

Filesystem Architecture

Overview of User Home Directories:

1. Each user has a home directory, usually placed under `/home`.
2. The `/root` ("slash-root") directory on modern Linux systems is no more than the home directory of the root user (or superuser, or system administrator account).
3. On multi-user systems, the `/home` directory infrastructure is often mounted as a separate filesystem on its own partition, or even exported (shared) remotely on a network through NFS.

The `/bin` and `/sbin` Directories:

1. The `/bin` directory contains executable binaries, essential commands used to boot the system or in single-user mode, and essential commands required by all system users, such as `cat`, `cp`, `ls`, `mv`, `ps`, and `rm`.
2. Likewise, the `/sbin` directory is intended for essential binaries related to system administration, such as `fsck` and `ip`.
3. Commands that are not essential (theoretically) for the system to boot or operate in single-user mode are placed in the `/usr/bin` and `/usr/sbin` directories.

The `/proc` Filesystem:

1. Certain filesystems, like the one mounted at `/proc`, are called **pseudo-filesystems** because they have no permanent presence anywhere on the disk.
2. The `/proc` filesystem contains virtual files (files that exist only in memory) that permit viewing constantly changing kernel data.
3. `/proc` contains files and directories that mimic kernel structures and configuration information.
4. It does not contain real files, but runtime system information, e.g. system memory, devices mounted, hardware configuration, etc.
5. Some important entries in `/proc` are:
 - `/proc/cpuinfo`
 - `/proc/interrupts`
 - `/proc/meminfo`
 - `/proc/mounts`
 - `/proc/partitions`
 - `/proc/version`
6. `/proc` has subdirectories as well, including:
 - `/proc/<Process-ID-#>`
 - `/proc/sys`
7. The first example shows there is a directory for every process running on the system, which contains vital information about it.
8. The second example shows a virtual directory that contains a lot of information about the entire system, in particular its hardware and configuration.
9. The `/proc` filesystem is very useful because the information it reports is gathered only as needed and never needs storage on the disk.

```
File Virtual Machine Help
Activities Terminal Wed 14:41
student@openSUSE:~
File Edit View Search Terminal Help
student@openSUSE:~> ls /proc
1 15 2210 2393 2557 314 347 497 73 interrupts pagetypeinfo
10 16 2215 2398 262 315 348 5 783 iomem partitions
1027 17 2227 2403 263 316 349 503 8 ioports sched_debug
1036 1721 2280 2408 267 32 35 5413 9 irq schedstat
11 18 2281 2413 27 320 350 5585 acpi kallsyms scsi
1150 1922 2282 2420 2730 322 351 5631 asound kcore self
1152 1937 2283 2432 2745 33 352 5655 buddyinfo keys slabinfo
1161 1944 2291 2438 2783 332 353 58 bus key-users softirqs
1172 1947 2296 2446 2789 333 36 5828 cgroups kmsg stat
1180 1956 23 2451 28 334 37 5832 cmdline kpagecgroup swaps
1195 1969 2305 2454 2800 335 38 5874 config.gz kpagecount sys
1197 2 2310 2457 282 336 387 5901 consoles kpageflags sysrq-trigger
12 20 2312 2459 283 337 39 5908 cpuinfo latency_stats sysvipc
1202 2044 2328 2464 284 338 40 5919 crypto loadavg thread-self
1205 2078 2340 2465 29 339 4074 5920 devices locks timer_list
1216 2087 2343 2467 3 340 4075 60 diskstats meminfo timer_stats
1258 21 2345 2479 30 341 4077 6095 dma misc tty
1261 2119 2350 2495 300 342 414 6102 driver modules uptime
1264 2132 2355 25 307 343 428 6129 execdomains mounts version
1267 22 2362 2528 31 344 43 62 fb mpt vmallocinfo
1270 2201 2372 2531 310 345 44 63 filesystems mtrr vmstat
13 2206 2383 2550 313 346 45 7 fs net zoneinfo
student@openSUSE:~>
To release input, press Ctrl+Alt
```

The /proc Filesystem

The /dev Directory:

1. The **/dev** directory contains device nodes, a type of pseudo-file used by most hardware and software devices, except for network devices.
2. The **/dev** directory follows the below properties
 1. Empty on the disk partition when it is not mounted
 2. Contains entries which are created by the **udev** system, which creates and manages device nodes on Linux, creating them dynamically when devices are found. The **/dev** directory contains items such as:
 - **/dev/sda1** (first partition on the first hard disk)
 - **/dev/lp1** (second printer)
 - **/dev/random** (a source of random numbers).

```

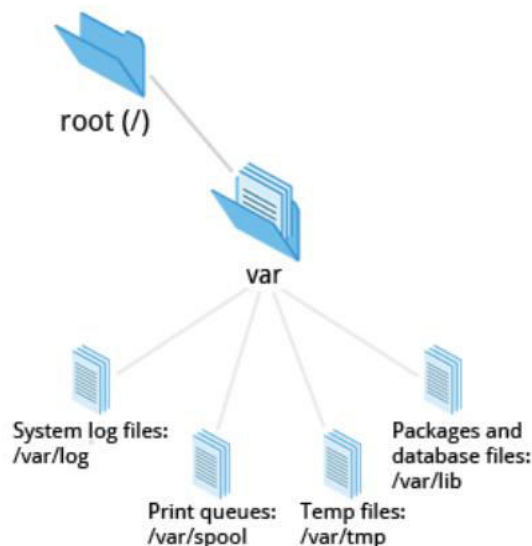
File Edit View Search Terminal Help
c7:/tmp>ls /dev
autofs          dm-5          kmsg           ptmx           sdb7           tty14          tty30          tty47          tty63          vcsa3
block           dm-6          log            ptp0           sequencer      tty15          tty31          tty48          tty7           vcsa4
bsg            dm-7          loop0         pps            sequencer2     tty16          tty32          tty49          tty8           vcsa5
bus            dm-8          loop-control  random         sg0            tty17          tty33          tty5           tty9           vcsa6
char           dm-9          lp0           rtc            sg1            tty18          tty34          tty50          urandom        VG
console        fb0           lp1           rtc0           shm            tty19          tty35          tty51          usb            VG2
core           fd           lp2           sda            snapshot       tty2           tty36          tty52          v4l            vga_arbiter
cpu            full          lp3           sda1           snd            tty20          tty37          tty53          vboxusb        video0
cpu_dma_latency fuse          mapper         sda2           stderr         tty21          tty38          tty54          vcs            vci
disk           hidraw0       mem           sda3           stdin          tty22          tty39          tty55          vcs1           vmmon
dm-0           hidraw1       memory_bandwidth sda4           stdout         tty23          tty4           tty56          vcs2           vmnet0
dm-1           hidraw2       network_latency sda5           tty            tty24          tty40          tty57          vcs3           vmnet1
dm-10          hidraw3       network_throughput sda6           tty0           tty25          tty41          tty58          vcs4           vmnet8
dm-11          hpet          null          sdb            tty1           tty26          tty42          tty59          vcs5           vsock
dm-12          hugepages     nvram         sdb1           tty10          tty27          tty43          tty6           vcs6           zero
dm-2           initctl       pktcdvd       sdb2           tty11          tty28          tty44          tty60          vcsa           vcsa1
dm-3           input         port          sdb5           tty12          tty29          tty45          tty61          vcsa1         vcsa2
dm-4

```

The /dev Directory

The /var Directory:

1. The **/var** directory contains files that are expected to change in size and content as the system is running (var stands for variable), such as the entries in the following directories:
 - System log files: **/var/log**
 - Packages and database files: **/var/lib**
 - Print queues: **/var/spool**
 - Temporary files: **/var/tmp**.
2. The **/var** directory may be put on its own filesystem so that growth of the files can be accommodated and any exploding file sizes do not fatally affect the system.
3. Network services directories such as **/var/ftp** (the FTP service) and **/var/www** (the HTTP web service) are also found under **/var**.



The /var Directory

The /etc Directory:

1. The **/etc** directory is the home for system configuration files. It contains no binary programs, although there are some executable scripts.
2. For example, **/etc/resolv.conf** tells the system where to go on the network to obtain host name to IP address mappings (DNS).
3. Files like **passwd**, **shadow** and **group** for managing user accounts are found in the **/etc** directory.
4. While some distributions have historically had their own extensive infrastructure under **/etc** (for example, Red Hat and SUSE have used **/etc/sysconfig**), with the advent of **systemd** there is much more uniformity among distributions today.
5. Note that **/etc** is for system-wide configuration files and only the superuser can modify files there.
6. User-specific configuration files are always found under their home directory.

The /boot Directory:

1. The **/boot** directory contains the few essential files needed to boot the system.
2. For every alternative kernel installed on the system there are four files. Each of these files has a kernel version appended to its name.
 - **Vmlinuz** - The compressed Linux kernel, required for booting.
 - **Initramfs** - The initial ram filesystem, required for booting, sometimes called **initrd**, not **initramfs**.
 - **Config** - The kernel configuration file, only used for debugging and bookkeeping.
 - **System.map** - Kernel symbol table, only used for debugging.
3. The Grand Unified Bootloader (**GRUB**) files such as **/boot/grub/grub.conf** or **/boot/grub2/grub2.cfg** are also found under the **/boot** directory.

The /lib and /lib64 Directories:

1. **/lib** contains libraries (common code shared by applications and needed for them to run) for the essential programs in **/bin** and **/sbin**.
2. These library filenames either start with **ld** or **lib**. For example, **/lib/libncurses.so.5.9**.

Removable media: the /media, /run and /mnt Directories:

1. One often uses removable media, such as USB drives, CDs and DVDs.
2. To make the material accessible through the regular filesystem, it has to be mounted at a convenient location.
3. Most Linux systems are configured so any removable media are automatically mounted when the system notices something has been plugged in.
4. While historically this was done under the **/media** directory, modern Linux distributions place these mount points under the **/run** directory.
5. For example, a USB pen drive with a label **myusbdrive** for a user named student would be mounted at **/run/media/student/myusbdrive**.
6. The **/mnt** directory has been used since the early days of UNIX for temporarily mounting filesystems.

7. These can be those on removable media, but more often might be network filesystems, which are not normally mounted. Or these can be temporary partitions, or so-called loopback filesystems, which are files which pretend to be partitions.

Additional Directories Under /:

1. There are some additional directories to be found under the root directory:

Directory Name	Usage
<code>/opt</code>	Optional application software packages
<code>/sys</code>	Virtual pseudo-filesystem giving information about the system and the hardware Can be used to alter system parameters and for debugging purposes
<code>/srv</code>	Site-specific data served up by the system Seldom used
<code>/tmp</code>	Temporary files; on some distributions erased across a reboot and/or may actually be a ramdisk in memory
<code>/usr</code>	Multi-user applications, utilities and data

The /usr Directory Tree:

1. The `/usr` directory tree contains theoretically non-essential programs and scripts (in the sense that they should not be needed to initially boot the system) and has at least the following sub-directories:

Directory Name	Usage
<code>/usr/include</code>	Header files used to compile applications
<code>/usr/lib</code>	Libraries for programs in <code>/usr/bin</code> and <code>/usr/sbin</code>
<code>/usr/lib64</code>	64-bit libraries for 64-bit programs in <code>/usr/bin</code> and <code>/usr/sbin</code>
<code>/usr/sbin</code>	Non-essential system binaries, such as system daemons
<code>/usr/share</code>	Shared data used by applications, generally architecture-independent
<code>/usr/src</code>	Source code, usually for the Linux kernel
<code>/usr/local</code>	Data and programs specific to the local machine; subdirectories include <code>bin</code> , <code>sbin</code> , <code>lib</code> , <code>share</code> , <code>include</code> , etc.
<code>/usr/bin</code>	This is the primary directory of executable commands on the system