

Linux From Scratch

Version 11.3

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**Created by Gerard Beekmans
Managing Editor: Bruce Dubbs**

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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 and Security Advisories	xix
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	18
2.7. Mounting the New Partition	18
3. Packages and Patches	20
3.1. Introduction	20
3.2. All Packages	21
3.3. Needed Patches	29
4. Final Preparations	31
4.1. Introduction	31
4.2. Creating a Limited Directory Layout in the LFS Filesystem	31
4.3. Adding the LFS User	31
4.4. Setting Up the Environment	32
4.5. About SBUs	34
4.6. About the Test Suites	35
III. Building the LFS Cross Toolchain and Temporary Tools	36
Important Preliminary Material	xxxvii
i. Introduction	xxxvii
ii. Toolchain Technical Notes	xxxvii
iii. General Compilation Instructions	xlii
5. Compiling a Cross-Toolchain	43
5.1. Introduction	43
5.2. Binutils-2.40 - Pass 1	44

5.3. GCC-12.2.0 - Pass 1	46
5.4. Linux-6.1.11 API Headers	49
5.5. Glibc-2.37	50
5.6. Libstdc++ from GCC-12.2.0	53
6. Cross Compiling Temporary Tools	55
6.1. Introduction	55
6.2. M4-1.4.19	56
6.3. Ncurses-6.4	57
6.4. Bash-5.2.15	59
6.5. Coreutils-9.1	60
6.6. Diffutils-3.9	61
6.7. File-5.44	62
6.8. Findutils-4.9.0	63
6.9. Gawk-5.2.1	64
6.10. Grep-3.8	65
6.11. Gzip-1.12	66
6.12. Make-4.4	67
6.13. Patch-2.7.6	68
6.14. Sed-4.9	69
6.15. Tar-1.34	70
6.16. Xz-5.4.1	71
6.17. Binutils-2.40 - Pass 2	72
6.18. GCC-12.2.0 - Pass 2	73
7. Entering Chroot and Building Additional Temporary Tools	75
7.1. Introduction	75
7.2. Changing Ownership	75
7.3. Preparing Virtual Kernel File Systems	75
7.4. Entering the Chroot Environment	76
7.5. Creating Directories	77
7.6. Creating Essential Files and Symlinks	78
7.7. Gettext-0.21.1	81
7.8. Bison-3.8.2	82
7.9. Perl-5.36.0	83
7.10. Python-3.11.2	84
7.11. Texinfo-7.0.2	85
7.12. Util-linux-2.38.1	86
7.13. Cleaning up and Saving the Temporary System	87
IV. Building the LFS System	89
8. Installing Basic System Software	90
8.1. Introduction	90
8.2. Package Management	91
8.3. Man-pages-6.03	95
8.4. Iana-Etc-20230202	96
8.5. Glibc-2.37	97
8.6. Zlib-1.2.13	104
8.7. Bzip2-1.0.8	105
8.8. Xz-5.4.1	107

8.9. Zstd-1.5.4	109
8.10. File-5.44	110
8.11. Readline-8.2	111
8.12. M4-1.4.19	113
8.13. Bc-6.2.4	114
8.14. Flex-2.6.4	115
8.15. Tcl-8.6.13	116
8.16. Expect-5.45.4	118
8.17. DejaGNU-1.6.3	119
8.18. Binutils-2.40	120
8.19. GMP-6.2.1	123
8.20. MPFR-4.2.0	125
8.21. MPC-1.3.1	126
8.22. Attr-2.5.1	127
8.23. Acl-2.3.1	128
8.24. Libcap-2.67	129
8.25. Shadow-4.13	130
8.26. GCC-12.2.0	134
8.27. Pkg-config-0.29.2	139
8.28. Ncurses-6.4	140
8.29. Sed-4.9	143
8.30. Psmisc-23.6	144
8.31. Gettext-0.21.1	145
8.32. Bison-3.8.2	147
8.33. Grep-3.8	148
8.34. Bash-5.2.15	149
8.35. Libtool-2.4.7	151
8.36. GDBM-1.23	152
8.37. Gperf-3.1	153
8.38. Expat-2.5.0	154
8.39. Inetutils-2.4	155
8.40. Less-608	157
8.41. Perl-5.36.0	158
8.42. XML::Parser-2.46	161
8.43. Intltool-0.51.0	162
8.44. Autoconf-2.71	163
8.45. Automake-1.16.5	165
8.46. OpenSSL-3.0.8	166
8.47. Kmod-30	168
8.48. Libelf from Elfutils-0.188	170
8.49. Libffi-3.4.4	171
8.50. Python-3.11.2	172
8.51. Wheel-0.38.4	175
8.52. Ninja-1.11.1	176
8.53. Meson-1.0.0	178
8.54. Coreutils-9.1	179
8.55. Check-0.15.2	184

8.56. Diffutils-3.9	185
8.57. Gawk-5.2.1	186
8.58. Findutils-4.9.0	187
8.59. Groff-1.22.4	188
8.60. GRUB-2.06	191
8.61. Gzip-1.12	193
8.62. IPRoute2-6.1.0	194
8.63. Kbd-2.5.1	196
8.64. Libpipeline-1.5.7	198
8.65. Make-4.4	199
8.66. Patch-2.7.6	200
8.67. Tar-1.34	201
8.68. Texinfo-7.0.2	202
8.69. Vim-9.0.1273	204
8.70. Eudev-3.2.11	207
8.71. Man-DB-2.11.2	209
8.72. Procps-ng-4.0.2	212
8.73. Util-linux-2.38.1	214
8.74. E2fsprogs-1.47.0	219
8.75. Sysklogd-1.5.1	222
8.76. Sysvinit-3.06	223
8.77. About Debugging Symbols	224
8.78. Stripping	224
8.79. Cleaning Up	226
9. System Configuration	227
9.1. Introduction	227
9.2. LFS-Bootscripts-20230101	228
9.3. Overview of Device and Module Handling	230
9.4. Managing Devices	233
9.5. General Network Configuration	235
9.6. System V Bootscript Usage and Configuration	238
9.7. The Bash Shell Startup Files	246
9.8. Creating the /etc/inputrc File	248
9.9. Creating the /etc/shells File	249
10. Making the LFS System Bootable	251
10.1. Introduction	251
10.2. Creating the /etc/fstab File	251
10.3. Linux-6.1.11	253
10.4. Using GRUB to Set Up the Boot Process	258
11. The End	261
11.1. The End	261
11.2. Get Counted	261
11.3. Rebooting the System	261
11.4. Additional Resources	262
11.5. Getting Started After LFS	263
V. Appendices	266
A. Acronyms and Terms	267

B. Acknowledgments	270
C. Dependencies	273
D. Boot and sysconfig scripts version-20230101	287
D.1. /etc/rc.d/init.d/rc	287
D.2. /lib/lsb/init-functions	290
D.3. /etc/rc.d/init.d/mountvirtfs	303
D.4. /etc/rc.d/init.d/modules	305
D.5. /etc/rc.d/init.d/udev	306
D.6. /etc/rc.d/init.d/swap	307
D.7. /etc/rc.d/init.d/setclock	308
D.8. /etc/rc.d/init.d/checkfs	309
D.9. /etc/rc.d/init.d/mountfs	312
D.10. /etc/rc.d/init.d/udev_retry	313
D.11. /etc/rc.d/init.d/cleanfs	314
D.12. /etc/rc.d/init.d/console	316
D.13. /etc/rc.d/init.d/localnet	318
D.14. /etc/rc.d/init.d/sysctl	319
D.15. /etc/rc.d/init.d/sysklogd	320
D.16. /etc/rc.d/init.d/network	322
D.17. /etc/rc.d/init.d/sendsignals	323
D.18. /etc/rc.d/init.d/reboot	324
D.19. /etc/rc.d/init.d/halt	325
D.20. /etc/rc.d/init.d/template	326
D.21. /etc/sysconfig/modules	327
D.22. /etc/sysconfig/createfiles	327
D.23. /etc/sysconfig/udev-retry	328
D.24. /sbin/ifup	328
D.25. /sbin/ifdown	331
D.26. /lib/services/ipv4-static	332
D.27. /lib/services/ipv4-static-route	334
E. Udev configuration rules	336
E.1. 55-lfs.rules	336
F. LFS Licenses	337
F.1. Creative Commons License	337
F.2. The MIT License	341
Index	342

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.

--
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Audience

There are many reasons why you would want to read this book. One of the questions many people raise is, “why go through all the hassle of manually building a Linux system from scratch when you can just download and install an existing one?”

One important reason for this project's existence is to help you learn how a Linux system works from the inside out. Building an LFS system helps demonstrate what makes Linux tick, and how things work together and depend on each other. One of the best things 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 gives you control of the system without relying on someone else's Linux implementation. With LFS, you are in the driver's seat. *You* dictate every aspect of your system.

LFS allows you to create very compact Linux systems. With other distributions you are often forced to install a great many programs you neither use nor understand. These programs waste resources. You may argue that with today's hard drives and CPUs, wasted resources are no longer a consideration. Sometimes, however, you are still constrained by the system's size, 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 you want. You don't have 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 good reasons to build your own LFS system to list them all here. In the end, education is by far the most important reason. As you continue your LFS experience, you will discover the power that information and knowledge can 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 alternative 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 some other distribution that targets that architecture. (Note that a 32-bit distribution can be installed and used as a host system on a 64-bit AMD/Intel computer.)

The gain from building on a 64-bit system, as 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 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 good enough. On the other hand, several packages in BLFS now need more than 4 GB of RAM to be built and/or to run; if you plan to use LFS as a desktop, the LFS authors recommend building a 64-bit system.

The default 64-bit build that results from LFS is 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 minimal instructions needed for a basic Linux system. Some of the LFS/BLFS editors maintain a multilib fork of LFS, accessible at <https://www.linuxfromscratch.org/~thomas/multilib/index.html>. But that's 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 know how 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 know how to use and install Linux software.

Because the LFS book assumes *at least* this basic level of skill, the various LFS support forums are unlikely 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 urge you to read these articles:

- Software-Building-HOWTO <https://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 used to build and install software.

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

This guide provides a good summary of the 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 specifications: Core, Desktop, Runtime Languages, and Imaging. Some parts of Core and Desktop specifications are architecture specific. There are also two optional specifications: Gtk3 and Graphics. LFS attempts to conform to the LSB specifications for the IA32 (32-bit x86) or AMD64 (x86_64) architectures discussed in the previous section.



Note

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

While it is possible to create a complete system that will pass the LSB certification tests "from scratch", this can't be done without many additional packages that are beyond the scope of the LFS book. Installation instructions for these additional packages can be found 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

<i>LSB Desktop:</i>	None
<i>LSB Runtime Languages:</i>	Perl, Python
<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>	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

The goal of LFS is to build a complete and usable foundation-level system—including all the packages needed to replicate itself—and providing a relatively minimal base from which to customize a more complete system based on the user's choices. This does not mean that LFS is the smallest system possible. Several important packages are included that are not, strictly speaking, required. The list below documents the reasons each package in the book has been included.

- Acl

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

- Attr

This package contains programs for managing extended attributes on file system objects.

- Autoconf

This package supplies 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 the build procedure has been updated.

- Automake

This package contains programs for generating Make files from a template. It is often needed to rebuild a package after the build procedure has been updated.

- 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.

- Bc

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

- Binutils

This package supplies 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.

- Bison

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

- Bzip2

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

- Check

This package provides 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.

- DejaGNU

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

- Eudev

This package is a device manager. It dynamically controls the ownership, permissions, names, and symbolic links of device nodes in the /dev directory when devices are added to or removed from the system.

- Expat

This package yields 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.

- 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 provides 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 supplies 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 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 provides utilities and libraries for the internationalization and localization of many packages.

- Glibc

This package contains the main C library. Linux programs will not run without it.

- GMP

This package supplies math libraries that provide useful functions for arbitrary precision arithmetic. It is needed to build GCC.

- Gperf

This package produces a program that generates a perfect hash function from a set of keys. It is required by Eudev .

- Grep

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

- Groff

This package contributes programs for processing and formatting text. One important function of these programs is to format man pages.

- GRUB

This is the Grand Unified Boot Loader. It is the most flexible of several boot loaders available.

- Gzip

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

- Iana-etc

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

- Inetutils

This package supplies programs for basic network administration.

- Intltool

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

- Kmod

This package supplies 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. Many packages use it for paging the output.

- Libcap

This package implements the userspace 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 supplies 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 into 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 provides 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 because of its superior internationalization capabilities. It supplies the man program.

- Man-pages

This package provides 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 of Meson is to minimize the amount of time that software developers need to spend configuring a build system. It's required to build Systemd, as well as many BLFS packages.

- MPC

This package supplies arithmetic functions for complex numbers. It is required by GCC.

- MPFR

This package contains functions for multiple precision arithmetic. It is required by GCC.

- Ninja

This package furnishes 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. This package is required by Meson.

- 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 the packages in LFS.

- Openssl

This package provides management tools and libraries relating to cryptography. These supply 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 produces 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 emphasizing code readability.

- Readline

This package is a set of libraries that offer 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 many LFS packages' configure scripts.

- Shadow

This package contains programs for handling passwords securely.

- Sysklogd

This package supplies programs for logging system messages, such as those emitted by the kernel or daemon processes when unusual events occur.

- Sysvinit

This package provides the init program, the parent of all the other processes on a running Linux system.

- Tar

This package provides archiving and extraction capabilities of virtually all the packages used in LFS.

- Tcl

This package contains the Tool Command Language used in many test suites.

- Texinfo

This package supplies 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 provides 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. Any other editor can be substituted, if you wish.

- Wheel

This package supplies a Python module that is the reference implementation of the Python wheel packaging standard.

- 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 supplies compression and decompression routines used by some programs. It provides 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`.



Note

Please configure your browser to display fixed-width text with a good monospace" font-size="9ptd font, with which you can distinguish the glyphs of `lll` or `oo` clearly.

Emphasis

This form of text is used for several purposes in the book. Its main purpose is to emphasize important points or items.

<https://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 and Security Advisories

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 repair security vulnerabilities or to fix other bugs—please visit <https://www.linuxfromscratch.org/lfs/errata/11.3/> before proceeding with your build. You should note any changes shown and apply them to the relevant sections of the book as you build the LFS system.

In addition, the Linux From Scratch editors maintain a list of security vulnerabilities discovered *after* a book has been released. To read the list, please visit <https://www.linuxfromscratch.org/lfs/advisories/> before proceeding with your build. You should apply the changes suggested by the advisories to the relevant sections of the book as you build the LFS system. And, if you will use the LFS system as a real desktop or server system, you should continue to consult the advisories and fix any security vulnerabilities, even when the LFS system has been completely constructed.

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 include these tools.

As an alternative to installing a separate distribution on 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, where the new LFS system will be compiled and installed. Chapter 3 explains which packages and patches must 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 should be aware of before you begin 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, where we use the new tools to build all the rest of the tools needed to create the LFS 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-blown 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 usual.

To finish the installation, the basic system configuration is set up in Chapter 9, and the kernel and boot loader are created in Chapter 10. Chapter 11 contains information on continuing the LFS experience beyond this book. After the steps in this chapter have been implemented, the computer is ready to boot into the new LFS system.

This is the process in a nutshell. Detailed information on each step is presented in the following chapters. Items that seem complicated now will be clarified, and everything will fall into place as you commence your LFS adventure.

1.2. What's new since the last release

In the 11.3 release, `--enable-default-pie` and `--enable-default-ssp` are enabled for GCC. These techniques can mitigate some malicious attacks, but they do not provide perfect security. Note that some textbooks assume these options are disabled, so that if you run examples from such a textbook on an LFS system, you may need to disable PIE and SSP with the GCC options `-fno-pie -no-pie -fno-stack-protection`.

Here is a list of the packages updated since the previous release of LFS.

Upgraded to:

-
- Bash 5.2.15

- Bc 6.2.4
- Binutils-2.40
- Diffutils-3.9
- E2fsprogs-1.47.0
- Expat-2.5.0
- File-5.44
- Gawk-5.2.1
- Gettext-0.21.1
- Glibc-2.37
- Grep-3.8
- IANA-Etc-20230202
- Inetutils-2.4
- IPRoute2-6.1.0
- Less-608
- Libcap-2.67
- Libelf-0.188 (from elfutils)
- Libffi-3.4.4
- Linux-6.1.11
- Make-4.4
- Man-DB-2.11.2
- Man-pages-6.03
- Meson-1.0.0
- MPC-1.3.1
- MPFR-4.2.0
- Ncurses-6.4
- Ninja-1.11.1
- Openssl-3.0.8
- Procps-ng-4.0.2
- Psmisc-23.6
- Python-3.11.2
- Readline-8.2
- Sed-4.9
- Shadow-4.13
- SysVinit-3.06
- Tcl-8.6.13
- Texinfo-7.0.2
- Tzdata-2022g

- Vim-9.0.1273
- wheel-0.38.4
- XZ-Uutils-5.4.1
- Zlib-1.2.13
- Zstd-1.5.4

Added:

-
- grub-2.06-upstream_fixes-1.patch
- readline-8.2-upstream_fix-1.patch

Removed:

-
- zstd-1.5.2-upstream_fixes-1.patch

1.3. Changelog

This is version 11.3 of the Linux From Scratch book, dated March 1st, 2023. 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 <https://www.linuxfromscratch.org/mirrors.html>.

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

Changelog Entries:

- 2023-03-01
 - [bdubbs] - LFS-11.3 released.
- 2023-02-19
 - [xry111] - Apply a patch for GRUB for an issue triggered with e2fsprogs-1.47.0. Fixes #5219.
- 2023-02-13
 - [bdubbs] - Update to man-pages-6.03. Fixes #5216.
- 2023-02-11
 - [bdubbs] - Update to iana-etc-20230202. Addresses #5006.
 - [bdubbs] - Update to zstd-1.5.4. Fixes #5215.
 - [bdubbs] - Update to Python3-3.11.2. Fixes #5214.
 - [bdubbs] - Update to e2fsprogs-1.47.0. Fixes #5213.
 - [bdubbs] - Update to linux-6.1.11. Fixes #5210.
 - [bdubbs] - Update to libcap-2.67. Fixes #5209.
 - [bdubbs] - Update to bc-6.2.4. Fixes #5207.
- 2023-02-07
 - [renodr] - Update to OpenSSL-3.0.8 (Security Update). Fixes #5211.
 - [renodr] - Update to e2fsprogs-1.46.6 (Security Update). Fixes #5208.

- 2023-02-02
 - [xry111] - Update to glibc-2.37. Fixes #5203.
 - [xry111] - Update to bc-6.2.3. Fixes #5204.
 - [xry111] - Update to linux-6.1.9. Fixes #5205.
 - [xry111] - Update to vim-9.0.1273. Addresses #4500.
 - [xry111] - Remove `--disable-exec-static-tramp` for libffi.
- 2023-02-01
 - [bdubbs] - Update to texinfo-7.0.2. Fixes #5202.
 - [bdubbs] - Update to linux-6.1.8. Fixes #5201.
 - [bdubbs] - Update to diffutils-3.9. Fixes #5199.
- 2023-01-15
 - [thomas] - Add libframe to online_usrlib in stripping. libframe.so.0.0.0 is in use by strip.
 - [bdubbs] - Update to iana-etc-20230109. Addresses #5006.
 - [bdubbs] - Update to binutils-2.40. Fixes #5198.
 - [bdubbs] - Update to bc-6.2.2. Fixes #5192.
 - [bdubbs] - Update to linux-6.1.6. Fixes #5193.
 - [bdubbs] - Update to man-db-2.11.2. Fixes #5196.
 - [bdubbs] - Update to mpfr-4.2.0. Fixes #5195.
 - [bdubbs] - Update to ncurses-6.4. Fixes #5194.
 - [bdubbs] - Update to xz-5.4.1. Fixes #5197.
- 2023-01-01
 - [thomas] - Remove an obsolete sed from mpc.
- 2022-12-31
 - [bdubbs] - Update to iana-etc-20221220. Addresses #5006.
 - [bdubbs] - Update to sysvinit-3.06. Fixes #5186.
 - [bdubbs] - Update to mpc-1.3.1. Fixes #5185.
 - [bdubbs] - Update to meson-1.0.0. Fixes #5190.
 - [bdubbs] - Update to man-pages-6.02. Fixes #5188.
 - [bdubbs] - Update to linux-6.1.1. Fixes #5179.
 - [bdubbs] - Update to file-5.44. Fixes #5191.
 - [bdubbs] - Update to bc-6.2.1. Fixes #5189.
- 2022-12-15
 - [bdubbs] - Ensure a gawk hard link is updated in Chapter 8. Fixes #5180.
 - [bdubbs] - Update to iana-etc-20221209. Addresses #5006.
 - [bdubbs] - Update to vim-9.0.1060. Addresses #4500.
 - [bdubbs] - Update to iproute2-6.1.0. Fixes #5184.

- [bdubbs] - Update to xz-5.4.0. Fixes #5183.
- [bdubbs] - Update to bash-5.2.15. Fixes #5182.
- [bdubbs] - Update to psmisc-23.6. Fixes #5181.
- [bdubbs] - Update to mpc-1.3.0. Fixes #5178.
- [bdubbs] - Update to python3-3.11.1. Fixes #5177.
- [bdubbs] - Update to procps-ng-4.0.2. Fixes #5176.
- 2022-12-01
 - [bdubbs] - Update to linux-6.0.11 (Security update). Fixes #5175.
- 2022-12-01
 - [bdubbs] - Update to iana-etc-20221122. Addresses #5006.
 - [bdubbs] - Update to xz-5.2.9. Fixes #5174.
 - [bdubbs] - Update to tzdata-2022g. Fixes #5172.
 - [bdubbs] - Update to texinfo-7.0.1. Fixes #5173.
 - [bdubbs] - Update to tcl-8.6.13. Fixes #5170.
 - [bdubbs] - Update to meson-0.64.1. Fixes #5169.
 - [bdubbs] - Update to linux-6.0.10. Fixes #5171.
 - [bdubbs] - Update to gawk-5.2.1. Fixes #5168.
- 2022-11-22
 - [xry111] - Update to linux-6.0.9. Fixes #5162.
 - [xry111] - Update to libpipeline-1.5.7. Fixes #5163.
 - [xry111] - Update to xz-5.2.8. Fixes #5164.
 - [xry111] - Update to man-db-2.11.1. Fixes #5166.
 - [xry111] - Update to mpfr-4.1.1. Fixes #5167.
 - [xry111] - Stop disabling decimal float for temporary GCC, so mpfr will be built with decimal float support.
 - [xry111] - Update instruction for wheel to avoid relying on deprecated Python features.
- 2022-11-10
 - [bdubbs] - Fix make-4.4 bug. Fixes #5160.
 - [bdubbs] - Update to wheel-0.38.4 (Python Module). Fixes #5155.
 - [bdubbs] - Update to texinfo-7.0. Fixes #5159.
 - [bdubbs] - Update to sysvinit-3.05. Fixes #5153.
 - [bdubbs] - Update to shadow-4.13. Fixes #5161.
 - [bdubbs] - Update to sed-4.9. Fixes #5157.
 - [bdubbs] - Update to meson-0.64.0. Fixes #5156.
 - [bdubbs] - Update to linux-6.0.7. Fixes #5154.
 - [bdubbs] - Update to elfutils-0.188. Fixes #5152.
 - [bdubbs] - Update to bc-6.1.1. Fixes #5151.

- [bdubbs] - Update to bash-5.2.9. Fixes #5158.
- 2022-11-01
 - [bdubbs] - Update to openssl-3.0.7 (Security update). Fixes #5132.
 - [bdubbs] - Update to iana-etc-20221025. Addresses #5006.
 - [bdubbs] - Update to tzdata-2022f. Fixes #5148.
 - [bdubbs] - Update to Python3-3.11.0. Fixes #5145.
 - [bdubbs] - Update to procps-ng-4.0.1. Fixes #5141.
 - [bdubbs] - Update to man-pages-6.01. Fixes #5140.
 - [bdubbs] - Update to man-db-2.11.0. Fixes #5139.
 - [bdubbs] - Update to make-4.4. Fixes #5149.
 - [bdubbs] - Update to linux-6.0.6. Fixes #5142.
 - [bdubbs] - Update to libffi-3.4.4. Fixes #5144.
 - [bdubbs] - Update to inetutils-2.4. Fixes #5147.
 - [bdubbs] - Update to expat-2.5.0. Fixes #5132.
- 2022-10-17
 - [bdubbs] - Update to linux-6.0.2 (Security update). Fixes #5138.
- 2022-10-15
 - [bdubbs] - Update to iana-etc-20221007. Addresses #5006.
 - [bdubbs] - Update to vim-9.0.0739. Addresses #5006.
 - [bdubbs] - Add upstream patches to readline and bash. Fixes #5131.
 - [bdubbs] - Update to zlib-1.2.13. Fixes #5137.
 - [bdubbs] - Update to man-pages-6.00. Fixes #5136.
 - [bdubbs] - Update to gettext-0.21.1. Fixes #5130.
 - [bdubbs] - Update to iproute2-6.0.0. Fixes #5127.
 - [bdubbs] - Update to meson-0.63.3. Fixes #5129.
 - [bdubbs] - Update to Python-3.10.8. Fixes #5133.
 - [bdubbs] - Update to xz-5.2.7. Fixes #5133.
 - [bdubbs] - Update to tzdata-2022e. Fixes #5134.
 - [bdubbs] - Update to linux-6.0.1. Fixes #5135.
- 2022-10-04
 - [renodr] - Update to Linux-5.19.13. If you are using an Intel GPU on a laptop, please update from Linux-5.19.12 immediately to prevent damage to your display. Fixes #5125.
- 2022-10-01
 - [bdubbs] - Update to iana-etc-20220922. Addresses #5006.
 - [bdubbs] - Update to tzdata-2022d. Fixes #5119.
 - [bdubbs] - Update to readline-8.2. Fixes #5121.

- [bdubbs] - Update to linux-5.19.12. Fixes #5115.
- [bdubbs] - Update to libffi-3.4.3. Fixes #5116.
- [bdubbs] - Update to libcap-2.66. Fixes #5120.
- [bdubbs] - Update to bc-6.0.4. Fixes #5114.
- [bdubbs] - Update to bash-5.2. Fixes #5122.
- 2022-09-22
 - [bdubbs] - Update to expat-2.4.9 (Security Update). Fixes #5117.
- 2022-09-20
 - [bdubbs] - Adapt instructions depending on host setup of /dev/shm when creating virtual filesystems for chroot.
- 2022-09-15
 - [bdubbs] - Update to file-5.43. Fixes #5113.
 - [bdubbs] - Update to linux-5.19.8. Fixes #5111.
 - [bdubbs] - Update to gawk-5.2.0. Fixes #5108.
 - [bdubbs] - Update to meson-0.63.2. Fixes #5106.
 - [bdubbs] - Update to ninja-1.11.1. Fixes #5103.
 - [bdubbs] - Update to bc-6.0.2. Fixes #5102.
 - [bdubbs] - Fix the location of udev rules in eudev. Fixes #5112.
 - [bdubbs] - Remove a warning for egrep and fgrep that makes tests for some packages fail.
 - [bdubbs] - Delete an empty binutils man page. Fixes #5100.
- 2022-09-10
 - [pierre] - Add `--enable-default-pie` and `--enable-default-ssp` to GCC build. Rationale and some reports at #5107.
- 2022-09-07
 - [bdubbs] - Update to shadow-4.12.3. Fixes #5101.
 - [bdubbs] - Update to Python3-3.10.7. Fixes #5109.
 - [bdubbs] - Update to linux-5.19.7. Fixes #5099.
 - [bdubbs] - Update to less-608. Fixes #5104.
 - [bdubbs] - Update to grep-3.8. Fixes #5105.
- 2022-09-01
 - [bdubbs] - LFS-11.2 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 list of Frequently Asked Questions (FAQ), located at <https://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 you cannot find an answer to your problem on the FAQ page, the next step would be to search the mailing lists at <https://www.linuxfromscratch.org/search.html>.

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

1.4.3. IRC

Several members of the LFS community offer assistance via Internet Relay Chat (IRC). Before using this support, please make sure your question is not already answered in the LFS FAQ or the mailing list archives. You can find the IRC network at `irc.libera.chat`. 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 <https://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 <https://www.linuxfromscratch.org/faq/#generalfaq>. Questions are often already answered there. If your question is not answered on that page, try to find the source of the problem. The following hint will give you some guidance for troubleshooting: <https://www.linuxfromscratch.org/hints/downloads/files/errors.txt>.

If you cannot find your problem listed in the FAQ, search the mailing lists at <https://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 could have been easily answered by going to the FAQ or by searching the mailing lists first. So, for us to offer the best assistance possible, you should first do some research on your own. That allows us to focus on the more unusual support needs. If your searches do not produce a solution, please include all the 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, any request for help should include these essential things:

- The version of the book being used (in this case 11.3)
- 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 a clear description of the problem
- 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 up-front 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 all of the relevant information. Here is an example of the type of information to include from the **make** screen output.

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

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

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

This is not enough information to 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 all the associated error messages.

An excellent article about asking for help on the Internet is available online at <http://catb.org/~esr/faqs/smart-questions.html>. Read this document, and follow the hints. Doing so will 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

2.2.1. Hardware

The LFS editors recommend that the system CPU have at least four cores and that the system have at least 8 GB of memory. Older systems that do not meet these requirements will still work, but the time to build packages will be significantly longer than documented.

2.2.2. Software

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-2.13.1** (Versions greater than 2.40 are not recommended as they have not been tested)
- **Bison-2.7** (/usr/bin/yacc should be a link to bison or a small script that executes bison)
- **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-5.1** including the C++ compiler, **g++** (Versions greater than 12.2.0 are not recommended as they have not been tested). C and C++ standard libraries (with headers) must also be present so the C++ compiler can build hosted programs
- **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 5 and Chapter 8, at the recommendation of the developers.

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 commands:

```
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

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
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. This does not mean that the system has to be built in one sitting. The issue is that certain procedures must be repeated after a reboot when resuming LFS at different points.

2.3.1. Chapters 1–4

These chapters run commands on the host system. When restarting, be certain of one thing:

- Procedures performed as the `root` user after Section 2.4 must have the LFS environment variable set *FOR THE ROOT USER*.

2.3.2. Chapters 5–6

- The `/mnt/lfs` partition must be mounted.
- These two chapters *must* be done as user `lfs`. A **`su - lfs`** command must be issued before performing any task in these chapters. If you don't 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 a package has been installed correctly, ensure the previously expanded tarball has been removed, then re-extract the package, and complete all the instructions in that section.

2.3.3. Chapters 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 after the `chroot` environment has been entered.
- 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 7.3.1, “Mounting and Populating `/dev`” and Section 7.3.2, “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. With an SSD you will not be able to hear swapping, but you can tell how much swap space is being used by running the **top** or **free** programs. Use of an SSD 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 the **gdisk** command.



Note

The Grub Bios partition must be on the drive that the BIOS uses to boot the system. This is not necessarily the drive that holds the LFS root partition. The disks on a system may use different partition table types. The necessity of the Grub Bios 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 adequate.
- */boot/efi* – The EFI System Partition, which is needed for booting the system with UEFI. Read *the BLFS page* for details.
- */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* – In LFS, */bin*, */lib*, and */sbin* are symlinks to their counterparts in */usr*. So */usr* contains all the binaries needed for the system to run. For LFS a separate partition for */usr* is normally not needed. If you create it anyway, you should make a partition large enough to fit all the programs and libraries in the system. The root partition can be very small (maybe just one gigabyte) in this configuration, so it's suitable for a thin client or diskless workstation (where */usr* is mounted from a remote server). However, you should be aware that an *initramfs* (not covered by LFS) will be needed to boot a system with a separate */usr* partition.

- `/opt` – This directory is most useful for BLFS, where multiple large packages like KDE or Texlive 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. If you have enough RAM, you can mount a `tmpfs` on `/tmp` to make access to temporary files faster.
- `/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 provides plenty of room.

Any separate partition that you want automatically mounted when the system starts must be specified in the `/etc/fstab` file. 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

A partition is just a range of sectors on a disk drive, delimited by boundaries set in a partition table. Before the operating system can use a partition to store any files, the partition must be formatted to contain a file system, typically consisting of a label, directory blocks, data blocks, and an indexing scheme to locate a particular file on demand. The file system also helps the OS keep track of free space on the partition, reserve the needed sectors when a new file is created or an existing file is extended, and recycle the free data segments created when files are deleted. It may also provide support for data redundancy, and for error recovery.

LFS can use any file system recognized by the Linux kernel, but the most common types are `ext3` and `ext4`. The choice of the right file system can be complex; it 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` family of file systems. It provides several new capabilities including nano-second timestamps, creation and use of very large files (up to 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, and many others, can be found at https://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, issue the following command:

```
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 you may choose any directory name you want. 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 value 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 must 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 use an “if” test, and do not run the remaining `.bashrc` instructions for a non-interactive bash invocation. Be sure to place the export command ahead of the test for non-interactive use.

2.7. Mounting the New Partition

Now that a file system has been created, the partition must be mounted so the host system can access it. This book assumes that the file system is mounted at the directory specified by the `LFS` environment variable described in the previous section.

Strictly speaking, one cannot “mount a partition”. One mounts the *file system* embedded in that partition. But since a single partition can't contain more than one file system, people often speak of the partition and the associated file system as if they were one and the same.

Create the mount point and mount the LFS file system with these commands:

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

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

If you are using multiple partitions for LFS (e.g., one for `/` and another for `/home`), mount them like this:

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

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 must be remounted.



Warning

The above instructions assume that you will not restart 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 the host system's `/etc/fstab` file to automatically remount it when you reboot. For example, you might add this line to your `/etc/fstab` file:

```
/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 the new LFS partition is open for business, it's 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 different versions, because the build commands for one version may not work with a different version, unless the different version is specified by an LFS erratum or security advisory. 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.

For some packages, the release tarball and the (Git or SVN) repository snapshot tarball for that release may be published with similar file names. A release tarball contains **generated files** (for example, a **configure** script generated by **autoconf**), in addition to the contents of the corresponding repository snapshot. The book uses release tarballs whenever possible. Using a repository snapshot instead of a release tarball specified by the book will cause problems.

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

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 mirror sites listed at <https://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-sysv` as an input to the **wget** command, use:

```
wget --input-file=wget-list-sysv --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.

If the packages and patches are downloaded as a non-`root` user, these files will be owned by the user. The file system records the owner by its UID, and the UID of a normal user in the host distro is not assigned in LFS. So the files will be left owned by an unnamed UID in the final LFS system. If you won't assign the same UID for your user in the LFS system, change the owners of these files to `root` now to avoid this issue:

```
chown root:root $LFS/sources/*
```

3.2. All Packages



Note

Read the *security advisories* before downloading packages to figure out if a newer version of any package should be used to avoid security vulnerabilities.

The upstream sources may remove old releases, especially when those releases contain a security vulnerability. If one URL below is not reachable, you should read the security advisories first to figure out if a newer version (with the vulnerability fixed) should be used. If not, try to download the removed package from a mirror. Although it's possible to download an old release from a mirror even if this release has been removed because of a vulnerability, it's not a good idea to use a release known to be vulnerable when building your system.

Download or otherwise obtain the following packages:

- **Acl (2.3.1) - 348 KB:**

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

Download: <https://download.savannah.gnu.org/releases/acl/acl-2.3.1.tar.xz>

MD5 sum: 95ce715fe09acca7c12d3306d0f076b2

- **Attr (2.5.1) - 456 KB:**

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

Download: <https://download.savannah.gnu.org/releases/attr/attr-2.5.1.tar.gz>

MD5 sum: ac1c5a7a084f0f83b8cace34211f64d8

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

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

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

MD5 sum: 12cfa1687ffa2606337efe1a64416106

- **Automake (1.16.5) - 1,565 KB:**

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

Download: <https://ftp.gnu.org/gnu/automake/automake-1.16.5.tar.xz>

MD5 sum: 4017e96f89fca45ca946f1c5db6be714

SHA256 sum: 80facc09885a57e6d49d06972c0ae1089c5fa8f4d4c7cfe5baea58e5085f136d

- **Bash (5.2.15) - 10,695 KB:**

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

Download: <https://ftp.gnu.org/gnu/bash/bash-5.2.15.tar.gz>

MD5 sum: 4281bb43497f3905a308430a8d6a30a5

- **Bc (6.2.4) - 447 KB:**

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

Download: <https://github.com/gavinhoward/bc/releases/download/6.2.4/bc-6.2.4.tar.xz>

MD5 sum: 5245ff400df17b66be7621c7a6498953

• Binutils (2.40) - 24,650 KB:Home page: <https://www.gnu.org/software/binutils/>Download: <https://sourceware.org/pub/binutils/releases/binutils-2.40.tar.xz>

MD5 sum: 007b59bd908a737c06e5a8d3d2c737eb

• Bison (3.8.2) - 2,752 KB:Home page: <https://www.gnu.org/software/bison/>Download: <https://ftp.gnu.org/gnu/bison/bison-3.8.2.tar.xz>

MD5 sum: c28f119f405a2304ff0a7ccdcc629713

• 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: 50fcafcecd5a380415b12e9c574e0b2

• Coreutils (9.1) - 5,570 KB:Home page: <https://www.gnu.org/software/coreutils/>Download: <https://ftp.gnu.org/gnu/coreutils/coreutils-9.1.tar.xz>

MD5 sum: 8b1ca4e018a7dce9bb937faec6618671

• DejaGNU (1.6.3) - 608 KB:Home page: <https://www.gnu.org/software/dejagnu/>Download: <https://ftp.gnu.org/gnu/dejagnu/dejagnu-1.6.3.tar.gz>

MD5 sum: 68c5208c58236eba447d7d6d1326b821

• Diffutils (3.9) - 1,551 KB:Home page: <https://www.gnu.org/software/diffutils/>Download: <https://ftp.gnu.org/gnu/diffutils/diffutils-3.9.tar.xz>

MD5 sum: cf0a65266058bf22fe3feb69e57ffc5b

• E2fsprogs (1.47.0) - 9,412 KB:Home page: <http://e2fsprogs.sourceforge.net/>Download: <https://downloads.sourceforge.net/project/e2fsprogs/e2fsprogs/v1.47.0/e2fsprogs-1.47.0.tar.gz>

MD5 sum: 6b4f18a33873623041857b4963641ee9

• Elfutils (0.188) - 8,900 KB:Home page: <https://sourceware.org/elfutils/>Download: <https://sourceware.org/ftp/elfutils/0.188/elfutils-0.188.tar.bz2>

MD5 sum: efb25a91873b2eec4df9f31e6a4f4e5c

• Eudev (3.2.11) - 2,075 KB:Download: <https://github.com/eudev-project/eudev/releases/download/v3.2.11/eudev-3.2.11.tar.gz>

MD5 sum: 417ba948335736d4d81874fba47a30f7

• Expat (2.5.0) - 450 KB:Home page: <https://libexpat.github.io/>Download: <https://prdownloads.sourceforge.net/expat/expat-2.5.0.tar.xz>

MD5 sum: ac6677b6d1b95d209ab697ce8b688704

• 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 (5.44) - 1,159 KB:Home page: <https://www.darwinsys.com/file/>Download: <https://astron.com/pub/file/file-5.44.tar.gz>

MD5 sum: a60d586d49d015d842b9294864a89c7a

• Findutils (4.9.0) - 1,999 KB:Home page: <https://www.gnu.org/software/findutils/>Download: <https://ftp.gnu.org/gnu/findutils/findutils-4.9.0.tar.xz>

MD5 sum: 4a4a547e888a944b2f3af31d789a1137

• 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 (5.2.1) - 3,332 KB:Home page: <https://www.gnu.org/software/gawk/>Download: <https://ftp.gnu.org/gnu/gawk/gawk-5.2.1.tar.xz>

MD5 sum: 02956bc5d117a7437bb4f7039f23b964

• GCC (12.2.0) - 82,662 KB:Home page: <https://gcc.gnu.org/>Download: <https://ftp.gnu.org/gnu/gcc/gcc-12.2.0/gcc-12.2.0.tar.xz>

MD5 sum: 73bafd0af874439dcdb9fc063b6fb069

SHA256 sum:

• GDBM (1.23) - 1,092 KB:Home page: <https://www.gnu.org/software/gdbm/>Download: <https://ftp.gnu.org/gnu/gdbm/gdbm-1.23.tar.gz>

MD5 sum: 8551961e36bf8c70b7500d255d3658ec

• Gettext (0.21.1) - 9,819 KB:Home page: <https://www.gnu.org/software/gettext/>Download: <https://ftp.gnu.org/gnu/gettext/gettext-0.21.1.tar.xz>

MD5 sum: 27fcc8a42dbc8f334f23a08f1f2fe00a

• Glibc (2.37) - 18,244 KB:Home page: <https://www.gnu.org/software/libc/>Download: <https://ftp.gnu.org/gnu/glibc/glibc-2.37.tar.xz>

MD5 sum: e89cf3dcb64939d29f04b4ceead5cc4e

**Note**

The Glibc developers maintain a *Git branch* containing patches considered worthy for Glibc-2.37 but unfortunately developed after Glibc-2.37 release. The LFS editors will issue a security advisory if any security fix is added into the branch, but no actions will be taken for other newly added patches. You may review the patches yourself and incorporate some patches if you consider them important.

• GMP (6.2.1) - 1,980 KB:

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

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

MD5 sum: 0b82665c4a92fd2ade7440c13fcaa42b

• Gperf (3.1) - 1,188 KB:

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

Download: <https://ftp.gnu.org/gnu/gperf/gperf-3.1.tar.gz>

MD5 sum: 9e251c0a618ad0824b51117d5d9db87e

• Grep (3.8) - 1,670 KB:

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

Download: <https://ftp.gnu.org/gnu/grep/grep-3.8.tar.xz>

MD5 sum: dc6e4d18d4659e6e7552fc4a183c8ac9

• Groff (1.22.4) - 4,044 KB:

Home page: <https://www.gnu.org/software/groff/>

Download: <https://ftp.gnu.org/gnu/groff/groff-1.22.4.tar.gz>

MD5 sum: 08fb04335e2f5e73f23ea4c3adbf0c5f

• GRUB (2.06) - 6,428 KB:

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

Download: <https://ftp.gnu.org/gnu/grub/grub-2.06.tar.xz>

MD5 sum: cf0fd928b1e5479c8108ee52cb114363

• Gzip (1.12) - 807 KB:

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

Download: <https://ftp.gnu.org/gnu/gzip/gzip-1.12.tar.xz>

MD5 sum: 9608e4ac5f061b2a6479dc44e917a5db

• Iana-Etc (20230202) - 586 KB:

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

Download: <https://github.com/Mic92/iana-etc/releases/download/20230202/iana-etc-20230202.tar.gz>

MD5 sum: e64685d046cd0dfe94b5c66e294cf9ef

• Inetutils (2.4) - 1,522 KB:

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

Download: <https://ftp.gnu.org/gnu/inetutils/inetutils-2.4.tar.xz>

MD5 sum: 319d65bb5a6f1847c4810651f3b4ba74

SHA256 sum:

• 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 (6.1.0) - 885 KB:

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

Download: <https://www.kernel.org/pub/linux/utils/net/iproute2/iproute2-6.1.0.tar.xz>

MD5 sum: f3ff4461e25dbc5ef1fb7a9167a9523d

• Kbd (2.5.1) - 1,457 KB:Home page: <https://kbd-project.org/>Download: <https://www.kernel.org/pub/linux/utils/kbd/kbd-2.5.1.tar.xz>

MD5 sum: 10f10c0a9d897807733f2e2419814abb

• Kmod (30) - 555 KB:Download: <https://www.kernel.org/pub/linux/utils/kernel/kmod/kmod-30.tar.xz>

MD5 sum: 85202f0740a75eb52f2163c776f9b564

• Less (608) - 354 KB:Home page: <https://www.greenwoodsoftware.com/less/>Download: <https://www.greenwoodsoftware.com/less/less-608.tar.gz>

MD5 sum: 1cdec714569d830a68f4cff11203cdba

• LFS-Bootscripts (20230101) - 33 KB:Download: <https://www.linuxfromscratch.org/lfs/downloads/11.3/lfs-bootscripts-20230101.tar.xz>

MD5 sum: 569217b0b56f98fd267d38d72ee20132

• Libcap (2.67) - 183 KB:Home page: <https://sites.google.com/site/fullycapable/>Download: <https://www.kernel.org/pub/linux/libs/security/linux-privs/libcap2/libcap-2.67.tar.xz>

MD5 sum: 06333f4301657298890fd8d6f1fb4793

• Libffi (3.4.4) - 1,331 KB:Home page: <https://sourceware.org/libffi/>Download: <https://github.com/libffi/libffi/releases/download/v3.4.4/libffi-3.4.4.tar.gz>

MD5 sum: 0da1a5ed7786ac12dcba0d499d8a049

• Libpipeline (1.5.7) - 956 KB:Home page: <https://libpipeline.nongnu.org/>Download: <https://download.savannah.gnu.org/releases/libpipeline/libpipeline-1.5.7.tar.gz>

MD5 sum: 1a48b5771b9f6c790fb4efdb1ac71342

• Libtool (2.4.7) - 996 KB:Home page: <https://www.gnu.org/software/libtool/>Download: <https://ftp.gnu.org/gnu/libtool/libtool-2.4.7.tar.xz>

MD5 sum: 2fc0b6ddcd66a89ed6e45db28fa44232

• Linux (6.1.11) - 131,653 KB:Home page: <https://www.kernel.org/>Download: <https://www.kernel.org/pub/linux/kernel/v6.x/linux-6.1.11.tar.xz>

MD5 sum: f91621912cd58ac6d4128d4057980e7d

**Note**

The Linux kernel is updated quite frequently, 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 (1.4.19) - 1,617 KB:Home page: <https://www.gnu.org/software/m4/>Download: <https://ftp.gnu.org/gnu/m4/m4-1.4.19.tar.xz>

MD5 sum: 0d90823e1426f1da2fd872df0311298d

• Make (4.4) - 2,254 KB:Home page: <https://www.gnu.org/software/make/>Download: <https://ftp.gnu.org/gnu/make/make-4.4.tar.gz>

MD5 sum: d7575a26a94ee8427130e9db23cdaa78

• Man-DB (2.11.2) - 1,908 KB:Home page: <https://www.nongnu.org/man-db/>Download: <https://download.savannah.gnu.org/releases/man-db/man-db-2.11.2.tar.xz>

MD5 sum: a7d59fb2df6158c44f8f7009dcc6d875

• Man-pages (6.03) - 2,134 KB:Home page: <https://www.kernel.org/doc/man-pages/>Download: <https://www.kernel.org/pub/linux/docs/man-pages/man-pages-6.03.tar.xz>

MD5 sum: c62b7c944bb0887a35edab7cab301357

• Meson (1.0.0) - 2,051 KB:Home page: <https://mesonbuild.com>Download: <https://github.com/mesonbuild/meson/releases/download/1.0.0/meson-1.0.0.tar.gz>

MD5 sum: 009b78125467cd9ee4d467175a5c12e1

• MPC (1.3.1) - 756 KB:Home page: <https://www.multiprecision.org/>Download: <https://ftp.gnu.org/gnu/mpc/mpc-1.3.1.tar.gz>

MD5 sum: 5c9bc658c9fd0f940e8e3e0f09530c62

• MPFR (4.2.0) - 1,443 KB:Home page: <https://www.mpfr.org/>Download: <https://ftp.gnu.org/gnu/mpfr/mpfr-4.2.0.tar.xz>

MD5 sum: a25091f337f25830c16d2054d74b5af7

• Ncurses (6.4) - 3,528 KB:Home page: <https://www.gnu.org/software/ncurses/>Download: <https://invisible-mirror.net/archives/ncurses/ncurses-6.4.tar.gz>

MD5 sum: 5a62487b5d4ac6b132fe2bf9f8fad29b

• Ninja (1.11.1) - 225 KB:Home page: <https://ninja-build.org/>Download: <https://github.com/ninja-build/ninja/archive/v1.11.1/ninja-1.11.1.tar.gz>

MD5 sum: 32151c08211d7ca3c1d832064f6939b0

• OpenSSL (3.0.8) - 14,800 KB:Home page: <https://www.openssl.org/>Download: <https://www.openssl.org/source/openssl-3.0.8.tar.gz>

MD5 sum: 61e017cf4fealb599048f621f1490fbd

• Patch (2.7.6) - 766 KB:Home page: <https://savannah.gnu.org/projects/patch/>Download: <https://ftp.gnu.org/gnu/patch/patch-2.7.6.tar.xz>

MD5 sum: 78ad9937e4caadcba1526ef1853730d5

• Perl (5.36.0) - 12,746 KB:Home page: <https://www.perl.org/>Download: <https://www.cpan.org/src/5.0/perl-5.36.0.tar.xz>

MD5 sum: 826e42da130011699172fd655e49cfa2

• Pkg-config (0.29.2) - 1,970 KB:Home page: <https://www.freedesktop.org/wiki/Software/pkg-config>Download: <https://pkg-config.freedesktop.org/releases/pkg-config-0.29.2.tar.gz>

MD5 sum: f6e931e319531b736fadc017f470e68a

• Procps (4.0.2) - 1250 KB:Home page: <https://sourceforge.net/projects/procps-ng>Download: <https://sourceforge.net/projects/procps-ng/files/Production/procps-ng-4.0.2.tar.xz>

MD5 sum: 691748c4767f19b9d94ed9d088e40c4d

• Psmisc (23.6) - 415 KB:Home page: <https://gitlab.com/psmisc/psmisc>Download: <https://sourceforge.net/projects/psmisc/files/psmisc/psmisc-23.6.tar.xz>

MD5 sum: ed3206da1184ce9e82d607dc56c52633

• Python (3.11.2) - 19,428 KB:Home page: <https://www.python.org/>Download: <https://www.python.org/ftp/python/3.11.2/Python-3.11.2.tar.xz>

MD5 sum: a957cffb58a89303b62124896881950b

• Python Documentation (3.11.2) - 7,598 KB:Download: <https://www.python.org/ftp/python/doc/3.11.2/python-3.11.2-docs-html.tar.bz2>

MD5 sum: eb4132c780b60b5782a4f66b29b08d5c

• Readline (8.2) - 2,973 KB:Home page: <https://tiswww.case.edu/php/chet/readline/rltop.html>Download: <https://ftp.gnu.org/gnu/readline/readline-8.2.tar.gz>

MD5 sum: 4aa1b31be779e6b84f9a96cb66bc50f6

• Sed (4.9) - 1,365 KB:Home page: <https://www.gnu.org/software/sed/>Download: <https://ftp.gnu.org/gnu/sed/sed-4.9.tar.xz>

MD5 sum: 6aac9b2dbafcd5b7a67a8a9bcb8036c3

• Shadow (4.13) - 1,722 KB:Home page: <https://shadow-maint.github.io/shadow/>Download: <https://github.com/shadow-maint/shadow/releases/download/4.13/shadow-4.13.tar.xz>

MD5 sum: b1ab01b5462ddcf43588374d57bec123

• Sysklogd (1.5.1) - 88 KB:Home page: <https://www.infodrom.org/projects/sysklogd/>Download: <https://www.infodrom.org/projects/sysklogd/download/sysklogd-1.5.1.tar.gz>

MD5 sum: c70599ab0d037fde724f7210c2c8d7f8

• Sysvinit (3.06) - 247 KB:Home page: <https://savannah.nongnu.org/projects/sysvinit>Download: <https://github.com/slicer69/sysvinit/releases/download/3.06/sysvinit-3.06.tar.xz>

MD5 sum: 96771d0a88315c91199830ea49b859ca

• Tar (1.34) - 2,174 KB:Home page: <https://www.gnu.org/software/tar/>Download: <https://ftp.gnu.org/gnu/tar/tar-1.34.tar.xz>

MD5 sum: 9a08d29a9ac4727130b5708347c0f5cf

• Tcl (8.6.13) - 10,581 KB:Home page: <http://tcl.sourceforge.net/>Download: <https://downloads.sourceforge.net/tcl/tcl8.6.13-src.tar.gz>

MD5 sum: 0e4358aade2f5db8a8b6f2f6d9481ec2

• Tcl Documentation (8.6.13) - 1,165 KB:Download: <https://downloads.sourceforge.net/tcl/tcl8.6.13-html.tar.gz>

MD5 sum: 4452f2f6d557f5598cca17b786d6eb68

• Texinfo (7.0.2) - 4,762 KB:Home page: <https://www.gnu.org/software/texinfo/>Download: <https://ftp.gnu.org/gnu/texinfo/texinfo-7.0.2.tar.xz>

MD5 sum: be9500f3a361525622850ecb1b1fc024

• Time Zone Data (2022g) - 430 KB:Home page: <https://www.iana.org/time-zones>Download: <https://www.iana.org/time-zones/repository/releases/tzdata2022g.tar.gz>

MD5 sum: 884250fd2a8a55f6322900ad4ab94d7b

• Udev-lfs Tarball (udev-lfs-20171102) - 11 KB:Download: <https://anduin.linuxfromscratch.org/LFS/udev-lfs-20171102.tar.xz>

MD5 sum: 27cd82f9a61422e186b9d6759ddf1634

• Util-linux (2.38.1) - 7,321 KB:Home page: <https://git.kernel.org/pub/scm/utils/util-linux/util-linux.git/>Download: <https://www.kernel.org/pub/linux/utils/util-linux/v2.38/util-linux-2.38.1.tar.xz>

MD5 sum: cd11456f4ddd31f7fbfdd9488c0c0d02

• Vim (9.0.1273) - 10,892 KB:Home page: <https://www.vim.org>Download: <https://anduin.linuxfromscratch.org/LFS/vim-9.0.1273.tar.xz>

MD5 sum: 9c80755d2d95ec4ef713f66e57671797

**Note**The version of vim changes daily. To get the latest version, go to <https://github.com/vim/vim/tags>.**• Wheel (0.38.4) - 66 KB:**Home page: <https://pypi.org/project/wheel/>Download: <https://pypi.org/packages/source/w/wheel/wheel-0.38.4.tar.gz>

MD5 sum: 83bb4e7bd4d687d398733f341a64ab91

- **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 (5.4.1) - 1,451 KB:**

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

Download: <https://tukaani.org/xz/xz-5.4.1.tar.xz>

MD5 sum: 47d831c659e94071d5dd384d0d1ed4c6

- **Zlib (1.2.13) - 1267 KB:**

Home page: <https://www.zlib.net/>

Download: <https://zlib.net/zlib-1.2.13.tar.xz>

MD5 sum: 7d9fc1d78ae2fa3e84fe98b77d0006c63

- **Zstd (1.5.4) - 2,111 KB:**

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

Download: <https://github.com/facebook/zstd/releases/download/v1.5.4/zstd-1.5.4.tar.gz>

MD5 sum: 2352b1f9ccc7446641046bb3d440c3ed

Total size of these packages: about 462 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: https://www.linuxfromscratch.org/patches/lfs/11.3/bzip2-1.0.8-install_docs-1.patch

MD5 sum: 6a5ac7e89b791aae556de0f745916f7f

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

Download: <https://www.linuxfromscratch.org/patches/lfs/11.3/coreutils-9.1-i18n-1.patch>

MD5 sum: c1ac7edf095027460716577633da9fc5

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

Download: <https://www.linuxfromscratch.org/patches/lfs/11.3/glibc-2.37-fhs-1.patch>

MD5 sum: 9a5997c3452909b1769918c759eff8a2

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

Download: https://www.linuxfromscratch.org/patches/lfs/11.3/grub-2.06-upstream_fixes-1.patch

MD5 sum: da388905710bb4cbfbc7bd7346ff9174

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

Download: <https://www.linuxfromscratch.org/patches/lfs/11.3/kbd-2.5.1-backspace-1.patch>

MD5 sum: f75cca16a38da6caa7d52151f7136895

- **Readline Upstream Fix Patch - 1.3 KB:**

Download: https://www.linuxfromscratch.org/patches/lfs/11.3/readline-8.2-upstream_fix-1.patch

MD5 sum: dd1764b84cfca6b677f44978218a75da

• **Sysvinit Consolidated Patch - 2.5 KB:**

Download: <https://www.linuxfromscratch.org/patches/lfs/11.3/sysvinit-3.06-consolidated-1.patch>

MD5 sum: 17ffccbb8e18c39e8cedc32046f3a475

Total size of these patches: about 194.2 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 <https://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` (in which we will install the temporary tools), add an unprivileged user, and create an appropriate build environment for that user. We will also explain the units of time (“SBUs”) we use to measure how long it takes to build LFS packages, and provide some information about package test suites.

4.2. Creating a Limited Directory Layout in the LFS Filesystem

In this section, we begin populating the LFS filesystem with the pieces that will constitute the final Linux system. The first step is to create a limited directory hierarchy, so that the programs compiled in Chapter 6 (as well as `glibc` and `libstdc++` in Chapter 5) can be installed in their final location. We do this so those temporary programs will be overwritten when the final versions are built in Chapter 8.

Create the required directory layout by issuing the following commands as `root`:

```
mkdir -pv $LFS/{etc,var} $LFS/usr/{bin,lib,sbin}

for i in bin lib sbin; do
    ln -sv usr/$i $LFS/$i
done

case $(uname -m) in
    x86_64) mkdir -pv $LFS/lib64 ;;
esac
```

Programs in Chapter 6 will be compiled with a cross-compiler (more details can be found in section Toolchain Technical Notes). This cross-compiler will be installed in a special directory, to separate it from the other programs. Still acting as `root`, create that directory with this command:

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



Note

The LFS editors have deliberately decided not to use a `/usr/lib64` directory. Several steps are taken to be sure the toolchain will not use it. If for any reason this directory appears (either because you made an error in following the instructions, or because you installed a binary package that created it after finishing LFS), it may break your system. You should always be sure this directory does not exist.

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, we will create a new user called `lfs` as a member of a new group (also named `lfs`) and run commands as `lfs` 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
```

This is what the command line options mean:

```
-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 (the default is `/etc/skel`) by changing the input location to the special null device.

`lfs`

This is the name of the new user.

If you want to log in as `lfs` or switch to `lfs` from a non-`root` user (as opposed to switching to user `lfs` when logged in as `root`, which does not require the `lfs` user to have a password), you need to set a password for `lfs`. Issue the following command as the `root` user to set the password:

```
passwd lfs
```

Grant `lfs` full access to all the directories under `$LFS` by making `lfs` the owner:

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



Note

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

Next, start a shell running as user `lfs`. This can be done by logging in as `lfs` on a virtual console, 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 is described 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`, or when switched to the `lfs` user using an `su` command with the “-” option, the initial shell is 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 new instance of the shell is a **non-login shell**, which does not read, and execute, the contents of the `/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 to 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. Switching off the hash function forces the shell to search the `PATH` whenever a program is to be run. As such, the shell will find the newly compiled tools in `$LFS/tools/bin` as soon as they are available without remembering a previous version of the same program provided by the host distro, in `/usr/bin` or `/bin`.

`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 cross-compilation 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 provided by 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 should 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**, it must 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 is 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 preceding commands have set some variables, in order to make them visible within any sub-shells, we export them.



Important

Several commercial distributions add an undocumented 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
```

When the `lfs` user is no longer needed (at the beginning of Chapter 7), you may safely restore `/etc/bash.bashrc` (if desired).

Note that the LFS Bash package we will build in Section 8.34, “Bash-5.2.15” is not configured to load or execute `/etc/bash.bashrc`, so this file is useless on a completed LFS system.

Finally, to ensure the environment is fully prepared for building the temporary tools, force the **bash** shell to read the new 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 absolute time estimates. The biggest package (`gcc`) will take approximately 5 minutes on the fastest systems, but could take 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 is **binutils** in Chapter 5. The time it takes to compile using one core is what we will refer to as the Standard Build Unit or SBU. All other compile times will be expressed in terms of this unit of time.

For example, consider a package whose compilation time is 4.5 SBUs. This means that if your system took 10 minutes to compile and install the first pass of `binutils`, it will take *approximately* 45 minutes to build the example package. Fortunately, most build times are shorter than one SBU.

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 by 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 from different processes will be interleaved. If you run into a problem with a build step, revert to a single processor build to properly analyze the error messages.

The times presented here are based upon using four cores (-j4). The times in Chapter 8 also include the time to run the regression tests for the package unless specified otherwise.

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 pointless; since the test programs are compiled with a cross-compiler, they probably can't 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 large 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 <https://www.linuxfromscratch.org/lfs/faq.html#no-ptys>.

Sometimes package test suites will fail for reasons which the developers are aware of and have deemed non-critical. Consult the logs located at <https://www.linuxfromscratch.org/lfs/build-logs/11.3/> to verify whether or not these failures are expected. This site is valid for all test suites 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, using this cross toolchain to build several utilities in a way that isolates them from the host distribution; and third, entering the chroot environment (which further improves host isolation) and constructing the remaining tools needed to build the final system.



Important

This is where the real work of building a new system begins. Be very careful to follow the instructions exactly as the book shows them. You should try to understand what each command does, and no matter how eager you are to finish your build, you should refrain from blindly typing the commands as shown. Read the documentation when there is something you do not understand. Also, keep track of your typing and of the output of commands, by using the **tee** utility to send the terminal output to a file. This makes debugging easier if something goes wrong.

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

Toolchain Technical Notes

This section explains some of the rationale and technical details behind the overall build method. Don't try to immediately understand everything in this section. Most of this information will be clearer after performing an actual build. Come back and re-read this chapter at any time during the build process.

The overall goal of Chapter 5 and Chapter 6 is to produce a temporary area containing a set of tools that are known to be good, and that are isolated from the host system. By using the **chroot** command, the compilations in the remaining chapters will be isolated 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.

This build process is based on *cross-compilation*. Cross-compilation is normally used to build a compiler and its associated toolchain for a machine different from the one that is used for the build. This is not strictly necessary 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 one great advantage: anything that is cross-compiled cannot depend on the host environment.

About Cross-Compilation



Note

The LFS book is not (and does not contain) a general tutorial to build a cross- (or native) toolchain. Don't use the commands in the book for a cross-toolchain for some purpose other than building LFS, unless you really understand what you are doing.

Cross-compilation involves some concepts that deserve a section of their own. Although this section may be omitted on a first reading, coming back to it later will help you gain a fuller understanding of the process.

Let us first define some terms used in this context.

The build

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

The 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.

The target

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

As an example, let us imagine the following scenario (sometimes referred to as “**Canadian Cross**”). We have a compiler on a slow machine only, let's call it machine A, and the compiler ccA. We also have a fast machine (B), but no compiler for (B), and we want to produce code for a third, slow machine (C). We will build a compiler for machine C in 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 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 newly built programs until machine C itself is running. For example, to run a test suite on ccC, we may want to add a fourth stage:

Stage	Build	Host	Target	Action
4	C	C	C	Rebuild and test ccC using ccC 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

All the cross-compiled packages in this book use an **autoconf-based building** system. The autoconf-based building system accepts system types in the form `cpu-vendor-kernel-os`, referred to as the system triplet. Since the vendor field is often irrelevant, autoconf lets you omit it.

An astute reader may wonder why a “triplet” refers to a four component name. The kernel field and the os field began as a single “system” field. Such a three-field form is still valid today for some systems, for example, `x86_64-unknown-freebsd`. But two systems can share the same kernel and still be too different to use the same triplet to describe them. For example, Android running on a mobile phone is completely different from Ubuntu running on an ARM64 server, even though they are both running on the same type of CPU (ARM64) and using the same kernel (Linux).

Without an emulation layer, you cannot run an executable for a server on a mobile phone or vice versa. So the “system” field has been divided into **kernel** and **os fields**, to designate these systems unambiguously. In our example, the Android system is designated `aarch64-unknown-linux-android`, and the Ubuntu system is designated `aarch64-unknown-linux-gnu`.

The word “triplet” remains embedded in the lexicon. A simple way to determine your system triplet is to run the **config.guess** script that comes with the source for many packages. Unpack the binutils sources, 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`. On most Linux systems the even simpler **gcc -dumpmachine** command will give you similar information.

You should 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 package `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 is `ld-linux.so.2`; it's `ld-linux-x86-64.so.2` on 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 in LFS, the name of the host triplet is slightly adjusted by changing the “vendor” field in the `LFS_TGT` variable so it says “lfs”. 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, plus 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> .

Stage	Build	Host	Target	Action
2	pc	lfs	lfs	Build compiler cc-lfs using cc1 on pc.
3	lfs	lfs	lfs	Rebuild and test cc-lfs using cc-lfs on lfs.

In the preceding 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.

This is not yet the end of the story. The **C language** is not merely a compiler; it also defines a **standard library**. In this book, the GNU C library, named glibc, is used (there is an alternative, "musl"). This library must be compiled for the **LFS machine**; that is, using the cross-compiler cc1. But the compiler itself uses an **internal library** providing complex subroutines for functions not available in the assembler instruction set. This internal library is named **libgcc**, and it must be linked to the glibc library to be fully functional. Furthermore, the standard library for C++ (**libstdc++**) must also be linked with glibc. The solution to this chicken and egg problem is first to build a degraded cc1-based libgcc, lacking some functionalities such as threads and exception handling, and then to build glibc using this degraded compiler (glibc itself is not degraded), and also to build libstdc++. This last library will lack some of the functionality of libgcc.

The upshot of the preceding paragraph is that cc1 is unable to build a fully functional libstdc++ with the degraded libgcc, but cc1 is the only compiler available for building the C/C++ libraries during stage 2. There are two reasons we don't immediately use the compiler built in stage 2, cc-lfs, to build those libraries.

- Generally speaking, cc-lfs cannot run on pc (the host system). Even though the triplets for pc and lfs are compatible with each other, an executable for lfs must depend on **glibc-2.37**; the host distro may utilize either a different implementation of libc (for example, musl), or a previous release of glibc (for example, glibc-2.13).
- Even if cc-lfs can run on pc, using it on pc would create a risk of **linking to the pc libraries**, since cc-lfs is a native compiler.

So when we build gcc stage 2, we instruct the building system to rebuild **libgcc** and **libstdc++** with cc1, but we link libstdc++ to the newly rebuilt libgcc instead of the old, degraded build. This makes the rebuilt libstdc++ fully functional.

In Chapter 8 (or “stage 3”), all the packages needed for the LFS system are built. Even if a package has already been installed into the LFS system in a previous chapter, we still rebuild the package. The main reason for rebuilding these packages is to make them stable: if we reinstall an LFS package on a completed LFS system, the reinstalled content of the package should be the same as the content of the same package when first installed in Chapter 8. The temporary packages installed in Chapter 6 or Chapter 7 cannot satisfy this requirement, because some of them are built without optional dependencies, and autoconf cannot perform some feature checks in Chapter 6 because of cross-compilation, causing the temporary packages to lack optional features, or use suboptimal code routines. Additionally, a minor reason for rebuilding the packages is to run the test suites.

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 realize at first. 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. (Note that this example can be run as shown only while logged in as user `lfs`. If you come back to this page later, replace `$LFS_TGT-ld` with `ld`).

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: `$LFS_TGT-gcc -print-prog-name=ld`. (Again, remove the `$LFS_TGT-` prefix if coming back to this later.)

Detailed information can be obtained from gcc by passing it the `-v` command line option while compiling a program. For example, `$LFS_TGT-gcc -v example.c` (or without `$LFS_TGT-` if coming back later) will show detailed information about the preprocessor, compilation, and assembly stages, including gcc's **search paths** for **included headers** and their order.

Next up: sanitized **Linux API headers**. These allow the standard C library (glibc) to interface with features that the Linux kernel will provide.

Next comes 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 `$LFS_TGT-gcc`. The binary tools and kernel headers can be a bit more complicated. Therefore, we take no risks and use the available configure switches to enforce the correct selections. After the run of **configure**, check the contents of the `config.make` file in the `build` directory for all important details. Note the use of `CC="$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 mentioned above, the standard C++ library is compiled next, followed in Chapter 6 by other programs that must be cross-compiled to break circular dependencies at build time. The install step of all those packages uses the `DESTDIR` variable to force installation in the LFS filesystem.

At the end of Chapter 6 the native LFS compiler is installed. First `binutils-pass2` is built, in the same `DESTDIR` directory as the other programs, then the second pass of gcc is constructed, omitting some non-critical 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 different from the build system. This is why `CC_FOR_TARGET=$LFS_TGT-gcc` is declared explicitly as one of the configuration options.

Upon entering the chroot environment in Chapter 7, the 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

Here are some things you should know about building each package:

- Several packages are patched before compilation, but only when the patch is needed to circumvent a problem. A patch is often needed in both the current and the following chapters, but sometimes, when the same package is built more than once, the patch is not needed right away. 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; the patch was still successfully applied.
- During the compilation of most packages, some warnings will scroll by on the screen. These are normal and can safely be ignored. These warnings are usually about deprecated, but not invalid, use of the C or C++ syntax. C standards change fairly often, and some packages have not yet been updated. This is not a serious problem, but it does cause the warnings to appear.
- 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 to a small script that executes bison.



Important

Here is a synopsis of 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 `/mnt/lfs/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.

Do not use any method except the **tar** command to extract the source code. Notably, using the **cp -R** command to copy the source code tree somewhere else can destroy links and timestamps in the source tree, and cause the build to fail.

- b. Change to the directory created when the package was extracted.
- c. Follow the instructions for building the package.
- d. Change back to the sources directory when the build is complete.
- 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-2.40 - 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: 639 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       \
             --enable-gprofng=no \
             --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.

`--enable-gprofng=no`

This disables building `gprofng` which 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-12.2.0 - Pass 1

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

Approximate build time: 3.3 SBU

Required disk space: 3.8 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-12.2.0 tarball from the sources directory, and then change to the directory created. Only then should you proceed with the instructions below.

```
tar -xf ../mpfr-4.2.0.tar.xz
mv -v mpfr-4.2.0 mpfr
tar -xf ../gmp-6.2.1.tar.xz
mv -v gmp-6.2.1 gmp
tar -xf ../mpc-1.3.1.tar.gz
mv -v mpc-1.3.1 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=2.37 \
--with-sysroot=$LFS \
--with-newlib \
--without-headers \
--enable-default-pie \
--enable-default-ssp \
--disable-nls \
--disable-shared \
--disable-multilib \
--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=2.37`

This option specifies the version of Glibc which will be used on the target. It is not relevant to the libc of the host distro because everything compiled by pass1 GCC will run in the chroot environment, which is isolated from libc of the host distro.

`--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-default-pie` and `--enable-default-ssp`

Those switches allow GCC to compile programs with some hardening security features (more information on those in the note on PIE and SSP in chapter 8) by default. They are not strictly needed at this stage, since the compiler will only produce temporary executables. But it is cleaner to have the temporary packages be as close as possible to the final ones.

`--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-threads`, `--disable-libatomic`, `--disable-libgomp`, `--disable-libquadmath`, `--disable-libssp`, `--disable-libvtv`, `--disable-libstdcxx`

These switches disable support for threading, libatomic, libgomp, libquadmath, libssp, libvtv, and the C++ standard library respectively. These features may 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:



Note

The command below shows an example of nested command substitution using two methods: backquotes and a `$()` construct. It could be rewritten using the same method for both substitutions, but is shown this way to demonstrate how they can be mixed. Generally the `$()` method is preferred.

```
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-6.1.11 API Headers

The Linux API Headers (in linux-6.1.11.tar.xz) expose the kernel's API for use by Glibc.

Approximate build time: less than 0.1 SBU

Required disk space: 1.5 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 -type f ! -name '*.h' -delete
cp -rv usr/include $LFS/usr
```

5.4.2. Contents of Linux API Headers

Installed headers:	<code>/usr/include/asm/*.h</code> , <code>/usr/include/asm-generic/*.h</code> , <code>/usr/include/drm/*.h</code> , <code>/usr/include/linux/*.h</code> , <code>/usr/include/misc/*.h</code> , <code>/usr/include/mtd/*.h</code> , <code>/usr/include/rdma/*.h</code> , <code>/usr/include/scsi/*.h</code> , <code>/usr/include/sound/*.h</code> , <code>/usr/include/video/*.h</code> , and <code>/usr/include/xen/*.h</code>
Installed directories:	<code>/usr/include/asm</code> , <code>/usr/include/asm-generic</code> , <code>/usr/include/drm</code> , <code>/usr/include/linux</code> , <code>/usr/include/misc</code> , <code>/usr/include/mtd</code> , <code>/usr/include/rdma</code> , <code>/usr/include/scsi</code> , <code>/usr/include/sound</code> , <code>/usr/include/video</code> , and <code>/usr/include/xen</code>

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-2.37

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: 1.5 SBU

Required disk space: 822 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
```



Note

The above command is correct. The **ln** command has several syntactic versions, so be sure to check **info coreutils ln** and **ln(1)** before reporting what may appear to be an error.

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-2.37-fhs-1.patch
```

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

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

Ensure that the **ldconfig** and **sln** utilities are installed into `/usr/sbin`:

```
echo "rootsbindir=/usr/sbin" > configparms
```

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=/usr/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=/usr/lib
```

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

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 that occurs, rerun the make command with the "-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 will almost certainly render it unusable. So double-check that the environment is correctly set, and that you are not `root`, 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 is installed in `$LFS`, which will become the root directory in Section 7.4, “Entering the Chroot Environment”.

Fix a hard coded path to the executable loader in the **ldd** script:

```
sed '/RTLDLIST=/s@/usr@g' -i $LFS/usr/bin/ldd
```



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(){}' | $LFS_TGT-gcc -xc -
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 as shown above, or there is 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.

Once all is well, clean up the test file:

```
rm -v a.out
```



Note

Building the 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 preceding Binutils, GCC, or Glibc installations.

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

```
$LFS/tools/libexec/gcc/$LFS_TGT/12.2.0/install-tools/mkheaders
```

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

5.6. Libstdc++ from GCC-12.2.0

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

Approximate build time: 0.2 SBU

Required disk space: 1.1 GB

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-12.2.0` 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++/12.2.0
```

The meaning of the configure options:

`--host=...`

Specifies that the cross-compiler we have just built should be used 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++/12.2.0`

This specifies the installation directory for include files. Because Libstdc++ is the standard C++ library for LFS, this directory should match the location where the C++ compiler (`$LFS_TGT-g++`) would search for the standard C++ include files. In a normal build, this information is automatically passed to the Libstdc++ **configure** options from the top level directory. In our case, this information must be explicitly given. The C++ compiler will prepend the sysroot path `$LFS` (specified when building GCC-pass1) to the include file search path, so it will actually search in `$LFS/tools/$LFS_TGT/include/c++/12.2.0`. The combination of the `DESTDIR` variable (in the **make install** command below) and this switch causes the headers to be installed there.

Compile Libstdc++ by running:

```
make
```

Install the library:

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


Remove the libtool archive files because they are harmful for cross-compilation:

```
rm -v $LFS/usr/lib/lib{stdc++,stdc++fs,supc++}.la
```

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 the 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. M4-1.4.19

The M4 package contains a macro processor.

Approximate build time: 0.1 SBU

Required disk space: 31 MB

6.2.1. Installation of M4

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-6.4

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

Approximate build time: 0.3 SBU

Required disk space: 51 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-normal \
            --with-cxx-shared \
            --without-debug \
            --without-ada \
            --disable-stripping \
            --enable-widex
```

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.

`--with-shared`

This makes Ncurses build and install **shared C libraries**.

`--without-normal`

This prevents Ncurses building and installing **static C libraries**.

`--without-debug`

This prevents Ncurses building and installing debug libraries.

`--with-cxx-shared`

This makes Ncurses build and install **shared C++ bindings**. It also prevents it building and installing static C++ bindings.

`--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.

--disable-stripping

This switch prevents the building system from using the **strip** program from the host. Using host tools on cross-compiled programs can cause failure.

--enable-widec

This switch causes **wide-character libraries** (e.g., `libncursesw.so.6.4`) to be built instead of normal ones (e.g., `libncurses.so.6.4`). These wide-character libraries are usable in both multibyte and traditional 8-bit locales, while normal libraries work properly only in 8-bit locales. Wide-character and normal libraries are source-compatible, but not binary-compatible.

Compile the package:

```
make
```

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 newly built **tic** program that runs on the building machine, so 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.

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

6.4. Bash-5.2.15

The Bash package contains the Bourne-Again Shell.

Approximate build time: 0.2 SBU

Required disk space: 67 MB

6.4.1. Installation of Bash

Prepare Bash for compilation:

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

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-9.1

The Coreutils package contains the basic utility programs needed by every operating system.

Approximate build time: 0.3 SBU

Required disk space: 162 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/chroot $LFS/usr/sbin
mkdir -pv $LFS/usr/share/man/man8
mv -v $LFS/usr/share/man/man1/chroot.1 $LFS/usr/share/man/man8/chroot.8
sed -i 's/"1"/"8"/' $LFS/usr/share/man/man8/chroot.8
```

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

6.6. Diffutils-3.9

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

Approximate build time: 0.2 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 8.56.2, “Contents of Diffutils.”

6.7. File-5.44

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: 36 MB

6.7.1. Installation of File

The **file** command on the build host needs to be the same version as the one we are building in order to create the signature file. Run the following commands to make a temporary copy of the **file** command:

```
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
```

Remove the libtool archive file because it is harmful for cross compilation:

```
rm -v $LFS/usr/lib/libmagic.la
```

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

6.8. Findutils-4.9.0

The Findutils package contains programs to find files. Programs are provided to search through all the files in a directory tree and to create, maintain, and search a database (often faster than the recursive find, but unreliable unless the database has been updated recently). Findutils also supplies the **xargs program**, which can be used to run a specified command on each file selected by a search.

Approximate build time: 0.2 SBU

Required disk space: 42 MB

6.8.1. Installation of Findutils

Prepare Findutils for compilation:

```
./configure --prefix=/usr \
            --localstatedir=/var/lib/locate \
            --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 8.58.2, “Contents of Findutils.”

6.9. Gawk-5.2.1

The Gawk package contains programs for manipulating text files.

Approximate build time: 0.1 SBU

Required disk space: 47 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=$LFS_TGT \
            --build=$(build-aux/config.guess)
```

Compile the package:

```
make
```

Install the package:

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

Details on this package are located in Section 8.57.2, “Contents of Gawk.”

6.10. Grep-3.8

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

Approximate build time: 0.2 SBU

Required disk space: 25 MB

6.10.1. Installation of Grep

Prepare Grep 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 8.33.2, “Contents of Grep.”

6.11. Gzip-1.12

The Gzip package contains programs for compressing and decompressing files.

Approximate build time: 0.1 SBU

Required disk space: 11 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
```

Details on this package are located in Section 8.61.2, “Contents of Gzip.”

6.12. Make-4.4

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: less than 0.1 SBU

Required disk space: 15 MB

6.12.1. Installation of Make

First, fix an issue identified upstream:

```
sed -e '/ifdef SIGPIPE/,+2 d' \
    -e '/undef FATAL_SIG/i FATAL_SIG (SIGPIPE);' \
    -i src/main.c
```

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 8.65.2, “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: 12 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 8.66.2, “Contents of Patch.”

6.14. Sed-4.9

The Sed package contains a stream editor.

Approximate build time: 0.2 SBU

Required disk space: 19 MB

6.14.1. Installation of Sed

Prepare Sed 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 8.29.2, “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: 0.1 SBU

Required disk space: 38 MB

6.15.1. Installation of Tar

Prepare Tar 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 8.67.2, “Contents of Tar.”

6.16. Xz-5.4.1

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: 20 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-5.4.1
```

Compile the package:

```
make
```

Install the package:

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

Remove the libtool archive file because it is harmful for cross compilation:

```
rm -v $LFS/usr/lib/liblzma.la
```

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

6.17. Binutils-2.40 - Pass 2

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

Approximate build time: 0.4 SBU

Required disk space: 525 MB

6.17.1. Installation of Binutils

Binutils ships an outdated copy of libtool in the tarball. It lacks sysroot support, so the produced binaries will be mistakenly linked to libraries from the host distro. Work around this issue:

```
sed '6009s/$add_dir//' -i ltmain.sh
```

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       \
--enable-gprofng=no   \
--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 smaller word sizes). This may not be needed on 64-bit systems, but it does no harm.

Compile the package:

```
make
```

Install the package:

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

Remove the libtool archive files because they are harmful for cross compilation, and remove unnecessary static libraries:

```
rm -v $LFS/usr/lib/lib{bfd,ctf,ctf-nobfd,opcodes}.{a,la}
```

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

6.18. GCC-12.2.0 - Pass 2

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

Approximate build time: 4.6 SBU

Required disk space: 4.7 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 directories:

```
tar -xf ../mpfr-4.2.0.tar.xz
mv -v mpfr-4.2.0 mpfr
tar -xf ../gmp-6.2.1.tar.xz
mv -v gmp-6.2.1 gmp
tar -xf ../mpc-1.3.1.tar.gz
mv -v mpc-1.3.1 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
```

Override the building rule of libgcc and libstdc++ headers, to allow building these libraries with POSIX threads support:

```
sed '/thread_header =/s/@.*@/gthr-posix.h/' \
-i libgcc/Makefile.in libstdc++-v3/include/Makefile.in
```

Create a separate build directory again:

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

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

Now prepare GCC for compilation:

```
../configure \
--build=$(../config.guess) \
--host=$LFS_TGT \
--target=$LFS_TGT \
LDFLAGS_FOR_TARGET=-L$PWD/$LFS_TGT/libgcc \
--prefix=/usr \
--with-build-sysroot=$LFS \
--enable-default-pie \
--enable-default-ssp \
--disable-nls \
--disable-multilib \
--disable-libatomic \
--disable-libgomp \
--disable-libquadmath \
--disable-libssp \
--disable-libvtv \
--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 `$LFS`. But the build system for GCC uses other tools, which are not aware of this location. This switch is needed so those tools will find the needed files in `$LFS`, and not on the host.

```
--target=$LFS_TGT
```

We are cross-compiling GCC, so it's impossible to build target libraries (`libgcc` and `libstdc++`) with the previously compiled GCC binaries—those binaries won't run on the host. The GCC build system will attempt to use the host's C and C++ compilers as a workaround by default. Building the GCC target libraries with a different version of GCC is not supported, so using the host's compilers may cause the build to fail. This parameter ensures the libraries are built by GCC pass 1.

```
LDFLAGS_FOR_TARGET=...
```

Allow `libstdc++` to use the shared `libgcc` being built in this pass, instead of the static version that was built in GCC pass 1. This is necessary to support C++ exception handling.

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: the tools needed to build the various packages. Now that **all circular dependencies** have been resolved, a “chroot” environment, completely isolated from the host operating system (except for the running kernel), can be used for the build.

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

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 bad 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

Applications running in userspace utilize various file systems created by the kernel to communicate with the kernel itself. These file systems are virtual: no disk space is used for them. The content of these file systems resides in memory. These file systems must be mounted in the `$LFS` directory tree so the applications can find them in the chroot environment.

Begin by creating the directories on which these virtual file systems will be mounted:

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

7.3.1. Mounting and Populating /dev

During a normal boot of an LFS system, the kernel automatically mounts the **devtmpfs file system** on the `/dev` directory; the kernel creates device nodes on that virtual file system during the boot process, or when a device is first detected or accessed. The **udev daemon** may change the ownership or permissions of the device nodes created by the kernel,

and create new device nodes or symlinks, to ease the work of distro maintainers and system administrators. (See Section 9.3.2.2, “Device Node Creation” for details.) If the host kernel supports `devtmpfs`, we can simply mount a `devtmpfs` at `$LFS/dev` and rely on the kernel to populate it.

But some host kernels lack `devtmpfs` support; these host distros use different methods to create the content of `/dev`. So the only host-agnostic way to populate the `$LFS/dev` directory is by bind mounting the host system's `/dev` directory. A **bind mount** is a special type of mount that makes a directory subtree or a file visible at some other location. Use the following command to do this.

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

7.3.2. Mounting Virtual Kernel File Systems

Now mount the remaining virtual kernel file systems:

```
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.

In other host systems `/dev/shm` is a mount point for a `tmpfs`. In that case the mount of `/dev` above will only create `/dev/shm` as a directory in the chroot environment. In this situation we must explicitly mount a `tmpfs`:

```
if [ -h $LFS/dev/shm ]; then
    mkdir -pv $LFS/$(readlink $LFS/dev/shm)
else
    mount -t tmpfs -o nosuid,nodev tmpfs $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 and finish installing the temporary tools. This environment will also be used to install the final system. As user **root**, run the following command to enter the environment that is, at the moment, populated with nothing but temporary tools:

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

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

From this point on, there is no need to use the `LFS` variable any more because all work will be restricted to the `LFS` file system; the **chroot** command runs the Bash shell with the root (`/`) directory set to `$LFS`.

Notice that `/tools/bin` is not in the `PATH`. This means that the cross toolchain will no longer be used.

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 7.3.1, “Mounting and Populating /dev” and Section 7.3.2, “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 directory structure in the LFS file system.

**Note**

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

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

```
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/}{include,src}
mkdir -pv /usr/local/{bin,lib,sbin}
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 everywhere. 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—just like a normal user would do with his or her own 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

This 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 additional directories such as `/usr/local/games` and `/usr/share/games`. In LFS, we create only the directories that are really necessary. However, feel free to create more directories, if you wish.



Warning

The FHS does not mandate the existence of the directory `/usr/lib64`, and the LFS editors have decided not to use it. For the instructions in LFS and BLFS to work correctly, it is imperative that this directory be non-existent. From time to time you should verify that it does not exist, because it is easy to create it inadvertently, and this will probably break your system.

7.6. Creating Essential Files and Symlinks

Historically, Linux maintained a list of the mounted file systems in the file `/etc/mtab`. Modern kernels maintain this list internally and expose it to the user via the `/proc` filesystem. To satisfy utilities that expect to find `/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:

```
cat > /etc/hosts << EOF
127.0.0.1 localhost $(hostname)
::1 localhost
EOF
```

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:/usr/bin/false
daemon:x:6:6:Daemon User:/dev/null:/usr/bin/false
messagebus:x:18:18:D-Bus Message Daemon User:/run/dbus:/usr/bin/false
uidd:x:80:80:UUID Generation Daemon User:/dev/null:/usr/bin/false
nobody:x:65534:65534:Unprivileged User:/dev/null:/usr/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:
input:x:24:
mail:x:34:
kvm:x:61:
uucdd:x:80:
wheel:x:97:
users:x:999:
nogroup:x:65534:
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 conventions 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 <https://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. The GID of 5 is widely used for the `tty` group, and the number 5 is also used in `/etc/fstab` for the `devpts` filesystem. 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.

The ID 65534 is used by the kernel for NFS and separate user namespaces for unmapped users and groups (those exist on the NFS server or the parent user namespace, but “do not exist” on the local machine or in the separate namespace). We assign `nobody` and `nogroup` to avoid an unnamed ID. But other distros may treat this ID differently, so any portable program should not depend on this assignment.

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:101:101::/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 /usr/bin/bash --login
```

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. Gettext-0.21.1

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

Approximate build time: 1.0 SBU

Required disk space: 287 MB

7.7.1. 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.”

7.8. Bison-3.8.2

The Bison package contains a parser generator.

Approximate build time: 0.2 SBU

Required disk space: 57 MB

7.8.1. Installation of Bison

Prepare Bison for compilation:

```
./configure --prefix=/usr \  
            --docdir=/usr/share/doc/bison-3.8.2
```

The meaning of the new configure option:

```
--docdir=/usr/share/doc/bison-3.8.2
```

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.”

7.9. Perl-5.36.0

The Perl package contains the Practical Extraction and Report Language.

Approximate build time: 0.6 SBU

Required disk space: 281 MB

7.9.1. Installation of Perl

Prepare Perl for compilation:

```
sh Configure -des \
-Dprefix=/usr \
-Dvendorprefix=/usr \
-Dprivlib=/usr/lib/perl5/5.36/core_perl \
-Darchlib=/usr/lib/perl5/5.36/core_perl \
-Dsitelib=/usr/lib/perl5/5.36/site_perl \
-Dsitearch=/usr/lib/perl5/5.36/site_perl \
-Dvendorlib=/usr/lib/perl5/5.36/vendor_perl \
-Dvendorarch=/usr/lib/perl5/5.36/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 8.41.2, “Contents of Perl.”

7.10. Python-3.11.2

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

Approximate build time: 0.4 SBU

Required disk space: 529 MB

7.10.1. Installation of Python



Note

There are two package files whose name starts with “python”. The one to extract from is `Python-3.11.2.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
```



Note

Some Python 3 modules can't be built now because the dependencies are not installed yet. The building system still attempts to build them however, so the compilation of some files will fail and the compiler message may seem to indicate “fatal error”. The message should be ignored. Just make sure the toplevel **make** command has not failed. The optional modules are not needed now and they will be built in Chapter 8.

Install the package:

```
make install
```

Details on this package are located in Section 8.50.2, “Contents of Python 3.”

7.11. Texinfo-7.0.2

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

Approximate build time: 0.2 SBU

Required disk space: 116 MB

7.11.1. Installation of Texinfo

Prepare Texinfo for compilation:

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

Compile the package:

```
make
```

Install the package:

```
make install
```

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

7.12. Util-linux-2.38.1

The Util-linux package contains miscellaneous utility programs.

Approximate build time: 0.2 SBU

Required disk space: 150 MB

7.12.1. 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 \
--libdir=/usr/lib \
--docdir=/usr/share/doc/util-linux-2.38.1 \
--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.

`--libdir=/usr/lib`

This switch ensures the `.so` symlinks targeting the shared library file in the same directory (`/usr/lib`) directly.

`--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.”

7.13. Cleaning up and Saving the Temporary System

7.13.1. Cleaning

First, remove the currently installed documentation files to prevent them from ending up in the final system, and to save about 35 MB:

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

Second, on a modern Linux system, the libtool .la files are only useful for libltdl. No libraries in LFS are loaded by libltdl, and it's known that some .la files can cause BLFS package failures. Remove those files now:

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

The current system size is now about 3 GB, however the /tools directory is no longer needed. It uses about 1 GB of disk space. Delete it now:

```
rm -rf /tools
```

7.13.2. Backup

At this point the essential programs and libraries have been created and your current LFS system is in a good state. Your system can now 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 way to recover. Unfortunately, all the temporary files will be removed, too. To avoid spending extra time to redo something which has been done successfully, creating a backup of the current LFS system may prove useful.



Note

All the remaining steps in this section are optional. Nevertheless, as soon as you begin installing packages in Chapter 8, the temporary files will be overwritten. So it may be a good idea to do a backup of the current system as described below.

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 get access to file system locations outside of the chroot environment to store/read the backup archive, which ought not be placed within the \$LFS hierarchy.

If you have decided to make a backup, leave the chroot environment:

```
exit
```



Important

All of the following instructions are executed by `root` on your host system. Take extra care about the commands you're going to run as mistakes made here can modify your host system. Be aware that the environment variable `LFS` is set for user `lfs` by default but may *not* be set for `root`.

Whenever commands are to be executed by `root`, make sure you have set `LFS`.

This has been discussed in Section 2.6, “Setting The \$LFS Variable”.

Before making a backup, unmount the virtual file systems:

```
mountpoint -q $LFS/dev/shm && umount $LFS/dev/shm
umount $LFS/dev/pts
umount $LFS/{sys,proc,run,dev}
```

Make sure you have at least 1 GB free disk space (the source tarballs will be included in the backup archive) on the file system containing the directory where you create the backup archive.

Note that the instructions below specify the home directory of the host system's `root` user, which is typically found on the root file system. Replace `$HOME` by a directory of your choice if you do not want to have the backup stored in `root`'s home directory.

Create the backup archive by running the following command:



Note

Because the backup archive is compressed, it takes a relatively long time (over 10 minutes) even on a reasonably fast system.

```
cd $LFS
tar -cJpf $HOME/lfs-temp-tools-11.3.tar.xz .
```



Note

If continuing to chapter 8, don't forget to reenter the chroot environment as explained in the “Important” box below.

7.13.3. Restore

In case some mistakes have been made and you need to start over, you can use this backup to restore the system 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, you can restore the backup by executing the following commands:



Warning

The following commands are extremely dangerous. If you run `rm -rf /*` as the `root` user and you do not change to the `$LFS` directory or the `LFS` environment variable is not set for the `root` user, it will destroy your entire host system. **YOU ARE WARNED.**

```
cd $LFS
rm -rf /*
tar -xpf $HOME/lfs-temp-tools-11.3.tar.xz
```

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



Important

If you left the chroot environment to create a backup or restart building using a restore, remember to check that the virtual file systems are still mounted (`findmnt | grep $LFS`). If they are not mounted, remount them now 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”) 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 customized 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 with a customized optimization, try to compile it without optimization and see if that fixes the problem. Even if the package does compile when using a customized optimization, there is the risk it may have been compiled incorrectly because of the complex interactions between the code and the 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 by customizing compiler optimizations are often outweighed by the risks. First-time builders of LFS are encouraged to build without custom optimizations.

On the other hand, we keep the optimizations enabled by the default configuration of the packages. In addition, we sometimes explicitly enable an optimized configuration provided by a package but not enabled by default. The package maintainers have already tested these configurations and consider them safe, so it's not likely they would break the build. Generally the default configuration already enables `-O2` or `-O3`, so the resulting system will still run very fast without any customized optimization, 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 include test suite data for all applicable packages in Chapter 8. SBU values have been calculated using four CPU cores (`-j4`) for all operations unless specified otherwise.

8.1.1. About Libraries

In general, the LFS editors discourage building and installing static libraries. Most static libraries have 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, every program that uses the static library will need to be relinked with 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.

The procedures in this chapter 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 an essential feature of the package building process.

For a more complete discussion of libraries, see *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 tracks the installation of files, making it easier to remove and upgrade packages. A good package manager will also handle the configuration files specially to keep the user configuration when the package is reinstalled or upgraded. Before you begin to wonder, NO—this section will not talk about nor recommend any particular package manager. What it does provide is a roundup of the more popular techniques and how they work. The perfect package manager for you may be among these techniques, or it 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. Finding one solution 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 needs.

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 the Linux kernel needs to be upgraded (for example, from 5.10.17 to 5.10.18 or 5.11.1), nothing else needs to be rebuilt. The system will keep working fine thanks to the well-defined interface between the kernel and userspace. Specifically, Linux API headers need not be (and should not be, see the next item) upgraded along with the kernel. You will merely need to reboot your system to use the upgraded kernel.
- If the Linux API headers or Glibc need 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 packages dynamically linked to the library must be recompiled, to link against the newer library. (Note that there is no correlation between the package version and the name of the library.) For example, consider a package foo-1.2.3 that installs a shared library with the name `libfoo.so.1`. Suppose you upgrade the package to a newer version foo-1.2.4 that installs a shared library with the 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 old libraries until all the dependent packages have been recompiled.
- If a package containing a shared library is updated, and the name of the library doesn't change, but the version number of the library **file** decreases (for example, the library is still named `libfoo.so.1`, but the name of the library file is changed from `libfoo.so.1.25` to `libfoo.so.1.24`), you should remove the library file from the previously installed version (`libfoo.so.1.25` in this case). Otherwise, a **ldconfig** command (invoked by yourself from the command line, or by the installation of some package) will reset the symlink `libfoo.so.1` to point to the old library file because it seems to be a “newer” version; its version number is larger. This situation may arise if you have to downgrade a package, or if the authors change the versioning scheme for library files.

- If a package containing a shared library is updated, and the name of the library doesn't change, but a severe issue (especially, a security vulnerability) is fixed, all running programs linked to the shared library should be restarted. The following command, run as `root` after the update is complete, will list which processes are using the old versions of those libraries (replace `libfoo` with the name of the library):

```
grep -l -e 'libfoo.*deleted' /proc/*/maps |
tr -cd 0-9\\n | xargs -r ps u
```

If OpenSSH is being used to access the system and it is linked to the updated library, you must restart the `sshd` service, then logout, login again, and rerun the preceding `ps` command to confirm that nothing is still using the deleted libraries.

- If an executable program or a shared library is overwritten, the processes using the code or data in that program or library may crash. The correct way to update a program or a shared library without causing the process to crash is to remove it first, then install the new version. The **install** command provided by `coreutils` has already implemented this, and most packages use that command to install binary files and libraries. This means that you won't be troubled by this issue most of the time. However, the install process of some packages (notably Mozilla JS in BLFS) just overwrites the file if it exists; this causes a crash. So it's safer to save your work and close unneeded running processes before updating a package.

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 each particular scheme.

8.2.2.1. It is All in My Head!

Yes, this is a package management technique. Some folks do not need a package manager because they know the packages intimately and know which files are installed by each package. Some users also do not need any package management because they plan on rebuilding the entire system whenever a package is changed.

8.2.2.2. Install in Separate Directories

This is a simplistic package management technique that does not need a special program to manage the packages. 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 a new version `foo-1.2` comes along, 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`. If you install 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 as in the previous scheme. But instead of making the symlink via a generic package name, 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, many package managers use this approach, and automate the creation of the symlinks. A few of the popular ones include `Stow`, `Epkg`, `Graft`, and `Depot`.

The installation script needs to be fooled, so the package thinks 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, suppose 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` variable to direct the installation. 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 install the package manually, 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 that uses 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 packages are installed one at a time. The logs are not reliable if two packages are installed simultaneously from 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's a good idea to perform some tests to ensure that the package manager does not break anything, and that it logs all the appropriate files.

Another technique is to use `strace`, which logs all the 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 previously described in the symlink style package management section. After the installation, a package archive is created using the installed files. This archive is then used to install the package on the local machine or even 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 <https://www.linuxfromscratch.org/hints/downloads/files/fakeroot.txt>.

The creation of package files that include dependency information is complex, and 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 <https://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 https://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 900MB uncompressed for a basic LFS build), copying that file via network transfer or CD-ROM / USB stick to the new system, and expanding it. After that, 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`, `/etc/ld.so.conf`, `/etc/sysconfig/rc.site`, `/etc/sysconfig/network`, and `/etc/sysconfig/ifconfig.eth0`.

A custom kernel may be needed 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 the AMD processor's instructions, and later versions of some processors may provide instructions that are unavailable with 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-6.03

The Man-pages package contains over 2,400 man pages.

Approximate build time: less than 0.1 SBU

Required disk space: 32 MB

8.3.1. Installation of Man-pages

Install Man-pages by running:

```
make prefix=/usr 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-20230202

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

Approximate build time: less than 0.1 SBU

Required disk space: 4.8 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-2.37

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: 11 SBU

Required disk space: 2.9 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-2.37-fhs-1.patch
```

Fix a security issue identified upstream:

```
sed '/width -=/s/workend - string/number_length/' \
-i stdio-common/vfprintf-process-arg.c
```

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

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

Ensure that the **ldconfig** and **sln** utilities will be installed into `/usr/sbin`:

```
echo "rootsbindir=/usr/sbin" > configparms
```

Prepare Glibc for compilation:

```
../configure --prefix=/usr          \
              --disable-werror       \
              --enable-kernel=3.2    \
              --enable-stack-protector=strong \
              --with-headers=/usr/include \
              libc_cv_slibdir=/usr/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=/usr/lib`

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

Compile the package:

```
make
```



Important

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

Generally a few tests do not pass. The test failures listed below are usually safe to ignore.

```
make check
```

You may see some test failures. The Glibc test suite is somewhat dependent on the host system. A few failures out of over 5000 tests can generally be ignored. This is a list of the most common issues seen for recent versions of LFS:

- *io/tst-lchmod* is known to fail in the LFS chroot environment.
- *misc/tst-ttynname* is known to fail in the LFS chroot environment.
- The *stdlib/tst-arc4random-thread* test is known to fail if the host kernel is relatively old.
- Some tests, for example *nss/tst-nss-files-hosts-multi*, are known to fail on relatively slow systems due to an internal timeout.

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 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
```

Fix a hardcoded path to the executable loader in the **ldd** script:

```
sed '/RTLDLIST=/s@/usr@g' -i /usr/bin/ldd
```

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

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

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

Individual locales can be installed using the **localedef** program. E.g., the second **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 ISO-8859-1 en_GB
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_ES -f ISO-8859-15 es_ES@euro
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 is_IS -f ISO-8859-1 is_IS
localedef -i is_IS -f UTF-8 is_IS.UTF-8
localedef -i it_IT -f ISO-8859-1 it_IT
localedef -i it_IT -f ISO-8859-15 it_IT@euro
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.SJIS 2> /dev/null || true
localedef -i ja_JP -f UTF-8 ja_JP.UTF-8
localedef -i nl_NL@euro -f ISO-8859-15 nl_NL@euro
localedef -i ru_RU -f KOI8-R ru_RU.KOI8-R
localedef -i ru_RU -f UTF-8 ru_RU.UTF-8
localedef -i se_NO -f UTF-8 se_NO.UTF-8
localedef -i ta_IN -f UTF-8 ta_IN.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
localedef -i zh_TW -f UTF-8 zh_TW.UTF-8
```

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

Alternatively, install all the locales listed in the `glibc-2.37/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-2.37/localedata/SUPPORTED` file when you need them. For instance, the following two locales are needed for some tests later in this chapter:

```
localedef -i POSIX -f UTF-8 C.UTF-8 2> /dev/null || true
localedef -i ja_JP -f SHIFT_JIS ja_JP.SJIS 2> /dev/null || true
```



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 ../../tzdata2022g.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 `/usr/lib` for dynamic libraries that are needed by programs as they are run. However, if there are libraries in directories other than `/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:	gencat, getconf, getent, iconv, iconvconfig, ldconfig, ldd, lddlibc4, ld.so (symlink to ld-linux-x86-64.so.2 or ld-linux.so.2), locale, localedef, makedb, mtrace, nscd, pcprofiledump, pldd, sln, sotruss, sprof, tzselect, xtrace , zdump, and zic
Installed libraries:	ld-linux-x86-64.so.2, ld-linux.so.2, libBrokenLocale.{a,so}, libanl.{a,so}, libc.{a,so}, libc_nonshared.a, libc_malloc_debug.so, libcrypt.{a,so}, libdl.{a,so.2}, libg.a, libm.{a,so}, libmcheck.a, libmemusage.so, libmvec.{a,so}, libnsl.so.1, libnss_compat.so, libnss_dns.so, libnss_files.so, libnss_hesiod.so, libpcprofile.so, libpthread.{a,so.0}, libresolv.{a,so}, librt.{a,so.1}, libthread_db.so, and libutil.{a,so.1}
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

gencat	Generates message catalogues
getconf	Displays the system configuration values for file system specific variables
getent	Gets entries from an administrative database
iconv	Performs character set conversion
iconvconfig	Creates fastloading iconv module configuration files
ldconfig	Configures the dynamic linker runtime bindings
ldd	Reports which shared libraries are required by each given program or shared library
lddlibc4	Assists ldd with object files. It does not exist on newer architectures like x86_64
locale	Prints various information about the current locale
localedef	Compiles locale specifications
makedb	Creates a simple database from textual input
mtrace	Reads and interprets a memory trace file and displays a summary in human-readable format
nscd	A daemon that provides a cache for the most common name service requests
pcprofiledump	Dump information generated by PC profiling
pldd	Lists dynamic shared objects used by running processes
sln	A statically linked ln program
sotruss	Traces shared library procedure calls of a specified command
sprof	Reads and displays shared object profiling data
tzselect	Asks the user about the location of the system and reports the corresponding time zone description
xtrace	Traces the execution of a program by printing the currently executed function
zdump	The time zone dumper
zic	The time zone compiler

<code>ld-*.so</code>	The helper program for shared library executables
<code>libBrokenLocale</code>	Used internally by Glibc as a gross hack to get broken programs (e.g., some Motif applications) running. See comments in <code>glibc-2.37/locale/broken_cur_max.c</code> for more information
<code>libanl</code>	An asynchronous name lookup library
<code>libc</code>	The main C library
<code>libc_malloc_debug</code>	Turns on memory allocation checking when preloaded
<code>libcrypt</code>	The cryptography library
<code>libdl</code>	Dummy library containing no functions. Previously was the dynamic linking interface library, whose functions are now in <code>libc</code>
<code>libg</code>	Dummy library containing no functions. Previously was a runtime library for <code>g++</code>
<code>libm</code>	The mathematical library
<code>libmvec</code>	The vector math library , linked in as needed when <code>libm</code> is used
<code>libmcheck</code>	Turns on memory allocation checking when linked to
<code>libmemusage</code>	Used by memusage to help collect information about the memory usage of a program
<code>libnsl</code>	The network services library , now deprecated
<code>libnss_*</code>	The Name Service Switch modules, containing functions for resolving host names, user names, group names, aliases, services, protocols, etc. Loaded by <code>libc</code> according to the configuration in <code>/etc/nsswitch.conf</code>
<code>libpcprofile</code>	Can be preloaded to PC profile an executable
<code>libpthread</code>	Dummy library containing no functions. Previously contained functions providing most of the interfaces specified by the POSIX.1b Realtime Extension , now the functions are in <code>libc</code>
<code>libresolv</code>	Contains functions for creating, sending, and interpreting packets to the Internet domain name servers
<code>librt</code>	Contains functions providing most of the interfaces specified by the POSIX.1b Realtime Extension
<code>libthread_db</code>	Contains functions useful for building debuggers for multi-threaded programs
<code>libutil</code>	Dummy library containing no functions. Previously contained code for “standard” functions used in many different Unix utilities. These functions are now in <code>libc</code>

8.6. Zlib-1.2.13

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

Approximate build time: less than 0.1 SBU

Required disk space: 6.2 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
```

Remove a 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: 7.2 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 library:

```
cp -av libbz2.so.* /usr/lib
ln -sv libbz2.so.1.0.8 /usr/lib/libbz2.so
```

Install the shared **bzip2** binary into the `/usr/bin` directory, and replace two copies of **bzip2** with symlinks:

```
cp -v bzip2-shared /usr/bin/bzip2
for i in /usr/bin/{bzcat,bunzip2}; do
    ln -sfv bzip2 $i
done
```

Remove a useless static library:

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

8.7.2. Contents of Bzip2

Installed programs:	bunzip2 (link to bzip2), bzipcat (link to bzip2), bzipcmp (link to bzipdiff), bzipdiff, bzipgrep (link to bzipgrep), bzipfgrep (link to bzipgrep), bzipgrep, bzip2, bzip2recover, bzipless (link to bzipmore), and bzipmore
Installed libraries:	libbzip2.so
Installed directory:	/usr/share/doc/bzip2-1.0.8

Short Descriptions

bunzip2	Decompresses bzipped files
bzcat	Decompresses to standard output
bzcmp	Runs cmp on bzipped files
bzdiff	Runs diff on bzipped files
bzegrep	Runs egrep on bzipped files
bzfgrep	Runs fgrep on bzipped files
bzgrep	Runs grep on bzipped files
bzip2	Compresses files using the Burrows-Wheeler block sorting text compression algorithm with Huffman coding; the compression rate is better than that achieved by more conventional compressors using “Lempel-Ziv” algorithms, like gzip
bzip2recover	Tries to recover data from damaged bzipped files
bzless	Runs less on bzipped files
bzmore	Runs more on bzipped files
libbz2	The library implementing lossless, block-sorting data compression, using the Burrows-Wheeler algorithm

8.8. Xz-5.4.1

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: 21 MB

8.8.1. Installation of Xz

Prepare Xz for compilation with:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/xz-5.4.1
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

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-5.4.1

Short Descriptions

lzcat	Decompresses to standard output
lzcmp	Runs cmp on LZMA compressed files
lzdiff	Runs diff on LZMA compressed files
lzegrep	Runs egrep on LZMA compressed files
lzfgrep	Runs fgrep on LZMA compressed files
lzgrep	Runs grep on LZMA compressed files
lzless	Runs less on LZMA compressed files
lzma	Compresses or decompresses files using the LZMA format
lzmadec	A small and fast decoder for LZMA compressed files
lzmainfo	Shows information stored in the LZMA compressed file header

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

8.9. Zstd-1.5.4

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: 0.4 SBU

Required disk space: 75 MB

8.9.1. Installation of Zstd

Compile the package:

```
make prefix=/usr
```



Note

In the test output there are several places that indicate 'failed'. These are expected and only 'FAIL' is an actual test failure. There should be no test failures.

To test the results, issue:

```
make check
```

Install the package:

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

Remove the static library:

```
rm -v /usr/lib/libzstd.a
```

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-5.44

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: 16 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-8.2

The Readline package is a set of libraries that offer command-line editing and history capabilities.

Approximate build time: less than 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 '/{OLDSUFF}/c:' support/shlib-install
```

Now fix a problem identified upstream:

```
patch -Np1 -i ../readline-8.2-upstream_fix-1.patch
```

Prepare Readline for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --with-curses \
            --docdir=/usr/share/doc/readline-8.2
```

The meaning of the new configure option:

--with-curses

This option tells Readline that it can find the **termcap library** functions in the **curses library**, not a separate termcap library. This will generate the 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
```

If desired, install the documentation:

```
install -v -m644 doc/*.{ps,pdf,html,dvi} /usr/share/doc/readline-8.2
```

8.11.2. Contents of Readline

Installed libraries: libhistory.so and libreadline.so

Installed directories: /usr/include/readline and /usr/share/doc/readline-8.2

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. M4-1.4.19

The M4 package contains a macro processor.

Approximate build time: 0.3 SBU

Required disk space: 49 MB

8.12.1. Installation of M4

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-6.2.4

The Bc package contains an arbitrary precision numeric processing language.

Approximate build time: less than 0.1 SBU

Required disk space: 7.6 MB

8.13.1. Installation of Bc

Prepare Bc for compilation:

```
CC=gcc ./configure --prefix=/usr -G -O3 -r
```

The meaning of the configure options:

CC=gcc

This parameter specifies the compiler to use.

-G

Omit parts of the test suite that won't work until the bc program has been installed.

-O3

Specify the optimization to use.

-r

Enable the use of Readline to improve the line editing feature of bc.

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: 0.1 SBU

Required disk space: 33 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
<code>libfl</code>	The <code>flex</code> library

8.15. Tcl-8.6.13

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

Approximate build time: 2.7 SBU

Required disk space: 89 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, 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.

Prepare Tcl for compilation:

```
SRCDIR=$(pwd)
cd unix
./configure --prefix=/usr \
            --mandir=/usr/share/man
```

Build the package:

```
make

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

sed -e "s|$SRCDIR/unix/pkgs/tdbc1.1.5|/usr/lib/tdbc1.1.5|" \
    -e "s|$SRCDIR/pkgs/tdbc1.1.5/generic|/usr/include|" \
    -e "s|$SRCDIR/pkgs/tdbc1.1.5/library|/usr/lib/tcl8.6|" \
    -e "s|$SRCDIR/pkgs/tdbc1.1.5|/usr/include|" \
    -i pkgs/tdbc1.1.5/tdbcConfig.sh

sed -e "s|$SRCDIR/unix/pkgs/itcl4.2.3|/usr/lib/itcl4.2.3|" \
    -e "s|$SRCDIR/pkgs/itcl4.2.3/generic|/usr/include|" \
    -e "s|$SRCDIR/pkgs/itcl4.2.3|/usr/include|" \
    -i pkgs/itcl4.2.3/itclConfig.sh

unset SRCDIR
```

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

To test the results, issue:

```
make test
```

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
```

Rename a man page that conflicts with a Perl man page:

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

Optionally, install the documentation by issuing the following commands:

```
cd ..
tar -xf ../tcl8.6.13-html.tar.gz --strip-components=1
mkdir -v -p /usr/share/doc/tcl-8.6.13
cp -v -r ./html/* /usr/share/doc/tcl-8.6.13
```

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

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

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: libexpect5.45.4.so

Short Descriptions

expect	Communicates with other interactive programs according to a script
<code>libexpect-5.45.4.so</code>	Contains functions that allow Expect to be used as a Tcl extension or to be used directly from C or C++ (without Tcl)

8.17. DejaGNU-1.6.3

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: 0.1 SBU

Required disk space: 6.9 MB

8.17.1. Installation of DejaGNU

The upstream recommends building DejaGNU in a dedicated build directory:

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

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-1.6.3
install -v -m644  doc/dejagnu.{html,txt} /usr/share/doc/dejagnu-1.6.3
```

To test the results, issue:

```
make check
```

8.17.2. Contents of DejaGNU

Installed program: dejagnu and runtest

Short Descriptions

dejagnu DejaGNU auxiliary command launcher

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

8.18. Binutils-2.40

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

Approximate build time: 2.2 SBU

Required disk space: 2.6 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.
```

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

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

Prepare Binutils for compilation:

```
../configure --prefix=/usr      \  
             --sysconfdir=/etc  \  
             --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` (alongside 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** instead of 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-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 were 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
```

For a list of failed tests, run:

```
grep '^FAIL:' $(find -name '*.log')
```

Twelve tests fail in the gold test suite when the `--enable-default-pie` and `--enable-default-ssp` options are passed to GCC.

Install the package:

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

Remove useless static libraries and an empty man page:

```
rm -fv /usr/lib/lib{bfd,ctf,ctf-nobfd,sframe,opcodes}.a
rm -fv /usr/share/man/man1/{gprofng,gp-*}.1
```

8.18.2. Contents of Binutils

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

Short Descriptions

addr2line	Translates program addresses to file names and line numbers; given an address and the name of an executable, it uses the debugging information in the executable to determine which source file and line number are associated with the address
ar	Creates, modifies, and extracts from archives
as	An assembler that assembles the output of gcc into object files
c++filt	Used by the linker to de-mangle C++ and Java symbols and to keep overloaded functions from clashing
dwp	The DWARF packaging utility
elfedit	Updates the ELF headers of ELF files
gprof	Displays call graph profile data

gprofng	Gathers and analyzes performance data
ld	A linker that combines a number of object and archive files into a single file, relocating their data and tying up symbol references
ld.gold	A cut down version of ld that only supports the elf object file format
ld.bfd	A hard link to ld
nm	Lists the symbols occurring in a given object file
objcopy	Translates one type of object file into another
objdump	Displays information about the given object file, with options controlling the particular information to display; the information shown is useful to programmers who are working on the compilation tools
ranlib	Generates an index of the contents of an archive and stores it in the archive; the index lists all of the symbols defined by archive members that are relocatable object files
readelf	Displays information about ELF type binaries
size	Lists the section sizes and the total size for the given object files
strings	Outputs, for each given file, the sequences of printable characters that are of at least the specified length (defaulting to four); for object files, it prints, by default, only the strings from the initializing and loading sections while for other types of files, it scans the entire file
strip	Discards symbols from object files
libbfd	The Binary File Descriptor library
libctf	The Compat ANSI-C Type Format debugging support library
libctf-nobfd	A libctf variant which does not use libbfd functionality
libopcodes	A library for dealing with opcodes—the “readable text” versions of instructions for the processor; it is used for building utilities like objdump
libsframe	A library to support online backtracing using a simple unwinder

8.19. GMP-6.2.1

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

Approximate build time: 0.3 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-pc-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+=1} ; 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-4.2.0

The MPFR package contains functions for multiple precision math.

Approximate build time: 0.2 SBU

Required disk space: 43 MB

8.20.1. Installation of MPFR

Fix a test case based on a bug of old Glibc releases:

```
sed -e 's/+01,234,567/+1,234,567 /' \
    -e 's/13.10Pd/13Pd/' \
    -i tests/tsprintf.c
```

Prepare MPFR for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --enable-thread-safe \
            --docdir=/usr/share/doc/mpfr-4.2.0
```

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 197 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-4.2.0

Short Descriptions

`libmpfr` Contains multiple-precision math functions

8.21. MPC-1.3.1

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: 0.1 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-1.3.1
```

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-1.3.1

Short Descriptions

`libmpc` Contains complex math functions

8.22. Attr-2.5.1

The Attr package contains utilities to administer the extended attributes of filesystem objects.

Approximate build time: less than 0.1 SBU

Required disk space: 4.1 MB

8.22.1. Installation of Attr

Prepare Attr for compilation:

```
./configure --prefix=/usr      \
            --disable-static  \
            --sysconfdir=/etc \
            --docdir=/usr/share/doc/attr-2.5.1
```

Compile the package:

```
make
```

The tests must 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
```

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-2.5.1

Short Descriptions

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

8.23. Acl-2.3.1

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

Approximate build time: less than 0.1 SBU

Required disk space: 6.1 MB

8.23.1. Installation of Acl

Prepare Acl for compilation:

```
./configure --prefix=/usr      \
            --disable-static    \
            --docdir=/usr/share/doc/acl-2.3.1
```

Compile the package:

```
make
```

The Acl tests must be run on a filesystem that supports access controls, but not until the Coreutils package has been built, using the Acl libraries. If desired, return to this package and run **make check** after the Coreutils package has been built.

Install the package:

```
make install
```

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-2.3.1

Short Descriptions

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

8.24. Libcap-2.67

The Libcap package implements the userspace interface to the POSIX 1003.1e capabilities available in Linux kernels. These capabilities partition the all-powerful root privilege into a set of distinct privileges.

Approximate build time: less than 0.1 SBU

Required disk space: 2.9 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:

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

8.24.2. Contents of Libcap

Installed programs: capsh, getcap, getpcaps, and setcap

Installed library: libcap.so and libpsx.so

Short Descriptions

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

8.25. Shadow-4.13

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

Approximate build time: 0.1 SBU

Required disk space: 46 MB

8.25.1. Installation of Shadow



Note

If you would like to enforce the use of strong passwords, refer to <https://www.linuxfromscratch.org/blfs/view/11.3/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-6.03”:

```
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. In addition, set the number of rounds to 500,000 instead of the default 5000, which is much too low to prevent brute force password attacks. 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. And, remove `/bin` and `/sbin` from the `PATH`, since they are simply symlinks to their counterparts in `/usr`.



Note

If you wish to include `/bin` and/or `/sbin` in the `PATH` for some reason, modify the `PATH` in `.bashrc` after LFS has been built.

```
sed -e 's:#ENCRYPT_METHOD DES:ENCRYPT_METHOD SHA512:' \
    -e 's@#(SHA_CRYPT_...ROUNDS 5000\)\@100@' \
    -e 's:/var/spool/mail:/var/mail:' \
    -e '/PATH={s@/sbin:@;s@/bin:@}' \
    -i etc/login.defs
```



Note

If you chose to build Shadow with Cracklib support, issue this command:

```
sed -i 's:DICTPATH.*:DICTPATH\t/lib/cracklib/pw_dict:' etc/login.defs
```

Prepare Shadow for compilation:

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

The meaning of the new configuration options:**touch /usr/bin/passwd**

The file `/usr/bin/passwd` needs to exist because its location is hardcoded in some programs; if it does not already exist, the installation script will create it in the wrong place.

`--with-group-name-max-length=32`

The longest permissible user name is 32 characters. Make the maximum length of a group name the same.

Compile the package:

```
make
```

This package does not come with a test suite.

Install the package:

```
make exec_prefix=/usr install
make -C man install-man
```

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 you use 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 must 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 default configuration for the **useradd** utility needs some explanation. First, the default action for the **useradd** utility is to create the user and a group with the same name as the user. By default the user ID (UID) and group ID (GID) numbers will begin at 1000. This means if you don't pass extra 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 either the `-g` or `-N` parameter to **useradd**, or else change the setting of `USERGROUPS_ENAB` in `/etc/login.defs`. See `useradd(8)` for more information.

Second, to change the default parameters, the file `/etc/default/useradd` must be created and tailored to suit your particular needs. Create it with:

```
mkdir -p /etc/default
useradd -D --gid 999
```

`/etc/default/useradd` parameter explanations

`GROUP=999`

This parameter sets the beginning of the group numbers used in the `/etc/group` file. The particular value 999 comes from the `--gid` parameter above. You may set it to any desired value. 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. Note also that if you don't have a group with an ID equal to this number on your system, then the first time you use **useradd** without the `-g` parameter, an error message will be generated—`useradd: unknown GID 999`, even though the account has been

created correctly. That is why we created the group `users` with this group ID in Section 7.6, “Creating Essential Files and Symlinks”.

```
CREATE_MAIL_SPOOL=yes
```

This parameter causes **useradd** to create a mailbox file for each new user. **useradd** will assign the group ownership of this file to the `mail` group with 0660 permissions. If you would rather not create these files, issue the following command:

```
sed -i '/MAIL/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:	<code>chage</code> , <code>chfn</code> , <code>chgpaswd</code> , <code>chpaswd</code> , <code>chsh</code> , <code>expiry</code> , <code>faillog</code> , <code>getsubids</code> , <code>gpaswd</code> , <code>groupadd</code> , <code>groupdel</code> , <code>groupmems</code> , <code>groupmod</code> , <code>grpck</code> , <code>grpconv</code> , <code>grpunconv</code> , <code>lastlog</code> , <code>login</code> , <code>logout</code> , <code>newgidmap</code> , <code>newgrp</code> , <code>newuidmap</code> , <code>newusers</code> , <code>nologin</code> , <code>passwd</code> , <code>pwck</code> , <code>pwconv</code> , <code>pwunconv</code> , <code>sg</code> (link to <code>newgrp</code>), <code>su</code> , <code>useradd</code> , <code>userdel</code> , <code>usermod</code> , <code>vigr</code> (link to <code>vipw</code>), and <code>vipw</code>
Installed directories:	<code>/etc/default</code> and <code>/usr/include/shadow</code>
Installed libraries:	<code>libsubid.so</code>

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
chgpaswd	Used to update group passwords in batch mode
chpaswd	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, and to reset the failure count
getsubids	Is used to list the subordinate id ranges for a user
gpaswd	Is used to add and delete members and administrators to groups
groupadd	Creates a group with the given name
groupdel	Deletes the group with the given name
groupmems	Allows a user to administer his/her own group membership list without the requirement of super user privileges.
groupmod	Is used to modify the given group's name or GID
grpck	Verifies the integrity of the group files <code>/etc/group</code> and <code>/etc/gshadow</code>
grpconv	Creates or updates the shadow group file from the normal group file
grpunconv	Updates <code>/etc/group</code> from <code>/etc/gshadow</code> and then deletes the latter

lastlog	Reports the most recent login of all users or of a given user
login	Is used by the system to let users sign on
logoutd	Is a daemon used to enforce restrictions on log-on time and ports
newgidmap	Is used to set the gid mapping of a user namespace
newgrp	Is used to change the current GID during a login session
newuidmap	Is used to set the uid mapping of a user namespace
newusers	Is used to create or update an entire series of user accounts
nologin	Displays a message saying an account is not available; it is designed to be used as the default shell for disabled accounts
passwd	Is used to change the password for a user or group account
pwck	Verifies the integrity of the password files <code>/etc/passwd</code> and <code>/etc/shadow</code>
pwconv	Creates or updates the shadow password file from the normal password file
pwunconv	Updates <code>/etc/passwd</code> from <code>/etc/shadow</code> and then deletes the latter
sg	Executes a given command while the user's GID is set to that of the given group
su	Runs a shell with substitute user and group IDs
useradd	Creates a new user with the given name, or updates the default new-user information
userdel	Deletes the specified user account
usermod	Is used to modify the given user's login name, user identification (UID), shell, initial group, home directory, etc.
vigr	Edits the <code>/etc/group</code> or <code>/etc/gshadow</code> files
vipw	Edits the <code>/etc/passwd</code> or <code>/etc/shadow</code> files
libsubid	library to handle subordinate id ranges for users and groups

8.26. GCC-12.2.0

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

Approximate build time: 43 SBU (with tests)

Required disk space: 5.1 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++ \
             --enable-default-pie   \
             --enable-default-ssp   \
             --disable-multilib     \
             --disable-bootstrap    \
             --with-system-zlib
```

GCC supports seven different computer languages, but the prerequisites for most of them have not yet been installed. 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 program installed by the Binutils package 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.



Note

PIE (position-independent executables) are binary programs that can be loaded anywhere in memory. Without PIE, the security feature named ASLR (Address Space Layout Randomization) can be applied for the shared libraries, but not for the executables themselves. Enabling PIE allows ASLR for the executables in addition to the shared libraries, and mitigates some attacks based on fixed addresses of sensitive code or data in the executables.

SSP (Stack Smashing Protection) is a technique to ensure that the parameter stack is not corrupted. Stack corruption can, for example, alter the return address of a subroutine, thus transferring control to some dangerous code (existing in the program or shared libraries, or injected by the attacker somehow).

Compile the package:

```
make
```



Important

In this section, the test suite for GCC is considered important, but it takes a long time. First-time builders are encouraged to run the test suite. The time to run the tests can be reduced significantly by adding `-jx` to the **make -k check** command below, where `x` is the number of CPU cores on your system.

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 extract a summary of the test suite results, run:

```
../contrib/test_summary
```

To filter out only the summaries, pipe the output through `grep -A7 Summ.`

Results can be compared with those located at <https://www.linuxfromscratch.org/lfs/build-logs/11.3/> and <https://gcc.gnu.org/ml/gcc-testresults/>.

Eleven tests in the i386 test suite for the gcc compiler are known to FAIL. It's because the test files do not account for the `--enable-default-pie` option.

Four tests related to PR100400 may be reported as both XPASS and FAIL when testing the g++ compiler; the test file is not well written.

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:

```
make install
```

The GCC build directory is owned by `tester` now, and the ownership of the installed header directory (and its content) is incorrect. Change the ownership to the `root` user and group:

```
chown -v -R root:root \
  /usr/lib/gcc/$(gcc -dumpmachine)/12.2.0/include{,-fixed}
```

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

```
ln -svr /usr/bin/cpp /usr/lib
```

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

```
ln -sfv ../../libexec/gcc/$(gcc -dumpmachine)/12.2.0/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 set up to use the correct start files:

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

The output of the last command should be:

```
/usr/lib/gcc/x86_64-pc-linux-gnu/12.2.0/../../../../lib/Scrt1.o succeeded
/usr/lib/gcc/x86_64-pc-linux-gnu/12.2.0/../../../../lib/crti.o succeeded
/usr/lib/gcc/x86_64-pc-linux-gnu/12.2.0/../../../../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/12.2.0/include
/usr/local/include
/usr/lib/gcc/x86_64-pc-linux-gnu/12.2.0/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 use a few other 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 /usr/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 /usr/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 should 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

Installed programs:	c++, cc (link to gcc), cpp, g++, gcc, gcc-ar, gcc-nm, gcc-ranlib, gcov, gcov-dump, gcov-tool, and lto-dump
Installed libraries:	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}
Installed directories:	/usr/include/c++, /usr/lib/gcc, /usr/libexec/gcc, and /usr/share/gcc-12.2.0

Short Descriptions

c++	The C++ compiler
cc	The C compiler
cpp	The C preprocessor; it is used by the compiler to expand the <code>#include</code> , <code>#define</code> , and similar directives in the source files
g++	The C++ compiler
gcc	The C compiler
gcc-ar	A wrapper around ar that adds a plugin to the command line. This program is only used to add "link time optimization" and is not useful with the default build options.
gcc-nm	A wrapper around nm that adds a plugin to the command line. This program is only used to add "link time optimization" and is not useful with the default build options.
gcc-ranlib	A wrapper around ranlib that adds a plugin to the command line. This program is only used to add "link time optimization" and is not useful with the default build options.

gcov	A coverage testing tool; it is used to analyze programs to determine where optimizations will have the greatest effect
gcov-dump	Offline gcda and gcno profile dump tool
gcov-tool	Offline gcda profile processing tool
lto-dump	Tool for dumping object files produced by GCC with LTO enabled
libasan	The Address Sanitizer runtime library
libatomic	GCC atomic built-in runtime library
libcc1	The C preprocessing library
libgcc	Contains run-time support for gcc
libgcov	This library is linked into a program when GCC is instructed to enable profiling
libgomp	GNU implementation of the OpenMP API for multi-platform shared-memory parallel programming in C/C++ and Fortran
libitm	The GNU transactional memory library
liblsan	The Leak Sanitizer runtime library
liblto_plugin	GCC's LTO plugin allows Binutils to process object files produced by GCC with LTO enabled
libquadmath	GCC Quad Precision Math Library API
libssp	Contains routines supporting GCC's stack-smashing protection functionality. Normally it is not used, because Glibc also provides those routines.
libstdc++	The standard C++ library
libstdc++fs	ISO/IEC TS 18822:2015 Filesystem library
libsupc++	Provides supporting routines for the C++ programming language
libtsan	The Thread Sanitizer runtime library
libubsan	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: 0.1 SBU

Required disk space: 29 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-6.4

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

Approximate build time: 0.2 SBU

Required disk space: 45 MB

8.28.1. Installation of Ncurses

Prepare Ncurses for compilation:

```
./configure --prefix=/usr \
            --mandir=/usr/share/man \
            --with-shared \
            --without-debug \
            --without-normal \
            --with-cxx-shared \
            --enable-pc-files \
            --enable-widec \
            --with-pkg-config-libdir=/usr/lib/pkgconfig
```

The meaning of the new configure options:

--with-shared

This makes Ncurses build and install shared C libraries.

--without-normal

This prevents Ncurses building and installing static C libraries.

--without-debug

This prevents Ncurses building and installing debug libraries.

--with-cxx-shared

This makes Ncurses build and install shared C++ bindings. It also prevents it building and installing static C++ bindings.

--enable-pc-files

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

--enable-widec

This switch causes wide-character libraries (e.g., `libncursesw.so.6.4`) to be built instead of normal ones (e.g., `libncurses.so.6.4`). These wide-character libraries are usable in both multibyte and traditional 8-bit locales, while normal libraries work properly only in 8-bit locales. Wide-character and normal libraries are source-compatible, but not binary-compatible.

Compile the package:

```
make
```

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

The installation of this package will overwrite `libncursesw.so.6.4` in-place. It may crash the shell process which is using code and data from the library file. Install the package with `DESTDIR`, and replace the library file correctly using **install** command:

```
make DESTDIR=$PWD/dest install
install -vm755 dest/usr/lib/libncursesw.so.6.4 /usr/lib
rm -v dest/usr/lib/libncursesw.so.6.4
cp -av dest/* /
```

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

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

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

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

If desired, install the Ncurses documentation:

```
mkdir -pv /usr/share/doc/ncurses-6.4
cp -v -R doc/* /usr/share/doc/ncurses-6.4
```



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:	captainfo (link to tic), clear, infocmp, infotocap (link to tic), ncursesw6-config, reset (link to tset), tabs, tic, toe, tput, and tset
Installed libraries:	libcursesw.so (symlink and linker script to libncursesw.so), libformw.so, libmenuw.so, libncursesw.so, libncurses++w.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-6.4

Short Descriptions

captainfo	Converts a termcap description into a terminfo description
clear	Clears the screen, if possible
infocmp	Compares or prints out terminfo descriptions
infotocap	Converts a terminfo description into a termcap description
ncursesw6-config	Provides configuration information for ncurses

reset	Reinitializes a terminal to its default values
tabs	Clears and sets tab stops on a terminal
tic	The terminfo entry-description compiler that translates a terminfo file from source format into the binary format needed for the ncurses library routines [A terminfo file contains information on the capabilities of a certain terminal.]
toe	Lists all available terminal types, giving the primary name and description for each
tput	Makes the values of terminal-dependent capabilities available to the shell; it can also be used to reset or initialize a terminal or report its long name
tset	Can be used to initialize terminals
<code>libcursesw</code>	A link to <code>libncursesw</code>
<code>libncursesw</code>	Contains functions to display text in many complex ways on a terminal screen; a good example of the use of these functions is the menu displayed during the kernel's make menuconfig
<code>libncurses++w</code>	Contains C++ binding for other libraries in this package
<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-4.9

The Sed package contains a stream editor.

Approximate build time: 0.3 SBU

Required disk space: 31 MB

8.29.1. Installation of Sed

Prepare Sed for compilation:

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

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-4.9
install -m644 doc/sed.html /usr/share/doc/sed-4.9
```

8.29.2. Contents of Sed

Installed program: sed

Installed directory: /usr/share/doc/sed-4.9

Short Descriptions

sed Filters and transforms text files in a single pass

8.30. Psmisc-23.6

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

Approximate build time: less than 0.1 SBU

Required disk space: 6.5 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
```

8.30.2. Contents of Psmisc

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

Short Descriptions

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

8.31. Gettext-0.21.1

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

Approximate build time: 1.3 SBU

Required disk space: 241 MB

8.31.1. Installation of Gettext

Prepare Gettext for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/gettext-0.21.1
```

Compile the package:

```
make
```

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

```
make check
```

Install the package:

```
make install
chmod -v 0755 /usr/lib/preloadable_libintl.so
```

8.31.2. Contents of Gettext

Installed programs:	autopoint, envsubst, gettext, gettext.sh, gettextize, msgattrib, msgcat, msgcmp, msgcomm, msgconv, msgen, msgexec, msgfilter, msgfmt, msggrep, msginit, msgmerge, msgunfmt, msguniq, ngettext, recode-sr-latin, and xgettext
Installed libraries:	libasprintf.so, libgettextlib.so, libgettextpo.so, libgettextsrc.so, libtextstyle.so, and preloadable_libintl.so
Installed directories:	/usr/lib/gettext, /usr/share/doc/gettext-0.21.1, /usr/share/gettext, and /usr/share/gettext-0.19.8

Short Descriptions

autopoint	Copies standard Gettext infrastructure files into a source package
envsubst	Substitutes environment variables in shell format strings
gettext	Translates a natural language message into the user's language by looking up the translation in a message catalog
gettext.sh	Primarily serves as a shell function library for gettext
gettextize	Copies all standard Gettext files into the given top-level directory of a package to begin internationalizing it
msgattrib	Filters the messages of a translation catalog according to their attributes and manipulates the attributes
msgcat	Concatenates and merges the given .po files
msgcmp	Compares two .po files to check that both contain the same set of msgid strings

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

8.32. Bison-3.8.2

The Bison package contains a parser generator.

Approximate build time: 2.3 SBU

Required disk space: 62 MB

8.32.1. Installation of Bison

Prepare Bison for compilation:

```
./configure --prefix=/usr --docdir=/usr/share/doc/bison-3.8.2
```

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-3.8

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

Approximate build time: 0.4 SBU

Required disk space: 37 MB

8.33.1. Installation of Grep

First, remove a warning about using `egrep` and `fgrep` that makes tests on some packages fail:

```
sed -i "s/echo/#echo/" src/egrep.sh
```

Prepare Grep for compilation:

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

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. It is obsolete, use **grep -E** instead
- fgrep** Prints lines matching a list of fixed strings. It is obsolete, use **grep -F** instead
- grep** Prints lines matching a basic regular expression

8.34. Bash-5.2.15

The Bash package contains the Bourne-Again Shell.

Approximate build time: 1.2 SBU

Required disk space: 52 MB

8.34.1. Installation of Bash

Prepare Bash for compilation:

```
./configure --prefix=/usr          \
            --without-bash-malloc  \
            --with-installed-readline \
            --docdir=/usr/share/doc/bash-5.2.15
```

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 .
```

The test suite of this package is designed to be run as a `non-root` user who owns the terminal connected to standard input. To satisfy the requirement, spawn a new pseudo terminal using Expect and run the tests as the `tester` user:

```
su -s /usr/bin/expect tester << EOF
set timeout -1
spawn make tests
expect eof
lassign [wait] _ _ _ value
exit $value
EOF
```

The test suite uses **diff** to detect the difference between test script output and the expected output. Any output from **diff** (prefixed with `<` and `>`) indicates a test failure, unless there is a message saying the difference can be ignored. One test named `run-builtins` is known to fail on some host distros with a difference on the first line of the output.

Install the package:

```
make install
```

Run the newly compiled **bash** program (replacing the one that is currently being executed):

```
exec /usr/bin/bash --login
```

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-5.2.15

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-2.4.7

The Libtool package contains the GNU generic library support script. It makes the use of shared libraries simpler with a consistent, portable interface.

Approximate build time: 1.4 SBU

Required disk space: 44 MB

8.35.1. Installation of Libtool

Prepare Libtool for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make -k 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 these tests pass if rechecked after automake has been installed. Additionally, with grep-3.8, two tests will trigger a warning for non-POSIX regular expressions and fail.

Install the package:

```
make install
```

Remove a 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 opening dynamically loaded libraries

8.36. GDBM-1.23

The GDBM package contains the GNU Database Manager. It is a library of database functions that uses extensible hashing and works like 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: less than 0.1 SBU

Required disk space: 13 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
```

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

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

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: 6.1 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-2.5.0

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

Approximate build time: 0.1 SBU

Required disk space: 12 MB

8.38.1. Installation of Expat

Prepare Expat for compilation:

```
./configure --prefix=/usr \
            --disable-static \
            --docdir=/usr/share/doc/expat-2.5.0
```

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,css} /usr/share/doc/expat-2.5.0
```

8.38.2. Contents of Expat

Installed program: xmlwf

Installed libraries: libexpat.so

Installed directory: /usr/share/doc/expat-2.5.0

Short Descriptions

xmlwf Is a non-validating utility to check whether or not XML documents are well formed

libexpat Contains API functions for parsing XML

8.39. Inetutils-2.4

The Inetutils package contains programs for basic networking.

Approximate build time: 0.2 SBU

Required disk space: 31 MB

8.39.1. Installation of Inetutils

Prepare Inetutils for compilation:

```
./configure --prefix=/usr \
            --bindir=/usr/bin \
            --localstatedir=/var \
            --disable-logger \
            --disable-whois \
            --disable-rcp \
            --disable-rexec \
            --disable-rlogin \
            --disable-rsh \
            --disable-servers
```

The meaning of the configure options:

--disable-logger

This option prevents Inetutils from installing the **logger** program, which is used by scripts to pass messages to the System Log Daemon. Do not install it because Util-linux installs a more recent version.

--disable-whois

This option disables the building of the Inetutils **whois** client, which is out of date. Instructions for a better **whois** client are in the BLFS book.

*--disable-r**

These parameters disable building obsolete programs that should not be used due to security issues. The functions provided by these programs can be provided by the openssh package in the BLFS book.

--disable-servers

This disables the installation of the various network servers included as part of the Inetutils package. These servers are deemed not appropriate in a basic LFS system. Some are insecure by nature and are only considered safe on trusted networks. Note that better replacements are available for many of these servers.

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

Move a program to the proper location:

```
mv -v /usr/{,s}bin/ifconfig
```

8.39.2. Contents of Inetutils

Installed programs: dnsdomainname, ftp, ifconfig, hostname, ping, ping6, talk, telnet, tftp, and traceroute

Short Descriptions

dnsdomainname	Show the system's DNS domain name
ftp	Is the file transfer protocol program
hostname	Reports or sets the name of the host
ifconfig	Manages network interfaces
ping	Sends echo-request packets and reports how long the replies take
ping6	A version of ping for IPv6 networks
talk	Is used to chat with another user
telnet	An interface to the TELNET protocol
tftp	A trivial file transfer program
traceroute	Traces the route your packets take from the host you are working on to another host on a network, showing all the intermediate hops (gateways) along the way

8.40. Less-608

The Less package contains a text file viewer.

Approximate build time: less than 0.1 SBU

Required disk space: 4.3 MB

8.40.1. 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
```

8.40.2. Contents of Less

Installed programs: less, lessecho, and lesskey

Short Descriptions

less	A file viewer or pager; it displays the contents of the given file, letting the user scroll, find strings, and jump to marks
lessecho	Needed to expand meta-characters, such as <code>*</code> and <code>?</code> , in filenames on Unix systems
lesskey	Used to specify the key bindings for less

8.41. Perl-5.36.0

The Perl package contains the Practical Extraction and Report Language.

Approximate build time: 7.9 SBU

Required disk space: 234 MB

8.41.1. Installation of Perl

This version of Perl 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 shown below to use the defaults that Perl auto-detects:

```
sh Configure -des \
-Dprefix=/usr \
-Dvendorprefix=/usr \
-Dprivlib=/usr/lib/perl5/5.36/core_perl \
-Darchlib=/usr/lib/perl5/5.36/core_perl \
-Dsitelib=/usr/lib/perl5/5.36/site_perl \
-Dsitearch=/usr/lib/perl5/5.36/site_perl \
-Dvendorlib=/usr/lib/perl5/5.36/vendor_perl \
-Dvendorarch=/usr/lib/perl5/5.36/vendor_perl \
-Dman1dir=/usr/share/man/man1 \
-Dman3dir=/usr/share/man/man3 \
-Dpager="/usr/bin/less -isR" \
-Duseshrplib \
-Dusethreads
```

The meaning of the configure options:

`-Dvendorprefix=/usr`

This ensures **perl** knows how to tell packages where they should install their Perl modules.

`-Dpager="/usr/bin/less -isR"`

This ensures that **less** is used instead of **more**.

`-Dman1dir=/usr/share/man/man1 -Dman3dir=/usr/share/man/man3`

Since Groff is not installed yet, **Configure** will not create man pages for Perl. These parameters override this behavior.

`-Duseshrplib`

Build a shared libperl needed by some Perl modules.

`-Dusethreads`

Build Perl with support for threads.

`-Dprivlib,-Darchlib,-Dsitelib,...`

These settings define where Perl looks for installed modules. The LFS editors chose to put them in a directory structure based on the MAJOR.MINOR version of Perl (5.36) which allows upgrading Perl to newer patch levels (the patch level is the last dot separated part in the full version string like 5.36.0) without reinstalling all of the modules.

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
```

8.41.2. Contents of Perl

Installed programs: corelist, cpan, enc2xs, encguess, h2ph, h2xs, instmodsh, json_pp, libnetcfg, perl, perl5.36.0 (hard link to perl), perlbug, perldoc, perlvp, perlthanks (hard link to perlbug), piconv, pl2pm, pod2html, pod2man, pod2text, pod2usage, podchecker, podselect, prove, ptar, ptardiff, ptargrep, shasum, splain, xsubpp, and zipdetails

Installed libraries: Many which cannot all be listed here

Installed directory: /usr/lib/perl5

Short Descriptions

corelist	A command line front end to Module::CoreList
cpan	Interact with the Comprehensive Perl Archive Network (CPAN) from the command line
enc2xs	Builds a Perl extension for the Encode module from either Unicode Character Mappings or Tcl Encoding Files
encguess	Guess the encoding type of one or several files
h2ph	Converts .h C header files to .ph Perl header files
h2xs	Converts .h C header files to Perl extensions
instmodsh	Shell script for examining installed Perl modules; it can create a tarball from an installed module
json_pp	Converts data between certain input and output formats
libnetcfg	Can be used to configure the libnet Perl module
perl	Combines some of the best features of C, sed , awk and sh into a single Swiss Army language
perl5.36.0	A hard link to perl
perlbug	Used to generate bug reports about Perl, or the modules that come with it, and mail them
perldoc	Displays a piece of documentation in pod format that is embedded in the Perl installation tree or in a Perl script
perlvp	The Perl Installation Verification Procedure; it can be used to verify that Perl and its libraries have been installed correctly
perlthanks	Used to generate thank you messages to mail to the Perl developers
piconv	A Perl version of the character encoding converter iconv
pl2pm	A rough tool for converting Perl4 .pl files to Perl5 .pm modules
pod2html	Converts files from pod format to HTML format
pod2man	Converts pod data to formatted *roff input

pod2text	Converts pod data to formatted ASCII text
pod2usage	Prints usage messages from embedded pod docs in files
podchecker	Checks the syntax of pod format documentation files
podselect	Displays selected sections of pod documentation
prove	Command line tool for running tests against the Test::Harness module
ptar	A tar -like program written in Perl
ptardiff	A Perl program that compares an extracted archive with an unextracted one
ptargrep	A Perl program that applies pattern matching to the contents of files in a tar archive
shasum	Prints or checks SHA checksums
splain	Is used to force verbose warning diagnostics in Perl
xsubpp	Converts Perl XS code into C code
zipdetails	Displays details about the internal structure of a Zip file

8.42. 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: 2.3 MB

8.42.1. 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
```

8.42.2. Contents of XML::Parser

Installed module: Expat.so

Short Descriptions

Expat provides the Perl Expat interface

8.43. 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

8.43.1. 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
```

8.43.2. Contents of Intltool

Installed programs: intltool-extract, intltool-merge, intltool-prepare, intltool-update, and intltoolize

Installed directories: /usr/share/doc/intltool-0.51.0 and /usr/share/intltool

Short Descriptions

intltoolize	Prepares a package to use intltool
intltool-extract	Generates header files that can be read by gettext
intltool-merge	Merges translated strings into various file types
intltool-prepare	Updates pot files and merges them with translation files
intltool-update	Updates the po template files and merges them with the translations

8.44. 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 6.2 SBU with tests)

Required disk space: 24 MB

8.44.1. Installation of Autoconf

First, fix several problems with the tests caused by bash-5.2 and later:

```
sed -e 's/SECONDS|/&SHLVL|/' \
    -e '/BASH_ARGV=/a\      /^SHLVL=/ d' \
    -i.orig tests/local.at
```

Prepare Autoconf for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```



Note

The test time for autoconf 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.

Install the package:

```
make install
```

8.44.2. Contents of Autoconf

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

Installed directory: /usr/share/autoconf

Short Descriptions

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

autoupdate	Modifies a <code>configure.in</code> file that still calls autoconf macros by their old names to use the current macro names
ifnames	Helps when writing <code>configure.in</code> files for a software package; it prints the identifiers that the package uses in C preprocessor conditionals [If a package has already been set up to have some portability, this program can help determine what configure needs to check for. It can also fill in gaps in a <code>configure.in</code> file generated by autoscan .]

8.45. Automake-1.16.5

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

Approximate build time: less than 0.1 SBU (about 7.3 SBU with tests)

Required disk space: 114 MB

8.45.1. Installation of Automake

Prepare Automake for compilation:

```
./configure --prefix=/usr --docdir=/usr/share/doc/automake-1.16.5
```

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 test `t/subobj.sh` is known to fail.

Install the package:

```
make install
```

8.45.2. 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-1.16.5`

Short Descriptions

aclocal	Generates <code>aclocal.m4</code> files based on the contents of <code>configure.in</code> files
aclocal-1.16	A hard link to aclocal
automake	A tool for automatically generating <code>Makefile.in</code> files from <code>Makefile.am</code> files [To create all the <code>Makefile.in</code> files for a package, run this program in the top-level directory. By scanning the <code>configure.in</code> file, it automatically finds each appropriate <code>Makefile.am</code> file and generates the corresponding <code>Makefile.in</code> file.]
automake-1.16	A hard link to automake

8.46. OpenSSL-3.0.8

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: 3.2 SBU

Required disk space: 520 MB

8.46.1. 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 (depending on inconsistent values of CONFIG_CRYPTO_USER_API* settings.) If it fails, it can safely be ignored.

Install the package:

```
sed -i 's/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-3.0.8
```

If desired, install some additional documentation:

```
cp -vfr doc/* /usr/share/doc/openssl-3.0.8
```



Note

You should update OpenSSL when a new version which fixes vulnerabilities is announced. Since OpenSSL 3.0.0, the OpenSSL versioning scheme follows the MAJOR.MINOR.PATCH format. API/ABI compatibility is guaranteed for the same MAJOR version number. Because LFS installs only the shared libraries, there is no need to recompile packages which link to `libcrypto.so` or `libssl.so` *when upgrading to a version with the same MAJOR version number*.

However, any running programs linked to those libraries need to be stopped and restarted. Read the related entries in Section 8.2.1, “Upgrade Issues” for details.

8.46.2. 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-3.0.8`

Short Descriptions

c_rehash	is a Perl script that scans all files in a directory and adds symbolic links to their hash values. Use of c_rehash is considered obsolete and should be replaced by openssl rehash command
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
<code>libcrypto.so</code>	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
<code>libssl.so</code>	implements the Transport Layer Security (TLS v1) protocol. It provides a rich API, documentation on which can be found by running man 7 ssl

8.47. Kmod-30

The Kmod package contains libraries and utilities for loading kernel modules

Approximate build time: less than 0.1 SBU

Required disk space: 12 MB

8.47.1. Installation of Kmod

Prepare Kmod for compilation:

```
./configure --prefix=/usr      \
            --sysconfdir=/etc  \
            --with-openssl     \
            --with-xz          \
            --with-zstd        \
            --with-zlib
```

The meaning of the configure options:

--with-openssl

This option enables Kmod to handle PKCS7 signatures for kernel modules.

--with-xz, *--with-zlib*, and *--with-zstd*

These options enable Kmod to handle compressed kernel modules.

Compile the package:

```
make
```

The test suite of this package requires raw kernel headers (not the “sanitized” kernel headers installed earlier), which are beyond the scope of LFS.

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 modinfo modprobe rmmod; do
    ln -sfv ../bin/kmod /usr/sbin/$target
done

ln -sfv kmod /usr/bin/lsmmod
```

8.47.2. Contents of Kmod

Installed programs: depmod (link to kmod), insmod (link to kmod), kmod, lsmod (link to kmod), modinfo (link to kmod), modprobe (link to kmod), and rmmod (link to kmod)

Installed library: libkmod.so

Short Descriptions

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

insmod Installs a loadable module in the running kernel

kmod Loads and unloads kernel modules

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

8.48. Libelf from Elfutils-0.188

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

Approximate build time: 0.3 SBU

Required disk space: 120 MB

8.48.1. Installation of Libelf

Libelf is part of the elfutils-0.188 package. Use the elfutils-0.188.tar.bz2 file as the source tarball.

Prepare Libelf for compilation:

```
./configure --prefix=/usr \
            --disable-debuginfod \
            --enable-libdebuginfod=dummy
```

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

The test named `run-native-test.sh` is known to fail.

Install only Libelf:

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

8.48.2. Contents of Libelf

Installed Library: libelf.so (symlink) and libelf-0.188.so

Installed Directory: /usr/include/elfutils

Short Descriptions

`libelf` Contains API functions to handle ELF object files

8.49. Libffi-3.4.4

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.

FFI stands for Foreign Function Interface. An FFI allows a program written in one language to call a program written in another language. Specifically, Libffi can provide a bridge between an interpreter like Perl, or Python, and shared library subroutines written in C, or C++.

Approximate build time: 1.8 SBU

Required disk space: 11 MB

8.49.1. Installation of Libffi



Note

Like GMP, Libffi builds with optimizations specific to the processor in use. If building for another system, change the value of the `--with-gcc-arch=` parameter in the following command to an architecture name fully implemented by the CPU on that system. 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. 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
```

8.49.2. Contents of Libffi

Installed library: libffi.so

Short Descriptions

`libffi` Contains the foreign function interface API functions

8.50. Python-3.11.2

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

Approximate build time: 2.0 SBU

Required disk space: 372 MB

8.50.1. Installation of Python 3

Prepare Python for compilation:

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

The meaning of the configure options:

--with-system-expat

This switch enables linking against the system version of Expat.

--with-system-ffi

This switch enables linking against the system version of `libffi.so`.

--enable-optimizations

This switch enables extensive, but time-consuming, optimization steps. The interpreter is built twice; tests performed on the first build are used to improve the optimized final version.

Compile the package:

```
make
```

Running the tests at this point is not recommended. The tests are known to hang indefinitely in the partial LFS environment. If desired, the tests can be rerun at the end of this chapter, or when Python 3 is reinstalled in BLFS. To run the tests anyway, issue **make test**.

Install the package:

```
make install
```

We use the **pip3** command to install Python 3 programs and modules for all users as `root` in several places in this book. This conflicts with the Python developers' recommendation: to install packages into a virtual environment, or into the home directory of a regular user (by running **pip3** as this user). A multi-line warning is triggered whenever **pip3** is issued by the `root` user.

The main reason for the recommendation is to avoid conflicts with the system's package manager (**dpkg**, for example). LFS does not have a system-wide package manager, so this is not a problem. Also, **pip3** will check for a new version of itself whenever it's run. Since domain name resolution is not yet configured in the LFS chroot environment, **pip3** cannot check for a new version of itself, and will produce a warning.

After we boot the LFS system and set up a network connection, a different warning will be issued, telling the user to update **pip3** from a pre-built wheel on PyPI (whenever a new version is available). But LFS considers **pip3** to be a part of Python 3, so it should not be updated separately. Also, an update from a pre-built wheel would deviate

from our objective: to build a Linux system from source code. So the warning about a new version of **pip3** should be ignored as well. If you wish, you can suppress all these warnings by running the following command, which creates a configuration file:

```
cat > /etc/pip.conf << EOF
[global]
root-user-action = ignore
disable-pip-version-check = true
EOF
```



Important

In LFS and BLFS we normally build and install Python modules with the **pip3** command. Please be sure that the **pip3 install** commands in both books are run as the `root` user (unless it's for a Python virtual environment). Running **pip3 install** as a non-`root` user may seem to work, but it will cause the installed module to be inaccessible by other users.

pip3 install will not reinstall an already installed module automatically. When using the **pip3 install** command to upgrade a module (for example, from `meson-0.61.3` to `meson-0.62.0`), insert the option `--upgrade` into the command line. If it's really necessary to downgrade a module, or reinstall the same version for some reason, insert `--force-reinstall --no-deps` into the command line.

If desired, install the preformatted documentation:

```
install -v -dm755 /usr/share/doc/python-3.11.2/html

tar --strip-components=1 \
  --no-same-owner \
  --no-same-permissions \
  -C /usr/share/doc/python-3.11.2/html \
  -xvf ../python-3.11.2-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, tar will install the package files with the upstream creator's values.

8.50.2. Contents of Python 3

Installed Programs:	2to3, idle3, pip3, pydoc3, python3, and python3-config
Installed Library:	libpython3.11.so and libpython3.so
Installed Directories:	/usr/include/python3.11, /usr/lib/python3, and /usr/share/doc/python-3.11.2

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 the interpreter for Python, an interpreted, interactive, object-oriented programming language

8.51. Wheel-0.38.4

Wheel is a Python library that is the reference implementation of the Python wheel packaging standard.

Approximate build time: less than 0.1 SBU

Required disk space: 1.3 MB

8.51.1. Installation of Wheel

Compile Wheel with the following command:

```
PYTHONPATH=src pip3 wheel -w dist --no-build-isolation --no-deps $PWD
```

Install Wheel with the following command:

```
pip3 install --no-index --find-links=dist wheel
```

The meaning of the pip3 configuration options and commands:

`PYTHONPATH=src`

Allows this package (not installed yet) to build a wheel archive for itself, to avoid a chicken-or-egg problem.

wheel

This command builds the wheel archive for this package.

`-w dist`

Instructs pip to put the created wheel into the `dist` directory.

install

This command installs the package.

`--no-build-isolation`, `--no-deps`, and `--no-index`

These options prevent fetching files from the online package repository (PyPI). If packages are installed in the correct order, pip won't need to fetch any files in the first place; these options add some safety in case of user error.

`--find-links dist`

Instructs pip to search for wheel archives in the `dist` directory.

8.51.2. Contents of Wheel

Installed program: wheel

Installed directories: /usr/lib/python3.11/site-packages/wheel and /usr/lib/python3.11/site-packages/wheel-0.38.4.dist-info

Short Descriptions

wheel is a utility to unpack, pack, or convert wheel archives

8.52. Ninja-1.11.1

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

Approximate build time: 0.3 SBU

Required disk space: 77 MB



Tip

This section is not strictly required when LFS does not use systemd. On the other hand, Ninja, along with Meson, makes a powerful build system combination, which will probably be used more and more often. It is required for several packages in *the BLFS book*.

8.52.1. Installation of Ninja

When run, **ninja** normally utilizes the greatest possible number of processes in parallel. By default this is the number of cores on the system, plus two. This may overheat the CPU, or make the system run out of memory. When **ninja** is invoked from the command line, passing the `-jN` parameter will limit the number of parallel processes. Some packages embed the execution of **ninja**, and do not pass the `-j` parameter on to it.

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, make **ninja** recognize the environment variable **NINJAJOBS** by running the stream editor:

```
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
```

8.52.2. Contents of Ninja

Installed programs: ninja

Short Descriptions

ninja is the Ninja build system

8.53. Meson-1.0.0

Meson is an open source build system designed to be both extremely fast and as user friendly as possible.

Approximate build time: less than 0.1 SBU

Required disk space: 41 MB



Tip

This section is not strictly required when LFS does not use systemd. On the other hand, Meson, along with Ninja, makes a powerful build system combination, which will probably be used more and more often. It is required for several packages in *the BLFS book*.

8.53.1. Installation of Meson

Compile Meson with the following command:

```
pip3 wheel -w dist --no-build-isolation --no-deps $PWD
```

The test suite requires some packages outside the scope of LFS.

Install the package:

```
pip3 install --no-index --find-links dist meson
install -vDm644 data/shell-completions/bash/meson /usr/share/bash-completion/completions/meson
install -vDm644 data/shell-completions/zsh/_meson /usr/share/zsh/site-functions/_meson
```

The meaning of the install parameters:

`-w dist`

Puts the created wheels into the `dist` directory.

`--find-links dist`

Installs wheels from the `dist` directory.

8.53.2. Contents of Meson

Installed programs: meson

Installed directory: /usr/lib/python3.11/site-packages/meson-1.0.0.dist-info and /usr/lib/python3.11/site-packages/mesonbuild

Short Descriptions

meson A high productivity build system

8.54. Coreutils-9.1

The Coreutils package contains the basic utility programs needed by every operating system.

Approximate build time: 0.9 SBU

Required disk space: 156 MB

8.54.1. Installation of Coreutils

POSIX requires that programs from Coreutils recognize character boundaries correctly even in multibyte locales. The following patch fixes this non-compliance and other internationalization-related bugs.

```
patch -Np1 -i ../coreutils-9.1-il8n-1.patch
```



Note

Many bugs have been found in this patch. When reporting new bugs to the Coreutils maintainers, please check first to see if those bugs are reproducible without this patch.

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 build system, so the configuration files must be regenerated.

```
FORCE_UNSAFE_CONFIGURE=1
```

This environment variable allows the package to be built by the `root` user.

```
--enable-no-install-program=kill,uptime
```

The purpose of this switch is to prevent Coreutils from installing programs that will be installed by other packages.

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 may 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/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
```

8.54.2. Contents of Coreutils

Installed programs: [, b2sum, base32, base64, basename, basenc, cat, chcon, chgrp, chmod, chown, chroot, cksum, comm, cp, csplit, cut, date, dd, df, dir, dircolors, dirname, du, echo, env, expand, expr, factor, false, fmt, fold, groups, head, hostid, id, install, join, link, ln, logname, ls, md5sum, mkdir, mkfifo, mknod, mktemp, mv, nice, nl, nohup, nproc, numfmt, od, paste, pathchk, pinky, pr, printenv, printf, ptx, pwd, readlink, realpath, rm, rmdir, runcon, seq, sha1sum, sha224sum, sha256sum, sha384sum, sha512sum, shred, shuf, sleep, sort, split, stat, stdbuf, stty, sum, sync, tac, tail, tee, test, timeout, touch, tr, true, truncate, tsort, tty, uname, unexpand, uniq, unlink, users, vdir, wc, who, whoami, and yes

Installed library: libstdbuf.so (in /usr/libexec/coreutils)

Installed directory: /usr/libexec/coreutils

Short Descriptions

[Is an actual command, /usr/bin/[]; it 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)
b2sum	Prints or checks BLAKE2 (512-bit) checksums
basename	Strips any path and a given suffix from a file name
basenc	Encodes or decodes data using various algorithms
cat	Concatenates files to standard output
chcon	Changes security context for files and directories
chgrp	Changes the group ownership of files and directories
chmod	Changes the permissions of each file to the given mode; the mode can be either a symbolic representation of the changes to be made, or an octal number representing the new permissions
chown	Changes the user and/or group ownership of files and directories
chroot	Runs a command with the specified directory as the / directory
cksum	Prints the Cyclic Redundancy Check (CRC) checksum and the byte counts of each specified file
comm	Compares two sorted files, outputting in three columns the lines that are unique and the lines that are common
cp	Copies files

csplit	Splits a given file into several new files, separating them according to given patterns or line numbers, and outputting the byte count of each new file
cut	Prints sections of lines, selecting the parts according to given fields or positions
date	Displays the current date and time in the given format, or sets the system date and time
dd	Copies a file using the given block size and count, while optionally performing conversions on it
df	Reports the amount of disk space available (and used) on all mounted file systems, or only on the file systems holding the selected files
dir	Lists the contents of each given directory (the same as the ls command)
dircolors	Outputs commands to set the <code>LS_COLOR</code> environment variable to change the color scheme used by ls
dirname	Extracts the directory portion(s) of the given name(s)
du	Reports the amount of disk space used by the current directory, by each of the given directories (including all subdirectories) or by each of the given files
echo	Displays the given strings
env	Runs a command in a modified environment
expand	Converts tabs to spaces
expr	Evaluates expressions
factor	Prints the prime factors of the specified integers
false	Does nothing, unsuccessfully; it always exits with a status code indicating failure
fmt	Reformats the paragraphs in the given files
fold	Wraps the lines in the given files
groups	Reports a user's group memberships
head	Prints the first ten lines (or the given number of lines) of each given file
hostid	Reports the numeric identifier (in hexadecimal) of the host
id	Reports the effective user ID, group ID, and group memberships of the current user or specified user
install	Copies files while setting their permission modes and, if possible, their owner and group
join	Joins the lines that have identical join fields from two separate files
link	Creates a hard link (with the given name) to a file
ln	Makes hard links or soft (symbolic) links between files
logname	Reports the current user's login name
ls	Lists the contents of each given directory
md5sum	Reports or checks Message Digest 5 (MD5) checksums
mkdir	Creates directories with the given names
mkfifo	Creates First-In, First-Outs (FIFOs), "named pipes" in UNIX parlance, with the given names
mknod	Creates device nodes with the given names; a device node is a character special file, a block special file, or a FIFO
mktemp	Creates temporary files in a secure manner; it is used in scripts
mv	Moves or renames files or directories

nice	Runs a program with modified scheduling priority
nl	Numbers the lines from the given files
nohup	Runs a command immune to hangups, with its output redirected to a log file
nproc	Prints the number of processing units available to a process
numfmt	Converts numbers to or from human-readable strings
od	Dumps files in octal and other formats
paste	Merges the given files, joining sequentially corresponding lines side by side, separated by tab characters
pathchk	Checks if file names are valid or portable
pinky	Is a lightweight finger client; it reports some information about the given users
pr	Paginates and columnates files for printing
printenv	Prints the environment
printf	Prints the given arguments according to the given format, much like the C printf function
ptx	Produces a permuted index from the contents of the given files, with each keyword in its context
pwd	Reports the name of the current working directory
readlink	Reports the value of the given symbolic link
realpath	Prints the resolved path
rm	Removes files or directories
rmdir	Removes directories if they are empty
runcon	Runs a command with specified security context
seq	Prints a sequence of numbers within a given range and with a given increment
sha1sum	Prints or checks 160-bit Secure Hash Algorithm 1 (SHA1) checksums
sha224sum	Prints or checks 224-bit Secure Hash Algorithm checksums
sha256sum	Prints or checks 256-bit Secure Hash Algorithm checksums
sha384sum	Prints or checks 384-bit Secure Hash Algorithm checksums
sha512sum	Prints or checks 512-bit Secure Hash Algorithm checksums
shred	Overwrites the given files repeatedly with complex patterns, making it difficult to recover the data
shuf	Shuffles lines of text
sleep	Pauses for the given amount of time
sort	Sorts the lines from the given files
split	Splits the given file into pieces, by size or by number of lines
stat	Displays file or filesystem status
stdbuf	Runs commands with altered buffering operations for its standard streams
stty	Sets or reports terminal line settings
sum	Prints checksum and block counts for each given file
sync	Flushes file system buffers; it forces changed blocks to disk and updates the super block
tac	Concatenates the given files in reverse

tail	Prints the last ten lines (or the given number of lines) of each given file
tee	Reads from standard input while writing both to standard output and to the given files
test	Compares values and checks file types
timeout	Runs a command with a time limit
touch	Changes file timestamps, setting the access and modification times of the given files to the current time; files that do not exist are created with zero length
tr	Translates, squeezes, and deletes the given characters from standard input
true	Does nothing, successfully; it always exits with a status code indicating success
truncate	Shrinks or expands a file to the specified size
tsort	Performs a topological sort; it writes a completely ordered list according to the partial ordering in a given file
tty	Reports the file name of the terminal connected to standard input
uname	Reports system information
unexpand	Converts spaces to tabs
uniq	Discards all but one of successive identical lines
unlink	Removes the given file
users	Reports the names of the users currently logged on
vdir	Is the same as ls -l
wc	Reports the number of lines, words, and bytes for each given file, as well as grand totals when more than one file is given
who	Reports who is logged on
whoami	Reports the user name associated with the current effective user ID
yes	Repeatedly outputs “y”, or a given string, until killed
libstdbuf	Library used by stdbuf

8.55. Check-0.15.2

Check is a unit testing framework for C.

Approximate build time: 0.1 SBU (about 1.7 SBU with tests)

Required disk space: 12 MB

8.55.1. 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
```

Install the package:

```
make docdir=/usr/share/doc/check-0.15.2 install
```

8.55.2. Contents of Check

Installed program: checkmk

Installed library: libcheck.so

Short Descriptions

checkmk	Awk script for generating C unit tests for use with the Check unit testing framework
<code>libcheck.so</code>	Contains functions that allow Check to be called from a test program

8.56. Diffutils-3.9

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

Approximate build time: 0.3 SBU

Required disk space: 35 MB

8.56.1. Installation of Diffutils

Prepare Diffutils for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

8.56.2. Contents of Diffutils

Installed programs: cmp, diff, diff3, and sdiff

Short Descriptions

cmp	Compares two files and reports any differences byte by byte
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

8.57. Gawk-5.2.1

The Gawk package contains programs for manipulating text files.

Approximate build time: 0.2 SBU

Required disk space: 43 MB

8.57.1. Installation of Gawk

First, ensure some unneeded files are not installed:

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

Prepare Gawk for compilation:

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

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make LN='ln -f' install
```

The meaning of the overridden make variable:

```
LN='ln -f'
```

This variable ensures that the previous hard link installed in Section 6.9, “Gawk-5.2.1” is updated here.

If desired, install the documentation:

```
mkdir -pv /usr/share/doc/gawk-5.2.1
cp -v doc/{awkforai.txt,*.eps,pdf,jpg} /usr/share/doc/gawk-5.2.1
```

8.57.2. Contents of Gawk

Installed programs: awk (link to gawk), gawk, and gawk-5.2.1

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

Installed directories: /usr/lib/gawk, /usr/libexec/awk, /usr/share/awk, and /usr/share/doc/gawk-5.2.1

Short Descriptions

awk	A link to gawk
gawk	A program for manipulating text files; it is the GNU implementation of awk
gawk-5.2.1	A hard link to gawk

8.58. Findutils-4.9.0

The Findutils package contains programs to find files. Programs are provided to search through all the files in a directory tree and to create, maintain, and search a database (often faster than the recursive `find`, but unreliable unless the database has been updated recently). Findutils also supplies the **xargs** program, which can be used to run a specified command on each file selected by a search.

Approximate build time: 0.4 SBU

Required disk space: 51 MB

8.58.1. Installation of Findutils

Prepare Findutils for compilation:

```
case $(uname -m) in
  i?86)    TIME_T_32_BIT_OK=yes ./configure --prefix=/usr --localstatedir=/var/lib/locate ;;
  x86_64)  ./configure --prefix=/usr --localstatedir=/var/lib/locate ;;
esac
```

The meaning of the configure options:

TIME_32_BIT_OK=yes

This setting is needed for building on a 32 bit system.

--localstatedir

This option moves the **locate** database to `/var/lib/locate`, which is the FHS-compliant location.

Compile the package:

```
make
```

To test the results, issue:

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

Install the package:

```
make install
```

8.58.2. Contents of Findutils

Installed programs: find, locate, updatedb, and xargs

Installed directory: /var/lib/locate

Short Descriptions

find	Searches given directory trees for files matching the specified criteria
locate	Searches through a database of file names and reports the names that contain a given string or match a given pattern
updatedb	Updates the locate database; it scans the entire file system (including other file systems that are currently mounted, unless told not to) and puts every file name it finds into the database
xargs	Can be used to apply a given command to a list of files

8.59. Groff-1.22.4

The Groff package contains programs for processing and formatting text and images.

Approximate build time: 0.2 SBU

Required disk space: 89 MB

8.59.1. Installation of Groff

Groff expects the environment variable `PAGE` to contain the default paper size. For users in the United States, `PAGE=letter` is appropriate. Elsewhere, `PAGE=A4` may be more suitable. While the default paper size is configured during compilation, it can be overridden later by echoing either “A4” or “letter” to the `/etc/papersize` file.

Prepare Groff for compilation:

```
PAGE=<paper_size> ./configure --prefix=/usr
```

Build the package:

```
make
```

This package does not come with a test suite.

Install the package:

```
make install
```

8.59.2. Contents of Groff

Installed programs: addftinfo, afmtodit, chem, eqn, eqn2graph, gdiffmk, glilypond, gperl, gpinyin, grap2graph, grn, grodvi, groff, groffer, grog, grolbp, grolj4, gropdf, grops, grotty, 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

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

grap2graph	Converts a grap program file into a cropped bitmap image (grap is an old Unix programming language for creating diagrams)
grn	A groff preprocessor for gremlin files
grodvi	A driver for groff that produces TeX dvi format output files
groff	A front end to the groff document formatting system; normally, it runs the troff program and a post-processor appropriate for the selected device
groffer	Displays groff files and man pages on X and tty terminals
grog	Reads files and guesses which of the groff options <code>-e</code> , <code>-man</code> , <code>-me</code> , <code>-mm</code> , <code>-ms</code> , <code>-p</code> , <code>-s</code> , and <code>-t</code> are required for printing files, and reports the groff command including those options
grolbp	Is a groff driver for Canon CAPSL printers (LBP-4 and LBP-8 series laser printers)
grolj4	Is a driver for groff that produces output in PCL5 format suitable for an HP LaserJet 4 printer
gropdf	Translates the output of GNU troff to PDF
grops	Translates the output of GNU troff to PostScript
grotty	Translates the output of GNU troff into a form suitable for typewriter-like devices
hpftodit	Creates a font file for use with groff -Tlj4 from an HP-tagged font metric file
indxbib	Creates an inverted index for the bibliographic databases with a specified file for use with refer , lookbib , and lkbib
lkbib	Searches bibliographic databases for references that contain specified keys and reports any references found
lookbib	Prints a prompt on the standard error (unless the standard input is not a terminal), reads a line containing a set of keywords from the standard input, searches the bibliographic databases in a specified file for references containing those keywords, prints any references found on the standard output, and repeats this process until the end of input
mmroff	A simple preprocessor for groff
neqn	Formats equations for American Standard Code for Information Interchange (ASCII) output
nroff	A script that emulates the nroff command using groff
pdfmom	Is a wrapper around groff that facilitates the production of PDF documents from files formatted with the mom macros.
pdfroff	Creates pdf documents using groff
pfbtops	Translates a PostScript font in <code>.pfb</code> format to ASCII
pic	Compiles descriptions of pictures embedded within troff or TeX input files into commands understood by TeX or troff
pic2graph	Converts a PIC diagram into a cropped image
post-grohtml	Translates the output of GNU troff to HTML
preconv	Converts encoding of input files to something GNU troff understands
pre-grohtml	Translates the output of GNU troff to HTML
refer	Copies the contents of a file to the standard output, except that lines between <code>./</code> and <code>./</code> are interpreted as citations, and lines between <code>.R1</code> and <code>.R2</code> are interpreted as commands for how citations are to be processed

roff2dvi	Transforms roff files into DVI format
roff2html	Transforms roff files into HTML format
roff2pdf	Transforms roff files into PDFs
roff2ps	Transforms roff files into ps files
roff2text	Transforms roff files into text files
roff2x	Transforms roff files into other formats
soelim	Reads files and replaces lines of the form <i>.so file</i> by the contents of the mentioned <i>file</i>
tbl	Compiles descriptions of tables embedded within troff input files into commands that are understood by troff
tfmtodit	Creates a font file for use with groff -Tdvi
troff	Is highly compatible with Unix troff ; it should usually be invoked using the groff command, which will also run preprocessors and post-processors in the appropriate order and with the appropriate options

8.60. GRUB-2.06

The GRUB package contains the GRand Unified Bootloader.

Approximate build time: 0.3 SBU

Required disk space: 161 MB

8.60.1. Installation of GRUB



Note

If your system has UEFI support and you wish to boot LFS with UEFI, you can skip this package in LFS, and install GRUB with UEFI support (and its dependencies) by following the instructions on *the BLFS page*.



Warning

Unset any environment variables which may affect the build:

```
unset {C,CPP,CXX,LD}FLAGS
```

Don't try “tuning” this package with custom compilation flags. This package is a bootloader. The low-level operations in the source code may be broken by aggressive optimization.

Fix an issue causing **grub-install** to fail when the `/boot` partition (or the root partition if `/boot` is not a separate partition) is created by `e2fsprogs-1.47.0` or later:

```
patch -Np1 -i ../grub-2.06-upstream_fixes-1.patch
```

Prepare GRUB for compilation:

```
./configure --prefix=/usr      \
            --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 versions of Flex.

`--disable-efiemu`

This option minimizes what is built by disabling a feature and eliminating some test programs not needed for LFS.

Compile the package:

```
make
```

The test suite for this packages is not recommended. Most of the tests depend on packages that are not available in the limited LFS environment. To run the tests anyway, run **make check**.

Install the package:

```
make install
mv -v /etc/bash_completion.d/grub /usr/share/bash-completion/completions
```

Making your LFS system **bootable** with GRUB will be discussed in Section 10.4, “Using GRUB to Set Up the Boot Process”.

8.60.2. Contents of GRUB

Installed programs:	grub-bios-setup, grub-editenv, grub-file, grub-fstest, grub-glue-efi, grub-install, grub-kbdcomp, grub-macbless, grub-menulst2cfg, grub-mkconfig, grub-mkimage, grub-mklayout, grub-mknetdir, grub-mkpasswd-pbkdf2, grub-mkreldpath, grub-mkrescue, grub-mkstandalone, grub-ofpathname, grub-probe, grub-reboot, grub-render-label, grub-script-check, grub-set-default, grub-sparc64-setup, and grub-syslinux2cfg
Installed directories:	/usr/lib/grub, /etc/grub.d, /usr/share/grub, and /boot/grub (when grub-install is first run)

Short Descriptions

grub-bios-setup	Is a helper program for grub-install
grub-editenv	Is a tool to edit the environment block
grub-file	Checks to see if the given file is of the specified type
grub-fstest	Is a tool to debug the filesystem driver
grub-glue-efi	Glues 32-bit and 64-bit binaries into a single file (for Apple machines)
grub-install	Installs GRUB on your drive
grub-kbdcomp	Is a script that converts an xkb layout into one recognized by GRUB
grub-macbless	Is the Mac-style bless for HFS or HFS+ file systems (bless is peculiar to Apple machines; it makes a device bootable)
grub-menulst2cfg	Converts a GRUB Legacy <code>menu.lst</code> into a <code>grub.cfg</code> for use with GRUB 2
grub-mkconfig	Generates a <code>grub.cfg</code> file
grub-mkimage	Makes a bootable image of GRUB
grub-mklayout	Generates a GRUB keyboard layout file
grub-mknetdir	Prepares a GRUB netboot directory
grub-mkpasswd-pbkdf2	Generates an encrypted PBKDF2 password for use in the boot menu
grub-mkreldpath	Makes a system pathname relative to its root
grub-mkrescue	Makes a bootable image of GRUB suitable for a floppy disk, CDROM/DVD, or a USB drive
grub-mkstandalone	Generates a standalone image
grub-ofpathname	Is a helper program that prints the path to a GRUB device
grub-probe	Probes device information for a given path or device
grub-reboot	Sets the default boot entry for GRUB for the next boot only
grub-render-label	Renders Apple <code>.disk_label</code> for Apple Macs
grub-script-check	Checks the GRUB configuration script for syntax errors
grub-set-default	Sets the default boot entry for GRUB
grub-sparc64-setup	Is a helper program for grub-setup
grub-syslinux2cfg	Transforms a syslinux config file into <code>grub.cfg</code> format

8.61. Gzip-1.12

The Gzip package contains programs for compressing and decompressing files.

Approximate build time: 0.3 SBU

Required disk space: 21 MB

8.61.1. 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
```

8.61.2. Contents of Gzip

Installed programs: gunzip, gzexe, gzip, uncompress (hard link with gunzip), zcat, zcmp, zdiff, zegrep, zfgrep, zforce, zgrep, zless, zmore, and znew

Short Descriptions

gunzip	Decompresses gzipped files
gzexe	Creates self-decompressing executable files
gzip	Compresses the given files using Lempel-Ziv (LZ77) coding
uncompress	Decompresses compressed files
zcat	Decompresses the given gzipped files to standard output
zcmp	Runs cmp on gzipped files
zdiff	Runs diff on gzipped files
zegrep	Runs egrep on gzipped files
zfgrep	Runs fgrep on gzipped files
zforce	Forces a .gz extension on all given files that are gzipped files, so that gzip will not compress them again; this can be useful when file names were truncated during a file transfer
zgrep	Runs grep on gzipped files
zless	Runs less on gzipped files
zmore	Runs more on gzipped files
znew	Re-compresses files from compress format to gzip format— .z to .gz

8.62. IPRoute2-6.1.0

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

Approximate build time: 0.1 SBU

Required disk space: 17 MB

8.62.1. Installation of IPRoute2

The **arpd** program included in this package will not be built since it depends on Berkeley DB, which is not installed in LFS. However, a directory and a man page for **arpd** will still be installed. Prevent this by running the commands shown below. (If the **arpd** program is needed, instructions for compiling Berkeley DB can be found in the BLFS book at <https://www.linuxfromscratch.org/blfs/view/11.3/server/db.html>.)

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

Compile the package:

```
make NETNS_RUN_DIR=/run/netns
```

This package does not have a working test suite.

Install the package:

```
make SBINDIR=/usr/sbin install
```

If desired, install the documentation:

```
mkdir -pv /usr/share/doc/iproute2-6.1.0
cp -v COPYING README* /usr/share/doc/iproute2-6.1.0
```

8.62.2. Contents of IPRoute2

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

Installed directories: /etc/iproute2, /usr/lib/tc, and /usr/share/doc/iproute2-6.1.0

Short Descriptions

bridge Configures network bridges

ctstat Connection status utility

genl Generic netlink utility front end

ifstat Shows interface statistics, including the number of packets transmitted and received, by interface

ip The main executable. It has several different functions, including these:

- ip link** <device> allows users to look at the state of devices and to make changes
- ip addr** allows users to look at addresses and their properties, add new addresses, and delete old ones
- ip neighbor** allows users to look at neighbor bindings and their properties, add new neighbor entries, and delete old ones
- ip rule** allows users to look at the routing policies and change them
- ip route** allows users to look at the routing table and change routing table rules
- ip tunnel** allows users to look at the IP tunnels and their properties, and change them

ip maddr allows users to look at the multicast addresses and their properties, and change them

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

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

lnstat Provides Linux network statistics; it is a generalized and more feature-complete replacement for the old **rtstat** program

nstat Displays network statistics

routel A component of **ip route**, for listing the routing tables

rtacct Displays the contents of `/proc/net/rt_acct`

rtmon Route monitoring utility

rtpr Converts the output of **ip -o** into a readable form

rtstat Route status utility

ss Similar to the **netstat** command; shows active connections

tc Traffic control for Quality of Service (QoS) and Class of Service (CoS) implementations

tc qdisc allows users to set up the queueing discipline

tc class allows users to set up classes based on the queueing discipline scheduling

tc filter allows users to set up the QoS/CoS packet filtering

tc monitor can be used to view changes made to Traffic Control in the kernel.

8.63. Kbd-2.5.1

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

Approximate build time: 0.1 SBU

Required disk space: 35 MB

8.63.1. Installation of Kbd

The behavior 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-2.5.1-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 -pv /usr/share/doc/kbd-2.5.1
cp -R -v docs/doc/* /usr/share/doc/kbd-2.5.1
```

8.63.2. Contents of Kbd

Installed programs:	chvt, deallocvt, dumpkeys, fgconsole, getkeycodes, kbinfo, kbd_mode, kbdrate, loadkeys, loadunimap, mapscrn, openvt, psfaddtable (link to psfxtable), psfgettable (link to psfxtable), psfstriptide (link to psfxtable), psfxtable, setfont, setkeycodes, setleds, setmetamode, setvtrgb, showconsolefont, showkey, unicode_start, and unicode_stop
Installed directories:	/usr/share/consolefonts, /usr/share/consoletrans, /usr/share/keymaps, /usr/share/doc/kbd-2.5.1, and /usr/share/unimaps

Short Descriptions

chvt	Changes the foreground virtual terminal
deallocvt	Deallocates unused virtual terminals
dumpkeys	Dumps the keyboard translation tables
fgconsole	Prints the number of the active virtual terminal
getkeycodes	Prints the kernel scancode-to-keycode mapping table
kbinfo	Obtains information about the status of a console
kbd_mode	Reports or sets the keyboard mode
kbdrate	Sets the keyboard repeat and delay rates
loadkeys	Loads the keyboard translation tables
loadunimap	Loads the kernel unicode-to-font mapping table
mapscrn	An obsolete program that used to load a user-defined output character mapping table into the console driver; this is now done by setfont
openvt	Starts a program on a new virtual terminal (VT)
psfaddtable	Adds a Unicode character table to a console font
psfgettable	Extracts the embedded Unicode character table from a console font
psfstriptide	Removes the embedded Unicode character table from a console font
psfxtable	Handles Unicode character tables for console fonts
setfont	Changes the Enhanced Graphic Adapter (EGA) and Video Graphics Array (VGA) fonts on the console
setkeycodes	Loads kernel scancode-to-keycode mapping table entries; this is useful if there are unusual keys on the keyboard
setleds	Sets the keyboard flags and Light Emitting Diodes (LEDs)
setmetamode	Defines the keyboard meta-key handling
setvtrgb	Sets the console color map in all virtual terminals
showconsolefont	Shows the current EGA/VGA console screen font
showkey	Reports the scancodes, keycodes, and ASCII codes of the keys pressed on the keyboard
unicode_start	Puts the keyboard and console in UNICODE mode [Don't use this program unless your keymap file is in the ISO-8859-1 encoding. For other encodings, this utility produces incorrect results.]
unicode_stop	Reverts keyboard and console from UNICODE mode

8.64. Libpipeline-1.5.7

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: 10 MB

8.64.1. 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
```

8.64.2. Contents of Libpipeline

Installed library: libpipeline.so

Short Descriptions

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

8.65. Make-4.4

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: 0.5 SBU

Required disk space: 13 MB

8.65.1. Installation of Make

First, fix some issues identified upstream:

```
sed -e '/ifdef SIGPIPE/,+2 d' \
    -e '/undef FATAL_SIG/i FATAL_SIG (SIGPIPE);' \
    -i src/main.c
```

Prepare Make 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 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

8.66. 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: 12 MB

8.66.1. 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
```

8.66.2. 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.)

8.67. 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: 1.5 SBU

Required disk space: 40 MB

8.67.1. Installation of Tar

Prepare Tar for compilation:

```
FORCE_UNSAFE_CONFIGURE=1 \
./configure --prefix=/usr
```

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, issue:

```
make check
```

One test, capabilities: binary store/restore, is known to fail if it is run because LFS lacks selinux, but will be skipped if the host kernel does not support extended attributes on the filesystem used for building LFS.

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-7.0.2

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

Approximate build time: 0.3 SBU

Required disk space: 128 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 <code>/usr/lib/texinfo</code>)
Installed directories:	<code>/usr/share/texinfo</code> and <code>/usr/lib/texinfo</code>

Short Descriptions

info	Used to read info pages which are similar to man pages, but often go much deeper than just explaining all the available command line options [For example, compare man bison and info bison .]
-------------	--

install-info	Used to install info pages; it updates entries in the info index file
makeinfo	Translates the given Texinfo source documents into info pages, plain text, or HTML
pdftexi2dvi	Used to format the given Texinfo document into a Portable Document Format (PDF) file
pod2texi	Converts Pod to Texinfo format
texi2any	Translate Texinfo source documentation to various other formats
texi2dvi	Used to format the given Texinfo document into a device-independent file that can be printed
texi2pdf	Used to format the given Texinfo document into a Portable Document Format (PDF) file
texindex	Used to sort Texinfo index files

8.69. Vim-9.0.1273

The Vim package contains a powerful text editor.

Approximate build time: 2.4 SBU

Required disk space: 235 MB



Alternatives to Vim

If you prefer another editor—such as Emacs, Joe, or Nano—please refer to <https://www.linuxfromscratch.org/blfs/view/11.3/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 reflexively type **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-9.0.1273`, making it consistent with the location of documentation for other packages:

```
ln -sv ../vim/vim90/doc /usr/share/doc/vim-9.0.1273
```

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 <https://www.linuxfromscratch.org/blfs/view/11.3/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-checking files for the English language. To install spell-checking files for your preferred language, copy the `.spl` and optionally, the `.sug` files for your language and character encoding from `runtime/spell` into `/usr/share/vim/vim90/spell/`.

To use these spell-checking files, some configuration in `/etc/vimrc` is needed, e.g.:

```
set spelllang=en,ru
set spell
```

For more information, see `runtime/spell/README.txt`.

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

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

8.70. Eudev-3.2.11

The Eudev package contains programs for dynamic creation of device nodes.

Approximate build time: 0.1 SBU

Required disk space: 83 MB

8.70.1. Installation of Eudev

First fix the location of udev rules in the .pc file:

```
sed -i '/udevdir/a udev_dir=${udevdir}' src/udev/udev.pc.in
```

Prepare Eudev for compilation:

```
./configure --prefix=/usr      \
            --bindir=/usr/sbin \
            --sysconfdir=/etc   \
            --enable-manpages   \
            --disable-static
```

Compile the package:

```
make
```

Create some directories now that are needed for tests, but will also be used as a part of installation:

```
mkdir -pv /usr/lib/udev/rules.d
mkdir -pv /etc/udev/rules.d
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

Install some custom rules and support files useful in an LFS environment:

```
tar -xvf ../udev-lfs-20171102.tar.xz
make -f udev-lfs-20171102/Makefile.lfs install
```

8.70.2. Configuring Eudev

Information about hardware devices is maintained in the `/etc/udev/hwdb.d` and `/usr/lib/udev/hwdb.d` directories. Eudev needs that information to be compiled into a binary database `/etc/udev/hwdb.bin`. Create the initial database:

```
udevadm hwdb --update
```

This command needs to be run each time the hardware information is updated.

8.70.3. Contents of Eudev

Installed programs: udevadm and udevd

Installed libraries: libudev.so

Installed directories: /etc/udev, /usr/lib/udev, and /usr/share/doc/udev-udev-lfs-20171102

Short Descriptions

udevadm	Generic udev administration tool: controls the udevd daemon, provides info from the Udev database, monitors uevents, waits for uevents to finish, tests Udev configuration, and triggers uevents for a given device
udev	A daemon that listens for uevents on the netlink socket, creates devices and runs the configured external programs in response to these uevents
<code>libudev</code>	A library interface to udev device information
<code>/etc/udev</code>	Contains Udev configuration files, device permissions, and rules for device naming

8.71. Man-DB-2.11.2

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

Approximate build time: 0.2 SBU

Required disk space: 40 MB

8.71.1. Installation of Man-DB

Prepare Man-DB for compilation:

```
./configure --prefix=/usr \
            --docdir=/usr/share/doc/man-db-2.11.2 \
            --sysconfdir=/etc \
            --disable-setuid \
            --enable-cache-owner=bin \
            --with-browser=/usr/bin/lynx \
            --with-vgrind=/usr/bin/vgrind \
            --with-grap=/usr/bin/grap \
            --with-systemdtmpfilesdir= \
            --with-systemdsystemunitdir=
```

The meaning of the configure options:

--disable-setuid

This disables making the **man** program setuid to user `man`.

--enable-cache-owner=bin

This changes ownership of the system-wide cache files to 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.

--with-systemd...

These parameters prevent installing unneeded systemd directories and files.

Compile the package:

```
make
```

To test the results, issue:

```
make check
```

Install the package:

```
make install
```

8.71.2. 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	Greek (el)	ISO-8859-7
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

**Note**

Manual pages in languages not in the list are not supported.

8.71.3. Contents of Man-DB

- Installed programs:** accessdb, apropos (link to whatis), catman, lexgrog, man, man-recode, 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-2.11.2

Short Descriptions

accessdb Dumps the **whatis** database contents in human-readable form

apropos	Searches the whatis database and displays the short descriptions of system commands that contain a given string
catman	Creates or updates the pre-formatted manual pages
lexgrog	Displays one-line summary information about a given manual page
man	Formats and displays the requested manual page
man-recode	Converts manual pages to another encoding
mandb	Creates or updates the whatis database
manpath	Displays the contents of \$MANPATH or (if \$MANPATH is not set) a suitable search path based on the settings in man.conf and the user's environment
whatis	Searches the whatis database and displays the short descriptions of system commands that contain the given keyword as a separate word
libman	Contains run-time support for man
libmandb	Contains run-time support for man

8.72. Procps-ng-4.0.2

The Procps-ng package contains programs for monitoring processes.

Approximate build time: 0.1 SBU

Required disk space: 26 MB

8.72.1. Installation of Procps-ng

Prepare Procps-ng for compilation:

```
./configure --prefix=/usr \
            --docdir=/usr/share/doc/procps-ng-4.0.2 \
            --disable-static \
            --disable-kill
```

The meaning of the configure option:

`--disable-kill`

This switch disables building the **kill** command; it will be installed from the Util-linux package.

Compile the package:

```
make
```

To run the test suite, run:

```
make check
```

One test named `free with commit` may fail if some applications with a custom memory allocator (for example, JVM and Web browsers) are running on the host distro.

Install the package:

```
make install
```

8.72.2. Contents of Procps-ng

Installed programs: free, pgrep, pidof, pkill, pmap, ps, pwdx, slabtop, sysctl, tload, top, uptime, vmstat, w, and watch

Installed library: libproc-2.so

Installed directories: /usr/include/procps and /usr/share/doc/procps-ng-4.0.2

Short Descriptions

free	Reports the amount of free and used memory (both physical and swap memory) in the system
pgrep	Looks up processes based on their name and other attributes
pidof	Reports the PIDs of the given programs
pkill	Signals processes based on their name and other attributes
pmap	Reports the memory map of the given process
ps	Lists the current running processes
pwdx	Reports the current working directory of a process
slabtop	Displays detailed kernel slab cache information in real time

sysctl	Modifies kernel parameters at run time
tlload	Prints a graph of the current system load average
top	Displays a list of the most CPU intensive processes; it provides an ongoing look at processor activity in real time
uptime	Reports how long the system has been running, how many users are logged on, and the system load averages
vmstat	Reports virtual memory statistics, giving information about processes, memory, paging, block Input/Output (IO), traps, and CPU activity
w	Shows which users are currently logged on, where, and since when
watch	Runs a given command repeatedly, displaying the first screen-full of its output; this allows a user to watch the output change over time
<code>libproc-2</code>	Contains the functions used by most programs in this package

8.73. Util-linux-2.38.1

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

Approximate build time: 0.5 SBU

Required disk space: 283 MB

8.73.1. Installation of Util-linux

Prepare Util-linux for compilation:

```
./configure ADJTIME_PATH=/var/lib/hwclock/adjtime \
--bindir=/usr/bin \
--libdir=/usr/lib \
--sbindir=/usr/sbin \
--disable-chfn-chsh \
--disable-login \
--disable-nologin \
--disable-su \
--disable-setpriv \
--disable-runuser \
--disable-pylibmount \
--disable-static \
--without-python \
--without-systemd \
--without-systemdsystemunitdir \
--docdir=/usr/share/doc/util-linux-2.38.1
```

The `--disable` and `--without` options prevent warnings about building components that either 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 by booting into the completed LFS system and running:

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

```
chown -Rv tester .
su tester -c "make -k check"
```

The *hardlink* tests will fail if the host's kernel does not have the option `CONFIG_CRYPTO_USER_API_HASH` set. In addition, two sub-tests from `misc`: `mbsencode` and one sub-test from `script`: `replay` are known to fail.

Install the package:

```
make install
```

8.73.2. Contents of Util-linux

Installed programs:	addpart, agetty, blkdiscard, blkid, blkzone, blockdev, cal, cfdisk, chcpu, chmem, choom, chrt, col, colcrt, colrm, column, ctrlaltdel, delpart, dmesg, eject, fallocate, fdisk, findcore, findfs, findmnt, flock, fsck, fsck.cramfs, fsck.minix, fsfreeze, fstrim, getopt, hardlink, hexdump, hwclock, i386 (link to setarch), ionice, ipcmk, ipcrm, ipcs, irqtop, isosize, kill, last, lastb (link to last), ldattach, linux32 (link to setarch), linux64 (link to setarch), logger, look, losetup, lsblk, lscpu, lsipc, lsirq, lsfd, lslocks, lslogins, lsmem, lsns, mcookie, mesg, mkfs, mkfs.bfs, mkfs.cramfs, mkfs.minix, mkswap, more, mount, mountpoint, namei, nsenter, partx, pivot_root, prlimit, readprofile, rename, renice, resizepart, rev, rfcill, rtcwake, script, scriptlive, scriptreplay, setarch, setid, setterm, sfdisk, sulogin, swapon, swapoff, swapon, switch_root, taskset, uclampset, ul, umount, uname26 (link to setarch), unshare, utmpdump, uuid, uuidgen, uuidparse, wall, wdcctl, whereis, wipefs, x86_64 (link to setarch), and zramctl
Installed libraries:	libblkid.so, libfdisk.so, libmount.so, libsmartcols.so, and libuuid.so
Installed directories:	/usr/include/blkid, /usr/include/libfdisk, /usr/include/libmount, /usr/include/libsmartcols, /usr/include/uuid, /usr/share/doc/util-linux-2.38.1, and /var/lib/hwclock

Short Descriptions

addpart	Notifies the Linux kernel of new partitions
agetty	Opens a tty port, prompts for a login name, and then invokes the login program
blkdiscard	Discards sectors on a device
blkid	A command line utility to locate and print block device attributes
blkzone	Is used to manage zoned storage block devices
blockdev	Allows users to call block device ioctls from the command line
cal	Displays a simple calendar
cfdisk	Manipulates the partition table of the given device
chcpu	Modifies the state of CPUs
chmem	Configures memory
choom	Displays and adjusts OOM-killer scores, used to determine which process to kill first when Linux is Out Of Memory
chrt	Manipulates real-time attributes of a process
col	Filters out reverse line feeds
colcrt	Filters nroff output for terminals that lack some capabilities, such as overstriking and half-lines
colrm	Filters out the given columns
column	Formats a given file into multiple columns
ctrlaltdel	Sets the function of the Ctrl+Alt+Del key combination to a hard or a soft reset
delpart	Asks the Linux kernel to remove a partition
dmesg	Dumps the kernel boot messages
eject	Ejects removable media
fallocate	Preallocates space to a file

fdisk	Manipulates the partition table of the given device
findcore	Counts pages of file contents in core
findfs	Finds a file system, either by label or Universally Unique Identifier (UUID)
findmnt	Is a command line interface to the libmount library for working with mountinfo, fstab and mtab files
flock	Acquires a file lock and then executes a command with the lock held
fsck	Is used to check, and optionally repair, file systems
fsck.cramfs	Performs a consistency check on the Cramfs file system on the given device
fsck.minix	Performs a consistency check on the Minix file system on the given device
fsfreeze	Is a very simple wrapper around FIFREEZE/FITHAW ioctl kernel driver operations
fstrim	Discards unused blocks on a mounted filesystem
getopt	Parses options in the given command line
hardlink	Consolidates duplicate files by creating hard links
hexdump	Dumps the given file in hexadecimal, decimal, octal, or ascii
hwclock	Reads or sets the system's hardware clock, also called the Real-Time Clock (RTC) or Basic Input-Output System (BIOS) clock
i386	A symbolic link to setarch
ionice	Gets or sets the io scheduling class and priority for a program
ipcmk	Creates various IPC resources
ipcrm	Removes the given Inter-Process Communication (IPC) resource
ipcs	Provides IPC status information
irqtop	Displays kernel interrupt counter information in <code>top(1)</code> style view
isozsize	Reports the size of an iso9660 file system
kill	Sends signals to processes
last	Shows which users last logged in (and out), searching back through the <code>/var/log/wtmp</code> file; it also shows system boots, shutdowns, and run-level changes
lastb	Shows the failed login attempts, as logged in <code>/var/log/btmp</code>
ldattach	Attaches a line discipline to a serial line
linux32	A symbolic link to setarch
linux64	A symbolic link to setarch
logger	Enters the given message into the system log
look	Displays lines that begin with the given string
losetup	Sets up and controls loop devices
lsblk	Lists information about all or selected block devices in a tree-like format
lscpu	Prints CPU architecture information
lsfd	Displays information about open files; replaces lsdf
lsipc	Prints information on IPC facilities currently employed in the system

lsirq	Displays kernel interrupt counter information
lslocks	Lists local system locks
lslogins	Lists information about users, groups and system accounts
lsmem	Lists the ranges of available memory with their online status
lsns	Lists namespaces
mcookie	Generates magic cookies (128-bit random hexadecimal numbers) for xauth
mesg	Controls whether other users can send messages to the current user's terminal
mkfs	Builds a file system on a device (usually a hard disk partition)
mkfs.bfs	Creates a Santa Cruz Operations (SCO) bfs file system
mkfs.cramfs	Creates a cramfs file system
mkfs.minix	Creates a Minix file system
mkswap	Initializes the given device or file to be used as a swap area
more	A filter for paging through text one screen at a time
mount	Attaches the file system on the given device to a specified directory in the file-system tree
mountpoint	Checks if the directory is a mountpoint
namei	Shows the symbolic links in the given paths
nsenter	Runs a program with namespaces of other processes
partx	Tells the kernel about the presence and numbering of on-disk partitions
pivot_root	Makes the given file system the new root file system of the current process
prlimit	Gets and sets a process's resource limits
readprofile	Reads kernel profiling information
rename	Renames the given files, replacing a given string with another
renice	Alters the priority of running processes
resizepart	Asks the Linux kernel to resize a partition
rev	Reverses the lines of a given file
rkfill	Tool for enabling and disabling wireless devices
rtcwake	Used to enter a system sleep state until the specified wakeup time
script	Makes a typescript of a terminal session
scriptlive	Re-runs session typescripts using timing information
scriptreplay	Plays back typescripts using timing information
setarch	Changes reported architecture in a new program environment, and sets personality flags
setsid	Runs the given program in a new session
setterm	Sets terminal attributes
sfdisk	A disk partition table manipulator
sulogin	Allows root to log in; it is normally invoked by init when the system goes into single user mode
swapon	Makes changes to the swap area's UUID and label

swapoff	Disables devices and files for paging and swapping
swapon	Enables devices and files for paging and swapping, and lists the devices and files currently in use
switch_root	Switches to another filesystem as the root of the mount tree
taskset	Retrieves or sets a process's CPU affinity
uclampset	Manipulates the utilization clamping attributes of the system or a process
ul	A filter for translating underscores into escape sequences indicating underlining for the terminal in use
umount	Disconnects a file system from the system's file tree
uname26	A symbolic link to setarch
unshare	Runs a program with some namespaces unshared from parent
utmpdump	Displays the content of the given login file in a user-friendly format
uudd	A daemon used by the UUID library to generate time-based UUIDs in a secure and guaranteed-unique fashion
uuidgen	Creates new UUIDs. Each new UUID is a random number likely to be unique among all UUIDs created, on the local system and on other systems, in the past and in the future, with extremely high probability (~340 trillion trillion trillion unique UUIDs are possible)
uuidparse	A utility to parse unique identifiers
wall	Displays the contents of a file or, by default, its standard input, on the terminals of all currently logged in users
wdctl	Shows hardware watchdog status
whereis	Reports the location of the binary, source, and man page files for the given command
wipefs	Wipes a filesystem signature from a device
x86_64	A symbolic link to setarch
zramctl	A program to set up and control zram (compressed ram disk) devices
libblkid	Contains routines for device identification and token extraction
libfdisk	Contains routines for manipulating partition tables
libmount	Contains routines for block device mounting and unmounting
libsmartcols	Contains routines for aiding screen output in tabular form
libuuid	Contains routines for generating unique identifiers for objects that may be accessible beyond the local system

8.74. E2fsprogs-1.47.0

The E2fsprogs package contains the utilities for handling the `ext2` file system. It also supports the `ext3` and `ext4` journaling file systems.

Approximate build time: 2.4 SBU on a spinning disk, 0.4 SBU on an SSD

Required disk space: 95 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      \
             --sysconfdir=/etc  \
             --enable-elf-shlibs \
             --disable-libblkid \
             --disable-libuuid  \
             --disable-uuidd    \
             --disable-fsck
```

The meaning of the configure options:

`--enable-elf-shlibs`

This creates the shared libraries which some programs in this package use.

`--disable-*`

These prevent building and installing the `libuuid` and `libblkid` libraries, the `uuid` daemon, and the **fsck** wrapper; `util-linux` installs more recent versions.

Compile the package:

```
make
```

To run the tests, issue:

```
make check
```

One test, `u_direct_io`, is known to fail on some systems.

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. Configuring E2fsprogs

`/etc/mke2fs.conf` contains the default value of various command line options of **mke2fs**. You may edit the file to make the default values suitable for your need. For example, some utilities (not in LFS or BLFS) cannot recognize a `ext4` file system with `metadata_csum_seed` feature enabled. **If** you need such an utility, you may remove the feature from the default `ext4` feature list with the command:

```
sed 's/metadata_csum_seed,/' -i /etc/mke2fs.conf
```

Read the man page `mke2fs.conf(5)` for details.

8.74.3. Contents of E2fsprogs

Installed programs:	<code>badblocks</code> , <code>chattr</code> , <code>compile_et</code> , <code>debugfs</code> , <code>dumpe2fs</code> , <code>e2freefrag</code> , <code>e2fsck</code> , <code>e2image</code> , <code>e2label</code> , <code>e2mmpstatus</code> , <code>e2scrub</code> , <code>e2scrub_all</code> , <code>e2undo</code> , <code>e4crypt</code> , <code>e4defrag</code> , <code>filefrag</code> , <code>fsck.ext2</code> , <code>fsck.ext3</code> , <code>fsck.ext4</code> , <code>logsave</code> , <code>lsattr</code> , <code>mk_cmds</code> , <code>mke2fs</code> , <code>mkfs.ext2</code> , <code>mkfs.ext3</code> , <code>mkfs.ext4</code> , <code>mklost+found</code> , <code>resize2fs</code> , and <code>tune2fs</code>
Installed libraries:	<code>libcom_err.so</code> , <code>libe2p.so</code> , <code>libext2fs.so</code> , and <code>libss.so</code>
Installed directories:	<code>/usr/include/e2p</code> , <code>/usr/include/et</code> , <code>/usr/include/ext2fs</code> , <code>/usr/include/ss</code> , <code>/usr/lib/e2fsprogs</code> , <code>/usr/share/et</code> , and <code>/usr/share/ss</code>

Short Descriptions

badblocks	Searches a device (usually a disk partition) for bad blocks
chattr	Changes the attributes of files on <code>ext{234}</code> file systems
compile_et	An error table compiler; it converts a table of error-code names and messages into a C source file suitable for use with the <code>com_err</code> library
debugfs	A file system debugger; it can be used to examine and change the state of <code>ext{234}</code> file systems
dumpe2fs	Prints the super block and blocks group information for the file system present on a given device
e2freefrag	Reports free space fragmentation information
e2fsck	Is used to check and optionally repair <code>ext{234}</code> file systems
e2image	Is used to save critical <code>ext{234}</code> file system data to a file
e2label	Displays or changes the file system label on the <code>ext{234}</code> file system on a given device
e2mmpstatus	Checks MMP (Multiple Mount Protection) status of an <code>ext4</code> file system
e2scrub	Checks the contents of a mounted <code>ext{234}</code> file system
e2scrub_all	Checks all mounted <code>ext{234}</code> file systems for errors
e2undo	Replays the undo log for an <code>ext{234}</code> file system found on a device. [This can be used to undo a failed operation by an E2fsprogs program.]
e4crypt	<code>Ext4</code> file system encryption utility
e4defrag	Online defragmenter for <code>ext4</code> file systems
filefrag	Reports on how badly fragmented a particular file might be
fsck.ext2	By default checks <code>ext2</code> file systems and is a hard link to e2fsck
fsck.ext3	By default checks <code>ext3</code> file systems and is a hard link to e2fsck
fsck.ext4	By default checks <code>ext4</code> file systems and is a hard link to e2fsck

logsave	Saves the output of a command in a log file
lsattr	Lists the attributes of files on a second extended file system
mk_cmds	Converts a table of command names and help messages into a C source file suitable for use with the <code>libss</code> subsystem library
mke2fs	Creates an <code>ext{234}</code> file system on the given device
mkfs.ext2	By default creates <code>ext2</code> file systems and is a hard link to mke2fs
mkfs.ext3	By default creates <code>ext3</code> file systems and is a hard link to mke2fs
mkfs.ext4	By default creates <code>ext4</code> file systems and is a hard link to mke2fs
mklost+found	Creates a <code>lost+found</code> directory on an <code>ext{234}</code> file system; it pre-allocates disk blocks to this directory to lighten the task of e2fsck
resize2fs	Can be used to enlarge or shrink <code>ext{234}</code> file systems
tune2fs	Adjusts tunable file system parameters on <code>ext{234}</code> file systems
<code>libcom_err</code>	The common error display routine
<code>libe2p</code>	Used by dumpe2fs , chattr , and lsattr
<code>libext2fs</code>	Contains routines to enable user-level programs to manipulate <code>ext{234}</code> file systems
<code>libss</code>	Used by debugfs

8.75. Sysklogd-1.5.1

The Sysklogd package contains programs for logging system messages, such as those emitted by the kernel when unusual things happen.

Approximate build time: less than 0.1 SBU

Required disk space: 0.7 MB

8.75.1. Installation of Sysklogd

First, fix a problem that causes a segmentation fault in klogd under some conditions, and fix an obsolete program construct:

```
sed -i '/Error loading kernel symbols/{n;n;d}' ksym_mod.c
sed -i 's/union wait/int/' syslogd.c
```

Compile the package:

```
make
```

This package does not come with a test suite.

Install the package:

```
make BINDIR=/sbin install
```

8.75.2. Configuring Sysklogd

Create a new `/etc/syslog.conf` file by running the following:

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

auth,authpriv.* -/var/log/auth.log
*.*;auth,authpriv.none -/var/log/sys.log
daemon.* -/var/log/daemon.log
kern.* -/var/log/kern.log
mail.* -/var/log/mail.log
user.* -/var/log/user.log
*.emerg *

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

8.75.3. Contents of Sysklogd

Installed programs: klogd and syslogd

Short Descriptions

klogd A system daemon for intercepting and logging kernel messages

syslogd Logs the messages that system programs offer for logging [Every logged message contains at least a date stamp and a hostname, and normally the program's name too, but that depends on how trusting the logging daemon is told to be.]

8.76. Sysvinit-3.06

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

Approximate build time: less than 0.1 SBU

Required disk space: 4.4 MB

8.76.1. Installation of Sysvinit

First, apply a patch that removes several programs installed by other packages, clarifies a message, and fixes a compiler warning:

```
patch -Np1 -i ../sysvinit-3.06-consolidated-1.patch
```

Compile the package:

```
make
```

This package does not come with a test suite.

Install the package:

```
make install
```

8.76.2. Contents of Sysvinit

Installed programs: bootlogd, fstab-decode, halt, init, killall5, poweroff (link to halt), reboot (link to halt), runlevel, shutdown, and telinit (link to init)

Short Descriptions

bootlogd	Logs boot messages to a log file
fstab-decode	Runs a command with fstab-encoded arguments
halt	Normally invokes shutdown with the <i>-h</i> option, but when already in run-level 0, it tells the kernel to halt the system; it notes in the file <i>/var/log/wtmp</i> that the system is going down
init	The first process to be started when the kernel has initialized the hardware; it takes over the boot process and starts all the processes specified in its configuration file
killall5	Sends a signal to all processes, except the processes in its own session; it will not kill its parent shell
poweroff	Tells the kernel to halt the system and switch off the computer (see halt)
reboot	Tells the kernel to reboot the system (see halt)
runlevel	Reports the previous and the current run-level, as noted in the last run-level record in <i>/run/utmp</i>
shutdown	Brings the system down in a secure way, signaling all processes and notifying all logged-in users
telinit	Tells init which run-level to change to

8.77. About Debugging Symbols

Most programs and libraries are, by default, compiled with debugging symbols included (with **gcc's** `-g` option). This means that when debugging a program or library that was compiled with debugging information, the debugger can provide not only memory addresses, but also the names of the routines and variables.

The inclusion of these debugging symbols enlarges a program or library significantly. Here are two examples of the amount of space these symbols occupy:

- A **bash** binary with debugging symbols: 1200 KB
- A **bash** binary without debugging symbols: 480 KB (60% smaller)
- Glibc and GCC files (`/lib` and `/usr/lib`) with debugging symbols: 87 MB
- Glibc and GCC files without debugging symbols: 16 MB (82% smaller)

Sizes will vary depending on which compiler and C library were used, but a program that has been stripped of debugging symbols is usually some 50% to 80% smaller than its unstripped counterpart. 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.

8.78. Stripping

This section is optional. If the intended user is not a programmer and does not plan to do any debugging of the system software, the system's size can be decreased by some 2 GB by removing the debugging symbols, and some unnecessary symbol table entries, from binaries and libraries. This causes no real inconvenience for a typical Linux user.

Most people who use the commands mentioned below do not experience any difficulties. However, it is easy to make a mistake 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.

A **strip** command with the `--strip-unneeded` option removes all debug symbols from a binary or library. It also removes all symbol table entries not needed by the linker (for static libraries) or dynamic linker (for dynamically linked binaries and shared libraries).

The debugging symbols from selected libraries are preserved in separate files. That debugging information is needed to run regression tests with *valgrind* or *gdb* later, in BLFS.

Note that **strip** will overwrite the binary or library file it is processing. This can crash the processes using code or data from the file. If the process running **strip** is affected, the binary or library being stripped can be destroyed; this can make the system completely unusable. To avoid this problem we copy some libraries and binaries into `/tmp`, strip them there, then reinstall them with the **install** command. (The related entry in Section 8.2.1, “Upgrade Issues” gives the rationale for using the **install** command here.)



Note

The ELF loader's name is `ld-linux-x86-64.so.2` on 64-bit systems and `ld-linux.so.2` on 32-bit systems. The construct below selects the correct name for the current architecture, excluding anything ending with “g”, in case the commands below have already been run.



Important

If any package of which the version is different from the version specified by the book (either following a security advisory or satisfying personal preference), it may be necessary to update the the library file name in `save_usrlib` Or `online_usrlib`. **Failing to do so may render the system completely unusable.**

```
save_usrlib="$(cd /usr/lib; ls ld-linux*[^g])
    libc.so.6
    libthread_db.so.1
    libquadmath.so.0.0.0
    libstdc++.so.6.0.30
    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
    cp $LIB /tmp/$LIB
    strip --strip-unneeded /tmp/$LIB
    objcopy --add-gnu-debuglink=$LIB.dbg /tmp/$LIB
    install -vm755 /tmp/$LIB /usr/lib
    rm /tmp/$LIB
done

online_usrbin="bash find strip"
online_usrlib="libbfd-2.40.so
    libframe.so.0.0.0
    libhistory.so.8.2
    libncursesw.so.6.4
    libm.so.6
    libreadline.so.8.2
    libz.so.1.2.13
    $(cd /usr/lib; find libnss*.so* -type f)"

for BIN in $online_usrbin; do
    cp /usr/bin/$BIN /tmp/$BIN
    strip --strip-unneeded /tmp/$BIN
    install -vm755 /tmp/$BIN /usr/bin
    rm /tmp/$BIN
done

for LIB in $online_usrlib; do
    cp /usr/lib/$LIB /tmp/$LIB
    strip --strip-unneeded /tmp/$LIB
    install -vm755 /tmp/$LIB /usr/lib
    rm /tmp/$LIB
done

for i in $(find /usr/lib -type f -name \*.so* ! -name \*dbg) \
    $(find /usr/lib -type f -name \*.a) \
    $(find /usr/{bin,sbin,libexec} -type f); do
    case "$online_usrbin $online_usrlib $save_usrlib" in
        *$(basename $i)* )
            ;;
        * ) strip --strip-unneeded $i
            ;;
    esac
done

unset BIN LIB save_usrlib online_usrbin online_usrlib
```

A large number of files will be flagged as errors because their file format is not recognized. These warnings can be safely ignored. They indicate that those files are scripts, not binaries.

8.79. Cleaning Up

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

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

There are also several files in the `/usr/lib` and `/usr/libexec` directories with a file name extension of `.la`. These are "libtool archive" files. On a modern Linux system the libtool `.la` files are only useful for `libltdl`. No libraries in LFS are expected to be loaded by `libltdl`, and it's known that some `.la` files can break BLFS package builds. Remove those files now:

```
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
```

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

Booting a Linux system involves several tasks. The process must mount both virtual and real file systems, initialize devices, check file systems for integrity, mount and activate any swap partitions or files, set the system clock, bring up networking, start any daemons required by the system, and accomplish any other custom tasks specified by the user. This process must be organized to ensure the tasks are performed in the correct order and executed as quickly as possible.

9.1.1. System V

System V is the classic boot process that has been used in Unix and Unix-like systems such as Linux since about 1983. It consists of a small program, **init**, that sets up basic processes such as **login** (via **getty**) and runs a script. This script, usually named **rc**, controls the execution of a set of additional scripts that perform the tasks required to initialize the system.

The **init** program is controlled by the `/etc/inittab` file and is organized into run levels that can be chosen by the user. In LFS, they are used as follows:

```
0 — halt
1 — Single user mode
2 — User definable
3 — Full multiuser mode
4 — User definable
5 — Full multiuser mode with display manager
6 — reboot
```

The usual default run level is 3 or 5.

Advantages

- Established, well understood system.
- Easy to customize.

Disadvantages

- May be slower to boot. A medium speed base LFS system takes 8-12 seconds where the boot time is measured from the first kernel message to the login prompt. Network connectivity is typically established about 2 seconds after the login prompt.
- Serial processing of boot tasks. This is related to the previous point. A delay in any process, such as a file system check, will delay the entire boot process.
- Does not directly support advanced features like control groups (cgroups) and per-user fair share scheduling.
- Adding scripts requires manual, static sequencing decisions.

9.2. LFS-Bootscripts-20230101

The LFS-Bootscripts package contains a set of scripts to start/stop the LFS system at bootup/shutdown. The configuration files and procedures needed to customize the boot process are described in the following sections.

Approximate build time: less than 0.1 SBU

Required disk space: 244 KB

9.2.1. Installation of LFS-Bootscripts

Install the package:

```
make install
```

9.2.2. Contents of LFS-Bootscripts

Installed scripts: checkfs, cleanfs, console, functions, halt, ifdown, ifup, localnet, modules, mountfs, mountvirtfs, network, rc, reboot, sendsignals, setclock, ipv4-static, swap, sysctl, sysklogd, template, udev, and udev_retry

Installed directories: /etc/rc.d, /etc/init.d (symbolic link), /etc/sysconfig, /lib/services, /lib/lsb (symbolic link)

Short Descriptions

checkfs	Checks the integrity of the file systems before they are mounted (with the exception of journaling and network-based file systems)
cleanfs	Removes files that should not be preserved between reboots, such as those in <code>/run/</code> and <code>/var/lock/</code> ; it re-creates <code>/run/utmp</code> and removes the possibly present <code>/etc/nologin</code> , <code>/fastboot</code> , and <code>/forcefsck</code> files
console	Loads the correct keymap table for the desired keyboard layout; it also sets the screen font
functions	Contains common functions, such as error and status checking, that are used by several bootscripts
halt	Halts the system
ifdown	Stops a network device
ifup	Initializes a network device
localnet	Sets up the system's hostname and local loopback device
modules	Loads kernel modules listed in <code>/etc/sysconfig/modules</code> , using arguments that are also given there
mountfs	Mounts all file systems, except those that are marked <i>noauto</i> , or are network based
mountvirtfs	Mounts virtual kernel file systems, such as <code>proc</code>
network	Sets up network interfaces, such as network cards, and sets up the default gateway (where applicable)
rc	The master run-level control script; it is responsible for running all the other bootscripts one-by-one, in a sequence determined by the names of the symbolic links to those other bootscripts
reboot	Reboots the system
sendsignals	Makes sure every process is terminated before the system reboots or halts
setclock	Resets the system clock to local time if the hardware clock is not set to UTC
ipv4-static	Provides the functionality needed to assign a static Internet Protocol (IP) address to a network interface

swap	Enables and disables swap files and partitions
sysctl	Loads system configuration values from <code>/etc/sysctl.conf</code> , if that file exists, into the running kernel
sysklogd	Starts and stops the system and kernel log daemons
template	A template to create custom bootscripts for other daemons
udev	Prepares the <code>/dev</code> directory and starts the udev daemon
udev_retry	Retries failed udev uevents, and copies generated rules files from <code>/run/udev</code> to <code>/etc/udev/rules.d</code> if required

9.3. Overview of Device and Module Handling

In Chapter 8, we installed the `udev` daemon when `eudev` was built. Before we go into the details regarding how `udev` 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 contained 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, device nodes are only created for those devices which are detected by the kernel. These device nodes are created each time the system boots; they are stored in 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 configurable, the device naming policy should be chosen by system administrators, and not imposed on them by the developer(s). The `devfs` file system also suffered from race conditions that were inherent in its design; these could not be fixed without a substantial revision of the kernel. `devfs` was marked as deprecated for a long time, 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 provide information about the system's hardware configuration to userspace processes. With this userspace-visible representation, it became possible to develop a userspace replacement for `devfs`.

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 register their objects in `sysfs` (`devtmpfs` internally) as they are detected by the kernel. For drivers compiled as modules, registration happens when the module is loaded. Once the `sysfs` filesystem is mounted (on `/sys`), data which the drivers have registered 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 in the `devtmpfs` file system. Any driver that wishes to register a device node will use the `devtmpfs` (via the driver core) to do it. When a `devtmpfs` instance is mounted on `/dev`, the device node will initially be exposed to userspace 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`, `/usr/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-6.1.11, `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-6.1.11, 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.

If the module in question is not a wrapper and is useful by itself, configure the **modules** bootscript to load this module on system boot. To do this, add the module name to the `/etc/sysconfig/modules` file on a separate line. This works for wrapper modules too, but is suboptimal in that case.

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 the 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

First, be certain that the driver is built into the kernel or already loaded as a module, and that udev isn't creating a misnamed device.

If a kernel driver does not export its data to `sysfs`, udev lacks the information needed to create a device node. This is most likely to happen with third party drivers from outside the kernel tree. Create a static device node in `/usr/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 9.5, “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
- The `sysfs` Filesystem <https://www.kernel.org/pub/linux/kernel/people/mochel/doc/papers/ols-2005/mochel.pdf>

9.4. Managing Devices

9.4.1. Network Devices

Udev, by default, names network devices according to Firmware/BIOS data or physical characteristics like the bus, slot, or MAC address. The purpose of this naming convention is to ensure that network devices are named consistently, not based on when the network card was discovered. In older versions of Linux—on a computer with two network cards made by Intel and Realtek, for instance—the network card manufactured by Intel might have become `eth0` while the Realtek card became `eth1`. After a reboot, the cards would sometimes get renumbered the other way around.

In the new naming scheme, typical network device names are something like `enp5s0` or `wlp3s0`. If this naming convention is not desired, the traditional naming scheme, or a custom scheme, can be implemented.

9.4.1.1. Disabling Persistent Naming on the Kernel Command Line

The traditional naming scheme using `eth0`, `eth1`, etc. can be restored by adding `net.ifnames=0` on the kernel command line. This is most appropriate for systems that have just one ethernet device of a particular type. Laptops often have two ethernet connections named `eth0` and `wlan0`; such laptops can also use this method. The command line is in the GRUB configuration file. See Section 10.4.4, “Creating the GRUB Configuration File”.

9.4.1.2. Creating Custom Udev Rules

The naming scheme can be customized by creating custom udev rules. A script has been included that generates the initial rules. Generate these rules by running:

```
bash /usr/lib/udev/init-net-rules.sh
```

Now, inspect the `/etc/udev/rules.d/70-persistent-net.rules` file, to find out which name was assigned to which network device:

```
cat /etc/udev/rules.d/70-persistent-net.rules
```



Note

In some cases, such as when MAC addresses have been assigned to a network card manually, or in a virtual environment such as Qemu or Xen, the network rules file may not be generated because addresses are not consistently assigned. In these cases, this method cannot be used.

The file begins with a comment block, followed by two lines for each NIC. The first line for each NIC is a commented description showing its hardware IDs (e.g. its PCI vendor and device IDs, if it's a PCI card), along with its driver (in parentheses, if the driver can be found). Neither the hardware ID nor the driver is used to determine which name to give an interface; this information is only for reference. The second line is the udev rule that matches this NIC and actually assigns it a name.

All udev rules are made up of several keywords, separated by commas and optional whitespace. Here are the keywords, and an explanation of each one:

- `SUBSYSTEM=="net"` - This tells udev to ignore devices that are not network cards.
- `ACTION=="add"` - This tells udev to ignore this rule for a uevent that isn't an add ("remove" and "change" uevents also happen, but don't need to rename network interfaces).
- `DRIVERS=="*"` - This exists so that udev will ignore VLAN or bridge sub-interfaces (because these sub-interfaces do not have drivers). These sub-interfaces are skipped because the name that would be assigned would collide with the parent devices.

- `ATTR{address}` - The value of this keyword is the NIC's MAC address.
- `ATTR{type}=="1"` - This ensures the rule only matches the primary interface in the case of certain wireless drivers which create multiple virtual interfaces. The secondary interfaces are skipped for the same reason that VLAN and bridge sub-interfaces are skipped: there would be a name collision otherwise.
- `NAME` - The value of this keyword is the name that udev will assign to this interface.

The value of `NAME` is the important part. Make sure you know which name has been assigned to each of your network cards before proceeding, and be sure to use that `NAME` value when creating your network configuration files.

9.4.2. CD-ROM Symlinks

Some software that you may want to install later (e.g., various media players) expects the `/dev/cdrom` and `/dev/dvd` symlinks to exist, and to point to a CD-ROM or DVD-ROM device. Also, it may be convenient to put references to those symlinks into `/etc/fstab`. Udev comes with a script that will generate rules files to create these symlinks for you, depending on the capabilities of each device, but you need to decide which of two modes of operation you wish to have the script use.

First, the script can operate in “by-path” mode (used by default for USB and FireWire devices), where the rules it creates depend on the physical path to the CD or DVD device. Second, it can operate in “by-id” mode (default for IDE and SCSI devices), where the rules it creates depend on identification strings stored on the CD or DVD device itself. The path is determined by udev's **path_id** script, and the identification strings are read from the hardware by its **ata_id** or **scsi_id** programs, depending on which type of device you have.

There are advantages to each approach; the correct approach depends on what kinds of device changes may happen. If you expect the physical path to the device (that is, the ports and/or slots that it plugs into) to change, for example because you plan on moving the drive to a different IDE port or a different USB connector, then you should use the “by-id” mode. On the other hand, if you expect the device's identification to change, for example because it may die, and you intend to replace it with a different device that plugs into the same connectors, then you should use the “by-path” mode.

If either type of change is possible with your drive, then choose a mode based on the type of change you expect to happen more often.



Important

External devices (for example, a USB-connected CD drive) should not use by-path persistence, because each time the device is plugged into a new external port, its physical path will change. All externally-connected devices will have this problem if you write udev rules to recognize them by their physical path; the problem is not limited to CD and DVD drives.

If you wish to see the values that the udev scripts will use, then for the appropriate CD-ROM device, find the corresponding directory under `/sys` (e.g., this can be `/sys/block/hdd`) and run a command similar to the following:

```
udevadm test /sys/block/hdd
```

Look at the lines containing the output of various `*_id` programs. The “by-id” mode will use the `ID_SERIAL` value if it exists and is not empty, otherwise it will use a combination of `ID_MODEL` and `ID_REVISION`. The “by-path” mode will use the `ID_PATH` value.

If the default mode is not suitable for your situation, then the following modification can be made to the `/etc/udev/rules.d/83-cdrom-symlinks.rules` file, as follows (where `mode` is one of “by-id” or “by-path”):

```
sed -e 's/"write_cd_rules"/"write_cd_rules mode"/' \
-i /etc/udev/rules.d/83-cdrom-symlinks.rules
```

Note that it is not necessary to create the rules files or symlinks at this time because you have bind-mounted the host's `/dev` directory into the LFS system and we assume the symlinks exist on the host. The rules and symlinks will be created the first time you boot your LFS system.

However, if you have multiple CD-ROM devices, then the symlinks generated at that time may point to different devices than they point to on your host because devices are not discovered in a predictable order. The assignments created when you first boot the LFS system will be stable, so this is only an issue if you need the symlinks on both systems to point to the same device. If you need that, then inspect (and possibly edit) the generated `/etc/udev/rules.d/70-persistent-cd.rules` file after booting, to make sure the assigned symlinks match your needs.

9.4.3. 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 to create persistent symlinks. The case of network cards is covered separately in Section 9.5, “General Network Configuration”, and sound card configuration can be found in *BLFS*.

For each of your devices that is likely to have this problem (even if the problem doesn't exist in your current Linux distribution), find the corresponding directory under `/sys/class` or `/sys/block`. For video devices, this may be `/sys/class/video4linux/videoX`. Figure out the attributes that identify the device uniquely (usually, vendor and product IDs and/or serial numbers work):

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

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

```
cat > /etc/udev/rules.d/83-duplicate_devs.rules << "EOF"

# Persistent symlinks for webcam and tuner
KERNEL=="video*", ATTRS{idProduct}=="1910", ATTRS{idVendor}=="0d81", SYMLINK+="webcam"
KERNEL=="video*", ATTRS{device}=="0x036f", ATTRS{vendor}=="0x109e", SYMLINK+="tvtuner"

EOF
```

The result is that `/dev/video0` and `/dev/video1` devices still refer randomly to the tuner and the web camera (and thus should never be used directly), but there are symlinks `/dev/tvtuner` and `/dev/webcam` that always point to the correct device.

9.5. General Network Configuration

9.5.1. Creating Network Interface Configuration Files

The files in `/etc/sysconfig/` usually determine which interfaces are brought up and down by the network script. This directory should contain a file for each interface to be configured, such as `ifconfig.xyz`, where “xyz” describes the network card. The interface name (e.g. `eth0`) is usually appropriate. Each file contains the attributes of one interface, such as its IP address(es), subnet masks, and so forth. The stem of the filename must be *ifconfig*.



Note

If the procedure in the previous section was not used, udev will assign network card interface names based on system physical characteristics such as `enp2s1`. If you are not sure what your interface name is, you can always run **`ip link`** or **`ls /sys/class/net`** after you have booted your system.

The interface names depend on the implementation and configuration of the udev daemon running on the system. The udev daemon for LFS (installed in Section 8.70, “Eudev-3.2.11”) will not run until the LFS system is booted. So the interface names in the LFS system cannot always be determined by running those commands on the host distro, *even in the chroot environment*.

The following command creates a sample file for the `eth0` device with a static IP address:

```
cd /etc/sysconfig/
cat > ifconfig.eth0 << "EOF"
ONBOOT=yes
IFACE=eth0
SERVICE=ipv4-static
IP=192.168.1.2
GATEWAY=192.168.1.1
PREFIX=24
BROADCAST=192.168.1.255
EOF
```

The values in italics must be changed in each file, to set the interfaces up correctly.

If the `ONBOOT` variable is set to “yes” the System V network script will bring up the Network Interface Card (NIC) during the system boot process. If set to anything besides “yes”, the NIC will be ignored by the network script and will not be started automatically. Interfaces can be manually started or stopped with the **`ifup`** and **`ifdown`** commands.

The `IFACE` variable defines the interface name, for example, `eth0`. It is required for all network device configuration files. The filename extension must match this value.

The `SERVICE` variable defines the method used for obtaining the IP address. The LFS-Bootscripts package has a modular IP assignment format, and creating additional files in the `/lib/services/` directory allows other IP assignment methods. This is commonly used for Dynamic Host Configuration Protocol (DHCP), which is addressed in the BLFS book.

The `GATEWAY` variable should contain the default gateway IP address, if one is present. If not, then comment out the variable entirely.

The `PREFIX` variable specifies the number of bits used in the subnet. Each segment of an IP address is 8 bits. If the subnet's netmask is `255.255.255.0`, then it is using the first three segments (24 bits) to specify the network number. If the netmask is `255.255.255.240`, the subnet is using the first 28 bits. Prefixes longer than 24 bits are commonly used by DSL and cable-based Internet Service Providers (ISPs). In this example (`PREFIX=24`), the netmask is `255.255.255.0`. Adjust the `PREFIX` variable according to your specific subnet. If omitted, the `PREFIX` defaults to 24.

For more information see the **`ifup`** man page.

9.5.2. Creating the `/etc/resolv.conf` File

The system will need some means of obtaining 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`. Create the file by running the following:

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

domain <Your Domain Name>
nameserver <IP address of your primary nameserver>
nameserver <IP address of your secondary nameserver>

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

The domain statement can be omitted or replaced with a `search` statement. See the man page for `resolv.conf` for more details.

Replace `<IP address of the nameserver>` with the IP address of the DNS most appropriate for the setup. There will often be more than one entry (requirements demand secondary servers for fallback capability). If you only need or want one DNS server, remove the second `nameserver` line from the file. The IP address may also be a router on the local network.



Note

The Google Public IPv4 DNS addresses are 8.8.8.8 and 8.8.4.4.

9.5.3. 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 goes in the `/etc/hosts` file.

9.5.4. Customizing the `/etc/hosts` File

Decide on the IP address, fully-qualified domain name (FQDN), and possible aliases for use in the `/etc/hosts` file. The syntax is:

```
IP_address myhost.example.org aliases
```

Unless the computer is to be visible to the Internet (i.e., there is a registered domain and a valid block of assigned IP addresses—most users do not have this), make sure that the IP address is in the private network IP address range. Valid ranges are:

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

x can be any number in the range 16-31. y can be any number in the range 0-255.

A valid private IP address could be 192.168.1.1. A valid FQDN for this IP could be `lfs.example.org`.

Even if not using a network card, a valid FQDN is still required. This is necessary for certain programs to operate correctly.

Create the `/etc/hosts` file by running:

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

127.0.0.1 localhost.localdomain localhost
127.0.1.1 <FQDN> <HOSTNAME>
<192.168.1.1> <FQDN> <HOSTNAME> [alias1] [alias2 ...]
::1      localhost ip6-localhost ip6-loopback
ff02::1  ip6-allnodes
ff02::2  ip6-allrouters

# End /etc/hosts
EOF
```

The `<192.168.1.1>`, `<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.

9.6. System V Bootscript Usage and Configuration

9.6.1. How Do the System V Bootscripts Work?

This version of LFS uses a special booting facility named SysVinit, based on a series of *run levels*. The boot procedure can be quite different from one system to another; the fact that things worked one way in a particular Linux distribution does not guarantee they will work the same way in LFS. LFS has its own way of doing things, but it does respect generally accepted standards.

There is an alternative boot procedure called **systemd**. We will not discuss that boot process any further here. For a detailed description visit <https://www.linux.com/training-tutorials/understanding-and-using-systemd/>.

SysVinit (which will be referred to as “init” from now on) uses a run levels scheme. There are seven run levels, numbered 0 to 6. (Actually, there are more run levels, but the others are for special cases and are generally not used. See `init(8)` for more details.) Each one of the seven corresponds to actions the computer is supposed to perform when it starts up or shuts down. The default run level is 3. Here are the descriptions of the different run levels as they are implemented in LFS:

```
0: halt the computer
1: single-user mode
2: reserved for customization, otherwise the same as 3
3: multi-user mode with networking
4: reserved for customization, otherwise the same as 3
5: same as 4, it is usually used for GUI login (like GNOME's gdm or LXDE's lxdm)
6: reboot the computer
```



Note

Classically, run level 2 above was defined as "multi-user mode without networking", but this was only the case many years ago when multiple users could connect to a system via serial ports. In today's environment it makes no sense, and we now say it is "reserved".

9.6.2. Configuring Sysvinit

During kernel initialization, the first program that is run (if not overridden on the command line) is **init**. This program reads the initialization file `/etc/inittab`. Create this file with:

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

id:3:initdefault:

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

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

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

su:S06:once:/sbin/sulogin
s1:1:respawn:/sbin/sulogin

1:2345:respawn:/sbin/agetty --noclear tty1 9600
2:2345:respawn:/sbin/agetty tty2 9600
3:2345:respawn:/sbin/agetty tty3 9600
4:2345:respawn:/sbin/agetty tty4 9600
5:2345:respawn:/sbin/agetty tty5 9600
6:2345:respawn:/sbin/agetty tty6 9600

# End /etc/inittab
EOF
```

An explanation of this initialization file is in the man page for *inittab*. In LFS, the key command is **rc**. The initialization file above instructs **rc** to run all the scripts starting with an **S** in the `/etc/rc.d/rcS.d` directory followed by all the scripts starting with an **S** in the `/etc/rc.d/rc?.d` directory where the question mark is specified by the `initdefault` value.

As a convenience, the **rc** script reads a library of functions in `/lib/lsb/init-functions`. This library also reads an optional configuration file, `/etc/sysconfig/rc.site`. Any of the system configuration parameters described in subsequent sections can be placed in this file, allowing consolidation of all system parameters in this one file.

As a debugging convenience, the functions script also logs all output to `/run/var/bootlog`. Since the `/run` directory is a tmpfs, this file is not persistent across boots; however, it is appended to the more permanent file `/var/log/boot.log` at the end of the boot process.

9.6.2.1. Changing Run Levels

Changing run levels is done with **init** *<runlevel>*, where *<runlevel>* is the target run level. For example, to reboot the computer, a user could issue the **init 6** command, which is an alias for the **reboot** command. Likewise, **init 0** is an alias for the **halt** command.

There are a number of directories under `/etc/rc.d` that look like `rc?.d` (where `?` is the number of the run level) and `rcS.d`, all containing a number of symbolic links. Some links begin with a **K**; the others begin with an **S**, and all of them have two numbers following the initial letter. The **K** means to stop (kill) a service and the **S** means to start a service. The numbers determine the order in which the scripts are run, from 00 to 99—the smaller the number, the sooner the script runs. When **init** switches to another run level, the appropriate services are either started or stopped, depending on the run level chosen.

The real scripts are in `/etc/rc.d/init.d`. They do the actual work, and the symlinks all point to them. K links and S links point to the same script in `/etc/rc.d/init.d`. This is because the scripts can be called with different parameters like `start`, `stop`, `restart`, `reload`, and `status`. When a K link is encountered, the appropriate script is run with the `stop` argument. When an S link is encountered, the appropriate script is run with the `start` argument.

These are descriptions of what the arguments make the scripts do:

`start`

The service is started.

`stop`

The service is stopped.

`restart`

The service is stopped and then started again.

`reload`

The configuration of the service is updated. This is used after the configuration file of a service was modified, when the service does not need to be restarted.

`status`

Tells if the service is running and with which PIDs.

Feel free to modify the way the boot process works (after all, it is your own LFS system). The files given here are an example of how it can be done.

9.6.3. Udev Bootscripts

The `/etc/rc.d/init.d/udev` initscript starts **udev**, triggers any "coldplug" devices that have already been created by the kernel, and waits for any rules to complete. The script also unsets the uevent handler from the default of `/sbin/hotplug`. This is done because the kernel no longer needs to call an external binary. Instead, **udev** will listen on a netlink socket for uevents that the kernel raises.

The `/etc/rc.d/init.d/udev_retry` script takes care of re-triggering events for subsystems whose rules may rely on file systems that are not mounted until the **mountfs** script is run (in particular, `/usr` and `/var` may cause this). This script runs after the **mountfs** script, so those rules (if re-triggered) should succeed the second time around. It is configured by the `/etc/sysconfig/udev_retry` file; any words in this file other than comments are considered subsystem names to trigger at retry time. To find the subsystem of a device, use **udevadm info --attribute-walk <device>** where `<device>` is an absolute path in `/dev` or `/sys`, such as `/dev/sr0`, or `/sys/class/rtc`.

For information on kernel module loading and udev, see Section 9.3.2.3, "Module Loading".

9.6.4. Configuring the System Clock

The **setclock** script reads the time from the hardware clock, also known as the BIOS or Complementary Metal Oxide Semiconductor (CMOS) clock. If the hardware clock is set to UTC, this script will convert the hardware clock's time to the local time using the `/etc/localtime` file (which tells the **hwclock** program which time zone to use). There is no way to detect whether or not the hardware clock is set to UTC, so this must be configured manually.

The **setclock** program is run via udev when the kernel detects the hardware capability upon boot. It can also be run manually with the `stop` parameter to store the system time to the CMOS clock.

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 number of hours for your time zone to the time shown by **hwclock**. For example, if you are currently in the MST time zone, which is also known as GMT -0700, add seven hours to the local time.

Change the value of the `UTC` variable below to a value of *0* (zero) if the hardware clock is *NOT* set to UTC time.

Create a new file `/etc/sysconfig/clock` by running the following:

```
cat > /etc/sysconfig/clock << "EOF"
# Begin /etc/sysconfig/clock

UTC=1

# Set this to any options you might need to give to hwclock,
# such as machine hardware clock type for Alphas.
CLOCKPARAMS=

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

A good hint explaining how to deal with time on LFS is available at <https://www.linuxfromscratch.org/hints/downloads/files/time.txt>. It explains issues such as time zones, UTC, and the `TZ` environment variable.



Note

The `CLOCKPARAMS` and `UTC` parameters may also be set in the `/etc/sysconfig/rc.site` file.

9.6.5. Configuring the Linux Console

This section discusses how to configure the **console** bootscript that sets up the keyboard map, console font, and console kernel log level. If non-ASCII characters (e.g., the copyright sign, the British pound sign, and the Euro symbol) will not be used and the keyboard is a U.S. one, much of this section can be skipped. Without the configuration file, (or equivalent settings in `rc.site`), the **console** bootscript will do nothing.

The **console** script reads the `/etc/sysconfig/console` file for configuration information. Decide which keymap and screen font will be used. Various language-specific HOWTOs can also help with this; see <https://tldp.org/HOWTO/HOWTO-INDEX/other-lang.html>. If still in doubt, look in the `/usr/share/keymaps` and `/usr/share/consolefonts` directories for valid keymaps and screen fonts. Read the `loadkeys(1)` and `setfont(8)` manual pages to determine the correct arguments for these programs.

The `/etc/sysconfig/console` file should contain lines of the form: `VARIABLE="value"`. The following variables are recognized:

LOGLEVEL

This variable specifies the log level for kernel messages sent to the console as set by **dmesg -n**. Valid levels are from "1" (no messages) to "8". The default level is "7".

KEYMAP

This variable specifies the arguments for the **loadkeys** program, typically, the name of the keymap to load, e.g., "it". If this variable is not set, the bootscript will not run the **loadkeys** program, and the default kernel keymap will be used. Note that a few keymaps have multiple versions with the same name (cz and its variants in `qwerty/` and `qwertyz/`, es in `olpc/` and `qwerty/`, and `trf` in `fgG1od/` and `qwerty/`). In these cases the parent directory should also be specified (e.g. `qwerty/es`) to ensure the proper keymap is loaded.

KEYMAP_CORRECTIONS

This (rarely used) variable specifies the arguments for the second call to the **loadkeys** program. This is useful if the stock keymap is not completely satisfactory and a small adjustment has to be made. E.g., to include the Euro sign into a keymap that normally doesn't have it, set this variable to “euro2”.

FONT

This variable specifies the arguments for the **setfont** program. Typically, this includes the font name, “-m”, and the name of the application character map to load. E.g., in order to load the “lat1-16” font together with the “8859-1” application character map (appropriate in the USA), set this variable to “lat1-16 -m 8859-1”. In UTF-8 mode, the kernel uses the application character map to convert 8-bit key codes to UTF-8. Therefore the argument of the “-m” parameter should be set to the encoding of the composed key codes in the keymap.

UNICODE

Set this variable to “1”, “yes”, or “true” in order to put the console into UTF-8 mode. This is useful in UTF-8 based locales and harmful otherwise.

LEGACY_CHARSET

For many keyboard layouts, there is no stock Unicode keymap in the Kbd package. The **console** bootscript will convert an available keymap to UTF-8 on the fly if this variable is set to the encoding of the available non-UTF-8 keymap.

Some examples:

- For a non-Unicode setup, only the KEYMAP and FONT variables are generally needed. E.g., for a Polish setup, one would use:

```
cat > /etc/sysconfig/console << "EOF"
# Begin /etc/sysconfig/console

KEYMAP="pl2"
FONT="lat2a-16 -m 8859-2"

# End /etc/sysconfig/console
EOF
```

- As mentioned above, it is sometimes necessary to adjust a stock keymap slightly. The following example adds the Euro symbol to the German keymap:

```
cat > /etc/sysconfig/console << "EOF"
# Begin /etc/sysconfig/console

KEYMAP="de-latin1"
KEYMAP_CORRECTIONS="euro2"
FONT="lat0-16 -m 8859-15"
UNICODE="1"

# End /etc/sysconfig/console
EOF
```

- The following is a Unicode-enabled example for Bulgarian, where a stock UTF-8 keymap exists:

```
cat > /etc/sysconfig/console << "EOF"
# Begin /etc/sysconfig/console

UNICODE="1"
KEYMAP="bg_bds-utf8"
FONT="LatArCyrHeb-16"

# End /etc/sysconfig/console
EOF
```

- Due to the use of a 512-glyph LatArCyrHeb-16 font in the previous example, bright colors are no longer available on the Linux console unless a framebuffer is used. If one wants to have bright colors without a framebuffer and can live without characters not belonging to his language, it is still possible to use a language-specific 256-glyph font, as illustrated below:

```
cat > /etc/sysconfig/console << "EOF"
# Begin /etc/sysconfig/console

UNICODE="1"
KEYMAP="bg_bds-utf8"
FONT="cyr-sun16"

# End /etc/sysconfig/console
EOF
```

- The following example illustrates keymap autoconversion from ISO-8859-15 to UTF-8 and enabling dead keys in Unicode mode:

```
cat > /etc/sysconfig/console << "EOF"
# Begin /etc/sysconfig/console

UNICODE="1"
KEYMAP="de-latin1"
KEYMAP_CORRECTIONS="euro2"
LEGACY_CHARSET="iso-8859-15"
FONT="LatArCyrHeb-16 -m 8859-15"

# End /etc/sysconfig/console
EOF
```

- Some keymaps have dead keys (i.e., keys that don't produce a character by themselves, but put an accent on the character produced by the next key) or define composition rules (such as: “press Ctrl+. A E to get Æ” in the default keymap). Linux-6.1.11 interprets dead keys and composition rules in the keymap correctly only when the source characters to be composed together are not multibyte. This deficiency doesn't affect keymaps for European languages, because there accents are added to unaccented ASCII characters, or two ASCII characters are composed together. However, in UTF-8 mode it is a problem; e.g., for the Greek language, where one sometimes needs to put an accent on the letter “alpha”. The solution is either to avoid the use of UTF-8, or to install the X window system, which doesn't have this limitation, in its input handling.
- For Chinese, Japanese, Korean, and some other languages, the Linux console cannot be configured to display the needed characters. Users who need such languages should install the X Window System, fonts that cover the necessary character ranges, and the proper input method (e.g., SCIM supports a wide variety of languages).



Note

The `/etc/sysconfig/console` file only controls the Linux text console localization. It has nothing to do with setting the proper keyboard layout and terminal fonts in the X Window System, with ssh sessions, or with a serial console. In such situations, limitations mentioned in the last two list items above do not apply.

9.6.6. Creating Files at Boot

At times, it is desirable to create files at boot time. For instance, the `/tmp/.ICE-unix` directory is often needed. This can be done by creating an entry in the `/etc/sysconfig/createfiles` configuration script. The format of this file is embedded in the comments of the default configuration file.

9.6.7. Configuring the Syslogd Script

The `syslogd` script invokes the **syslogd** program as a part of System V initialization. The `-m 0` option turns off the periodic timestamp mark that **syslogd** writes to the log files every 20 minutes by default. If you want to turn on this periodic timestamp mark, edit `/etc/sysconfig/rc.site` and define the variable `SYSKLOGD_PARMS` to the desired value. For instance, to remove all parameters, set the variable to a null value:

```
SYSKLOGD_PARMS=
```

See `man syslogd` for more options.

9.6.8. The rc.site File

The optional `/etc/sysconfig/rc.site` file contains settings that are automatically set for each SystemV boot script. It can alternatively set the values specified in the `hostname`, `console`, and `clock` files in the `/etc/sysconfig/` directory. If the associated variables are present in both these separate files and `rc.site`, the values in the script-specific files take effect.

`rc.site` also contains parameters that can customize other aspects of the boot process. Setting the `IPROMPT` variable will enable selective running of bootscripts. Other options are described in the file comments. The default version of the file is as follows:

```
# rc.site
# Optional parameters for boot scripts.

# Distro Information
# These values, if specified here, override the defaults
#DISTRO="Linux From Scratch" # The distro name
#DISTRO_CONTACT="lfs-dev@lists.linuxfromscratch.org" # Bug report address
#DISTRO_MINI="LFS" # Short name used in filenames for distro config

# Define custom colors used in messages printed to the screen

# Please consult `man console_codes` for more information
# under the "ECMA-48 Set Graphics Rendition" section
#
# Warning: when switching from a 8bit to a 9bit font,
# the linux console will reinterpret the bold (1;) to
# the top 256 glyphs of the 9bit font. This does
# not affect framebuffer consoles

# These values, if specified here, override the defaults
#BRACKET="\033[1;34m" # Blue
#FAILURE="\033[1;31m" # Red
#INFO="\033[1;36m" # Cyan
#NORMAL="\033[0;39m" # Grey
#SUCCESS="\033[1;32m" # Green
#WARNING="\033[1;33m" # Yellow

# Use a colored prefix
# These values, if specified here, override the defaults
#BMPREFIX=" "
#SUCCESS_PREFIX="${SUCCESS} * ${NORMAL} "
#FAILURE_PREFIX="${FAILURE}*****${NORMAL} "
#WARNING_PREFIX="${WARNING} *** ${NORMAL} "

# Manually set the right edge of message output (characters)
# Useful when resetting console font during boot to override
```

```

# automatic screen width detection
#COLUMNS=120

# Interactive startup
#IPROMPT="yes" # Whether to display the interactive boot prompt
#itime="3"      # The amount of time (in seconds) to display the prompt

# The total length of the distro welcome string, without escape codes
#wlen=$(echo "Welcome to ${DISTRO}" | wc -c )
#welcome_message="Welcome to ${INFO}${DISTRO}${NORMAL}"

# The total length of the interactive string, without escape codes
#ilen=$(echo "Press 'I' to enter interactive startup" | wc -c )
#i_message="Press '${FAILURE}I${NORMAL}' to enter interactive startup"

# Set scripts to skip the file system check on reboot
#FASTBOOT=yes

# Skip reading from the console
#HEADLESS=yes

# Write out fsck progress if yes
#VERBOSE_FSCK=no

# Speed up boot without waiting for settle in udev
#OMIT_UDEV_SETTLE=y

# Speed up boot without waiting for settle in udev_retry
#OMIT_UDEV_RETRY_SETTLE=yes

# Skip cleaning /tmp if yes
#SKIPTMPCLEAN=no

# For setclock
#UTC=1
#CLOCKPARAMS=

# For consolelog (Note that the default, 7=debug, is noisy)
#LOGLEVEL=7

# For network
#HOSTNAME=mylfs

# Delay between TERM and KILL signals at shutdown
#KILLDELAY=3

# Optional syslogd parameters
#SYSKLOGD_PARMS="-m 0"

# Console parameters
#UNICODE=1
#KEYMAP="de-latin1"
#KEYMAP_CORRECTIONS="euro2"
#FONT="lat0-16 -m 8859-15"
#LEGACY_CHARSET=

```

9.6.8.1. Customizing the Boot and Shutdown Scripts

The LFS boot scripts boot and shut down a system in a fairly efficient manner, but there are a few tweaks you can make in the `rc.site` file to improve speed even more, and to adjust messages according to your preferences. To do this, adjust the settings in the `/etc/sysconfig/rc.site` file above.

- During the boot script `udev`, there is a call to **udev settle** that requires some time to complete. This time may or may not be required depending on the devices in the system. If you only have simple partitions and a single ethernet card, the boot process will probably not need to wait for this command. To skip it, set the variable `OMIT_UDEV_SETTLE=y`.
- The boot script `udev_retry` also runs **udev settle** by default. This command is only needed if the `/var` directory is separately mounted, because the clock needs the `/var/lib/hwclock/adjtime` file. Other customizations may also need to wait for `udev` to complete, but in many installations it is not necessary. Skip the command by setting the variable `OMIT_UDEV_RETRY_SETTLE=y`.
- By default, the file system checks are silent. This can appear to be a delay during the bootup process. To turn on the **fsck** output, set the variable `VERBOSE_FSCK=y`.
- When rebooting, you may want to skip the filesystem check, **fsck**, completely. To do this, either create the file `/fastboot` or reboot the system with the command `/sbin/shutdown -f -r now`. On the other hand, you can force all file systems to be checked by creating `/forcefsck` or running **shutdown** with the `-F` parameter instead of `-f`.

Setting the variable `FASTBOOT=y` will disable **fsck** during the boot process until it is removed. This is not recommended on a permanent basis.

- Normally, all files in the `/tmp` directory are deleted at boot time. Depending on the number of files or directories present, this can cause a noticeable delay in the boot process. To skip removing these files set the variable `SKIPTMPCLEAN=y`.
- During shutdown, the **init** program sends a `TERM` signal to each program it has started (e.g. `agetty`), waits for a set time (default 3 seconds), then sends each process a `KILL` signal and waits again. This process is repeated in the **sendsignals** script for any processes that are not shut down by their own scripts. The delay for **init** can be set by passing a parameter. For example to remove the delay in **init**, pass the `-t0` parameter when shutting down or rebooting (e.g. `/sbin/shutdown -t0 -r now`). The delay for the **sendsignals** script can be skipped by setting the parameter `KILLDELAY=0`.

9.7. The Bash Shell Startup Files

The shell program `/bin/bash` (hereafter referred to as “the shell”) uses a collection of startup files to help create the environment to run in. Each file has a specific use and may affect login and interactive environments differently. The files in the `/etc` directory provide global settings. If equivalent files exist in the home directory, they may override the global settings.

An interactive login shell is started after a successful login, using `/bin/login`, by reading the `/etc/passwd` file. An interactive non-login shell is started at the command-line (e.g., `[prompt]$/bin/bash`). A non-interactive shell is usually present when a shell script is running. It is non-interactive because it is processing a script and not waiting for user input between commands.

For more information, see the *Bash Startup Files* and *Interactive Shells* sections in the *Bash Features* chapter of the Bash info pages (**info bash**).

The files `/etc/profile` and `~/.bash_profile` are read when the shell is invoked as an interactive login shell.

The base `/etc/profile` below sets some environment variables necessary for native language support. Setting them properly results in:

- The output of programs translated into the native language
- Correct classification of characters into letters, digits and other classes. This is necessary for **bash** to properly accept non-ASCII characters in command lines in non-English locales

- The correct alphabetical sorting order for the country
- Appropriate default paper size
- Correct formatting of monetary, time, and date values

Replace `<ll>` below with the two-letter code for the desired language (e.g., “en”) and `<cc>` with the two-letter code for the appropriate country (e.g., “GB”). `<charmap>` should be replaced with the canonical charmap for your chosen locale. Optional modifiers such as “@euro” may also be present.

The list of all locales supported by Glibc can be obtained by running the following command:

```
locale -a
```

Charmaps can have a number of aliases, e.g., “ISO-8859-1” is also referred to as “iso8859-1” and “iso88591”. Some applications cannot handle the various synonyms correctly (e.g., require that “UTF-8” is written as “UTF-8”, not “utf8”), so it is safest in most cases to choose the canonical name for a particular locale. To determine the canonical name, run the following command, where `<locale name>` is the output given by **locale -a** for your preferred locale (“en_GB.iso88591” in our example).

```
LC_ALL=<locale name> locale charmap
```

For the “en_GB.iso88591” locale, the above command will print:

```
ISO-8859-1
```

This results in a final locale setting of “en_GB.ISO-8859-1”. It is important that the locale found using the heuristic above is tested before it is 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 Section 8.5, “Glibc-2.37” 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.

Other packages may also function incorrectly (but will not necessarily display any error messages) if the locale name does not meet their expectations. In such 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/profile` file:

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

export LANG=<ll>_<CC>.<charmap><@modifiers>

# End /etc/profile
EOF
```

The “C” (default) and “en_US.utf8” (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-order bit set “on” as invalid characters. That's why, e.g., the `ls` command displays them as question marks in that locale. Also, an attempt to send mail with such characters from Mutt or Pine results in non-RFC-conforming messages being sent (the charset in the outgoing mail is indicated as “unknown 8-bit”). So you can only use the “C” locale if you are sure you will never need 8-bit characters.

UTF-8 based locales are not supported well by some programs. Work is in progress to document and, if possible, fix such problems. See <https://www.linuxfromscratch.org/blfs/view/11.3/introduction/locale-issues.html>.

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 8-bit 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
```

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
proc           /proc         proc      nosuid,noexec,nodev 0     0
sysfs          /sys          sysfs     nosuid,noexec,nodev 0     0
devpts         /dev/pts      devpts    gid=5,mode=620    0     0
tmpfs          /run          tmpfs     defaults         0     0
devtmpfs       /dev          devtmpfs  mode=0755,nosuid  0     0
tmpfs          /dev/shm      tmpfs     nosuid,nodev      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-6.1.11

The Linux package contains the Linux kernel.

Approximate build time: 1.5 - 130.0 SBU (typically about 12 SBU)

Required disk space: 1200 - 8800 MB (typically about 1700 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 <https://www.linuxfromscratch.org/hints/downloads/files/kernel-configuration.txt>. BLFS has some information regarding particular kernel configuration requirements of packages outside of LFS at <https://www.linuxfromscratch.org/blfs/view/11.3/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:

```
Processor type and features --->
  [*] Build a relocatable kernel [CONFIG_RELOCATABLE]
  [*] Randomize the address of the kernel image (KASLR) [CONFIG_RANDOMIZE_BASE]
General setup --->
  [ ] Compile the kernel with warnings as errors [CONFIG_WERROR]
  < > Enable kernel headers through /sys/kernel/kheaders.tar.xz [CONFIG_IKHEADERS]
General architecture-dependent options --->
  [*] Stack Protector buffer overflow detection [CONFIG_STACKPROTECTOR]
  [*] Strong Stack Protector [CONFIG_STACKPROTECTOR_STRONG]
Device Drivers --->
  Graphics support --->
    Frame buffer Devices --->
      <*> Support for frame buffer devices --->
    Console display driver support --->
      [*] Framebuffer Console support [CONFIG_FRAMEBUFFER_CONSOLE]
  Generic Driver Options --->
    [ ] Support for uevent helper [CONFIG_UEVENT_HELPER]
    [*] Maintain a devtmpfs filesystem to mount at /dev [CONFIG_DEVTMPFS]
    [*] Automount devtmpfs at /dev, after the kernel mounted the rootfs [CONFIG_DEVTMPFS_MOUNT]
```

Enable some additional features if you are building a 64-bit system. If you are using menuconfig, enable them in the order of `CONFIG_PCI_MSI` first, then `CONFIG_IRQ_REMAP`, at last `CONFIG_X86_X2APIC` because an option only shows up after its dependencies are selected.

```
Processor type and features --->
  [*] Support x2apic [CONFIG_X86_X2APIC]
Device Drivers --->
  [*] PCI Support ---> [CONFIG_PCI]
    [*] Message Signaled Interrupts (MSI and MSI-X) [CONFIG_PCI_MSI]
  [*] IOMMU Hardware Support ---> [CONFIG_IOMMU_SUPPORT]
  [*] Support for Interrupt Remapping [CONFIG_IRQ_REMAP]
```

There are several other options that may be desired depending on the requirements for the system. For a list of options needed for BLFS packages, see the *BLFS Index of Kernel Settings* (<https://www.linuxfromscratch.org/blfs/view/11.3/longindex.html#kernel-config-index>).



Note

If your host hardware is using UEFI and you wish to boot the LFS system with it, you should adjust some kernel configuration following *the BLFS page*.

The rationale for the above configuration items:

Randomize the address of the kernel image (KASLR)

Enable ASLR for kernel image, to mitigate some attacks based on fixed addresses of sensitive data or code in the kernel.

Compile the kernel with warnings as errors

This may cause building failure if the compiler and/or configuration are different from those of the kernel developers.

Enable kernel headers through /sys/kernel/kheaders.tar.xz

This will require **cpio** building the kernel. **cpio** is not installed by LFS.

Strong Stack Protector

Enable SSP for the kernel. We've enabled it for the entire userspace with `--enable-default-ssp` configuring GCC, but the kernel does not use GCC default setting for SSP. We enable it explicitly here.

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.

Automount devtmpfs at /dev

This will mount the kernel view of the devices on /dev upon switching to root filesystem just before starting init.

Framebuffer Console support

This is needed to display the Linux console on a frame buffer device. To allow the kernel to print debug messages at an early boot stage, it shouldn't be built as a kernel module unless an initramfs will be used. And, if `CONFIG_DRM` (Direct Rendering Manager) is enabled, it's likely `CONFIG_DRM_FBDEV_EMULATION` (Enable legacy fbdev support for your modesetting driver) should be enabled as well.

Support x2apic

Support running the interrupt controller of 64-bit x86 processors in x2APIC mode. x2APIC may be enabled by firmware on 64-bit x86 systems, and a kernel without this option enabled will panic on boot if x2APIC is enabled by firmware. This option has no effect, but also does no harm if x2APIC is disabled by the firmware.

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-6.1.11` 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-6.1.11/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 you've decided to use a separate `/boot` partition for the LFS system (maybe sharing a `/boot` partition with the host distro), the files copied below should go there. The easiest way to do that is to create the entry for `/boot` in `/etc/fstab` first (read the previous section for details), then issue the following command as the `root` user in the *chroot environment*:

```
mount /boot
```

The path to the device node is omitted in the command because **mount** can read it from `/etc/fstab`.

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-6.1.11-lfs-11.3
```

`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-6.1.11
```

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-6.1.11
```

Install the documentation for the Linux kernel:

```
install -d /usr/share/doc/linux-6.1.11
cp -r Documentation/* /usr/share/doc/linux-6.1.11
```

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-6.1.11` 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-6.1.11 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-6.1.11`, `vmlinuz-6.1.11-lfs-11.3`, and `System.map-6.1.11`
Installed directories: `/lib/modules`, `/usr/share/doc/linux-6.1.11`

Short Descriptions

<code>config-6.1.11</code>	Contains all the configuration selections for the kernel
<code>vmlinuz-6.1.11-lfs-11.3</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-6.1.11</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



Note

If your system has UEFI support and you wish to boot LFS with UEFI, you should skip this page, and configure GRUB with UEFI support using the instructions provided in *the BLFS page*.

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
```

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 numbers start from zero, but the partition numbers start from one for normal partitions (from 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`.

Leaving `/boot` on 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 8. 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 6.1.11-lfs-11.3" {
    linux    /boot/vmlinuz-6.1.11-lfs-11.3 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.



Note

The GRUB designator for a partition may change if you added or removed some disks (including removable disks like USB thumb devices). The change may cause boot failure because `grub.cfg` refers to some “old” designators. If you wish to avoid such a problem, you may use the UUID of a partition and the UUID of a filesystem instead of a GRUB designator to specify a device. Run **`lsblk -o UUID,PARTUUID,PATH,MOUNTPOINT`** to show the UUIDs of your filesystems (in the `UUID` column) and partitions (in the `PARTUUID` column). Then replace `set root=(hdx,y)` with `search --set=root --fs-uuid <UUID of the filesystem where the kernel is installed>`, and replace `root=/dev/sda2` with `root=PARTUUID=<UUID of the partition where LFS is built>`.

Note that the UUID of a partition is completely different from the UUID of the filesystem in this partition. Some online resources may instruct you to use `root=UUID=<filesystem UUID>` instead of `root=PARTUUID=<partition UUID>`, but doing so will require an `initramfs`, which is beyond the scope of LFS.

The name of the device node for a partition in `/dev` may also change (this is less likely than a GRUB designator change). You can also replace paths to device nodes like `/dev/sda1` with `PARTUUID=<partition UUID>`, in `/etc/fstab`, to avoid a potential boot failure in case the device node name has changed.

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 11.3 > /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="11.3"
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="11.3"
ID=lfs
PRETTY_NAME="Linux From Scratch 11.3"
VERSION_CODENAME="<your name here>"
EOF
```

Be sure to customize 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 <https://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, there are still a few things to check. Here are some suggestions:

- Install any *firmware* needed if the kernel driver for your hardware requires some firmware files to function properly.

- 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
 - /etc/sysconfig/ifconfig.eth0

Now that we have said that, let's move on to booting our shiny new LFS installation for the first time! *First exit from the chroot environment:*

```
logout
```

Then unmount the virtual file systems:

```
umount -v $LFS/dev/pts
mountpoint -q $LFS/dev/shm && umount $LFS/dev/shm
umount -v $LFS/dev
umount -v $LFS/run
umount -v $LFS/proc
umount -v $LFS/sys
```

If multiple partitions were created, unmount the other partitions before unmounting the main one, like this:

```
umount -v $LFS/home
umount -v $LFS
```

Unmount the LFS file system itself:

```
umount -v $LFS
```

Now, reboot the system.

Assuming the GRUB boot loader was set up as outlined earlier, the menu is set to boot *LFS 11.3* 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. Additional Resources

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:

- *LFS Security Advisories*

This is a list of security vulnerabilities discovered in the LFS book after it's published.

- *Open Source Security Mailing List*

This is a mailing list for discussion of security flaws, concepts, and practices in the Open Source community.

- LFS Hints

The LFS Hints are a collection of educational documents submitted by volunteers in the LFS community. The hints are available at <https://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 <https://tldp.org/>.

11.5. Getting Started After LFS

11.5.1. Deciding what to do next

Now that LFS is complete and you have a bootable system, what do you do? The next step is to decide how to use it. Generally, there are two broad categories to consider: workstation or server. Indeed, these categories are not mutually exclusive. The applications needed for each category can be combined onto a single system, but let's look at them separately for now.

A server is the simpler category. Generally this consists of a web server such as the *Apache HTTP Server* and a database server such as *MariaDB*. However other services are possible. The operating system embedded in a single use device falls into this category.

On the other hand, a workstation is much more complex. It generally requires a graphical user environment such as *LXDE*, *XFCE*, *KDE*, or *Gnome* based on a basic *graphical environment* and several graphical based applications such as the *Firefox web browser*, *Thunderbird email client*, or *LibreOffice office suite*. These applications require many (several hundred depending on desired capabilities) more packages of support applications and libraries.

In addition to the above, there is a set of applications for system management for all kinds of systems. These applications are all in the BLFS book. Not all packages are needed in every environments. For example *dhcpcd*, is not normally appropriate for a server and *wireless_tools*, are normally only useful for a laptop system.

11.5.2. Working in a basic LFS environment

When you initially boot into LFS, you have all the internal tools to build additional packages. Unfortunately, the user environment is quite sparse. There are a couple of ways to improve this:

11.5.2.1. Work from the LFS host in chroot

This method provides a complete graphical environment where a full featured browser and copy/paste capabilities are available. This method allows using applications like the host's version of `wget` to download package sources to a location available when working in the chroot environment.

In order to properly build packages in chroot, you will also need to remember to mount the virtual file systems if they are not already mounted. One way to do this is to create a script on the **HOST** system:

```
cat > ~/mount-virt.sh << "EOF"
#!/bin/bash

function mountbind
{
    if ! mountpoint $LFS/$1 >/dev/null; then
        $SUDO mount --bind /$1 $LFS/$1
        echo $LFS/$1 mounted
    else
        echo $LFS/$1 already mounted
    fi
}

function mounttype
{
    if ! mountpoint $LFS/$1 >/dev/null; then
        $SUDO mount -t $2 $3 $4 $5 $LFS/$1
        echo $LFS/$1 mounted
    else
        echo $LFS/$1 already mounted
    fi
}

if [ $EUID -ne 0 ]; then
    SUDO=sudo
else
    SUDO=""
fi

if [ x$LFS == x ]; then
    echo "LFS not set"
    exit 1
fi

mountbind dev
mounttype dev/pts devpts devpts -o gid=5,mode=620
mounttype proc    proc    proc
mounttype sys     sysfs   sysfs
mounttype run     tmpfs   run
if [ -h $LFS/dev/shm ]; then
    mkdir -pv $LFS/$(readlink $LFS/dev/shm)
else
    mounttype dev/shm tmpfs tmpfs -o nosuid,nodev
fi

#mountbind usr/src
#mountbind boot
#mountbind home
EOF
```

Note that the last three commands in the script are commented out. These are useful if those directories are mounted as separate partitions on the host system and will be mounted when booting the completed LFS/BLFS system.

The script can be run with **bash ~/mount-virt.sh** as either a regular user (recommended) or as `root`. If run as a regular user, `sudo` is required on the host system.

Another issue pointed out by the script is where to store downloaded package files. This location is arbitrary. It can be in a regular user's home directory such as `~/sources` or in a global location like `/usr/src`. Our recommendation is not to mix BLFS sources and LFS sources in (from the chroot environment) `/sources`. In any case, the packages must be accessible inside the chroot environment.

A last convenience feature presented here is to streamline the process of entering the chroot environment. This can be done with an alias placed in a user's `~/.bashrc` file on the host system:

```
alias lfs='sudo /usr/sbin/chroot /mnt/lfs /usr/bin/env -i HOME=/root TERM="$TERM" PS1="\u:\w\\\$ "
PATH=/bin:/usr/bin:/sbin:/usr/sbin /bin/bash --login'
```

This alias is a little tricky because of the quoting and levels of backslash characters. It must be all on a single line. The above command has been split in two for presentation purposes.

11.5.2.2. Work remotely via ssh

This method also provides a full graphical environment, but first requires installing *sshd* and *wget* on the LFS system, usually in chroot. It also requires a second computer. This method has the advantage of being simple by not requiring the complexity of the chroot environment. It also uses your LFS built kernel for all additional packages and still provides a complete system for installing packages.

11.5.2.3. Work from the LFS command line

This method requires installing *libtasn1*, *p11-kit*, *make-ca*, *wget*, *gpm*, and *links* (or *lynx*) in chroot and then rebooting into the new LFS system. At this point the default system has six virtual consoles. Switching consoles is as easy as using the **Alt+F_x** key combinations where **F_x** is between **F1** and **F6**. The **Alt+←** and **Alt+→** combinations also will change the console.

At this point you can log into two different virtual consoles and run the *links* or *lynx* browser in one console and *bash* in the other. GPM then allows copying commands from the browser with the left mouse button, switching consoles, and pasting into the other console.



Note

As a side note, switching of virtual consoles can also be done from an X Window instance with the **Ctrl+Alt+F_x** key combination, but the mouse copy operation does not work between the graphical interface and a virtual console. You can return to the X Window display with the **Ctrl+Alt+F_x** combination, where **F_x** is usually **F1** but may be **F7**.

Part V. Appendices

Appendix A. Acronyms and Terms

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

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

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

Appendix B. Acknowledgments

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Appendix C. Dependencies

Every package built in LFS relies on one or more other packages in order to build and install properly. Some packages even participate in circular dependencies, that is, the first package depends on the second which in turn depends on the first. Because of these dependencies, the order in which packages are built in LFS is very important. The purpose of this page is to document the dependencies of each package built in LFS.

For each package that is built, there are three, and sometimes up to five types of dependencies listed below. The first lists what other packages need to be available in order to compile and install the package in question. The second lists the packages that must be available when any programs or libraries from the package are used at runtime. The third lists what packages, in addition to those on the first list, need to be available in order to run the test suites. The fourth 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
Required at runtime: Attr and Glibc
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, Glibc, Grep, M4, Make, Perl, Sed, and Texinfo
Required at runtime: Glibc
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
Required at runtime: Bash, Coreutils, Grep, M4, Make, 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
Required at runtime:	Bash, Coreutils, Grep, M4, 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
Required at runtime:	Glibc, Ncurses, and Readline
Test suite depends on:	Expect and Shadow
Must be installed before:	None
Optional dependencies:	<i>Xorg</i>

Bc

Installation depends on:	Bash, Binutils, Coreutils, GCC, Glibc, Grep, Make, and Readline
Required at runtime:	Glibc, Ncurses, and Readline
Test suite depends on:	Gawk
Must be installed before:	Linux
Optional dependencies:	None

Binutils

Installation depends on:	Bash, Binutils, Coreutils, Diffutils, File, Flex, Gawk, GCC, Glibc, Grep, Make, Perl, Sed, Texinfo, and Zlib
Required at runtime:	Glibc and Zlib
Test suite depends on:	DejaGNU and Expect
Must be installed before:	None
Optional dependencies:	<i>Elfutils</i> and <i>Jansson</i>

Bison

Installation depends on:	Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, M4, Make, Perl, and Sed
Required at runtime:	Glibc
Test suite depends on:	Diffutils, Findutils, and Flex
Must be installed before:	Kbd and Tar
Optional dependencies:	<i>Doxygen</i>

Bzip2

Installation depends on:	Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, Make, and Patch
Required at runtime:	Glibc
Test suite depends on:	None
Must be installed before:	File
Optional dependencies:	None

Check

Installation depends on:	Gawk, GCC, Grep, Make, Sed, and Texinfo
Required at runtime:	Bash and Gawk
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, OpenSSL, Patch, Perl, Sed, and Texinfo
Required at runtime:	Glibc
Test suite depends on:	Diffutils, E2fsprogs, Findutils, Shadow, and Util-linux
Must be installed before:	Bash, Diffutils, Eudev, Findutils, and Man-DB
Optional dependencies:	<i>Expect.pm</i> and <i>IO::Tty</i>

DejaGNU

Installation depends on:	Bash, Coreutils, Diffutils, Expect, GCC, Grep, Make, Sed, and Texinfo
Required at runtime:	Expect and Bash
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
Required at runtime:	Glibc
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
Required at runtime:	Glibc 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
Required at runtime:	Glibc, Kmod, Xz, Util-linux, and Zlib.
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
Required at runtime: Glibc
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
Required at runtime: Glibc 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
Required at runtime: Glibc, Bzip2, Xz, and Zlib
Test suite depends on: None
Must be installed before: None
Optional dependencies: libseccomp

Findutils

Installation depends on: Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Sed, and Texinfo
Required at runtime: Bash and Glibc
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
Required at runtime: Bash, Glibc, and M4
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
Required at runtime: Bash, Glibc, and Mpfr
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
Required at runtime:	Bash, Binutils, Glibc, Mpc, and Python
Test suite depends on:	DejaGNU, Expect, and Shadow
Must be installed before:	None
Optional dependencies:	<i>GNAT</i> and <i>ISL</i>

GDBM

Installation depends on:	Bash, Binutils, Coreutils, Diffutils, GCC, Grep, Make, and Sed
Required at runtime:	Bash, Glibc, and Readline
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
Required at runtime:	Acl, Bash, Gcc, and Glibc
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
Required at runtime:	None
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
Required at runtime:	GCC and Glibc
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
Required at runtime:	GCC and Glibc
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
Required at runtime:	Glibc
Test suite depends on:	Gawk
Must be installed before:	Man-DB
Optional dependencies:	<i>PCRE2</i> and <i>libsigsegv</i>

Groff

Installation depends on:	Bash, Binutils, Bison, Coreutils, Gawk, GCC, Glibc, Grep, Make, Patch, Sed, and Texinfo
Required at runtime:	GCC, Glibc, and Perl
Test suite depends on:	No test suite available
Must be installed before:	Man-DB and Perl
Optional dependencies:	<i>ghostscript</i> and <i>Uchardet</i>

GRUB

Installation depends on:	Bash, Binutils, Bison, Coreutils, Diffutils, GCC, Gettext, Glibc, Grep, Make, Ncurses, Sed, Texinfo, and Xz
Required at runtime:	Bash, GCC, Gettext, Glibc, Xz, and Sed.
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
Required at runtime:	Bash and Glibc
Test suite depends on:	Diffutils and Less
Must be installed before:	Man-DB
Optional dependencies:	None

lana-Etc

Installation depends on:	Coreutils
Required at runtime:	None
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
Required at runtime:	GCC, Glibc, Ncurses, and Readline
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
Required at runtime:	Autoconf, Automake, Bash, Glibc, Grep, Perl, and Sed
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, Linux API Headers, and Zlib
Required at runtime:	Bash, Coreutils, Glibc, Libcap, Libelf, and Zlib
Test suite depends on:	No test suite available
Must be installed before:	None
Optional dependencies:	<i>Berkeley DB</i> and <i>iptables</i>

Kbd

Installation depends on:	Bash, Binutils, Bison, Check, Coreutils, Flex, GCC, Gettext, Glibc, Gzip, Make, Patch, and Sed
Required at runtime:	Bash, Coreutils, and Glibc
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, OpenSSL, Pkg-config, Sed, Xz, and Zlib
Required at runtime:	Glibc, Xz, 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
Required at runtime:	Glibc and Ncurses
Test suite depends on:	No test suite available
Must be installed before:	Gzip
Optional dependencies:	<i>PCRE2</i> or <i>PCRE</i>

Libcap

Installation depends on:	Attr, Bash, Binutils, Coreutils, GCC, Glibc, Perl, Make, and Sed
Required at runtime:	Glibc
Test suite depends on:	None
Must be installed before:	IProute2 and Shadow
Optional dependencies:	<i>Linux-PAM</i>

Libelf

Installation depends on:	Bash, Binutils, Coreutils, GCC, Glibc, and Make
Required at runtime:	Glibc and Zlib
Test suite depends on:	None
Must be installed before:	IProute2 and Linux
Optional dependencies:	None

Libffi

Installation depends on:	Bash, Binutils, Coreutils, GCC, Glibc, Make, and Sed
Required at runtime:	Glibc
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
Required at runtime:	Glibc
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
Required at runtime:	Autoconf, Automake, Bash, Binutils, Coreutils, File, GCC, Glibc, Grep, Make, and Sed
Test suite depends on:	Autoconf, Automake, and Findutils
Must be installed before:	None
Optional dependencies:	None

Linux

Installation depends on:	Bash, Bc, Binutils, Coreutils, Diffutils, Findutils, GCC, Glibc, Grep, Gzip, Kmod, Libelf, Make, Ncurses, OpenSSL, Perl, and Sed
Required at runtime:	None
Test suite depends on:	No test suite available
Must be installed before:	None
Optional dependencies:	<i>cpio</i> and <i>LLVM</i> (with Clang)

Linux API Headers

Installation depends on:	Bash, Binutils, Coreutils, Findutils, GCC, Glibc, Grep, Gzip, Make, Perl, and Sed
Required at runtime:	None
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
Required at runtime:	Bash and Glibc
Test suite depends on:	Diffutils
Must be installed before:	Autoconf and Bison
Optional dependencies:	<i>libsigsegv</i>

Make

Installation depends on:	Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Sed, and Texinfo
Required at runtime:	Glibc
Test suite depends on:	Perl and Procps-ng
Must be installed before:	None
Optional dependencies:	<i>Guile</i>

Man-DB

Installation depends on:	Bash, Binutils, Bzip2, Coreutils, Flex, GCC, GDBM, Gettext, Glibc, Grep, Groff, Gzip, Less, Libpipeline, Make, Sed, and Xz
Required at runtime:	Bash, GDBM, Groff, Glibc, Gzip, Less, Libpipeline, and Zlib
Test suite depends on:	Util-linux
Must be installed before:	None
Optional dependencies:	<i>libseccomp</i> and <i>po4a</i>

Man-Pages

Installation depends on:	Bash, Coreutils, and Make
Required at runtime:	None
Test suite depends on:	No test suite available
Must be installed before:	None
Optional dependencies:	None

Meson

Installation depends on:	Ninja and Python
Required at runtime:	Python
Test suite depends on:	No test suite available
Must be installed before:	None
Optional dependencies:	None

MPC

Installation depends on:	Bash, Binutils, Coreutils, Diffutils, Gawk, GCC, Glibc, Grep, GMP, Make, MPFR, Sed, and Texinfo
Required at runtime:	Glibc, GMP, and MPFR
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
Required at runtime:	Glibc and GMP
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
Required at runtime:	Glibc
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
Required at runtime:	GCC and Glibc
Test suite depends on:	None
Must be installed before:	Meson
Optional dependencies:	<i>Asciidoc</i> , <i>Doxygen</i> , <i>Emacs</i> , and <i>re2c</i>

OpenSSL

Installation depends on:	Binutils, Coreutils, GCC, Make, and Perl
Required at runtime:	Glibc and Perl
Test suite depends on:	None
Must be installed before:	Coreutils, Kmod, and Linux
Optional dependencies:	None

Patch

Installation depends on:	Bash, Binutils, Coreutils, GCC, Glibc, Grep, Make, and Sed
Required at runtime:	Glibc
Test suite depends on:	Diffutils
Must be installed before:	None
Optional dependencies:	<i>Ed</i>

Perl

Installation depends on:	Bash, Binutils, Coreutils, Gawk, GCC, GDBM, Glibc, Grep, Groff, Make, Sed, and Zlib
Required at runtime:	GDBM and Glibc
Test suite depends on:	Iana-Etc, Less, and Procps-ng
Must be installed before:	Autoconf
Optional dependencies:	<i>Berkeley DB</i>

Pkg-config

Installation depends on: Bash, Binutils, Coreutils, Gawk, GCC, Glibc, Grep, Make, and Sed
Required at runtime: Glibc
Test suite depends on: None
Must be installed before: Kmod
Optional dependencies: *Glib2*

Procps-ng

Installation depends on: Bash, Binutils, Coreutils, GCC, Glibc, Make, and Ncurses
Required at runtime: Glibc
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
Required at runtime: Glibc and Ncurses
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, OpenSSL, Sed, and Util-linux
Required at runtime: Bzip2, Expat, Gdbm, Glibc, Libffi, Ncurses, OpenSSL, and Zlib
Test suite depends on: GDB and Valgrind
Must be installed before: Ninja
Optional dependencies: *Berkeley DB, libnsl, SQLite, and Tk*

Readline

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

Sed

Installation depends on: Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Sed, and Texinfo
Required at runtime: Acl, Attr, and Glibc
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
Required at runtime:	Glibc
Test suite depends on:	No test suite available
Must be installed before:	Coreutils
Optional dependencies:	<i>CrackLib</i> and <i>Linux-PAM</i>

Sysklogd

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

Sysvinit

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

Tar

Installation depends on:	Acl, Attr, Bash, Binutils, Bison, Coreutils, GCC, Gettext, Glibc, Grep, Inetutils, Make, Sed, and Texinfo
Required at runtime:	Acl, Attr, Bzip2, Glibc, Gzip, and Xz
Test suite depends on:	Autoconf, Diffutils, Findutils, Gawk, and Gzip
Must be installed before:	None
Optional dependencies:	None

Tcl

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

Texinfo

Installation depends on:	Bash, Binutils, Coreutils, GCC, Gettext, Glibc, Grep, Make, Ncurses, Patch, and Sed
Required at runtime:	Glibc and Ncurses
Test suite depends on:	None
Must be installed before:	None
Optional dependencies:	None

Util-linux

Installation depends on:	Bash, Binutils, Coreutils, Diffutils, Eudev, Findutils, Gawk, GCC, Gettext, Glibc, Grep, Make, Ncurses, Sed, and Zlib
Required at runtime:	Glibc, Ncurses, Readline, and Zlib
Test suite depends on:	None
Must be installed before:	None
Optional dependencies:	<i>Libcap-NG, Linux-PAM and smartmontools</i>

Vim

Installation depends on:	Acl, Attr, Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, Grep, Make, Ncurses, and Sed
Required at runtime:	Acl, Attr, Glibc, Python, Ncurses, and Tcl
Test suite depends on:	None
Must be installed before:	None
Optional dependencies:	<i>Xorg, GTK+2, LessTif, Ruby, and GPM</i>

wheel

Installation depends on:	Python
Required at runtime:	Python
Test suite depends on:	No test suite available
Must be installed before:	None
Optional dependencies:	None

XML::Parser

Installation depends on:	Bash, Binutils, Coreutils, Expat, GCC, Glibc, Make, and Perl
Required at runtime:	Expat, Glibc, and Perl
Test suite depends on:	Perl
Must be installed before:	Intltool
Optional dependencies:	None

Xz

Installation depends on:	Bash, Binutils, Coreutils, Diffutils, GCC, Glibc, and Make
Required at runtime:	Glibc
Test suite depends on:	None
Must be installed before:	Eudev, File, GRUB, Kmod, and Man-DB
Optional dependencies:	None

Zlib

Installation depends on:	Bash, Binutils, Coreutils, GCC, Glibc, Make, and Sed
Required at runtime:	Glibc
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
Required at runtime:	Glibc
Test suite depends on:	None
Must be installed before:	GCC
Optional dependencies:	<i>LZ4</i>

Appendix D. Boot and sysconfig scripts

version-20230101

The scripts in this appendix are listed by the directory where they normally reside. The order is `/etc/rc.d/init.d`, `/etc/sysconfig`, `/etc/sysconfig/network-devices`, and `/etc/sysconfig/network-devices/services`. Within each section, the files are listed in the order they are normally called.

D.1. `/etc/rc.d/init.d/rc`

The `rc` script is the first script called by `init` and initiates the boot process.

```
#!/bin/bash
#####
# Begin rc
#
# Description : Main Run Level Control Script
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               : DJ Lucas - dj@linuxfromscratch.org
# Updates      : Bruce Dubbs - bdubbs@linuxfromscratch.org
#               : Pierre Labastie - pierre@linuxfromscratch.org
#
# Version      : LFS 7.0
#
# Notes        : Updates March 24th, 2022: new semantics of S/K files
#               - Instead of testing that S scripts were K scripts in the
#                 previous runlevel, test that they were not S scripts
#               - Instead of testing that K scripts were S scripts in the
#                 previous runlevel, test that they were not K scripts
#               - S scripts in runlevel 0 or 6 are now run with
#                 "script start" (was "script stop" previously).
#####

. /lib/lsb/init-functions

print_error_msg()
{
    log_failure_msg
    # $i is set when called
    MSG="FAILURE:\n\nYou should not be reading this error message.\n\n"
    MSG="${MSG}It means that an unforeseen error took place in\n"
    MSG="${MSG}${i},\n"
    MSG="${MSG}which exited with a return value of ${error_value}.\n"

    MSG="${MSG}If you're able to track this error down to a bug in one of\n"
    MSG="${MSG}the files provided by the ${DISTRO_MINI} book,\n"
    MSG="${MSG}please be so kind to inform us at ${DISTRO_CONTACT}.\n"
    log_failure_msg "${MSG}"

    log_info_msg "Press Enter to continue..."
    wait_for_user
}

check_script_status()
{
    # $i is set when called
    if [ ! -f ${i} ]; then
        log_warning_msg "${i} is not a valid symlink."
        SCRIPT_STAT="1"
    fi
}
```

```

fi

if [ ! -x ${i} ]; then
    log_warning_msg "${i} is not executable, skipping."
    SCRIPT_STAT="1"
fi
}

run()
{
    if [ -z $interactive ]; then
        ${1} ${2}
        return $?
    fi

    while true; do
        read -p "Run ${1} ${2} (Yes/no/continue)? " -n 1 runit
        echo

        case ${runit} in
            c | C)
                interactive=""
                ${i} ${2}
                ret=${?}
                break;
                ;;

            n | N)
                return 0
                ;;

            y | Y)
                ${i} ${2}
                ret=${?}
                break
                ;;

            esac
        done

        return $ret
    }

# Read any local settings/overrides
[ -r /etc/sysconfig/rc.site ] && source /etc/sysconfig/rc.site

DISTRO=${DISTRO:-"Linux From Scratch"}
DISTRO_CONTACT=${DISTRO_CONTACT:-"lfs-dev@lists.linuxfromscratch.org (Registration required)"}
DISTRO_MINI=${DISTRO_MINI:-"LFS"}
IPROMPT=${IPROMPT:-"no"}

# These 3 signals will not cause our script to exit
trap "" INT QUIT TSTP

[ "${1}" != "" ] && runlevel=${1}

if [ "${runlevel}" == "" ]; then
    echo "Usage: ${0} <runlevel>" >&2
    exit 1
fi

previous=${PREVLEVEL}
[ "${previous}" == "" ] && previous=N

```

```

if [ ! -d /etc/rc.d/rc${runlevel}.d ]; then
    log_info_msg "/etc/rc.d/rc${runlevel}.d does not exist.\n"
    exit 1
fi

if [ "$runlevel" == "6" -o "$runlevel" == "0" ]; then IPROMPT="no"; fi

# Note: In ${LOGLEVEL:-7}, it is ':' 'dash' '7', not minus 7
if [ "$runlevel" == "S" ]; then
    [ -r /etc/sysconfig/console ] && source /etc/sysconfig/console
    dmesg -n "${LOGLEVEL:-7}"
fi

if [ "${IPROMPT}" == "yes" -a "${runlevel}" == "S" ]; then
    # The total length of the distro welcome string, without escape codes
    wlen=${wlen:-$(echo "Welcome to ${DISTRO}" | wc -c )}
    welcome_message=${welcome_message:-"Welcome to ${INFO}${DISTRO}${NORMAL}"}

    # The total length of the interactive string, without escape codes
    ilen=${ilen:-$(echo "Press 'I' to enter interactive startup" | wc -c )}
    i_message=${i_message:-"Press '${FAILURE}I${NORMAL}' to enter interactive startup"}

    # dcol and icol are spaces before the message to center the message
    # on screen. itime is the amount of wait time for the user to press a key
    wcol=$(( ( ${COLUMNS} - ${wlen} ) / 2 ))
    icol=$(( ( ${COLUMNS} - ${ilen} ) / 2 ))
    itime=${itime:-"3"}

    echo -e "\n\n"
    echo -e "\\033[${wcol}G${welcome_message}"
    echo -e "\\033[${icol}G${i_message}${NORMAL}"
    echo ""
    read -t "${itime}" -n 1 interactive 2>&1 > /dev/null
fi

# Make lower case
[ "${interactive}" == "I" ] && interactive="i"
[ "${interactive}" != "i" ] && interactive=""

# Read the state file if it exists from runlevel S
[ -r /run/interactive ] && source /run/interactive

# Stop all services marked as K, except if marked as K in the previous
# runlevel: it is the responsibility of the script to not try to kill
# a non running service
if [ "${previous}" != "N" ]; then
    for i in $(ls -v /etc/rc.d/rc${runlevel}.d/K* 2> /dev/null)
    do
        check_script_status
        if [ "${SCRIPT_STAT}" == "1" ]; then
            SCRIPT_STAT="0"
            continue
        fi

        suffix=${i#/etc/rc.d/rc${runlevel}.d/K[0-9][0-9]}
        [ -e /etc/rc.d/rc${previous}.d/K[0-9][0-9]$suffix ] && continue

        run ${i} stop
        error_value=${?}

        if [ "${error_value}" != "0" ]; then print_error_msg; fi
    done
done

```

```

fi

if [ "${previous}" == "N" ]; then export IN_BOOT=1; fi

if [ "$runlevel" == "6" -a -n "${FASTBOOT}" ]; then
    touch /fastboot
fi

# Start all services marked as S in this runlevel, except if marked as
# S in the previous runlevel
# it is the responsibility of the script to not try to start an already running
# service
for i in $( ls -v /etc/rc.d/rc${runlevel}.d/S* 2> /dev/null )
do

    if [ "${previous}" != "N" ]; then
        suffix=${i#/etc/rc.d/rc${runlevel}.d/S[0-9][0-9]}
        [ -e /etc/rc.d/rc${previous}.d/S[0-9][0-9]$suffix ] && continue
    fi

    check_script_status
    if [ "${SCRIPT_STAT}" == "1" ]; then
        SCRIPT_STAT="0"
        continue
    fi

    run ${i} start

    error_value=${?}

    if [ "${error_value}" != "0" ]; then print_error_msg; fi
done

# Store interactive variable on switch from runlevel S and remove if not
if [ "${runlevel}" == "S" -a "${interactive}" == "i" ]; then
    echo "interactive=\"i\"" > /run/interactive
else
    rm -f /run/interactive 2> /dev/null
fi

# Copy the boot log on initial boot only
if [ "${previous}" == "N" -a "${runlevel}" != "S" ]; then
    cat $BOOTLOG >> /var/log/boot.log

    # Mark the end of boot
    echo "-----" >> /var/log/boot.log

    # Remove the temporary file
    rm -f $BOOTLOG 2> /dev/null
fi

# End rc

```

D.2. /lib/lsb/init-functions

```

#!/bin/sh
#####
#
# Begin /lib/lsb/init-funtions
#
# Description : Run Level Control Functions

```

```

#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#              : DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
# Notes        : With code based on Matthias Benkmann's simpleinit-msb
#               http://winterdrache.de/linux/newboot/index.html
#
#               The file should be located in /lib/lsb
#
#####

## Environmental setup
# Setup default values for environment
umask 022
export PATH="/bin:/usr/bin:/sbin:/usr/sbin"

## Set color commands, used via echo
# Please consult `man console_codes` for more information
# under the "ECMA-48 Set Graphics Rendition" section
#
# Warning: when switching from a 8bit to a 9bit font,
# the linux console will reinterpret the bold (1;) to
# the top 256 glyphs of the 9bit font. This does
# not affect framebuffer consoles

NORMAL="\033[0;39m"      # Standard console grey
SUCCESS="\033[1;32m"      # Success is green
WARNING="\033[1;33m"      # Warnings are yellow
FAILURE="\033[1;31m"      # Failures are red
INFO="\033[1;36m"         # Information is light cyan
BRACKET="\033[1;34m"      # Brackets are blue

# Use a colored prefix
BMPREFIX=""
SUCCESS_PREFIX="${SUCCESS} * ${NORMAL} "
FAILURE_PREFIX="${FAILURE} *****${NORMAL} "
WARNING_PREFIX="${WARNING} *** ${NORMAL} "
SKIP_PREFIX="${INFO} S ${NORMAL} "

SUCCESS_SUFFIX="${BRACKET}[${SUCCESS} OK ${BRACKET}]${NORMAL}"
FAILURE_SUFFIX="${BRACKET}[${FAILURE} FAIL ${BRACKET}]${NORMAL}"
WARNING_SUFFIX="${BRACKET}[${WARNING} WARN ${BRACKET}]${NORMAL}"
SKIP_SUFFIX="${BRACKET}[${INFO} SKIP ${BRACKET}]${NORMAL}"

BOOTLOG=/run/bootlog
KILLDELAY=3
SCRIPT_STAT="0"

# Set any user specified environment variables e.g. HEADLESS
[ -r /etc/sysconfig/rc.site ] && . /etc/sysconfig/rc.site

## Screen Dimensions
# Find current screen size
if [ -z "${COLUMNS}" ]; then
    COLUMNS=$(stty size)
    COLUMNS=${COLUMNS##* }
fi

# When using remote connections, such as a serial port, stty size returns 0
if [ "${COLUMNS}" = "0" ]; then

```

```

    COLUMNS=80
fi

## Measurements for positioning result messages
COL=$(( ${COLUMNS} - 8 ))
WCOL=$(( ${COL} - 2 ))

## Set Cursor Position Commands, used via echo
SET_COL="\033[${COL}G"      # at the $COL char
SET_WCOL="\033[${WCOL}G"    # at the $WCOL char
CURS_UP="\033[1A\033[0G"   # Up one line, at the 0'th char
CURS_ZERO="\033[0G"

#####
# start_daemon()                                     #
# Usage: start_daemon [-f] [-n nicelevel] [-p pidfile] pathname [args...] #
#                                                                 #
# Purpose: This runs the specified program as a daemon          #
#                                                                 #
# Inputs: -f: (force) run the program even if it is already running. #
#          -n nicelevel: specify a nice level. See 'man nice(1)'.   #
#          -p pidfile: use the specified file to determine PIDs.   #
#          pathname: the complete path to the specified program    #
#          args: additional arguments passed to the program (pathname) #
#                                                                 #
# Return values (as defined by LSB exit codes):                 #
#    0 - program is running or service is OK                    #
#    1 - generic or unspecified error                            #
#    2 - invalid or excessive argument(s)                       #
#    5 - program is not installed                               #
#####
start_daemon()
{
    local force=""
    local nice="0"
    local pidfile=""
    local pidlist=""
    local retval=""

    # Process arguments
    while true
    do
        case "${1}" in

            -f)
                force="1"
                shift 1
                ;;

            -n)
                nice="${2}"
                shift 2
                ;;

            -p)
                pidfile="${2}"
                shift 2
                ;;

            -*)
                return 2
                ;;
        esac
    done
}

```

```

        *)
            program="${1}"
            break
            ;;
    esac
done

# Check for a valid program
if [ ! -e "${program}" ]; then return 5; fi

# Execute
if [ -z "${force}" ]; then
    if [ -z "${pidfile}" ]; then
        # Determine the pid by discovery
        pidlist=`pidofproc "${1}"`
        retval="${?}"
    else
        # The PID file contains the needed PIDs
        # Note that by LSB requirement, the path must be given to pidofproc,
        # however, it is not used by the current implementation or standard.
        pidlist=`pidofproc -p "${pidfile}" "${1}"`
        retval="${?}"
    fi

    # Return a value ONLY
    # It is the init script's (or distribution's functions) responsibility
    # to log messages!
    case "${retval}" in

        0)
            # Program is already running correctly, this is a
            # successful start.
            return 0
            ;;

        1)
            # Program is not running, but an invalid pid file exists
            # remove the pid file and continue
            rm -f "${pidfile}"
            ;;

        3)
            # Program is not running and no pidfile exists
            # do nothing here, let start_daemon continue.
            ;;

        *)
            # Others as returned by status values shall not be interpreted
            # and returned as an unspecified error.
            return 1
            ;;
    esac
fi

# Do the start!
nice -n "${nice}" "${@}"
}

#####
# killproc()
# Usage: killproc [-p pidfile] pathname [signal]
#
# Purpose: Send control signals to running processes
#

```



```

#                                                                 #
# Inputs: -p pidfile, uses the specified pidfile                 #
#          pathname, pathname to the specified program           #
#          signal, send this signal to pathname                  #
#                                                                 #
# Return values (as defined by LSB exit codes):                  #
#     0 - program (pathname) has stopped/is already stopped or a #
#         running program has been sent specified signal and stopped #
#         successfully                                           #
#     1 - generic or unspecified error                           #
#     2 - invalid or excessive argument(s)                      #
#     5 - program is not installed                              #
#     7 - program is not running and a signal was supplied      #
#####
killproc()
{
    local pidfile
    local program
    local prefix
    local progname
    local signal="-TERM"
    local fallback="-KILL"
    local nosig
    local pidlist
    local retval
    local pid
    local delay="30"
    local piddead
    local dtime

    # Process arguments
    while true; do
        case "${1}" in
            -p)
                pidfile="${2}"
                shift 2
                ;;

            *)
                program="${1}"
                if [ -n "${2}" ]; then
                    signal="${2}"
                    fallback=""
                else
                    nosig=1
                fi

                # Error on additional arguments
                if [ -n "${3}" ]; then
                    return 2
                else
                    break
                fi
                ;;
        esac
    done

    # Check for a valid program
    if [ ! -e "${program}" ]; then return 5; fi

    # Check for a valid signal
    check_signal "${signal}"
    if [ "${?}" -ne 0 ]; then return 2; fi

```

```

# Get a list of pids
if [ -z "${pidfile}" ]; then
    # determine the pid by discovery
    pidlist=`pidofproc "${1}"`
    retval="${?}"
else
    # The PID file contains the needed PIDs
    # Note that by LSB requirement, the path must be given to pidofproc,
    # however, it is not used by the current implementation or standard.
    pidlist=`pidofproc -p "${pidfile}" "${1}"`
    retval="${?}"
fi

# Return a value ONLY
# It is the init script's (or distribution's functions) responsibility
# to log messages!
case "${retval}" in

    0)
        # Program is running correctly
        # Do nothing here, let killproc continue.
        ;;

    1)
        # Program is not running, but an invalid pid file exists
        # Remove the pid file.

        progname=${program##*/}

        if [[ -e "/run/${progname}.pid" ]]; then
            pidfile="/run/${progname}.pid"
            rm -f "${pidfile}"
        fi

        # This is only a success if no signal was passed.
        if [ -n "${nosig}" ]; then
            return 0
        else
            return 7
        fi
        ;;

    3)
        # Program is not running and no pidfile exists
        # This is only a success if no signal was passed.
        if [ -n "${nosig}" ]; then
            return 0
        else
            return 7
        fi
        ;;

    *)
        # Others as returned by status values shall not be interpreted
        # and returned as an unspecified error.
        return 1
        ;;

esac

# Perform different actions for exit signals and control signals
check_sig_type "${signal}"

```

```

if [ "${?}" -eq "0" ]; then # Signal is used to terminate the program

    # Account for empty pidlist (pid file still exists and no
    # signal was given)
    if [ "${pidlist}" != "" ]; then

        # Kill the list of pids
        for pid in ${pidlist}; do

            kill -0 "${pid}" 2> /dev/null

            if [ "${?}" -ne "0" ]; then
                # Process is dead, continue to next and assume all is well
                continue
            else
                kill "${signal}" "${pid}" 2> /dev/null

                # Wait up to ${delay}/10 seconds to for "${pid}" to
                # terminate in 10ths of a second

                while [ "${delay}" -ne "0" ]; do
                    kill -0 "${pid}" 2> /dev/null || piddead="1"
                    if [ "${piddead}" = "1" ]; then break; fi
                    sleep 0.1
                    delay=$(( ${delay} - 1 ))
                done

                # If a fallback is set, and program is still running, then
                # use the fallback
                if [ -n "${fallback}" -a "${piddead}" != "1" ]; then
                    kill "${fallback}" "${pid}" 2> /dev/null
                    sleep 1
                    # Check again, and fail if still running
                    kill -0 "${pid}" 2> /dev/null && return 1
                fi
            fi
        done
    fi
fi

# Check for and remove stale PID files.
if [ -z "${pidfile}" ]; then
    # Find the basename of $program
    prefix=`echo "${program}" | sed 's/[^/]*$//`
    proname=`echo "${program}" | sed "s@${prefix}@@"`

    if [ -e "/run/${proname}.pid" ]; then
        rm -f "/run/${proname}.pid" 2> /dev/null
    fi
else
    if [ -e "${pidfile}" ]; then rm -f "${pidfile}" 2> /dev/null; fi
fi

# For signals that do not expect a program to exit, simply
# let kill do its job, and evaluate kill's return for value

else # check_sig_type - signal is not used to terminate program
    for pid in ${pidlist}; do
        kill "${signal}" "${pid}"
        if [ "${?}" -ne "0" ]; then return 1; fi
    done
fi
}

```

```
#####
# pidofproc()
# Usage: pidofproc [-p pidfile] pathname
#
# Purpose: This function returns one or more pid(s) for a particular daemon
#
# Inputs: -p pidfile, use the specified pidfile instead of pidof
#         pathname, path to the specified program
#
# Return values (as defined by LSB status codes):
#         0 - Success (PIDs to stdout)
#         1 - Program is dead, PID file still exists (remaining PIDs output)
#         3 - Program is not running (no output)
#####
pidofproc()
{
    local pidfile
    local program
    local prefix
    local progname
    local pidlist
    local lpids
    local exitstatus="0"

    # Process arguments
    while true; do
        case "${1}" in

            -p)
                pidfile="${2}"
                shift 2
                ;;

            *)
                program="${1}"
                if [ -n "${2}" ]; then
                    # Too many arguments
                    # Since this is status, return unknown
                    return 4
                else
                    break
                fi
                ;;
        esac
    done

    # If a PID file is not specified, try and find one.
    if [ -z "${pidfile}" ]; then
        # Get the program's basename
        prefix=`echo "${program}" | sed 's/[^/]*$//`

        if [ -z "${prefix}" ]; then
            progname="${program}"
        else
            progname=`echo "${program}" | sed "s@${prefix}@@"`
        fi

        # If a PID file exists with that name, assume that is it.
        if [ -e "/run/${progname}.pid" ]; then
            pidfile="/run/${progname}.pid"
        fi
    fi
}
```

```

# If a PID file is set and exists, use it.
if [ -n "${pidfile}" -a -e "${pidfile}" ]; then

    # Use the value in the first line of the pidfile
    pidlist=`/bin/head -n1 "${pidfile}"`
    # This can optionally be written as 'sed 1q' to replace 'head -n1'
    # should LFS move /bin/head to /usr/bin/head
else
    # Use pidof
    pidlist=`pidof "${program}"`
fi

# Figure out if all listed PIDs are running.
for pid in ${pidlist}; do
    kill -0 ${pid} 2> /dev/null

    if [ "${?}" -eq "0" ]; then
        lpids="${lpids}${pid} "
    else
        exitstatus="1"
    fi
done

if [ -z "${lpids}" -a ! -f "${pidfile}" ]; then
    return 3
else
    echo "${lpids}"
    return "${exitstatus}"
fi
}

#####
# statusproc()
# Usage: statusproc [-p pidfile] pathname
#
# Purpose: This function prints the status of a particular daemon to stdout
#
# Inputs: -p pidfile, use the specified pidfile instead of pidof
#         pathname, path to the specified program
#
# Return values:
#     0 - Status printed
#     1 - Input error. The daemon to check was not specified.
#####
statusproc()
{
    local pidfile
    local pidlist

    if [ "${#}" = "0" ]; then
        echo "Usage: statusproc [-p pidfile] {program}"
        exit 1
    fi

    # Process arguments
    while true; do
        case "${1}" in
            -p)
                pidfile="${2}"
                shift 2
                ;;

```

```

*)
    if [ -n "${2}" ]; then
        echo "Too many arguments"
        return 1
    else
        break
    fi
    ;;
esac
done

if [ -n "${pidfile}" ]; then
    pidlist=`pidofproc -p "${pidfile}" $@`
else
    pidlist=`pidofproc $@`
fi

# Trim trailing blanks
pidlist=`echo "${pidlist}" | sed -r 's/ +$//`

base="${1##*/}"

if [ -n "${pidlist}" ]; then
    /bin/echo -e "${INFO}${base} is running with Process" \
        "ID(s) ${pidlist}.${NORMAL}"
else
    if [ -n "${base}" -a -e "/run/${base}.pid" ]; then
        /bin/echo -e "${WARNING}${1} is not running but" \
            "/run/${base}.pid exists.${NORMAL}"
    else
        if [ -n "${pidfile}" -a -e "${pidfile}" ]; then
            /bin/echo -e "${WARNING}${1} is not running" \
                "but ${pidfile} exists.${NORMAL}"
        else
            /bin/echo -e "${INFO}${1} is not running.${NORMAL}"
        fi
    fi
fi
}

#####
# timespec()
#
# Purpose: An internal utility function to format a timestamp
#          a boot log file.  Sets the STAMP variable.
#
# Return value: Not used
#####
timespec()
{
    STAMP="$(echo `date +"%b %d %T %:z" ` `hostname`)"
    return 0
}

#####
# log_success_msg()
# Usage: log_success_msg ["message"]
#
# Purpose: Print a successful status message to the screen and
#          a boot log file.
#
# Inputs: $@ - Message
#

```

```

# Return values: Not used #
#####
log_success_msg()
{
    /bin/echo -n -e "${BMPREFIX}${@}"
    /bin/echo -e "${CURS_ZERO}${SUCCESS_PREFIX}${SET_COL}${SUCCESS_SUFFIX}"

    # Strip non-printable characters from log file
    logmessage=`echo "${@}" | sed 's/\\033[^a-zA-Z]*.//g'`

    timespec
    /bin/echo -e "${STAMP} ${logmessage} OK" >> ${BOOTLOG}

    return 0
}

log_success_msg2()
{
    /bin/echo -n -e "${BMPREFIX}${@}"
    /bin/echo -e "${CURS_ZERO}${SUCCESS_PREFIX}${SET_COL}${SUCCESS_SUFFIX}"

    echo " OK" >> ${BOOTLOG}

    return 0
}

#####
# log_failure_msg() #
# Usage: log_failure_msg ["message"] #
# # #
# Purpose: Print a failure status message to the screen and #
#          a boot log file. #
# # #
# Inputs: $@ - Message #
# # #
# Return values: Not used #
#####
log_failure_msg()
{
    /bin/echo -n -e "${BMPREFIX}${@}"
    /bin/echo -e "${CURS_ZERO}${FAILURE_PREFIX}${SET_COL}${FAILURE_SUFFIX}"

    # Strip non-printable characters from log file

    timespec
    logmessage=`echo "${@}" | sed 's/\\033[^a-zA-Z]*.//g'`
    /bin/echo -e "${STAMP} ${logmessage} FAIL" >> ${BOOTLOG}

    return 0
}

log_failure_msg2()
{
    /bin/echo -n -e "${BMPREFIX}${@}"
    /bin/echo -e "${CURS_ZERO}${FAILURE_PREFIX}${SET_COL}${FAILURE_SUFFIX}"

    echo "FAIL" >> ${BOOTLOG}

    return 0
}

#####
# log_warning_msg() #

```

```

# Usage: log_warning_msg ["message"]
#
# Purpose: Print a warning status message to the screen and
#          a boot log file.
#
# Return values: Not used
#####
log_warning_msg()
{
    /bin/echo -n -e "${BMPREFIX}${@}"
    /bin/echo -e "${CURS_ZERO}${WARNING_PREFIX}${SET_COL}${WARNING_SUFFIX}"

    # Strip non-printable characters from log file
    logmessage=`echo "${@}" | sed 's/\\033[^a-zA-Z]*.//g'`
    timespec
    /bin/echo -e "${STAMP} ${logmessage} WARN" >> ${BOOTLOG}

    return 0
}

log_skip_msg()
{
    /bin/echo -n -e "${BMPREFIX}${@}"
    /bin/echo -e "${CURS_ZERO}${SKIP_PREFIX}${SET_COL}${SKIP_SUFFIX}"

    # Strip non-printable characters from log file
    logmessage=`echo "${@}" | sed 's/\\033[^a-zA-Z]*.//g'`
    /bin/echo "SKIP" >> ${BOOTLOG}

    return 0
}

#####
# log_info_msg()
# Usage: log_info_msg message
#
# Purpose: Print an information message to the screen and
#          a boot log file. Does not print a trailing newline character.
#
# Return values: Not used
#####
log_info_msg()
{
    /bin/echo -n -e "${BMPREFIX}${@}"

    # Strip non-printable characters from log file
    logmessage=`echo "${@}" | sed 's/\\033[^a-zA-Z]*.//g'`
    timespec
    /bin/echo -n -e "${STAMP} ${logmessage}" >> ${BOOTLOG}

    return 0
}

log_info_msg2()
{
    /bin/echo -n -e "${@}"

    # Strip non-printable characters from log file
    logmessage=`echo "${@}" | sed 's/\\033[^a-zA-Z]*.//g'`
    /bin/echo -n -e "${logmessage}" >> ${BOOTLOG}

    return 0
}

```



```
#####
# evaluate_retval() #
# Usage: Evaluate a return value and print success or failure as appropriate #
# #
# Purpose: Convenience function to terminate an info message #
# #
# Return values: Not used #
#####
evaluate_retval()
{
    local error_value="${?}"

    if [ ${error_value} = 0 ]; then
        log_success_msg2
    else
        log_failure_msg2
    fi
}

#####
# check_signal() #
# Usage: check_signal [ -{signal} ] #
# #
# Purpose: Check for a valid signal. This is not defined by any LSB draft, #
#         however, it is required to check the signals to determine if the #
#         signals chosen are invalid arguments to the other functions. #
# #
# Inputs: Accepts a single string value in the form of -{signal} #
# #
# Return values: #
#     0 - Success (signal is valid #
#     1 - Signal is not valid #
#####
check_signal()
{
    local valsig

    # Add error handling for invalid signals
    valsig="-ALRM -HUP -INT -KILL -PIPE -POLL -PROF -TERM -USR1 -USR2"
    valsig="${valsig} -VTALRM -STKFLT -PWR -WINCH -CHLD -URG -TSTP -TTIN"
    valsig="${valsig} -TTOU -STOP -CONT -ABRT -FPE -ILL -QUIT -SEGV -TRAP"
    valsig="${valsig} -SYS -EMT -BUS -XCPU -XFSZ -0 -1 -2 -3 -4 -5 -6 -8 -9"
    valsig="${valsig} -11 -13 -14 -15 "

    echo "${valsig}" | grep -- " ${1} " > /dev/null

    if [ "${?}" -eq 0 ]; then
        return 0
    else
        return 1
    fi
}

#####
# check_sig_type() #
# Usage: check_signal [ -{signal} | {signal} ] #
# #
# Purpose: Check if signal is a program termination signal or a control signal #
#         This is not defined by any LSB draft, however, it is required to #
#         check the signals to determine if they are intended to end a #
#         program or simply to control it. #
# #
```

```

# Inputs: Accepts a single string value in the form or -{signal} or {signal} #
#                                                                 #
# Return values:                                                                 #
#     0 - Signal is used for program termination                                                                 #
#     1 - Signal is used for program control                                                                 #
#####
check_sig_type()
{
    local valsig

    # The list of termination signals (limited to generally used items)
    valsig="-ALRM -INT -KILL -TERM -PWR -STOP -ABRT -QUIT -2 -3 -6 -9 -14 -15 "

    echo "${valsig}" | grep -- " ${1} " > /dev/null

    if [ "${?}" -eq "0" ]; then
        return 0
    else
        return 1
    fi
}

#####
# wait_for_user()                                                                 #
#                                                                 #
# Purpose: Wait for the user to respond if not a headless system                                                                 #
#                                                                 #
#####
wait_for_user()
{
    # Wait for the user by default
    [ "${HEADLESS=0}" = "0" ] && read ENTER
    return 0
}

#####
# is_true()                                                                 #
#                                                                 #
# Purpose: Utility to test if a variable is true | yes | 1                                                                 #
#                                                                 #
#####
is_true()
{
    [ "${1}" = "1" ] || [ "${1}" = "yes" ] || [ "${1}" = "true" ] || [ "${1}" = "y" ] ||
    [ "${1}" = "t" ]
}

# End /lib/lsb/init-functions

```

D.3. /etc/rc.d/init.d/mountvirtfs

```

#!/bin/sh
#####
# Begin mountvirtfs
#
# Description : Ensure proc, sysfs, run, and dev are mounted
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0

```

```

#
#####

### BEGIN INIT INFO
# Provides:          mountvirtfs
# Required-Start:    $first
# Should-Start:
# Required-Stop:
# Should-Stop:
# Default-Start:     S
# Default-Stop:
# Short-Description: Mounts various special fs needed at start
# Description:       Mounts /sys and /proc virtual (kernel) filesystems.
#                   Mounts /run (tmpfs) and /dev (devtmpfs).
#                   This is done only if they are not already mounted.
#                   with the kernel config proposed in the book, dev
#                   should be automatically mounted by the kernel.
# X-LFS-Provided-By: LFS
### END INIT INFO

. /lib/lsb/init-functions

case "${1}" in
    start)
        # Make sure /run is available before logging any messages
        if ! mountpoint /run >/dev/null; then
            mount /run || failed=1
        fi

        mkdir -p /run/lock
        chmod 1777 /run/lock

        log_info_msg "Mounting virtual file systems: ${INFO}/run"

        if ! mountpoint /proc >/dev/null; then
            log_info_msg2 " ${INFO}/proc"
            mount -o nosuid,noexec,nodev /proc || failed=1
        fi

        if ! mountpoint /sys >/dev/null; then
            log_info_msg2 " ${INFO}/sys"
            mount -o nosuid,noexec,nodev /sys || failed=1
        fi

        if ! mountpoint /dev >/dev/null; then
            log_info_msg2 " ${INFO}/dev"
            mount -o mode=0755,nosuid /dev || failed=1
        fi

        mkdir -p /dev/shm
        log_info_msg2 " ${INFO}/dev/shm"
        mount -o nosuid,nodev /dev/shm || failed=1

        (exit ${failed})
        evaluate_retval
        exit $failed
        ;;

    *)
        echo "Usage: ${0} {start}"
        exit 1
        ;;
esac

```

```
# End mountvirtfs
```

D.4. /etc/rc.d/init.d/modules

```
#!/bin/sh
#####
# Begin modules
#
# Description : Module auto-loading script
#
# Authors      : Zack Winkles
#                DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

### BEGIN INIT INFO
# Provides:      modules
# Required-Start: mountvirtfs
# Should-Start:
# Required-Stop:
# Should-Stop:
# Default-Start: S
# Default-Stop:
# Short-Description: Loads required modules.
# Description:    Loads modules listed in /etc/sysconfig/modules.
# X-LFS-Provided-By: LFS
### END INIT INFO

# Assure that the kernel has module support.
[ -e /proc/modules ] || exit 0

. /lib/lsb/init-functions

case "${1}" in
    start)
        # Exit if there's no modules file or there are no
        # valid entries
        [ -r /etc/sysconfig/modules ] || exit 0
        grep -E -qv '^(#|)' /etc/sysconfig/modules || exit 0

        log_info_msg "Loading modules:"

        # Only try to load modules if the user has actually given us
        # some modules to load.

        while read module args; do

            # Ignore comments and blank lines.
            case "$module" in
                ""|"#*") continue ;;
            esac

            # Attempt to load the module, passing any arguments provided.
            modprobe ${module} ${args} >/dev/null

            # Print the module name if successful, otherwise take note.
            if [ $? -eq 0 ]; then
                log_info_msg2 " ${module}"
            fi
        done
    ;;
esac
```

```

        else
            failedmod="${failedmod} ${module}"
        fi
    done < /etc/sysconfig/modules

    # Print a message about successfully loaded modules on the correct line.
    log_success_msg2

    # Print a failure message with a list of any modules that
    # may have failed to load.
    if [ -n "${failedmod}" ]; then
        log_failure_msg "Failed to load modules:${failedmod}"
        exit 1
    fi
    ;;

*)
    echo "Usage: ${0} {start}"
    exit 1
    ;;

esac

exit 0

# End modules

```

D.5. /etc/rc.d/init.d/udev

```

#!/bin/sh
#####
# Begin udev
#
# Description : Udev cold-plugging script
#
# Authors      : Zack Winkles, Alexander E. Patrakov
#                DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

### BEGIN INIT INFO
# Provides:          udev $time
# Required-Start:    localnet
# Should-Start:      modules
# Required-Stop:
# Should-Stop:
# Default-Start:     S
# Default-Stop:
# Short-Description: Populates /dev with device nodes.
# Description:        Mounts a tempfs on /dev and starts the udevd daemon.
#                      Device nodes are created as defined by udev.
# X-LFS-Provided-By: LFS
### END INIT INFO

. /lib/lsb/init-functions

case "${1}" in
    start)
        log_info_msg "Populating /dev with device nodes... "
        if ! grep -q '[:space:]sysfs' /proc/mounts; then

```

```

log_failure_msg2
msg="FAILURE:\n\nUnable to create "
msg="${msg}devices without a SysFS filesystem\n\n"
msg="${msg}After you press Enter, this system "
msg="${msg}will be halted and powered off.\n\n"
log_info_msg "$msg"
log_info_msg "Press Enter to continue..."
wait_for_user
/etc/rc.d/init.d/halt stop
fi

# Start the udev daemon to continually watch for, and act on,
# uevents
/sbin/udev --daemon

# Now traverse /sys in order to "coldplug" devices that have
# already been discovered
/sbin/udevadm trigger --action=add --type=subsystems
/sbin/udevadm trigger --action=add --type=devices
/sbin/udevadm trigger --action=change --type=devices

# Now wait for udevd to process the uevents we triggered
if ! is_true "$OMIT_UDEV_SETTLE"; then
    /sbin/udevadm settle
fi

# If any LVM based partitions are on the system, ensure they
# are activated so they can be used.
if [ -x /sbin/vgchange ]; then /sbin/vgchange -a y >/dev/null; fi

log_success_msg2
;;

*)
    echo "Usage ${0} {start}"
    exit 1
;;

esac

exit 0

# End udev

```

D.6. /etc/rc.d/init.d/swap

```

#!/bin/sh
#####
# Begin swap
#
# Description : Swap Control Script
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

### BEGIN INIT INFO
# Provides:      swap
# Required-Start: udev

```

```

# Should-Start:      modules
# Required-Stop:     localnet
# Should-Stop:       $local_fs
# Default-Start:     S
# Default-Stop:      0 6
# Short-Description: Activates and deactivates swap partitions.
# Description:       Activates and deactivates swap partitions defined in
#                   /etc/fstab.
# X-LFS-Provided-By: LFS
### END INIT INFO

. /lib/lsb/init-functions

case "${1}" in
    start)
        log_info_msg "Activating all swap files/partitions..."
        swapon -a
        evaluate_retval
        ;;

    stop)
        log_info_msg "Deactivating all swap files/partitions..."
        swapoff -a
        evaluate_retval
        ;;

    restart)
        ${0} stop
        sleep 1
        ${0} start
        ;;

    status)
        log_success_msg "Retrieving swap status."
        swapon -s
        ;;

    *)
        echo "Usage: ${0} {start|stop|restart|status}"
        exit 1
        ;;
esac

exit 0

# End swap

```

D.7. /etc/rc.d/init.d/setclock

```

#!/bin/sh
#####
# Begin setclock
#
# Description : Setting Linux Clock
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#              : DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

```

```

### BEGIN INIT INFO
# Provides:
# Required-Start:
# Should-Start:      modules
# Required-Stop:
# Should-Stop:       $syslog
# Default-Start:     S
# Default-Stop:
# Short-Description: Stores and restores time from the hardware clock
# Description:        On boot, system time is obtained from hwclock.  The
#                     hardware clock can also be set on shutdown.
# X-LFS-Provided-By:  LFS
### END INIT INFO

. /lib/lsb/init-functions

[ -r /etc/sysconfig/clock ] && . /etc/sysconfig/clock

case "${UTC}" in
    yes|true|1)
        CLOCKPARAMS="${CLOCKPARAMS} --utc"
        ;;

    no|false|0)
        CLOCKPARAMS="${CLOCKPARAMS} --localtime"
        ;;

esac

case ${1} in
    start)
        hwclock --hctosys ${CLOCKPARAMS} >/dev/null
        ;;

    stop)
        log_info_msg "Setting hardware clock..."
        hwclock --systohc ${CLOCKPARAMS} >/dev/null
        evaluate_retval
        ;;

    *)
        echo "Usage: ${0} {start|stop}"
        exit 1
        ;;

esac

exit 0

```

D.8. /etc/rc.d/init.d/checkfs

```

#!/bin/sh
#####
# Begin checkfs
#
# Description : File System Check
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               A. Luebke - luebke@users.sourceforge.net
#               DJ Lucas - dj@linuxfromscratch.org

```



```

# Update      : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version     : LFS 7.0
#
# Based on checkfs script from LFS-3.1 and earlier.
#
# From man fsck
# 0      - No errors
# 1      - File system errors corrected
# 2      - System should be rebooted
# 4      - File system errors left uncorrected
# 8      - Operational error
# 16     - Usage or syntax error
# 32     - Fsck canceled by user request
# 128    - Shared library error
#
#####

### BEGIN INIT INFO
# Provides:      checkfs
# Required-Start: udev swap
# Should-Start:
# Required-Stop:
# Should-Stop:
# Default-Start: S
# Default-Stop:
# Short-Description: Checks local filesystems before mounting.
# Description:      Checks local filesystems before mounting.
# X-LFS-Provided-By: LFS
### END INIT INFO

. /lib/lsb/init-functions

case "${1}" in
    start)
        if [ -f /fastboot ]; then
            msg="/fastboot found, will omit "
            msg="${msg} file system checks as requested.\n"
            log_info_msg "${msg}"
            exit 0
        fi

        log_info_msg "Mounting root file system in read-only mode... "
        mount -n -o remount,ro / >/dev/null

        if [ ${?} != 0 ]; then
            log_failure_msg2
            msg="\n\nCannot check root "
            msg="${msg}filesystem because it could not be mounted "
            msg="${msg}in read-only mode.\n\n"
            msg="${msg}After you press Enter, this system will be "
            msg="${msg}halted and powered off.\n\n"
            log_failure_msg "${msg}"

            log_info_msg "Press Enter to continue..."
            wait_for_user
            /etc/rc.d/init.d/halt stop
        else
            log_success_msg2
        fi

        if [ -f /forcefsck ]; then
            msg="/forcefsck found, forcing file"

```

```

    msg="${msg} system checks as requested."
    log_success_msg "$msg"
    options="-f"
else
    options=""
fi

log_info_msg "Checking file systems..."
# Note: -a option used to be -p; but this fails e.g. on fsck.minix
if is_true "$VERBOSE_FSCK"; then
    fsck ${options} -a -A -C -T
else
    fsck ${options} -a -A -C -T >/dev/null
fi

error_value=${?}

if [ "${error_value}" = 0 ]; then
    log_success_msg2
fi

if [ "${error_value}" = 1 ]; then
    msg="\nWARNING:\n\nFile system errors "
    msg="${msg}were found and have been corrected.\n"
    msg="${msg}      You may want to double-check that "
    msg="${msg}everything was fixed properly."
    log_warning_msg "$msg"
fi

if [ "${error_value}" = 2 -o "${error_value}" = 3 ]; then
    msg="\nWARNING:\n\nFile system errors "
    msg="${msg}were found and have been been "
    msg="${msg}corrected, but the nature of the "
    msg="${msg}errors require this system to be rebooted.\n\n"
    msg="${msg}After you press enter, "
    msg="${msg}this system will be rebooted\n\n"
    log_failure_msg "$msg"

    log_info_msg "Press Enter to continue..."
    wait_for_user
    reboot -f
fi

if [ "${error_value}" -gt 3 -a "${error_value}" -lt 16 ]; then
    msg="\nFAILURE:\n\nFile system errors "
    msg="${msg}were encountered that could not be "
    msg="${msg}fixed automatically.\nThis system "
    msg="${msg}cannot continue to boot and will "
    msg="${msg}therefore be halted until those "
    msg="${msg}errors are fixed manually by a "
    msg="${msg}System Administrator.\n\n"
    msg="${msg}After you press Enter, this system will be "
    msg="${msg}halted and powered off.\n\n"
    log_failure_msg "$msg"

    log_info_msg "Press Enter to continue..."
    wait_for_user
    /etc/rc.d/init.d/halt stop
fi

if [ "${error_value}" -ge 16 ]; then
    msg="FAILURE:\n\nUnexpected failure "
    msg="${msg}running fsck.  Exited with error "

```

```

        msg="${msg} code: ${error_value}.\n"
        log_info_msg $msg
        exit ${error_value}
    fi

    exit 0
;;
*)
    echo "Usage: ${0} {start}"
    exit 1
;;
esac

# End checkfs

```

D.9. /etc/rc.d/init.d/mountfs

```

#!/bin/sh
#####
# Begin mountfs
#
# Description : File System Mount Script
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

### BEGIN INIT INFO
# Provides:          $local_fs
# Required-Start:    udev checkfs
# Should-Start:      modules
# Required-Stop:     localnet
# Should-Stop:
# Default-Start:     S
# Default-Stop:      0 6
# Short-Description: Mounts/unmounts local filesystems defined in /etc/fstab.
# Description:       Remounts root filesystem read/write and mounts all
#                   remaining local filesystems defined in /etc/fstab on
#                   start. Remounts root filesystem read-only and unmounts
#                   remaining filesystems on stop.
# X-LFS-Provided-By: LFS
### END INIT INFO

. /lib/lsb/init-functions

case "${1}" in
    start)
        log_info_msg "Remounting root file system in read-write mode..."
        mount --options remount,rw / >/dev/null
        evaluate_retval

        # Remove fsck-related file system watermarks.
        rm -f /fastboot /forcefsck

        # Make sure /dev/pts exists
        mkdir -p /dev/pts

        # This will mount all filesystems that do not have _netdev in

```

```

# their option list. _netdev denotes a network filesystem.

log_info_msg "Mounting remaining file systems..."
failed=0
mount --all --test-opts no_netdev >/dev/null || failed=1
evaluate_retval
exit $failed
;;

stop)
# Don't unmount virtual file systems like /run
log_info_msg "Unmounting all other currently mounted file systems..."
# Ensure any loop devices are removed
losetup -D
umount --all --detach-loop --read-only \
    --types notmpfs,nosysfs,nodevtmpfs,noproc,nodevpts >/dev/null
evaluate_retval

# Make sure / is mounted read only (umount bug)
mount --options remount,ro /

# Make all LVM volume groups unavailable, if appropriate
# This fails if swap or / are on an LVM partition
#if [ -x /sbin/vgchange ]; then /sbin/vgchange -an > /dev/null; fi
if [ -r /etc/mdadm.conf ]; then
    log_info_msg "Mark arrays as clean..."
    mdadm --wait-clean --scan
    evaluate_retval
fi
;;

*)
echo "Usage: ${0} {start|stop}"
exit 1
;;

esac

# End mountfs

```

D.10. /etc/rc.d/init.d/udev_retry

```

#!/bin/sh
#####
# Begin udev_retry
#
# Description : Udev cold-plugging script (retry)
#
# Authors      : Alexander E. Patrakov
#                DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#                Bryan Kadzban -
#
# Version      : LFS 7.0
#
#####

### BEGIN INIT INFO
# Provides:      udev_retry
# Required-Start: udev
# Should-Start:  $local_fs cleanfs
# Required-Stop:
# Should-Stop:

```

```

# Default-Start:      S
# Default-Stop:
# Short-Description:  Replays failed uevents and creates additional devices.
# Description:        Replays any failed uevents that were skipped due to
#                      slow hardware initialization, and creates those needed
#                      device nodes
# X-LFS-Provided-By:   LFS
### END INIT INFO

. /lib/lsb/init-functions

case "${1}" in
    start)
        log_info_msg "Retrying failed uevents, if any..."

        # As of udev-186, the --run option is no longer valid
        #rundir=$(/sbin/udevadm info --run)
        rundir=/run/udev
        # From Debian: "copy the rules generated before / was mounted
        # read-write":

        for file in ${rundir}/tmp-rules--*; do
            dest=${file##*tmp-rules--}
            [ "$dest" = '*' ] && break
            cat $file >> /etc/udev/rules.d/$dest
            rm -f $file
        done

        # Re-trigger the uevents that may have failed,
        # in hope they will succeed now
        /bin/sed -e 's/#.*$//' /etc/sysconfig/udev_retry | /bin/grep -v '^$' | \
        while read line ; do
            for subsystem in $line ; do
                /sbin/udevadm trigger --subsystem-match=$subsystem --action=add
            done
        done

        # Now wait for udevd to process the uevents we triggered
        if ! is_true "$OMIT_UDEV_RETRY_SETTLE"; then
            /sbin/udevadm settle
        fi

        evaluate_retval
        ;;

    *)
        echo "Usage ${0} {start}"
        exit 1
        ;;
esac

exit 0

# End udev_retry

```

D.11. /etc/rc.d/init.d/cleanfs

```

#!/bin/sh
#####
# Begin cleanfs
#
# Description : Clean file system

```

```

#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#              : DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

### BEGIN INIT INFO
# Provides:      cleanfs
# Required-Start: $local_fs
# Should-Start:
# Required-Stop:
# Should-Stop:
# Default-Start: S
# Default-Stop:
# Short-Description: Cleans temporary directories early in the boot process.
# Description:    Cleans temporary directories /run, /var/lock, and
#                optionally, /tmp. cleanfs also creates /run/utmp
#                and any files defined in /etc/sysconfig/createfiles.
#
# X-LFS-Provided-By: LFS
### END INIT INFO

. /lib/lsb/init-functions

# Function to create files/directory on boot.
create_files()
{
    # Input to file descriptor 9 and output to stdin (redirection)
    exec 9>&0 < /etc/sysconfig/createfiles

    while read name type perm usr grp dtype maj min junk
    do
        # Ignore comments and blank lines.
        case "${name}" in
            ""|\#*) continue ;;
        esac

        # Ignore existing files.
        if [ ! -e "${name}" ]; then
            # Create stuff based on its type.
            case "${type}" in
                dir)
                    mkdir "${name}"
                    ;;
                file)
                    :> "${name}"
                    ;;
                dev)
                    case "${dtype}" in
                        char)
                            mknod "${name}" c ${maj} ${min}
                            ;;
                        block)
                            mknod "${name}" b ${maj} ${min}
                            ;;
                        pipe)
                            mknod "${name}" p
                            ;;
                        *)
                            log_warning_msg "\nUnknown device type: ${dtype}"
                            ;;
                    esac
                esac
            done
        }

```

```

        esac
        ;;
    *)
        log_warning_msg "\nUnknown type: ${type}"
        continue
        ;;
    esac

    # Set up the permissions, too.
    chown ${usr}:${grp} "${name}"
    chmod ${perm} "${name}"
fi
done

# Close file descriptor 9 (end redirection)
exec 0>&9 9>&-
return 0
}

case "${1}" in
    start)
        log_info_msg "Cleaning file systems:"

        if [ "${SKIPTMPCLEAN}" = "" ]; then
            log_info_msg2 " /tmp"
            cd /tmp &&
            find . -xdev -mindepth 1 ! -name lost+found -delete || failed=1
        fi

        > /run/utmp

        if grep -q '^utmp:' /etc/group ; then
            chmod 664 /run/utmp
            chgrp utmp /run/utmp
        fi

        (exit ${failed})
        evaluate_retval

        if grep -E -qv '^(#|$)' /etc/sysconfig/createfiles 2>/dev/null; then
            log_info_msg "Creating files and directories... "
            create_files      # Always returns 0
            evaluate_retval
        fi

        exit ${failed}
        ;;
    *)
        echo "Usage: ${0} {start}"
        exit 1
        ;;
esac

# End cleanfs

```

D.12. /etc/rc.d/init.d/console

```

#!/bin/sh
#####
# Begin console
#
# Description : Sets keymap and screen font

```

```

#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               Alexander E. Patrakov
#               DJ Lucas - dj@linuxfromscratch.org
# Update      : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

### BEGIN INIT INFO
# Provides:          console
# Required-Start:    $local_fs
# Should-Start:      udev_retry
# Required-Stop:
# Should-Stop:
# Default-Start:     S
# Default-Stop:
# Short-Description: Sets up a localised console.
# Description:       Sets up fonts and language settings for the user's
#                   local as defined by /etc/sysconfig/console.
# X-LFS-Provided-By: LFS
### END INIT INFO

. /lib/lsb/init-functions

# Native English speakers probably don't have /etc/sysconfig/console at all
[ -r /etc/sysconfig/console ] && . /etc/sysconfig/console

failed=0

case "${1}" in
    start)
        # See if we need to do anything
        if [ -z "${KEYMAP}" ] && [ -z "${KEYMAP_CORRECTIONS}" ] &&
           [ -z "${FONT}" ] && [ -z "${LEGACY_CHARSET}" ] &&
           ! is_true "${UNICODE}"; then
            exit 0
        fi

        # There should be no bogus failures below this line!
        log_info_msg "Setting up Linux console..."

        # Figure out if a framebuffer console is used
        [ -d /sys/class/graphics/fb0 ] && use_fb=1 || use_fb=0

        # Figure out the command to set the console into the
        # desired mode
        is_true "${UNICODE}" &&
            MODE_COMMAND="echo -en '\033%G' && kbd_mode -u" ||
            MODE_COMMAND="echo -en '\033%@\033(K' && kbd_mode -a"

        # On framebuffer consoles, font has to be set for each vt in
        # UTF-8 mode. This doesn't hurt in non-UTF-8 mode also.

        ! is_true "${use_fb}" || [ -z "${FONT}" ] ||
            MODE_COMMAND="${MODE_COMMAND} && setfont ${FONT}"

        # Apply that command to all consoles mentioned in
        # /etc/inittab. Important: in the UTF-8 mode this should
        # happen before setfont, otherwise a kernel bug will
        # show up and the unicode map of the font will not be
        # used.

```



```

for TTY in `grep '^[^#].*respawn:/sbin/agetty' /etc/inittab |
grep -o '\btty[[:digit:]]*\b'`
do
    openvt -f -w -c "${TTY#tty}" -- \
        /bin/sh -c "${MODE_COMMAND}" || failed=1
done

# Set the font (if not already set above) and the keymap
[ "${use_fb}" == "1" ] || [ -z "${FONT}" ] || setfont $FONT || failed=1

[ -z "${KEYMAP}" ] ||
    loadkeys ${KEYMAP} >/dev/null 2>&1 ||
    failed=1

[ -z "${KEYMAP_CORRECTIONS}" ] ||
    loadkeys ${KEYMAP_CORRECTIONS} >/dev/null 2>&1 ||
    failed=1

# Convert the keymap from $LEGACY_CHARSET to UTF-8
[ -z "$LEGACY_CHARSET" ] ||
    dumpkeys -c "$LEGACY_CHARSET" | loadkeys -u >/dev/null 2>&1 ||
    failed=1

# If any of the commands above failed, the trap at the
# top would set $failed to 1
( exit $failed )
evaluate_retval

exit $failed
;;

*)
    echo "Usage:  ${0} {start}"
    exit 1
    ;;

esac

# End console

```

D.13. /etc/rc.d/init.d/localnet

```

#!/bin/sh
#####
# Begin localnet
#
# Description : Loopback device
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

### BEGIN INIT INFO
# Provides:          localnet
# Required-Start:    mountvirtfs
# Should-Start:      modules
# Required-Stop:
# Should-Stop:

```

```

# Default-Start:      S
# Default-Stop:       0 6
# Short-Description:  Starts the local network.
# Description:        Sets the hostname of the machine and starts the
#                     loopback interface.
# X-LFS-Provided-By:   LFS
### END INIT INFO

. /lib/lsb/init-functions
[ -r /etc/sysconfig/network ] && . /etc/sysconfig/network
[ -r /etc/hostname ] && HOSTNAME=`cat /etc/hostname`

case "${1}" in
    start)
        log_info_msg "Bringing up the loopback interface..."
        ip addr add 127.0.0.1/8 label lo dev lo
        ip link set lo up
        evaluate_retval

        log_info_msg "Setting hostname to ${HOSTNAME}..."
        hostname ${HOSTNAME}
        evaluate_retval
        ;;

    stop)
        log_info_msg "Bringing down the loopback interface..."
        ip link set lo down
        evaluate_retval
        ;;

    restart)
        ${0} stop
        sleep 1
        ${0} start
        ;;

    status)
        echo "Hostname is: $(hostname)"
        ip link show lo
        ;;

    *)
        echo "Usage: ${0} {start|stop|restart|status}"
        exit 1
        ;;
esac

exit 0

# End localnet

```

D.14. /etc/rc.d/init.d/sysctl

```

#!/bin/sh
#####
# Begin sysctl
#
# Description : File uses /etc/sysctl.conf to set kernel runtime
#              parameters
#
# Authors      : Nathan Coulson (nathan@linuxfromscratch.org)
#              Matthew Burgess (matthew@linuxfromscratch.org)

```

```

# DJ Lucas - dj@linuxfromscratch.org
# Update      : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version     : LFS 7.0
#
#####

### BEGIN INIT INFO
# Provides:          sysctl
# Required-Start:    mountvirtfs
# Should-Start:      console
# Required-Stop:
# Should-Stop:
# Default-Start:     S
# Default-Stop:
# Short-Description: Makes changes to the proc filesystem
# Description:        Makes changes to the proc filesystem as defined in
#                     /etc/sysctl.conf. See 'man sysctl(8)'.
# X-LFS-Provided-By:  LFS
### END INIT INFO

. /lib/lsb/init-functions

case "${1}" in
    start)
        if [ -f "/etc/sysctl.conf" ]; then
            log_info_msg "Setting kernel runtime parameters..."
            sysctl -q -p
            evaluate_retval
        fi
        ;;

    status)
        sysctl -a
        ;;

    *)
        echo "Usage: ${0} {start|status}"
        exit 1
        ;;
esac

exit 0

# End sysctl

```

D.15. /etc/rc.d/init.d/sysklogd

```

#!/bin/sh
#####
# Begin sysklogd
#
# Description : Sysklogd loader
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

```

```

### BEGIN INIT INFO
# Provides:          $syslog
# Required-Start:    $first localnet
# Should-Start:
# Required-Stop:     $local_fs
# Should-Stop:      sendsignals
# Default-Start:     2 3 4 5
# Default-Stop:      0 1 6
# Short-Description: Starts kernel and system log daemons.
# Description:       Starts kernel and system log daemons.
#                    /etc/fstab.
# X-LFS-Provided-By: LFS
### END INIT INFO

. /lib/lsb/init-functions

case "${1}" in
    start)
        log_info_msg "Starting system log daemon..."
        parms=${SYSKLOGD_PARAMS-'-m 0'}
        start_daemon /sbin/syslogd $parms
        evaluate_retval

        log_info_msg "Starting kernel log daemon..."
        start_daemon /sbin/klogd
        evaluate_retval
        ;;

    stop)
        log_info_msg "Stopping kernel log daemon..."
        killproc /sbin/klogd
        evaluate_retval

        log_info_msg "Stopping system log daemon..."
        killproc /sbin/syslogd
        evaluate_retval
        ;;

    reload)
        log_info_msg "Reloading system log daemon config file..."
        pid=`pidofproc syslogd`
        kill -HUP "${pid}"
        evaluate_retval
        ;;

    restart)
        ${0} stop
        sleep 1
        ${0} start
        ;;

    status)
        statusproc /sbin/syslogd
        statusproc klogd
        ;;

    *)
        echo "Usage: ${0} {start|stop|reload|restart|status}"
        exit 1
        ;;
esac

exit 0

```

```
# End syslogd
```

D.16. /etc/rc.d/init.d/network

```
#!/bin/sh
#####
# Begin network
#
# Description : Network Control Script
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               Nathan Coulson - nathan@linuxfromscratch.org
#               Kevin P. Fleming - kpffleming@linuxfromscratch.org
#               DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

### BEGIN INIT INFO
# Provides:          $network
# Required-Start:    $local_fs localnet swap
# Should-Start:     $syslog firewalld iptables nftables
# Required-Stop:    $local_fs localnet swap
# Should-Stop:     $syslog firewalld iptables nftables
# Default-Start:    2 3 4 5
# Default-Stop:     0 1 6
# Short-Description: Starts and configures network interfaces.
# Description:      Starts and configures network interfaces.
# X-LFS-Provided-By: LFS
### END INIT INFO

case "${1}" in
    start)
        # if the default route exists, network is already configured
        if ip route | grep -q "^default"; then return 0; fi
        # Start all network interfaces
        for file in /etc/sysconfig/ifconfig.*
        do
            interface=${file##*/ifconfig.}

            # Skip if $file is * (because nothing was found)
            if [ "${interface}" = "*" ]; then continue; fi

            /sbin/ifup ${interface}
        done
        ;;

    stop)
        # Unmount any network mounted file systems
        umount --all --force --types nfs,cifs,nfs4

        # Reverse list
        net_files=""
        for file in /etc/sysconfig/ifconfig.*
        do
            net_files="${file} ${net_files}"
        done

        # Stop all network interfaces
    esac
```

```

for file in ${net_files}
do
    interface=${file##*/ifconfig.}

    # Skip if $file is * (because nothing was found)
    if [ "${interface}" = "*" ]; then continue; fi

    # See if interface exists
    if [ ! -e /sys/class/net/${interface} ]; then continue; fi

    # Is interface UP?
    ip link show $interface 2>/dev/null | grep -q "state UP"
    if [ $? -ne 0 ]; then continue; fi

    /sbin/ifdown ${interface}
done
;;

restart)
    ${0} stop
    sleep 1
    ${0} start
    ;;

*)
    echo "Usage: ${0} {start|stop|restart}"
    exit 1
    ;;
esac

exit 0

# End network

```

D.17. /etc/rc.d/init.d/sendsignals

```

#!/bin/sh
#####
# Begin sendsignals
#
# Description : Sendsignals Script
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

### BEGIN INIT INFO
# Provides:          sendsignals
# Required-Start:
# Should-Start:
# Required-Stop:     $local_fs swap localnet
# Should-Stop:
# Default-Start:
# Default-Stop:      0 6
# Short-Description: Attempts to kill remaining processes.
# Description:       Attempts to kill remaining processes.
# X-LFS-Provided-By: LFS
### END INIT INFO

```

```

. /lib/lsb/init-functions

case "${1}" in
    stop)
        omit=$(pidof mdmon)
        [ -n "$omit" ] && omit="-o $omit"

        log_info_msg "Sending all processes the TERM signal..."
        killall5 -15 $omit
        error_value=${?}

        sleep ${KILLDELAY}

        if [ "${error_value}" = 0 -o "${error_value}" = 2 ]; then
            log_success_msg
        else
            log_failure_msg
        fi

        log_info_msg "Sending all processes the KILL signal..."
        killall5 -9 $omit
        error_value=${?}

        sleep ${KILLDELAY}

        if [ "${error_value}" = 0 -o "${error_value}" = 2 ]; then
            log_success_msg
        else
            log_failure_msg
        fi
        ;;

    *)
        echo "Usage: ${0} {stop}"
        exit 1
        ;;

esac

exit 0

# End sendsignals

```

D.18. /etc/rc.d/init.d/reboot

```

#!/bin/sh
#####
# Begin reboot
#
# Description : Reboot Scripts
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               DJ Lucas - dj@linuxfromscratch.org
# Updates      : Bruce Dubbs - bdubbs@linuxfromscratch.org
#               Pierre Labastie - pierre@linuxfromscratch.org
#
# Version      : LFS 7.0
#
# Notes        : Update March 24th, 2022: change "stop" to "start".
#               Add the $last facility to Required-start
#

```

```
#####

### BEGIN INIT INFO
# Provides:          reboot
# Required-Start:    $last
# Should-Start:
# Required-Stop:
# Should-Stop:
# Default-Start:     6
# Default-Stop:
# Short-Description: Reboots the system.
# Description:       Reboots the System.
# X-LFS-Provided-By: LFS
### END INIT INFO

. /lib/lsb/init-functions

case "${1}" in
    start)
        log_info_msg "Restarting system..."
        reboot -d -f -i
        ;;

    *)
        echo "Usage: ${0} {start}"
        exit 1
        ;;

esac

# End reboot
```

D.19. /etc/rc.d/init.d/halt

```
#!/bin/sh
#####
# Begin halt
#
# Description : Halt Script
#
# Authors      : Gerard Beekmans - gerard@linuxfromscratch.org
#               DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#               Pierre Labastie - pierre@linuxfromscratch.org
#
# Version      : LFS 7.0
#
# Notes        : Update March 24th, 2022: change "stop" to "start".
#               Add the $last facility to Required-start
#
#####

### BEGIN INIT INFO
# Provides:          halt
# Required-Start:    $last
# Should-Start:
# Required-Stop:
# Should-Stop:
# Default-Start:     0
# Default-Stop:
# Short-Description: Halts the system.
# Description:       Halts the System.
```



```
# X-LFS-Provided-By:    LFS
### END INIT INFO

case "${1}" in
    start)
        halt -d -f -i -p
        ;;

    *)
        echo "Usage: {start}"
        exit 1
        ;;
esac

# End halt
```

D.20. /etc/rc.d/init.d/template

```
#!/bin/sh
#####
# Begin scriptname
#
# Description :
#
# Authors      :
#
# Version      : LFS x.x
#
# Notes        :
#
#####

### BEGIN INIT INFO
# Provides:          template
# Required-Start:
# Should-Start:
# Required-Stop:
# Should-Stop:
# Default-Start:
# Default-Stop:
# Short-Description:
# Description:
# X-LFS-Provided-By:
### END INIT INFO

. /lib/lsb/init-functions

case "${1}" in
    start)
        log_info_msg "Starting..."
        # if it is possible to use start_daemon
        start_daemon fully_qualified_path
        # if it is not possible to use start_daemon
        # (command to start the daemon is not simple enough)
        if ! pidofproc daemon_name_as_reported_by_ps >/dev/null; then
            command_to_start_the_service
        fi
        evaluate_retval
        ;;

    stop)
        log_info_msg "Stopping..."
```

```

# if it is possible to use killproc
killproc fully_qualified_path
# if it is not possible to use killproc
# (the daemon shouldn't be stopped by killing it)
if pidofproc daemon_name_as_reported_by_ps >/dev/null; then
    command_to_stop_the_service
fi
evaluate_retval
;;

restart)
    ${0} stop
    sleep 1
    ${0} start
    ;;

*)
    echo "Usage: ${0} {start|stop|restart}"
    exit 1
    ;;
esac

exit 0

# End scriptname

```

D.21. /etc/sysconfig/modules

```

#####
# Begin /etc/sysconfig/modules
#
# Description : Module auto-loading configuration
#
# Authors      :
#
# Version      : 00.00
#
# Notes        : The syntax of this file is as follows:
#                  <module> [<arg1> <arg2> ...]
#
# Each module should be on its own line, and any options that you want
# passed to the module should follow it. The line delimitator is either
# a space or a tab.
#####

# End /etc/sysconfig/modules

```

D.22. /etc/sysconfig/createfiles

```

#####
# Begin /etc/sysconfig/createfiles
#
# Description : Createfiles script config file
#
# Authors      :
#
# Version      : 00.00
#
# Notes        : The syntax of this file is as follows:
#                  if type is equal to "file" or "dir"
#                  <filename> <type> <permissions> <user> <group>
#

```

```
#         if type is equal to "dev"
#         <filename> <type> <permissions> <user> <group> <devtype>
#         <major> <minor>
#
#         <filename> is the name of the file which is to be created
#         <type> is either file, dir, or dev.
#             file creates a new file
#             dir creates a new directory
#             dev creates a new device
#         <devtype> is either block, char or pipe
#             block creates a block device
#             char creates a character device
#             pipe creates a pipe, this will ignore the <major> and
#             <minor> fields
#         <major> and <minor> are the major and minor numbers used for
#         the device.
#####

# End /etc/sysconfig/createfiles
```

D.23. /etc/sysconfig/udev-retry

```
#####
# Begin /etc/sysconfig/udev_retry
#
# Description : udev_retry script configuration
#
# Authors      :
#
# Version      : 00.00
#
# Notes        : Each subsystem that may need to be re-triggered after mountfs
#                  runs should be listed in this file.  Probable subsystems to be
#                  listed here are rtc (due to /var/lib/hwclock/adjtime) and sound
#                  (due to both /var/lib/alsa/asound.state and /usr/sbin/alsactl).
#                  Entries are whitespace-separated.
#####

rtc

# End /etc/sysconfig/udev_retry
```

D.24. /sbin/ifup

```
#!/bin/sh
#####
# Begin /sbin/ifup
#
# Description : Interface Up
#
# Authors      : Nathan Coulson - nathan@linuxfromscratch.org
#                  Kevin P. Fleming - kp Fleming@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#                  DJ Lucas - dj@linuxfromscratch.org
#
# Version      : LFS 7.7
#
# Notes        : The IFCONFIG variable is passed to the SERVICE script
#                  in the /lib/services directory, to indicate what file the
#                  service should source to get interface specifications.
#
```

```
#####

up()
{
    log_info_msg "Bringing up the ${1} interface..."

    if ip link show $1 > /dev/null 2>&1; then
        link_status=`ip link show $1`

        if [ -n "${link_status}" ]; then
            if ! echo "${link_status}" | grep -q UP; then
                ip link set $1 up
            fi
        fi

    else
        log_failure_msg "Interface ${IFACE} doesn't exist."
        exit 1
    fi

    evaluate_retval
}

RELEASE="7.7"

USAGE="Usage: $0 [ -hv ] [--help] [--version] interface"
VERSTR="LFS ifup, version ${RELEASE}"

while [ $# -gt 0 ]; do
    case "$1" in
        --help | -h)      help="y"; break ;;

        --version | -V)   echo "${VERSTR}"; exit 0 ;;

        -*)               echo "ifup: ${1}: invalid option" >&2
                           echo "${USAGE}" >& 2
                           exit 2 ;;

        *)               break ;;
    esac
done

if [ -n "$help" ]; then
    echo "${VERSTR}"
    echo "${USAGE}"
    echo
    cat << HERE_EOF
ifup is used to bring up a network interface.  The interface
parameter, e.g. eth0 or eth0:2, must match the trailing part of the
interface specifications file, e.g. /etc/sysconfig/ifconfig.eth0:2.

HERE_EOF
    exit 0
fi

file=/etc/sysconfig/ifconfig.${1}

# Skip backup files
[ "${file}" = "${file%""~"}" ] || exit 0

. /lib/lsb/init-functions

if [ ! -r "${file}" ]; then
```

```

    log_failure_msg "Unable to bring up ${1} interface! ${file} is missing or cannot be accessed."
    exit 1
fi

. $file

if [ "$IFACE" = "" ]; then
    log_failure_msg "Unable to bring up ${1} interface! ${file} does not define an interface [IFACE]."
    exit 1
fi

# Do not process this service if started by boot, and ONBOOT
# is not set to yes
if [ "${IN_BOOT}" = "1" -a "${ONBOOT}" != "yes" ]; then
    exit 0
fi

# Bring up the interface
if [ "$VIRTINT" != "yes" ]; then
    up ${IFACE}
fi

for S in ${SERVICE}; do
    if [ ! -x "/lib/services/${S}" ]; then
        MSG="\nUnable to process ${file}. Either "
        MSG="${MSG}the SERVICE '${S}' was not present "
        MSG="${MSG}or cannot be executed."
        log_failure_msg "$MSG"
        exit 1
    fi
done

if [ "${SERVICE}" = "wpa" ]; then log_success_msg; fi

# Create/configure the interface
for S in ${SERVICE}; do
    IFCONFIG=${file} /lib/services/${S} ${IFACE} up
done

# Set link up virtual interfaces
if [ "${VIRTINT}" == "yes" ]; then
    up ${IFACE}
fi

# Bring up any additional interface components
for I in $INTERFACE_COMPONENTS; do up $I; done

# Set MTU if requested. Check if MTU has a "good" value.
if test -n "${MTU}"; then
    if [[ ${MTU} =~ ^[0-9]+$ ]] && [[ $MTU -ge 68 ]]; then
        for I in $IFACE $INTERFACE_COMPONENTS; do
            ip link set dev $I mtu $MTU;
        done
    else
        log_info_msg2 "Invalid MTU $MTU"
    fi
fi

# Set the route default gateway if requested
if [ -n "${GATEWAY}" ]; then
    if ip route | grep -q default; then
        log_warning_msg "Gateway already setup; skipping."
    else

```

```

        log_info_msg "Adding default gateway ${GATEWAY} to the ${IFACE} interface..."
        ip route add default via ${GATEWAY} dev ${IFACE}
        evaluate_retval
    fi
fi

# End /sbin/ifup

```

D.25. /sbin/ifdown

```

#!/bin/bash
#####
# Begin /sbin/ifdown
#
# Description : Interface Down
#
# Authors      : Nathan Coulson - nathan@linuxfromscratch.org
#                Kevin P. Fleming - kpffleming@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
# Notes        : the IFCONFIG variable is passed to the scripts found
#                in the /lib/services directory, to indicate what file the
#                service should source to get interface specifications.
#
#####

RELEASE="7.0"

USAGE="Usage: $0 [ -hv ] [--help] [--version] interface"
VERSTR="LFS ifdown, version ${RELEASE}"

while [ $# -gt 0 ]; do
    case "$1" in
        --help | -h)      help="y"; break ;;

        --version | -V)    echo "${VERSTR}"; exit 0 ;;

        -*)                echo "ifup: ${1}: invalid option" >&2
                            echo "${USAGE}" >& 2
                            exit 2 ;;

        *)                break ;;
    esac
done

if [ -n "$help" ]; then
    echo "${VERSTR}"
    echo "${USAGE}"
    echo
    cat << HERE_EOF
ifdown is used to bring down a network interface. The interface
parameter, e.g. eth0 or eth0:2, must match the trailing part of the
interface specifications file, e.g. /etc/sysconfig/ifconfig.eth0:2.

HERE_EOF
    exit 0
fi

file=/etc/sysconfig/ifconfig.${1}

```

```
# Skip backup files
[ "${file}" = "${file%}"~""] ] || exit 0

. /lib/lsb/init-functions

if [ ! -r "${file}" ]; then
    log_warning_msg "${file} is missing or cannot be accessed."
    exit 1
fi

. ${file}

if [ "$IFACE" = "" ]; then
    log_failure_msg "${file} does not define an interface [IFACE]."
    exit 1
fi

# We only need to first service to bring down the interface
S=`echo ${SERVICE} | cut -f1 -d" "`

if ip link show ${IFACE} > /dev/null 2>&1; then
    if [ -n "${S}" -a -x "/lib/services/${S}" ]; then
        IFCONFIG=${file} /lib/services/${S} ${IFACE} down
    else
        MSG="Unable to process ${file}. Either "
        MSG="${MSG}the SERVICE variable was not set "
        MSG="${MSG}or the specified service cannot be executed."
        log_failure_msg "$MSG"
        exit 1
    fi
else
    log_warning_msg "Interface ${1} doesn't exist."
fi

# Leave the interface up if there are additional interfaces in the device
link_status=`ip link show ${IFACE} 2>/dev/null`

if [ -n "${link_status}" ]; then
    if [ "$(echo "${link_status}" | grep UP)" != "" ]; then
        if [ "$(ip addr show ${IFACE} | grep 'inet ')" == "" ]; then
            log_info_msg "Bringing down the ${IFACE} interface..."
            ip link set ${IFACE} down
            evaluate_retval
        fi
    fi
fi

# End /sbin/ifdown
```

D.26. /lib/services/ipv4-static

```
#!/bin/sh
#####
# Begin /lib/services/ipv4-static
#
# Description : IPV4 Static Boot Script
#
# Authors      : Nathan Coulson - nathan@linuxfromscratch.org
#               Kevin P. Fleming - kpffleming@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
```

```

#
#####

. /lib/lsb/init-functions
. ${IFCONFIG}

if [ -z "${IP}" ]; then
    log_failure_msg "\nIP variable missing from ${IFCONFIG}, cannot continue."
    exit 1
fi

if [ -z "${PREFIX}" -a -z "${PEER}" ]; then
    log_warning_msg "\nPREFIX variable missing from ${IFCONFIG}, assuming 24."
    PREFIX=24
    args="${args} ${IP}/${PREFIX}"

elif [ -n "${PREFIX}" -a -n "${PEER}" ]; then
    log_failure_msg "\nPREFIX and PEER both specified in ${IFCONFIG}, cannot continue."
    exit 1

elif [ -n "${PREFIX}" ]; then
    args="${args} ${IP}/${PREFIX}"

elif [ -n "${PEER}" ]; then
    args="${args} ${IP} peer ${PEER}"
fi

if [ -n "${LABEL}" ]; then
    args="${args} label ${LABEL}"
fi

if [ -n "${BROADCAST}" ]; then
    args="${args} broadcast ${BROADCAST}"
fi

case "${2}" in
    up)
        if [ "$(ip addr show ${1} 2>/dev/null | grep ${IP}/)" = "" ]; then
            log_info_msg "Adding IPv4 address ${IP} to the ${1} interface..."
            ip addr add ${args} dev ${1}
            evaluate_retval
        else
            log_warning_msg "Cannot add IPv4 address ${IP} to ${1}. Already present."
        fi
        ;;

    down)
        if [ "$(ip addr show ${1} 2>/dev/null | grep ${IP}/)" != "" ]; then
            log_info_msg "Removing IPv4 address ${IP} from the ${1} interface..."
            ip addr del ${args} dev ${1}
            evaluate_retval
        fi

        if [ -n "${GATEWAY}" ]; then
            # Only remove the gateway if there are no remaining ipv4 addresses
            if [ "$(ip addr show ${1} 2>/dev/null | grep 'inet ')" != "" ]; then
                log_info_msg "Removing default gateway..."
                ip route del default
                evaluate_retval
            fi
        fi
        ;;

```



```

*)
    echo "Usage: ${0} [interface] {up|down}"
    exit 1
;;
esac

# End /lib/services/ipv4-static

```

D.27. /lib/services/ipv4-static-route

```

#!/bin/sh
#####
# Begin /lib/services/ipv4-static-route
#
# Description : IPV4 Static Route Script
#
# Authors      : Kevin P. Fleming - kpfleming@linuxfromscratch.org
#               DJ Lucas - dj@linuxfromscratch.org
# Update       : Bruce Dubbs - bdubbs@linuxfromscratch.org
#
# Version      : LFS 7.0
#
#####

. /lib/lsb/init-functions
. ${IFCONFIG}

case "${TYPE}" in
    "" | "network")
        need_ip=1
        need_gateway=1
        ;;

    ("default")
        need_gateway=1
        args="${args} default"
        desc="default"
        ;;

    ("host")
        need_ip=1
        ;;

    ("unreachable")
        need_ip=1
        args="${args} unreachable"
        desc="unreachable "
        ;;

    (*)
        log_failure_msg "Unknown route type (${TYPE}) in ${IFCONFIG}, cannot continue."
        exit 1
        ;;
esac

if [ -n "${GATEWAY}" ]; then
    MSG="The GATEWAY variable cannot be set in ${IFCONFIG} for static routes.\n"
    log_failure_msg "$MSG Use STATIC_GATEWAY only, cannot continue"
    exit 1
fi

if [ -n "${need_ip}" ]; then

```

```

if [ -z "${IP}" ]; then
    log_failure_msg "IP variable missing from ${IFCONFIG}, cannot continue."
    exit 1
fi

if [ -z "${PREFIX}" ]; then
    log_failure_msg "PREFIX variable missing from ${IFCONFIG}, cannot continue."
    exit 1
fi

args="${args} ${IP}/${PREFIX}"
desc="${desc}${IP}/${PREFIX}"
fi

if [ -n "${need_gateway}" ]; then
    if [ -z "${STATIC_GATEWAY}" ]; then
        log_failure_msg "STATIC_GATEWAY variable missing from ${IFCONFIG}, cannot continue."
        exit 1
    fi
    args="${args} via ${STATIC_GATEWAY}"
fi

if [ -n "${SOURCE}" ]; then
    args="${args} src ${SOURCE}"
fi

case "${2}" in
    up)
        log_info_msg "Adding '${desc}' route to the ${1} interface..."
        ip route add ${args} dev ${1}
        evaluate_retval
        ;;
    down)
        log_info_msg "Removing '${desc}' route from the ${1} interface..."
        ip route del ${args} dev ${1}
        evaluate_retval
        ;;
    *)
        echo "Usage: ${0} [interface] {up|down}"
        exit 1
        ;;
esac

# End /lib/services/ipv4-static-route

```

Appendix E. Udev configuration rules

The rules in this appendix are listed for convenience. Installation is normally done via instructions in Section 8.70, “Eudev-3.2.11”.

E.1. 55-lfs.rules

```
# /etc/udev/rules.d/55-lfs.rules: Rule definitions for LFS.

# Core kernel devices

# This causes the system clock to be set as soon as /dev/rtc becomes available.
SUBSYSTEM=="rtc", ACTION=="add", MODE="0644", RUN+="/etc/rc.d/init.d/setclock start"
KERNEL=="rtc", ACTION=="add", MODE="0644", RUN+="/etc/rc.d/init.d/setclock start"

# Comms devices

KERNEL=="ippp[0-9]*",      GROUP="dialout"
KERNEL=="isdn[0-9]*",      GROUP="dialout"
KERNEL=="isdnctrl[0-9]*",  GROUP="dialout"
KERNEL=="dcbri[0-9]*",     GROUP="dialout"
```

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Index

Packages

Acl: 128
 Attr: 127
 Autoconf: 163
 Automake: 165
 Bash: 149
 tools: 59
 Bash: 149
 tools: 59
 Bc: 114
 Binutils: 120
 tools, pass 1: 44
 tools, pass 2: 72
 Binutils: 120
 tools, pass 1: 44
 tools, pass 2: 72
 Binutils: 120
 tools, pass 1: 44
 tools, pass 2: 72
 Bison: 147
 tools: 82
 Bison: 147
 tools: 82
 Bootscripts: 228
 usage: 238
 Bootscripts: 228
 usage: 238
 Bzip2: 105
 Check: 184
 Coreutils: 179
 tools: 60
 Coreutils: 179
 tools: 60
 DejaGNU: 119
 Diffutils: 185
 tools: 61
 Diffutils: 185
 tools: 61
 E2fsprogs: 219
 Eudev: 207
 configuring: 207
 Eudev: 207
 configuring: 207
 Expat: 154
 Expect: 118
 File: 110
 tools: 62
 File: 110
 tools: 62
 Findutils: 187
 tools: 63
 Findutils: 187
 tools: 63
 Flex: 115
 Gawk: 186
 tools: 64
 Gawk: 186
 tools: 64
 GCC: 134
 tools, libstdc++ pass 1: 53
 tools, pass 1: 46
 tools, pass 2: 73
 GCC: 134
 tools, libstdc++ pass 1: 53
 tools, pass 1: 46
 tools, pass 2: 73
 GCC: 134
 tools, libstdc++ pass 1: 53
 tools, pass 1: 46
 tools, pass 2: 73
 GCC: 134
 tools, libstdc++ pass 1: 53
 tools, pass 1: 46
 tools, pass 2: 73
 GCC: 134
 tools, libstdc++ pass 1: 53
 tools, pass 1: 46
 tools, pass 2: 73
 GDBM: 152
 Gettext: 145
 tools: 81
 Gettext: 145
 tools: 81
 Glibc: 97
 tools: 50
 Glibc: 97
 tools: 50
 GMP: 123
 Gperf: 153
 Grep: 148
 tools: 65
 Grep: 148
 tools: 65
 Groff: 188
 GRUB: 191

Gzip: 193
 tools: 66
 Gzip: 193
 tools: 66
 Iana-Etc: 96
 Inetutils: 155
 Intltool: 162
 IPRoute2: 194
 Kbd: 196
 Kmod: 168
 Less: 157
 Libcap: 129
 Libelf: 170
 libffi: 171
 Libpipeline: 198
 Libtool: 151
 Linux: 253
 tools, API headers: 49
 Linux: 253
 tools, API headers: 49
 M4: 113
 tools: 56
 M4: 113
 tools: 56
 Make: 199
 tools: 67
 Make: 199
 tools: 67
 Man-DB: 209
 Man-pages: 95
 Meson: 178
 MPC: 126
 MPFR: 125
 Ncurses: 140
 tools: 57
 Ncurses: 140
 tools: 57
 Ninja: 176
 OpenSSL: 166
 Patch: 200
 tools: 68
 Patch: 200
 tools: 68
 Perl: 158
 tools: 83
 Perl: 158
 tools: 83
 Pkgconfig: 139
 Procps-ng: 212
 Psmisc: 144
 Python: 172
 temporary: 84
 Python: 172
 temporary: 84
 rc.site: 244
 Readline: 111
 Sed: 143
 tools: 69
 Sed: 143
 tools: 69
 Shadow: 130
 configuring: 131
 Shadow: 130
 configuring: 131
 Sysklogd: 222
 configuring: 222
 Sysklogd: 222
 configuring: 222
 Sysvinit: 223
 configuring: 239
 Sysvinit: 223
 configuring: 239
 Tar: 201
 tools: 70
 Tar: 201
 tools: 70
 Tcl: 116
 Texinfo: 202
 temporary: 85
 Texinfo: 202
 temporary: 85
 Udev
 usage: 230
 Util-linux: 214
 tools: 86
 Util-linux: 214
 tools: 86
 Vim: 204
 wheel: 175
 XML::Parser: 161
 Xz: 107
 tools: 71
 Xz: 107
 tools: 71

Zlib: 104

zstd: 109

Programs

[: 179, 180

2to3: 172

accessdb: 209, 210

aclocal: 165, 165

aclocal-1.16: 165, 165

addftinfo: 188, 188

addpart: 214, 215

addr2line: 120, 121

afmtodit: 188, 188

agetty: 214, 215

apropos: 209, 211

ar: 120, 121

as: 120, 121

attr: 127, 127

autoconf: 163, 163

autoheader: 163, 163

autom4te: 163, 163

automake: 165, 165

automake-1.16: 165, 165

autopoint: 145, 145

autoreconf: 163, 163

autoscan: 163, 163

autoupdate: 163, 164

awk: 186, 186

b2sum: 179, 180

badblocks: 219, 220

base64: 179, 180, 179, 180

base64: 179, 180, 179, 180

basename: 179, 180

basenc: 179, 180

bash: 149, 150

bashbug: 149, 150

bc: 114, 114

bison: 147, 147

blkdiscard: 214, 215

blkid: 214, 215

blkzone: 214, 215

blockdev: 214, 215

bootlogd: 223, 223

bridge: 194, 194

bunzip2: 105, 106

bzipcat: 105, 106

bzipcmp: 105, 106

bzdifff: 105, 106

bzipgrep: 105, 106

bzfgrep: 105, 106

bzgrep: 105, 106

bzip2: 105, 106

bzip2recover: 105, 106

bzless: 105, 106

bzipmore: 105, 106

c++: 134, 137

c++filt: 120, 121

cal: 214, 215

capsh: 129, 129

captain: 140, 141

cat: 179, 180

catman: 209, 211

cc: 134, 137

cfdisk: 214, 215

chac1: 128, 128

chage: 130, 132

chattr: 219, 220

chcon: 179, 180

chcpu: 214, 215

checkmk: 184, 184

chem: 188, 188

chfn: 130, 132

chgpasswd: 130, 132

chgrp: 179, 180

chmem: 214, 215

chmod: 179, 180

choom: 214, 215

chown: 179, 180

chpasswd: 130, 132

chroot: 179, 180

chrt: 214, 215

chsh: 130, 132

chvt: 196, 197

cksum: 179, 180

clear: 140, 141

cmp: 185, 185

col: 214, 215

colcrt: 214, 215

colrm: 214, 215

column: 214, 215

comm: 179, 180

compile_et: 219, 220

corelist: 158, 159

cp: 179, 180

cpan: 158, 159
 cpp: 134, 137
 csplit: 179, 181
 ctrlaltdel: 214, 215
 ctstat: 194, 194
 cut: 179, 181
 c_rehash: 166, 167
 date: 179, 181
 dc: 114, 114
 dd: 179, 181
 deallocvt: 196, 197
 debugfs: 219, 220
 dejagru: 119, 119
 delpart: 214, 215
 depmod: 168, 168
 df: 179, 181
 diff: 185, 185
 diff3: 185, 185
 dir: 179, 181
 dircolors: 179, 181
 dirname: 179, 181
 dmesg: 214, 215
 dnsdomainname: 155, 156
 du: 179, 181
 dumpe2fs: 219, 220
 dumpkeys: 196, 197
 e2freefrag: 219, 220
 e2fsck: 219, 220
 e2image: 219, 220
 e2label: 219, 220
 e2mmpstatus: 219, 220
 e2scrub: 219, 220
 e2scrub_all: 219, 220
 e2undo: 219, 220
 e4crypt: 219, 220
 e4defrag: 219, 220
 echo: 179, 181
 egrep: 148, 148
 eject: 214, 215
 elfedit: 120, 121
 enc2xs: 158, 159
 encguess: 158, 159
 env: 179, 181
 envsubst: 145, 145
 eqn: 188, 188
 eqn2graph: 188, 188
 ex: 204, 206
 expand: 179, 181
 expect: 118, 118
 expiry: 130, 132
 expr: 179, 181
 factor: 179, 181
 faillog: 130, 132
 fallocate: 214, 215
 false: 179, 181
 fdisk: 214, 216
 fgconsole: 196, 197
 fgrep: 148, 148
 file: 110, 110
 filefrag: 219, 220
 fincore: 214, 216
 find: 187, 187
 findfs: 214, 216
 findmnt: 214, 216
 flex: 115, 115
 flex++: 115, 115
 flock: 214, 216
 fmt: 179, 181
 fold: 179, 181
 free: 212, 212
 fsck: 214, 216
 fsck.cramfs: 214, 216
 fsck.ext2: 219, 220
 fsck.ext3: 219, 220
 fsck.ext4: 219, 220
 fsck.minix: 214, 216
 fsfreeze: 214, 216
 fstab-decode: 223, 223
 fstrim: 214, 216
 ftp: 155, 156
 fuser: 144, 144
 g++: 134, 137
 gawk: 186, 186
 gawk-5.2.1: 186, 186
 gcc: 134, 137
 gc-ar: 134, 137
 gc-nm: 134, 137
 gc-ranlib: 134, 137
 gcov: 134, 138
 gcov-dump: 134, 138
 gcov-tool: 134, 138
 gdbmtool: 152, 152
 gdbm_dump: 152, 152
 gdbm_load: 152, 152

gdiffmk: 188, 188
 gencat: 97, 102
 genl: 194, 194
 getcap: 129, 129
 getconf: 97, 102
 getent: 97, 102
 getfacl: 128, 128
 getfattr: 127, 127
 getkeycodes: 196, 197
 getopt: 214, 216
 getpcaps: 129, 129
 getsubids: 130, 132
 gettext: 145, 145
 gettext.sh: 145, 145
 gettextize: 145, 145
 glilypond: 188, 188
 gpasswd: 130, 132
 gperf: 153, 153
 gperl: 188, 188
 gpinyin: 188, 188
 gprof: 120, 121
 gprofng: 120, 122
 grap2graph: 188, 189
 grep: 148, 148
 grn: 188, 189
 grodvi: 188, 189
 groff: 188, 189
 groffer: 188, 189
 grog: 188, 189
 grolbp: 188, 189
 grolj4: 188, 189
 gropdf: 188, 189
 grops: 188, 189
 grotty: 188, 189
 groupadd: 130, 132
 groupdel: 130, 132
 groupmems: 130, 132
 groupmod: 130, 132
 groups: 179, 181
 grpck: 130, 132
 grpconv: 130, 132
 grpunconv: 130, 132
 grub-bios-setup: 191, 192
 grub-editenv: 191, 192
 grub-file: 191, 192
 grub-fstest: 191, 192
 grub-glue-efi: 191, 192
 grub-install: 191, 192
 grub-kbdcomp: 191, 192
 grub-macbless: 191, 192
 grub-menulst2cfg: 191, 192
 grub-mkconfig: 191, 192
 grub-mkimage: 191, 192
 grub-mklayout: 191, 192
 grub-mknetdir: 191, 192
 grub-mkpasswd-pbkdf2: 191, 192
 grub-mkrelpath: 191, 192
 grub-mkrescue: 191, 192
 grub-mkstandalone: 191, 192
 grub-ofpathname: 191, 192
 grub-probe: 191, 192
 grub-reboot: 191, 192
 grub-render-label: 191, 192
 grub-script-check: 191, 192
 grub-set-default: 191, 192
 grub-setup: 191, 192
 grub-syslinux2cfg: 191, 192
 gunzip: 193, 193
 gzexe: 193, 193
 gzip: 193, 193
 h2ph: 158, 159
 h2xs: 158, 159
 halt: 223, 223
 hardlink: 214, 216
 head: 179, 181
 hexdump: 214, 216
 hostid: 179, 181
 hostname: 155, 156
 hpftodit: 188, 189
 hwclock: 214, 216
 i386: 214, 216
 iconv: 97, 102
 iconvconfig: 97, 102
 id: 179, 181
 idle3: 172
 ifconfig: 155, 156
 ifnames: 163, 164
 ifstat: 194, 194
 indxbib: 188, 189
 info: 202, 202
 infocmp: 140, 141
 infotocap: 140, 141
 init: 223, 223
 insmod: 168, 168

install: 179, 181
 install-info: 202, 203
 instmodsh: 158, 159
 intltool-extract: 162, 162
 intltool-merge: 162, 162
 intltool-prepare: 162, 162
 intltool-update: 162, 162
 intltoolize: 162, 162
 ionice: 214, 216
 ip: 194, 194
 ipcmk: 214, 216
 ipcrm: 214, 216
 ipcs: 214, 216
 irqtop: 214, 216
 isosize: 214, 216
 join: 179, 181
 json_pp: 158, 159
 kbdinfo: 196, 197
 kbdrate: 196, 197
 kbd_mode: 196, 197
 kill: 214, 216
 killall: 144, 144
 killall5: 223, 223
 klogd: 222, 222
 kmod: 168, 168
 last: 214, 216
 lastb: 214, 216
 lastlog: 130, 133
 ld: 120, 122
 ld.bfd: 120, 122
 ld.gold: 120, 122
 ldattach: 214, 216
 ldconfig: 97, 102
 ldd: 97, 102
 lddlibc4: 97, 102
 less: 157, 157
 lessecho: 157, 157
 lesskey: 157, 157
 lex: 115, 115
 lexgrog: 209, 211
 lfskernel-6.1.11: 253, 257
 libasan: 134, 138
 libatomic: 134, 138
 libcc1: 134, 138
 libnetcfg: 158, 159
 libtool: 151, 151
 libtoolize: 151, 151
 link: 179, 181
 linux32: 214, 216
 linux64: 214, 216
 lkbib: 188, 189
 ln: 179, 181
 lnstat: 194, 195
 loadkeys: 196, 197
 loadunimap: 196, 197
 locale: 97, 102
 localedef: 97, 102
 locate: 187, 187
 logger: 214, 216
 login: 130, 133
 logname: 179, 181
 logoutd: 130, 133
 logsave: 219, 221
 look: 214, 216
 lookbib: 188, 189
 losetup: 214, 216
 ls: 179, 181
 lsattr: 219, 221
 lsblk: 214, 216
 lscpu: 214, 216
 lsfd: 214, 216
 lsipc: 214, 216
 lsirq: 214, 217
 lslocks: 214, 217
 lslogins: 214, 217
 lsmem: 214, 217
 lsmod: 168, 169
 lsns: 214, 217
 lto-dump: 134, 138
 lzcat: 107, 107
 lzcmp: 107, 107
 lzdiff: 107, 107
 lzegrep: 107, 107
 lzfgrep: 107, 107
 lzgrep: 107, 107
 lzless: 107, 107
 lzma: 107, 107
 lzmadec: 107, 107
 lzmainfo: 107, 107
 lzmore: 107, 108
 m4: 113, 113
 make: 199, 199
 makedb: 97, 102
 makeinfo: 202, 203

man: 209, 211
 man-recode: 209, 211
 mandb: 209, 211
 manpath: 209, 211
 mapscrn: 196, 197
 mcookie: 214, 217
 md5sum: 179, 181
 mesg: 214, 217
 meson: 178, 178
 mkdir: 179, 181
 mke2fs: 219, 221
 mkfifo: 179, 181
 mkfs: 214, 217
 mkfs.bfs: 214, 217
 mkfs.cramfs: 214, 217
 mkfs.ext2: 219, 221
 mkfs.ext3: 219, 221
 mkfs.ext4: 219, 221
 mkfs.minix: 214, 217
 mklost+found: 219, 221
 mknod: 179, 181
 mkswap: 214, 217
 mktemp: 179, 181
 mk_cmds: 219, 221
 mmroff: 188, 189
 modinfo: 168, 169
 modprobe: 168, 169
 more: 214, 217
 mount: 214, 217
 mountpoint: 214, 217
 msgattrib: 145, 145
 msgcat: 145, 145
 msgcmp: 145, 145
 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: 179, 181
 namei: 214, 217
 ncursesw6-config: 140, 141
 neqn: 188, 189
 newgidmap: 130, 133
 newgrp: 130, 133
 newuidmap: 130, 133
 newusers: 130, 133
 ngettext: 145, 146
 nice: 179, 182
 ninja: 176, 177
 nl: 179, 182
 nm: 120, 122
 nohup: 179, 182
 nologin: 130, 133
 nproc: 179, 182
 nroff: 188, 189
 nscd: 97, 102
 nsenter: 214, 217
 nstat: 194, 195
 numfmt: 179, 182
 objcopy: 120, 122
 objdump: 120, 122
 od: 179, 182
 openssl: 166, 167
 openvt: 196, 197
 partx: 214, 217
 passwd: 130, 133
 paste: 179, 182
 patch: 200, 200
 pathchk: 179, 182
 pcprofiledump: 97, 102
 pdfmom: 188, 189
 pdfroff: 188, 189
 pdftexi2dvi: 202, 203
 peekfd: 144, 144
 perl: 158, 159
 perl5.36.0: 158, 159
 perlbug: 158, 159
 perldoc: 158, 159
 perlivp: 158, 159
 perlthanks: 158, 159
 pfbtops: 188, 189
 pgrep: 212, 212
 pic: 188, 189
 pic2graph: 188, 189
 piconv: 158, 159
 pidof: 212, 212
 ping: 155, 156

ping6: 155, 156
 pinky: 179, 182
 pip3: 172
 pivot_root: 214, 217
 pkg-config: 139, 139
 pkill: 212, 212
 pl2pm: 158, 159
 pldd: 97, 102
 pmap: 212, 212
 pod2html: 158, 159
 pod2man: 158, 159
 pod2texi: 202, 203
 pod2text: 158, 160
 pod2usage: 158, 160
 podchecker: 158, 160
 podselect: 158, 160
 post-grohtml: 188, 189
 poweroff: 223, 223
 pr: 179, 182
 pre-grohtml: 188, 189
 preconv: 188, 189
 printenv: 179, 182
 printf: 179, 182
 prlimit: 214, 217
 prove: 158, 160
 prtstat: 144, 144
 ps: 212, 212
 psfaddtable: 196, 197
 psfgettable: 196, 197
 psfstriptime: 196, 197
 psfxtable: 196, 197
 pslog: 144, 144
 pstree: 144, 144
 pstree.x11: 144, 144
 ptar: 158, 160
 ptardiff: 158, 160
 ptargrep: 158, 160
 ptx: 179, 182
 pwck: 130, 133
 pwconv: 130, 133
 pwd: 179, 182
 pwdx: 212, 212
 pwunconv: 130, 133
 pydoc3: 172
 python3: 172
 ranlib: 120, 122
 readelf: 120, 122
 readlink: 179, 182
 readprofile: 214, 217
 realpath: 179, 182
 reboot: 223, 223
 recode-sr-latin: 145, 146
 refer: 188, 189
 rename: 214, 217
 renice: 214, 217
 reset: 140, 142
 resize2fs: 219, 221
 resizepart: 214, 217
 rev: 214, 217
 rkfill: 214, 217
 rm: 179, 182
 rmdir: 179, 182
 rmmmod: 168, 169
 roff2dvi: 188, 190
 roff2html: 188, 190
 roff2pdf: 188, 190
 roff2ps: 188, 190
 roff2text: 188, 190
 roff2x: 188, 190
 routel: 194, 195
 rtacct: 194, 195
 rtcwake: 214, 217
 rtmon: 194, 195
 rtpr: 194, 195
 rtstat: 194, 195
 runcon: 179, 182
 runlevel: 223, 223
 runtest: 119, 119
 rview: 204, 206
 rvm: 204, 206
 script: 214, 217
 scriptlive: 214, 217
 scriptreplay: 214, 217
 sdif: 185, 185
 sed: 143, 143
 seq: 179, 182
 setarch: 214, 217
 setcap: 129, 129
 setfacl: 128, 128
 setfattr: 127, 127
 setfont: 196, 197
 setkeycodes: 196, 197
 setleds: 196, 197
 setmetamode: 196, 197

setsid: 214, 217
 setterm: 214, 217
 setvtrgb: 196, 197
 sfdisk: 214, 217
 sg: 130, 133
 sh: 149, 150
 sha1sum: 179, 182
 sha224sum: 179, 182
 sha256sum: 179, 182
 sha384sum: 179, 182
 sha512sum: 179, 182
 shasum: 158, 160
 showconsolefont: 196, 197
 showkey: 196, 197
 shred: 179, 182
 shuf: 179, 182
 shutdown: 223, 223
 size: 120, 122
 slabtop: 212, 212
 sleep: 179, 182
 sln: 97, 102
 soelim: 188, 190
 sort: 179, 182
 sotruss: 97, 102
 splain: 158, 160
 split: 179, 182
 sprof: 97, 102
 ss: 194, 195
 stat: 179, 182
 stdbuf: 179, 182
 strings: 120, 122
 strip: 120, 122
 stty: 179, 182
 su: 130, 133
 sulogin: 214, 217
 sum: 179, 182
 swapon: 214, 218
 swapoff: 214, 218
 swapon: 214, 218
 switch_root: 214, 218
 sync: 179, 182
 sysctl: 212, 213
 syslogd: 222, 222
 tabs: 140, 142
 tac: 179, 182
 tail: 179, 183
 talk: 155, 156
 tar: 201, 201
 taskset: 214, 218
 tbl: 188, 190
 tc: 194, 195
 tcsh: 116, 117
 tcsh8.6: 116, 117
 tee: 179, 183
 telinit: 223, 223
 telnet: 155, 156
 test: 179, 183
 texi2dvi: 202, 203
 texi2pdf: 202, 203
 texi2any: 202, 203
 texindex: 202, 203
 tfmtodit: 188, 190
 tftp: 155, 156
 tic: 140, 142
 timeout: 179, 183
 tload: 212, 213
 toe: 140, 142
 top: 212, 213
 touch: 179, 183
 tput: 140, 142
 tr: 179, 183
 traceroute: 155, 156
 troff: 188, 190
 true: 179, 183
 truncate: 179, 183
 tset: 140, 142
 tsort: 179, 183
 tty: 179, 183
 tune2fs: 219, 221
 tzselect: 97, 102
 uclampset: 214, 218
 udevadm: 207, 208
 udevd: 207, 208
 ul: 214, 218
 umount: 214, 218
 uname: 179, 183
 uname26: 214, 218
 uncompress: 193, 193
 unexpand: 179, 183
 unicode_start: 196, 197
 unicode_stop: 196, 197
 uniq: 179, 183
 unlink: 179, 183
 unlzma: 107, 108

unshare: 214, 218
 unxz: 107, 108
 updatedb: 187, 187
 uptime: 212, 213
 useradd: 130, 133
 userdel: 130, 133
 usermod: 130, 133
 users: 179, 183
 utmpdump: 214, 218
 uuid: 214, 218
 uuidgen: 214, 218
 uuidparse: 214, 218
 vdir: 179, 183
 vi: 204, 206
 view: 204, 206
 vigr: 130, 133
 vim: 204, 206
 vimdiff: 204, 206
 vimtutor: 204, 206
 vipw: 130, 133
 vmstat: 212, 213
 w: 212, 213
 wall: 214, 218
 watch: 212, 213
 wc: 179, 183
 wdctl: 214, 218
 whatis: 209, 211
 wheel: 175
 whereis: 214, 218
 who: 179, 183
 whoami: 179, 183
 wipefs: 214, 218
 x86_64: 214, 218
 xargs: 187, 187
 xgettext: 145, 146
 xmlwf: 154, 154
 xsubpp: 158, 160
 xtrace: 97, 102
 xxd: 204, 206
 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: 179, 183
 zcat: 193, 193
 zcmp: 193, 193
 zdiff: 193, 193
 zdump: 97, 102
 zegrep: 193, 193
 zfgrep: 193, 193
 zforce: 193, 193
 zgrep: 193, 193
 zic: 97, 102
 zipdetails: 158, 160
 zless: 193, 193
 zmore: 193, 193
 znew: 193, 193
 zramctl: 214, 218
 zstd: 109, 109
 zstdgrep: 109, 109
 zstdless: 109, 109

Libraries

Expat: 161, 161
 ld-2.37.so: 97, 103
 libacl: 128, 128
 libanl: 97, 103
 libasprintf: 145, 146
 libattr: 127, 127
 libbfd: 120, 122
 libblkid: 214, 218
 libBrokenLocale: 97, 103
 libbz2: 105, 106
 libc: 97, 103
 libcap: 129, 129
 libcheck: 184, 184
 libcom_err: 219, 221
 libcrypt: 97, 103
 libcrypto.so: 166, 167
 libctf: 120, 122
 libctf-nobfd: 120, 122
 libcursesw: 140, 142
 libc_malloc_debug: 97, 103
 libdl: 97, 103
 libe2p: 219, 221
 libelf: 170, 170
 libexpat: 154, 154

libexpect-5.45.4: 118, 118
 libext2fs: 219, 221
 libfdisk: 214, 218
 libffi: 171
 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, 111
 libitm: 134, 138
 libkmod: 168
 liblsan: 134, 138
 libltdl: 151, 151
 liblto_plugin: 134, 138
 liblzma: 107, 108
 libm: 97, 103
 libmagic: 110, 110
 libman: 209, 211
 libmandb: 209, 211
 libmcheck: 97, 103
 libmemusage: 97, 103
 libmenuw: 140, 142
 libmount: 214, 218
 libmpc: 126, 126
 libmpfr: 125, 125
 libmvec: 97, 103
 libncurses++w: 140, 142
 libncursesw: 140, 142
 libnsl: 97, 103
 libnss_*: 97, 103
 libopcodes: 120, 122
 libpanelw: 140, 142
 libpcprofile: 97, 103
 libpipeline: 198
 libproc-2: 212, 213
 libpsx: 129, 129
 libpthread: 97, 103
 libquadmath: 134, 138

libreadline: 111, 112
 libresolv: 97, 103
 librt: 97, 103
 libsframe: 120, 122
 libsmartcols: 214, 218
 libss: 219, 221
 libssl.so: 166, 167
 libssp: 134, 138
 libstdbuf: 179, 183
 libstdc++: 134, 138
 libstdc++fs: 134, 138
 libsubid: 130, 133
 libsupc++: 134, 138
 libtcl8.6.so: 116, 117
 libtclstub8.6.a: 116, 117
 libtextstyle: 145, 146
 libthread_db: 97, 103
 libtsan: 134, 138
 libubsan: 134, 138
 libudev: 207, 208
 libutil: 97, 103
 libuuid: 214, 218
 liby: 147, 147
 libz: 104, 104
 libzstd: 109, 109
 preloadable_libintl: 145, 146

Scripts

checkfs: 228, 228
 cleanfs: 228, 228
 console: 228, 228
 configuring: 241
 console: 228, 228
 configuring: 241
 File creation at boot
 configuring: 243
 functions: 228, 228
 halt: 228, 228
 hostname
 configuring: 237
 ifdown: 228, 228
 ifup: 228, 228
 ipv4-static: 228, 228
 localnet: 228, 228
 /etc/hosts: 237
 localnet: 228, 228
 /etc/hosts: 237

modules: 228, 228
 mountfs: 228, 228
 mountvirtfs: 228, 228
 network: 228, 228
 /etc/hosts: 237
 configuring: 235
 network: 228, 228
 /etc/hosts: 237
 configuring: 235
 network: 228, 228
 /etc/hosts: 237
 configuring: 235
 rc: 228, 228
 reboot: 228, 228
 sendsignals: 228, 228
 setclock: 228, 228
 configuring: 240
 setclock: 228, 228
 configuring: 240
 swap: 228, 229
 sysctl: 228, 229
 sysklogd: 228, 229
 configuring: 244
 sysklogd: 228, 229
 configuring: 244
 template: 228, 229
 udev: 228, 229
 udev_retry: 228, 229
 dwp: 120, 121

 /etc/passwd: 78
 /etc/profile: 246
 /etc/protocols: 96
 /etc/resolv.conf: 237
 /etc/services: 96
 /etc/syslog.conf: 222
 /etc/udev: 207, 208
 /etc/udev/hwdb.bin: 207
 /etc/vimrc: 205
 /run/utmp: 78
 /usr/include/asm-generic/*.h: 49, 49
 /usr/include/asm/*.h: 49, 49
 /usr/include/drm/*.h: 49, 49
 /usr/include/linux/*.h: 49, 49
 /usr/include/misc/*.h: 49, 49
 /usr/include/mtd/*.h: 49, 49
 /usr/include/rdma/*.h: 49, 49
 /usr/include/scsi/*.h: 49, 49
 /usr/include/sound/*.h: 49, 49
 /usr/include/video/*.h: 49, 49
 /usr/include/xen/*.h: 49, 49
 /var/log/btmp: 78
 /var/log/lastlog: 78
 /var/log/wtmp: 78
 /etc/shells: 249
 man pages: 95, 95

Others

/boot/config-6.1.11: 253, 257
 /boot/System.map-6.1.11: 253, 257
 /dev/*: 75
 /etc/fstab: 251
 /etc/group: 78
 /etc/hosts: 237
 /etc/inittab: 239
 /etc/inputrc: 248
 /etc/ld.so.conf: 101
 /etc/lfs-release: 261
 /etc/localtime: 100
 /etc/lsb-release: 261
 /etc/mke2fs.conf: 220
 /etc/modprobe.d/usb.conf: 257
 /etc/nsswitch.conf: 100
 /etc/os-release: 261