How to Build Linux Kernel From Scratch {Step-By-Step Guide}

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COMMANDS KERNEL LINUX

Contents

Introduction

The Linux Kernel is the foundation of the Unix-like operating systems. The kernel is responsible for communication between hardware and software and the allocation of available resources.

All Linux distributions are based on a predefined kernel. But, if you want to disable several options and drivers or try experimental patches, you need to build a Linux kernel.

In this step-by-step guide, you will learn how to build and compile a Linux kernel from scratch.

Prerequisites

- A system running Linux
- Access to the terminal/command line
- A user account with **sudo/root** privileges
- 12GB of available space on the hard drive

Building Linux Kernel

The process of building a Linux kernel takes seven easy steps to complete. However, the procedure requires a significant amount of time to complete, depending on the system speed.

Follow the steps below to build the latest Linux kernel at the time of writing this article.

Note: If the version on the kernel website does not match the one from the steps below, use these commands and replace the kernel version number.

Step 1: Download the Source Code

1. Visit the official kernel website and download the latest kernel version. The downloaded file contains a compressed source code.

2. Open the terminal and use the wget command to download the Linux kernel source code:

```
wget https://cdn.kernel.org/pub/linux/kernel/v5.x/linux-5.9.6.tar.xz
```

The output shows the “saved” message when the download completes.

```
n@n-VirtualBox:~$ wget https://cdn.kernel.org/pub/linux/kernel/v5.x/linux-5.9.6.tar.xz
--2020-11-06 16:10:11--  https://cdn.kernel.org/pub/linux/kernel/v5.x/linux-5.9.6.tar.x
z
Resolving cdn.kernel.org (cdn.kernel.org)... 199.232.17.176, 2a04:4e42:41::432
Connecting to cdn.kernel.org (cdn.kernel.org)|199.232.17.176|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 115547768 (110M) [application/x-xz]
Saving to: ‘linux-5.9.6.tar.xz’

linux-5.9.6.tar.xz  100%[==================>] 110,19M  34,9MB/s    in 3,2s

2020-11-06 16:10:15 (34,9 MB/s) - ‘linux-5.9.6.tar.xz’ saved [115547768/115547768]

n@n-VirtualBox:~$
```

Step 2: Extract the Source Code

When the file is ready, run the tar command to extract the source code:

```
tar xvf linux-5.9.6.tar.xz
```

```
n@n-VirtualBox:~$ tar xvf linux-5.9.6.tar.xz
linux-5.9.5/virt/kvm/
linux-5.9.5/virt/kvm/Kconfig
linux-5.9.5/virt/kvm/async_pf.c
linux-5.9.5/virt/kvm/async_pf.h
linux-5.9.5/virt/kvm/coalesced_mmio.c
linux-5.9.5/virt/kvm/coalesced_mmio.h
linux-5.9.5/virt/kvm/eventfd.c
linux-5.9.5/virt/kvm/irqchip.c
linux-5.9.5/virt/kvm/kvm_main.c
linux-5.9.5/virt/kvm/vfio.c
linux-5.9.5/virt/kvm/vfio.h
linux-5.9.5/virt/lib/
linux-5.9.5/virt/lib/Kconfig
linux-5.9.5/virt/lib/Makefile
linux-5.9.5/virt/lib/irqbypass.c
n@n-VirtualBox:~$
```

Step 3: Install Required Packages

Install additional packages before building a kernel. To do so, run this command:

```
sudo apt-get install git fakeroot build-essential ncurses-dev xz-utils libssl-dev bc flex libelf-dev bison
```

The command we used above installs the following packages:

Package	Package description
`git`	Tracks and makes a record of all changes during development in the source code. It also allows reverting the changes.
`fakeroot`	Packaging tool that makes the fake root environment.
`build-essential`	Installs development tools such as C, C++, gcc, and g++.
`ncurses-dev`	Programming library that provides API for the text-based terminals.
`xz-utils`	Provides fast file compression and decompression.
`libssl-dev`	Supports SSL and TSL that encrypt data and make the internet connection secure.
`bc` (Basic Calculator)	A mathematical scripting language that supports the interactive execution of statements.

`libelf-dev`	Issues a shared library for managing ELF files (executable files, core dumps and object code)
`bison`	GNU parser generator that converts grammar description to a C program.

```
n@n-VirtualBox:~$ sudo apt-get install git fakeroot build-essential ncurses-dev xz-util
s libssl-dev bc flex libelf-dev bison
Reading package lists... Done
Building dependency tree
Reading state information... Done
Note, selecting 'libncurses-dev' instead of 'ncurses-dev'
bc is already the newest version (1.07.1-2build1).
bc set to manually installed.
11 upgraded, 45 newly installed, 0 to remove and 227 not upgraded.
Need to get 47,7 MB/56,9 MB of archives.
After this operation, 196 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
Setting up build-essential (12.8ubuntu1.1) ...
Processing triggers for libc-bin (2.31-0ubuntu9) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for install-info (6.7.0.dfsg.2-5) ...
n@n-VirtualBox:~$
```

Step 4: Configure Kernel

The Linux kernel source code comes with the default configuration. However, you can adjust it to your needs. To do so, follow the steps below:

1. Navigate to the linux-5.9.6. directory using the **cd** command:

```
cd linux-5.9.6
```

2. Copy the existing configuration file using the **cp** command:

```
cp -v /boot/config-$(uname -r) .config
```

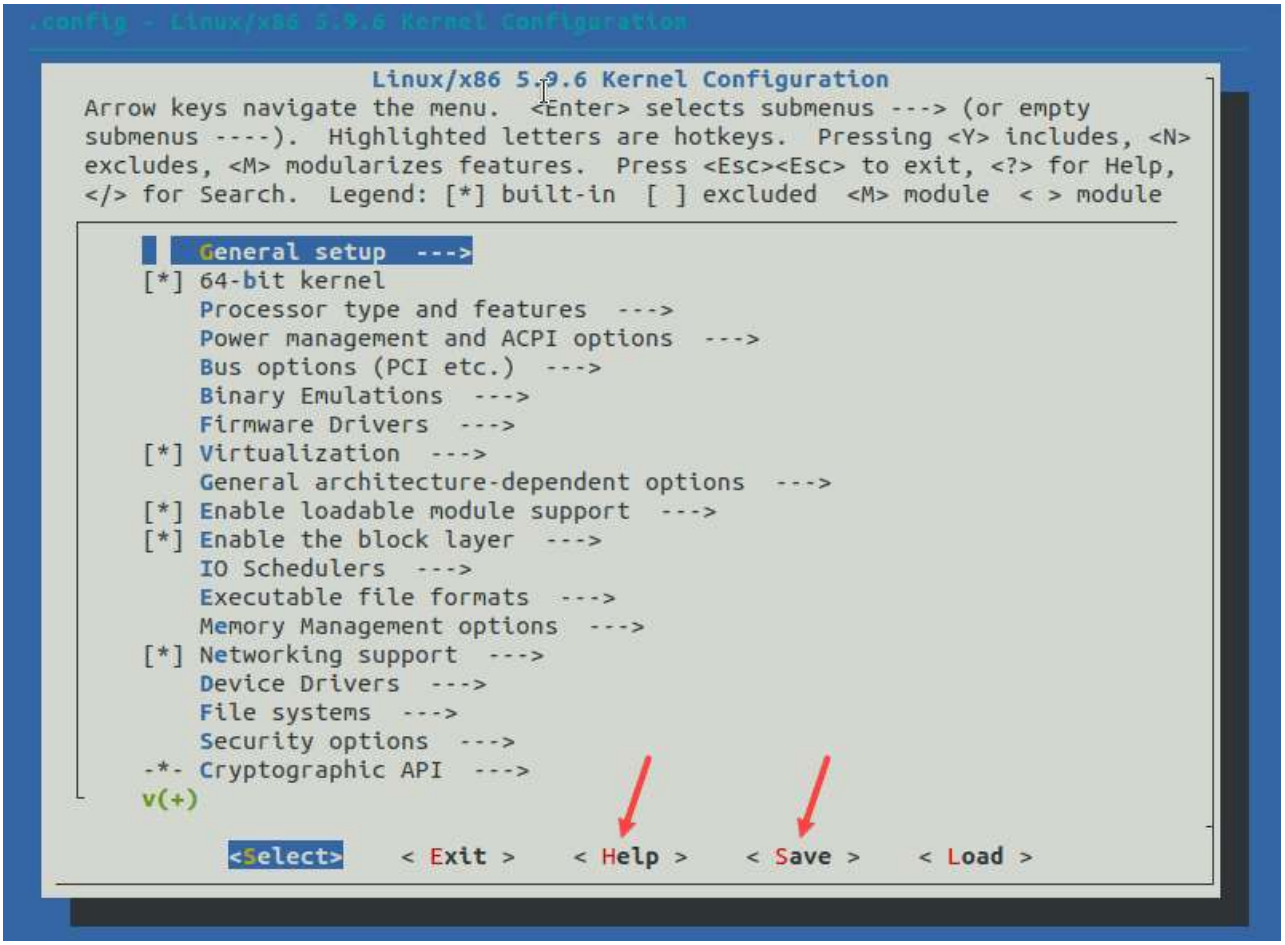
```
n@n-VirtualBox:~$ cd linux-5.9.6
n@n-VirtualBox:~/linux-5.9.6$ cp -v /boot/config-$(uname -r) .config
'/boot/config-5.9.6' -> '.config'
n@n-VirtualBox:~/linux-5.9.6$
```

3. To make changes to the configuration file, run the **make** command:

```
make menuconfig
```

```
n@n-VirtualBox:~/linux-5.9.6$ make menuconfig
  HOSTCC  scripts/basic/fixdep
  UPD     scripts/kconfig/mconf-cfg
  HOSTCC  scripts/kconfig/mconf.o
  HOSTCC  scripts/kconfig/lxdialog/checklist.o
  HOSTCC  scripts/kconfig/lxdialog/inputbox.o
  HOSTCC  scripts/kconfig/lxdialog/menubox.o
  HOSTCC  scripts/kconfig/lxdialog/textbox.o
  HOSTCC  scripts/kconfig/lxdialog/util.o
  HOSTCC  scripts/kconfig/lxdialog/yesno.o
  HOSTCC  scripts/kconfig/confdata.o
  HOSTCC  scripts/kconfig/expr.o
  LEX     scripts/kconfig/lexer.lex.c
  YACC    scripts/kconfig/parser.tab.[ch]
  HOSTCC  scripts/kconfig/lexer.lex.o
  HOSTCC  scripts/kconfig/parser.tab.o
  HOSTCC  scripts/kconfig/preprocess.o
  HOSTCC  scripts/kconfig/symbol.o
  HOSTCC  scripts/kconfig/util.o
  HOSTLD  scripts/kconfig/mconf
```

4. The configuration menu includes options such as firmware, file system, network, and memory settings. Use the arrows to make a selection or choose **HELP** to learn more about the options. When you finish making the changes, select **SAVE,** and then exit the menu.



Note: Changing settings for some options can lead to a non-functional kernel. If you are unsure what to change, leave the default settings.

1. Start building the kernel by running the following command:

```
make
```

The process of building and compiling the Linux kernel takes some time to complete.

The terminal lists all Linux kernel components: memory management, hardware device drivers, filesystem drivers, network drivers, and process management.

```
n@n-VirtualBox:~/linux-5.9.5$ make
  SYSTBL  arch/x86/include/generated/asm/syscalls_32.h
  SYSHDR  arch/x86/include/generated/asm/unistd_32_ia32.h
  SYSHDR  arch/x86/include/generated/asm/unistd_64_x32.h
  SYSTBL  arch/x86/include/generated/asm/syscalls_64.h
  HYPERCALLS arch/x86/include/generated/asm/xen-hypercalls.h
  SYSHDR  arch/x86/include/generated/uapi/asm/unistd_32.h
  SYSHDR  arch/x86/include/generated/uapi/asm/unistd_64.h
  SYSHDR  arch/x86/include/generated/uapi/asm/unistd_x32.h
  HOSTCC  arch/x86/tools/relocs_32.o
  HOSTCC  scripts/selinux/mdp/mdp
  LD [M]  sound/usb/usx2y/snd-usb-usx2y.ko
  CC [M]  sound/x86/snd-hdmi-lpe-audio.mod.o
  LD [M]  sound/x86/snd-hdmi-lpe-audio.ko
  CC [M]  sound/xen/snd_xen_front.mod.o
  LD [M]  sound/xen/snd_xen_front.ko
  GEN     scripts/gdb/linux/constants.py
n@n-VirtualBox:~/linux-5.9.6$
```

2. Install the required modules with this command:

```
sudo make modules_install
```

```
n@n-VirtualBox:~/linux-5.9.6$ sudo make modules_install
  INSTALL sound/usb/line6/snd-usb-line6.ko
  INSTALL sound/usb/line6/snd-usb-pod.ko
  INSTALL sound/usb/line6/snd-usb-podhd.ko
  INSTALL sound/usb/line6/snd-usb-toneport.ko
  INSTALL sound/usb/line6/snd-usb-variax.ko
  INSTALL sound/usb/misc/snd-ua101.ko
  INSTALL sound/usb/snd-usb-audio.ko
  INSTALL sound/usb/snd-usbmidi-lib.ko
  INSTALL sound/usb/usx2y/snd-usb-us122l.ko
  INSTALL sound/usb/usx2y/snd-usb-usx2y.ko
  INSTALL sound/x86/snd-hdmi-lpe-audio.ko
  INSTALL sound/xen/snd_xen_front.ko
  DEPMOD  5.9.6
n@n-VirtualBox:~/linux-5.9.6$
```

3. Finally, install the kernel by typing:

```
sudo make install
```

```
n@n-VirtualBox:~/linux-5.9.6$ sudo make install
sh ./arch/x86/boot/install.sh 5.9.6 arch/x86/boot/bzImage \
        System.map "/boot"
run-parts: executing /etc/kernel/postinst.d/apt-auto-removal 5.9.6 /boot/vmlinuz-5.9.6
run-parts: executing /etc/kernel/postinst.d/dkms 5.9.6 /boot/vmlinuz-5.9.6
 * dkms: running auto installation service for kernel 5.9.6                  [ OK ]
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 5.9.6 /boot/vmlinuz-5.9.6
update-initramfs: Generating /boot/initrd.img-5.9.6
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 5.9.6 /boot/vmlinuz-5.9
.6
run-parts: executing /etc/kernel/postinst.d/update-notifier 5.9.6 /boot/vmlinuz-5.9.6
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 5.9.6 /boot/vmlinuz-5.9.6
Sourcing file `/etc/default/grub'
Sourcing file `/etc/default/grub.d/init-select.cfg'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-5.9.6
Found initrd image: /boot/initrd.img-5.9.6
Found linux image: /boot/vmlinuz-5.4.0-52-generic
Found initrd image: /boot/initrd.img-5.4.0-52-generic
Found linux image: /boot/vmlinuz-5.4.0-42-generic
Found initrd image: /boot/initrd.img-5.4.0-42-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
done
n@n-VirtualBox:~/linux-5.9.6$
```

Step 6: Update the Bootloader (Optional)

The GRUB bootloader is the first program that runs when the system powers on.

The **`make install`** command performs this process automatically, but you can also do it manually.

1. Update the initramfs to the installed kernel version:

```
sudo update-initramfs -c -k 5.9.6
```

2. Update the GRUB bootloader with this command:

```
sudo update-grub
```

The terminal prints out the process and confirmation message:

```
Sourcing file `/etc/default/grub.d/init-select.cfg'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-5.9.6
Found initrd image: /boot/initrd.img-5.9.6
Found linux image: /boot/vmlinuz-5.4.0-52-generic
Found initrd image: /boot/initrd.img-5.4.0-52-generic
Found linux image: /boot/vmlinuz-5.4.0-42-generic
Found initrd image: /boot/initrd.img-5.4.0-42-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
done
```

Step 7: Reboot and Verify Kernel Version

When you complete the steps above, reboot the machine.

When the system boots up, verify the kernel version using the **uname** command:

```
uname -mrs
```

The terminal prints out the current Linux kernel version.

```
n@n-VirtualBox:~$ uname -mrs
Linux 5.9.6 x86_64
n@n-VirtualBox:~$
```

Conclusion

In this step-by-step guide, you learned how to build a Linux kernel from scratch and install the required packages.

If you follow the instructions carefully, the process will complete successfully on your Linux machine.

The Linux kernel has a modular design. Functionality is extendible with modules or drivers. Learn how to use the modprobe command to add or remove modules on Linux.

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