  
 xzless: 107, 108  
 xzmore: 107, 108  
 yacc: 147, 147  
 yes: 175, 179  
 zcat: 191, 191  
 zcmp: 191, 191  
 zdiff: 191, 191  
 zdump: 97, 103  
 zegrep: 191, 191  
 zfgrep: 191, 191  
 zforce: 191, 191  
 zgrep: 191, 191  
 zic: 97, 103  
 zipdetails: 157, 159  
 zless: 191, 191  
 zmore: 191, 192  
 znew: 191, 192

zramctl: 219, 223  
 zstd: 109, 109  
 zstdgrep: 109, 109  
 zstdless: 109, 109

## Libraries

Expat: 160, 160  
 ld-2.33.so: 97, 103  
 libacl: 128, 128  
 libanl: 97, 103  
 libasprintf: 145, 146  
 libattr: 127, 127  
 libbfd: 120, 122  
 libblkid: 219, 223  
 libBrokenLocale: 97, 103  
 libbz2: 105, 106  
 libc: 97, 103  
 libcap: 129, 129  
 libcheck: 181, 181  
 libcom\_err: 224, 226  
 libcrypt: 97, 103  
 libcrypto.so: 168, 169  
 libctf: 120, 122  
 libctf-nobfd: 120, 122  
 libcursesw: 140, 142  
 libdbus-1: 215, 216  
 libdl: 97, 103  
 libe2p: 224, 226  
 libelf: 166, 166  
 libexpat: 154, 154  
 libexpect-5.45: 118, 118  
 libext2fs: 224, 226  
 libfdisk: 219, 223  
 libffi: 167  
 libfl: 115, 115  
 libformw: 140, 142  
 libg: 97, 103  
 libgcc: 134, 138  
 libgcov: 134, 138  
 libgdbm: 152, 152  
 libgdbm\_compat: 152, 152  
 libgettextlib: 145, 146  
 libgettextpo: 145, 146  
 libgettextsrc: 145, 146  
 libgmp: 123, 124  
 libgmpxx: 123, 124  
 libgomp: 134, 138  
 libhistory: 111, 112  
 libkmod: 164  
 liblsan: 134, 138  
 libltdl: 151, 151  
 liblto\_plugin: 134, 138  
 liblzma: 107, 108  
 libm: 97, 103  
 libmagic: 110, 110  
 libman: 200, 202  
 libmandb: 200, 202  
 libmcheck: 97, 103  
 libmemusage: 97, 103  
 libmenuw: 140, 142  
 libmount: 219, 223  
 libmpc: 126, 126  
 libmpfr: 125, 125  
 libncursesw: 140, 142  
 libnsl: 97, 103  
 libnss: 97, 103  
 libopcodes: 120, 122  
 libpanelw: 140, 142  
 libpcprofile: 97, 103  
 libpipeline: 197  
 libprocps: 217, 218  
 libpsx: 129, 129  
 libpthread: 97, 103  
 libquadmath: 134, 138  
 libreadline: 111, 112  
 libresolv: 97, 103  
 librt: 97, 103  
 libSegFault: 97, 103  
 libsmartcols: 219, 223  
 libss: 224, 226  
 libssl.so: 168, 169  
 libssp: 134, 138  
 libstdbuf: 175, 180  
 libstdc++: 134, 138  
 libstdc++fs: 134, 138  
 libsupc++: 134, 138  
 libsystemd: 209, 214  
 libtcl8.6.so: 116, 117  
 libtclstub8.6.a: 116, 117  
 libtextstyle: 145, 146  
 libthread\_db: 97, 103  
 libtsan: 134, 138  
 libubsan: 134, 138  
 libudev: 209, 214

libutil: 97, 103  
 libuuid: 219, 223  
 liby: 147, 147  
 libz: 104, 104  
 libzstd: 109, 109  
 preloadable\_libintl: 145, 146

## Scripts

clock  
   configuring: 238  
 console  
   configuring: 239  
 hostname  
   configuring: 233  
 localnet  
   /etc/hosts: 233  
 network  
   /etc/hosts: 233  
   configuring: 230  
 network  
   /etc/hosts: 233  
   configuring: 230  
 dwp: 120, 122

/usr/include/asm/\*.h: 48, 48  
 /usr/include/drm/\*.h: 48, 48  
 /usr/include/linux/\*.h: 48, 48  
 /usr/include/misc/\*.h: 48, 48  
 /usr/include/mtd/\*.h: 48, 48  
 /usr/include/rdma/\*.h: 48, 48  
 /usr/include/scsi/\*.h: 48, 48  
 /usr/include/sound/\*.h: 48, 48  
 /usr/include/video/\*.h: 48, 48  
 /usr/include/xen/\*.h: 48, 48  
 /var/log/btmp: 76  
 /var/log/lastlog: 76  
 /var/log/wtmp: 76  
 /etc/locale.conf: 240  
 /etc/shells: 244  
 man pages: 95, 95  
 Systemd Customization: 244

## Others

/boot/config-5.10.17: 250, 254  
 /boot/System.map-5.10.17: 250, 254  
 /dev/\*: 73  
 /etc/fstab: 248  
 /etc/group: 76  
 /etc/hosts: 233  
 /etc/inputrc: 242  
 /etc/ld.so.conf: 101  
 /etc/lfs-release: 257  
 /etc/localtime: 100  
 /etc/lsb-release: 257  
 /etc/modprobe.d/usb.conf: 253  
 /etc/nsswitch.conf: 100  
 /etc/os-release: 257  
 /etc/passwd: 76  
 /etc/protocols: 96  
 /etc/resolv.conf: 232  
 /etc/services: 96  
 /etc/vimrc: 207  
 /run/utmp: 76  
 /usr/include/asm-generic/\*.h: 48, 48