Creating a customized Linux with Linux From Scratch

BAKING YOUR LINUX

Linux From Scratch helps you create a custom Linux system with everything you need and nothing more. And as you build your system, you'll get an insider's look at how Linux really works. **BY ERIC AMBERG**

Even minimal Linux distributions often contain components you will never need. If you prefer to keep control over the contents of your Linux system, one option is simply to build your own system from scratch. Building a Linux system package by package – including the kernel and shell – gives you an extremely lean and fast system. Also, you'll gain great insights into the structure of Linux.

The Linux From Scratch project (LFS) provides step-by-step instructions for building your own Linux system. LFS also maintains a Live CD you can use as a starting point for building your Linux. Just work through the LFS instruction book to create a complete system piece by piece. Keep in mind that the procedure takes much longer than a simple CD-based installation. In fact, it could take you several days or even weeks, but the effort is worthwhile for anybody wanting a peek behind the scenes at how a Linux system fits together. In the course of the build steps, you will come to understand many concepts that will help you in your daily work with Linux.

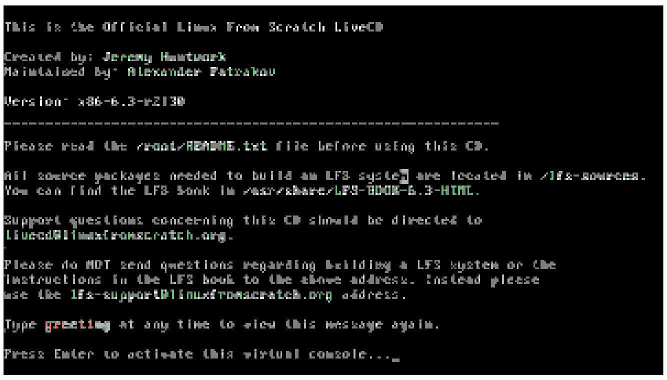
Check Your Tools

The *Linux From Scratch* manual is available from the project website [1] in PDF, text, or HTML format. To build you own Linux, you need good working knowledge of the shell: You should know how to create, copy, move, and delete files and folders. Basic knowledge of the installation and use of Linux software is

Linux From Scratch Resources

Linux From Scratch is primarily a set of documents, but the project also provides a Live CD to serve as a foundation or *build host* for your homegrown Linux. At the LFS website [1], you'll also find hints, patches, and other helpful materials. According to the LFS site, the project consists of the following components:

- LFS: *Linux From Scratch* is the main book from which all other projects derive.
- BLFS: *Beyond Linux From Scratch* helps you extend your finished LFS installation with additional components, such as Gnome or KDE.
- ALFS: *Automated Linux From Scratch* provides tools for automating and managing LFS and BLFS builds.
- CLFS: *Cross Linux From Scratch* provides the means to cross-compile an LFS system on many types of systems.
- HLFS: *Hardened Linux From Scratch* focuses on building an LFS system with heightened security.
- Hints: The Hints project is a collection of documents providing additional tips on how to enhance your LFS system.
- LiveCD: The Live CD project provides a CD to use as an LFS build host or a general rescue CD.
- Patches: The Patches project serves as a central repository for LFS-related patches.



```
This is the Official Linux From Scratch LiveCD

Created by: Jeremy Huntwork
Maintained by: Alexander Patrakov

Version: x86-6.3-r2130

----------------------------------------------------------------

Please read the /root/README.txt file before using this CD.

All source packages needed to build an LFS system are located in /lfs-sources.
You can find the LFS book in /usr/share/LFS-BOOK-6.3-HTML.

Support questions concerning this CD should be directed to
livecd@linuxfromscratch.org.

Please do NOT send questions regarding building a LFS system or the
instructions in the LFS book to the above address. Instead please
use the lfs-support@linuxfromscratch.org address.

Type greeting at any time to view this message again.

Press Enter to activate this virtual console..._
```

Figure 1: The LFS Live CD has everything you need to build your own Linux system.

also recommended. In particular, I recommend the *Software Building HOWTO* [2], the *Linux Users Guide* [3], and the LFS project's pre-reading list [4] as background reading.

Host System...

A new system is always built on an existing Linux system called the *host system*. The LFS main book defines the minimal requirements, which any fairly recent distribution will fulfill. Just to be sure, compare the minimal requirements with your host system. The LFS "Host System Requirements" section includes a shell script that helps you check for the necessary components.

...or Live CD

If you don't want to start with your own host system, you can use the LFS Live CD [5] instead (Figure 1). The Live CD includes all the tools you need, and the disc has a full set of required sources. This said, working from the LFS Live CD is not very convenient. The Knoppix Live CD is another alternative. When you are using the LFS documentation, make sure you check for any revisions at the errata website [6].

Overview

Before you get down to building your own special brand of Linux, it makes sense to take a bird's eye view of the procedure. To start, create a partition, then download the required packages and build the temporary tools you need to create your Linux system. This developer software is referred to as a tool chain. The new Linux system will be built within the tool chain, which you will need to resolve the package dependencies of the host system.

After setting up your base camp, *chroot* to a new environment where you will install more packages; then, it's on to the boot scripts, the kernel, and the boot loader. Finally, you can boot your computer from your new LFS system.

Listing 1: Enabling a Swap Partition

```
# export LFS=/mnt/lfs
# mkdir -pv $LFS
# mount -v -t ext3 /dev/hda1 $LFS
# swapon -v /dev/hda2
```

And They're Off!

To start, download the latest version of the LFS Live CD (currently 6.3-r2130) and burn the image onto a CD. It makes sense to print out the text of the manual and keep it next to your PC before you boot your host system from the Live CD. The sources are located in */lfs-sources*. The CD gives you the latest version of the LFS documentation in */usr/share/LFS-BOOK-6.3-HTML*. As with any other project, you should read the *README.txt* file before you start.

Creating a Partition

The LFS installation needs a separate partition. To create the partition, launch your favorite partitioning tool – cfdisk, for example – and create a native Linux partition. A minimal installation needs at least 1.3GB of disk space.

Depending on the applications you intend to install, you will need another 2 to 4GB of disk space later. Although the installation needs far less space later, the build process requires a fair amount of temporary memory. It also makes sense to create a swap partition.

After creating the partition, set up an ext3 filesystem on it. Assuming your partition is */dev/hda1*, the command for creating a filesystem is *mke2fs -jv /dev/hda1*. The documentation also recommends using the original E2fsprogs package named by the LFS sources rather than your distribution's own tools to avoid issues with incompatible extra functions.

If you have created a second partition (e.g., */dev/hda2*) as your swap partition, you can initialize the partition by typing *mkswap /dev/hda2*; then, mount the main partition. It makes sense to mount the partition as */mnt/lfs*. Because this path is used time and time again, it also makes sense to store it in a variable. Next, create a directory, and finally enable the swap partition if you have one (see Listing 1).

Packages and Patches

Chapter 3 of the LFS book describes the packages and patches required for a minimal installation. For your first steps, the authors recommend keeping to package versions that are known to work.

If you use the LFS Live CD, you won't need to worry about the package versions. Otherwise, you will find a download address for each package in the documentation. To store the packages, create a new directory and set the permissions. The second command adds the **sticky bit**, by stipulating *+t*, in addition to the write permission.

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

If you are using the Live CD, copy the whole archive to the directory you just created by typing *cp /lfs-sources/* $LFS/sources*. Otherwise, use this directory as your download directory.

Prep Work

The tool chain I referred to earlier also needs its own directory, *$LFS/tools*, which you can now create by typing *mkdir -v $LFS/tools*. Then type *ln -sv $LFS/tools /* to create a symbolic link to point to *$LFS/tools* as */tools*. The strange-sounding syntax is actually correct. The advantage is that the tool chain will always be able to reference */tools*, whether it's on the host system or on the

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Sticky bit: This bit means that only the owner of a file can delete the file, no matter who has write permissions for the directory.

LFS partition, which you will be making your temporary root directory later by running *chroot*.

To build the source packages, make sure you use a non-privileged user account; otherwise, you might damage the host system. It is a good idea to create an *lfs* user and grant the user full access to the *$LFS/sources* and *$LFS/tools* directories. Then type *su* and change to the new account:

```
# groupadd lfs
# useradd -s /bin/bash -g lfs ⮐
-m -k /dev/null lfs
# passwd lfs
# chown -v lfs $LFS/tools
# chown -v lfs $LFS/sources
# su - lfs
```

The LFS document explains the command-line options for the *useradd* command (Chapter 4.3), or you can check out the man page for the tool.

User Environment

The next step is to create a user environment without any potentially dangerous environmental variables. To do so, create a user-specific *~/.bash_profile* with just the following line:

```
exec env -i HOME=⮐
$HOME TERM=$TER⮐
M PS1='\u:\w\$ ' /bin/bash
```

This line simply defines the variables *HOME*, *TERM*, and *PS1* and launches a new Bash shell. As a non-login shell, the Bash shell parses the *~/.bashrc* file, which should contain just the following:

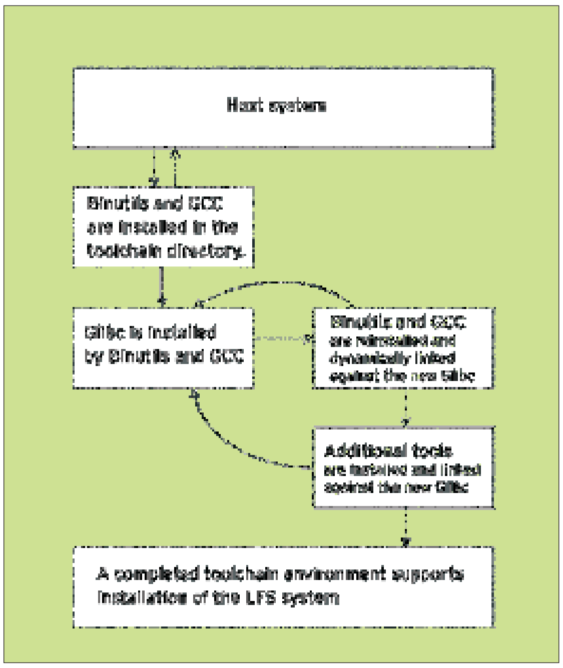
```
set +h
umask 022
LFS=/mnt/lfs
LC_ALL=POSIX
PATH=/tools/bin:/bin:/usr/bin
export LFS LC_ALL PATH
```

Again, these lines give you a pure environment for the *lfs* user. The LFS book explains all these options in detail. Parse the profile as the *lfs* user by typing *source ~/.bashrc*. The host system is now ready for the tool chain.

Creating a Tool Chain

The next step is to set up a temporary minimal Linux in which you will build up the LFS system. Chapter 5.1 of the LFS book gives an overview that tends to put people off because of the complexity of the processes – but don't dismay! Subsequent sections of the book provide details on every single step.

The *$LFS* variable should point to the LFS directory. Also, you need to know your host system platform, or *target triplet* as it is called. For a recent PC, this is typically *i686-pc-linux-gnu*. The name of the dynamic linker is very important for the remaining steps. Most systems use *ld-linux.so.2*, but you can find out by typing *readelf -l /bin/ls | grep interpreter*.



Host system
Binutils and GCC are installed in the toolchain directory.
Glibc is installed by Binutils and GCC
Binutils and GCC are reinstalled and dynamically linked against the new Glibc
Additional tools are installed and linked against the new Glibc
A completed toolchain environment supports installation of the LFS system

Figure 2: Creating an independent installation environment in multiple steps.

The next step is to unpack, build, and install the numerous basic and auxiliary packages. Chapter 5 of the LFS book tells you which packages to install and in which order.

The HOWTO assumes that the source code packages are in *$LFS/sources*, that you typed *tar -xjf package_name* to unpack, and that you changed to the package directory *$LFS/sources/package_name*. Path references in the guide are relative in some cases, as in *mkdir -v ../gcc-build*; your current working directory is thus critical.

It can take a while to build some of the packages – get a cup (or a whole flask) of coffee or tea. To create the tool chain, first install the critical developer tools (the compiler, linker, assembler) by installing the Binutils and GCC packages, the C standard library glibc, and the Kernel API. To detach from the host system, link all your programs against the new libraries, then install a number of required packages to enable use of the GCC and Binutils test suites. Later, you can enter *make check* to see whether the build was clean and whether the programs will work.

Patches

Before you continue, install GCC and Binutils a second time to allow these tools to use the new linker and libraries. Then, run the *patch* command to install a patch for the GCC code. Patches typically contain bug fixes and minor modifications that developers provide until the next release cycle comes around. In the course of the installation, you will need patches for various packages.

Memory Optimization

After installing the packages specified in Chapter 5, you now have a working environment that is independent of the host system and which you will use to build the LFS system in the next step. However, feel free to do some memory optimization beforehand. For example, you can run *strip --strip-debug /tools/lib/** and *strip --strip-unneeded /tools/{,s}bin/** to remove the debug symbols from executable files and libraries. This will save about 70MB of space, and you can save another 20MB by removing the documentation with *rm -rf /tools/{info,man}*.

The last step in creating the tool chain is to change the owner of the tool chain by typing *chown -R root:root $LFS/tools*. If you have been working as *lfs* previously, you should now become root.

Installing the Basic LFS System

Finally, you can install the LFS system. Chapter 6 of the LFS book explains the steps. To create the directories in which you will mount the required virtual kernel filesystems, type *mkdir -pv $LFS/*

Listing 2: The chroot Environment

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

Listing 3: Modifying chroot

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

{*dev,proc,sys*}. **Udev** also needs the */dev/console* and */dev/null* device files, which you can create as follows:

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

To create the device files in */dev*, use the *mount* command's *--bind* option to bind the */dev* directory on the host system (*mount -v --bind /dev $LFS/dev*). For details, refer to Chapter 6.2.2.

Additionally, mount the virtual kernel filesystem by running the following commands:

```
# mount -vt devpts devpts ⮐
$LFS/dev/pts
# mount -vt tmpfs shm ⮐
$LFS/dev/shm
# mount -vt proc proc ⮐
$LFS/proc
# mount -vt sysfs sysfs ⮐
$LFS/sys
```

Now you have everything you need to use the new working environment. The *chroot* command lets you create a temporary root directory in a directory of your choice.

After running the commands in the example, select */mnt/lfs* as your chroot environment (Listing 2).

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Udev: Version 2.6 of the kernel and later use Udev for dynamic device management. Udev replaces the legacy devfs filesystem. Chapter 7.4 of the LFS book gives you a detailed introduction to Udev.

FHS: The Filesystem Hierarchy Standard refers to a guideline for setting up a Linux filesystem [7].

Listing 2 also sets the right parameters for your new environment. Now follow the instructions in Chapter 6.5 to create a (**FHS**-compliant) folder structure for the new LFS system.

Now create a couple of required files (see Chapter 6.6), such as */etc/mtab*, */etc/passwd*, and */etc/group*, and a couple of symbolic links to various programs, which other tools require at various positions on the filesystem. Then, install individual packages in the normal way.

Housekeeping

After installing all the packages, you might want to take the opportunity to remove superfluous debugging symbols from all your binaries (Chapter 6.59). This saves another 90MB of space.

Then say goodbye to the temporary working environment (used by the tool chain), which is located in */tools*. To do so, modify the *chroot* command to use the new chroot environment (see Listing 3). Now you also can delete the */tools* directory.

Setting up Boot Scripts

The lfs-bootscripts-6.3 package contains various scripts for starting and stopping the system when you boot or shut down. Some of these scripts are likely to need customization, but most of them will run as is.

To discover more about the correlations between critical components of your Linux system, read Chapter 7, and make sure you add any configuration files that you are missing (for the network for example).

Start Your Engines!

Chapter 8 starts with setting up the */etc/fstab* file, which specifies where, in which order, and with which options the system mounts the partitions.

After editing the file, you can move on to installing the heart of your Linux system: the kernel. All you are missing now is a boot loader. Chapter 8.4 tells you how to configure Grub.

Believe it or not, you are done, and after a bit of clean-up work (Chapter 9.3), you can boot your new LFS system.

Where to Next?

With just a couple of functions and programs, you have successfully used LFS to build a minimal system. Apart from the standard tools, this system does not offer you much.

The BLFS subproject (see the box "Linux From Scratch Resources") shows you how to install further applications on your LFS system to give you a completely customized Linux.

Now you can think about package management – Chapter 6.3 of the LFS manual has a couple of suggestions. If you are interested in adding some protection to your system, check out the HLFS documentation, which is also available from the project website. ■

INFO

[1] LFS project: *http://linuxfromscratch.org*

[2] Software-building HOWTO: *http://www.tldp.org/HOWTO/Software-Building-HOWTO.html*

[3] Linux Users' Guide: *http://www.linuxhq.com/guides/LUG/guide.html*

[4] The essential pre-reading hint: *http://www.linuxfromscratch.org/hints/downloads/files/essential_prereading.txt*

[5] LFS Live CD: *http://www.linuxfromscratch.org/livecd/download.html*

[6] LFS errata list: *http://www.linuxfromscratch.org/lfs/errata/*

[7] FHS: *http://en.wikipedia.org/wiki/Filesystem_Hierarchy_Standard*

THE AUTHOR

Eric Amberg has worked as a system engineer for IT networks in various large corporations for many years. Eric's special fields include Linux and network security. He is also a freelance author and magazine writer. His latest book, *Linux Server with Debian GNU/Linux* [in German], was published in June 2007.