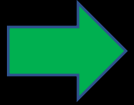


Operating Systems

Lab 02: Exploring the System

Content



Content
<i>ls</i> Command
Manual and Help
File Type and File Content
Linux Filesystem
Symbolic Links and Hard Links

ls Command

- *ls* used to see directory contents and determine a variety of important file and directory attributes.

```
lvl3@lvl3-vm:~/Desktop$ cd ~  
lvl3@lvl3-vm:~$ ls  
Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Videos
```

- Besides the current working directory, we can specify the directory to list, like so:

```
lvl3@lvl3-vm:~$ ls /usr  
bin      include  lib32    libexec  local    share  
games    lib      lib64    libx32   sbin     src
```

ls Command

- We can even specify multiple directories.
 - In the following example, we list both the user's home directory (symbolized by the "~" character) and the /usr directory.

```
lvl3@lvl3-vm:~$ ls ~ /usr
/home/lvl3:
Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Videos

/usr:
bin      include  lib32    libexec  local    share
games   lib      lib64    libx32   sbin     src
```

ls Command

- *ls* has option *-l* to show more details about the files and directories.
 - the *-l* option causes *ls* to display its results in long format.

```
lvl3@lvl3-vm:~$ ls -l
total 32
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Desktop
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Downloads
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Music
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Pictures
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Public
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Templates
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Videos
```

ls Command

```
lvl3@lvl3-vm:~$ ls -l
total 32
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Desktop
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Downloads
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Music
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Pictures
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Public
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Templates
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Videos
```

First value indicates file type. “d” for directory, “-” for a file

ls Command

```
lvl3@lvl3-vm:~$ ls -l
total 32
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Desktop
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Downloads
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Music
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Pictures
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Public
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Templates
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Videos
```

Indicates file permissions. “r” = read, “w” = write, “x” = execute.

Owner	Group	World
rwX	rwX	rwX

ls Command

```
lvl3@lvl3-vm:~$ ls -l
total 32
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Desktop
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Downloads
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Music
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Pictures
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Public
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Templates
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Videos
```

Number of hard links to the file. The link is between the filename and the actual data stored on the filesystem.

ls Command

```
lvl3@lvl3-vm:~$ ls -l
total 32
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Desktop
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Downloads
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Music
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Pictures
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Public
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Templates
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Videos
```

File owner

ls Command

```
lvl3@lvl3-vm:~$ ls -l
total 32
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Desktop
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Downloads
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Music
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Pictures
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Public
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Templates
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Videos
```

File group

ls Command

```
lvl3@lvl3-vm:~$ ls -l
total 32
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Desktop
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Downloads
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Music
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Pictures
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Public
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Templates
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Videos
```

File size in bytes

ls Command

```
lvl3@lvl3-vm:~$ ls -l
total 32
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Desktop
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Downloads
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Music
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Pictures
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Public
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Templates
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Videos
```

Date and time of the file's last modification.

ls Command

```
lvl3@lvl3-vm:~$ ls -l
total 32
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Desktop
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Downloads
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Music
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Pictures
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Public
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Templates
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Videos
```

File name

ls Command

- Commands are often followed by one or more options and arguments that modify their behaviour.

```
command -options arguments
```

- In the following example, the *ls* command is given two options, which are the *l* option to produce long format output, and the *t* option to sort the result by the file's modification time.

```
lvl3@lvl3-vm:~$ touch a.txt
lvl3@lvl3-vm:~$ touch b.txt
lvl3@lvl3-vm:~$ ls -lt
total 32
-rw-rw-r-- 1 lvl3 lvl3    0 00:26 27 فبر b.txt
-rw-rw-r-- 1 lvl3 lvl3    0 00:26 27 فبر a.txt
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Desktop
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Downloads
```

ls Command

- We can use `--reverse` option to reverse the order

```
lvl3@lvl3-vm:~$ ls --reverse
Videos      Public      Music       Documents   b.txt
Templates   Pictures    Downloads   Desktop     a.txt
lvl3@lvl3-vm:~$ ls
a.txt Desktop Downloads Pictures Templates
b.txt Documents Music Public Videos
```

```
lvl3@lvl3-vm:~$ ls -r
Videos      Public      Music       Documents   b.txt
Templates   Pictures    Downloads   Desktop     a.txt
```

- We can use it with `-lt` option:
- Note that command options, like filenames in Linux, are case-sensitive.

```
lvl3@lvl3-vm:~$ ls -lt --reverse
total 32
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Videos
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Templates
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Public
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Pictures
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Music
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Downloads
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4096 17:23 24 فبر Desktop
-rw-rw-r-- 1 lvl3 lvl3  0 00:26 27 فبر a.txt
-rw-rw-r-- 1 lvl3 lvl3  0 00:26 27 فبر b.txt
```


ls Command

- Options for *ls*

Option	Long Option	Description
-a	--all	List all files, even those with names that begin with a period, which are normally not listed (that is, hidden).
-A	--almost-all	Like the -a option above except it does not list . (current directory) and .. (parent directory).
-d	--directory	Ordinarily, if a directory is specified, ls will list the contents of the directory, not the directory itself. Use this option in conjunction with the -l option to see details about the directory rather than its contents.
-F	--classify	This option will append an indicator character to the end of each listed name. For example, a forward slash (/) if the name is a directory.
-h	--human-readable	In long format listings, display file sizes in human readable format rather than in bytes.
-l		Display results in long format.
-r	--reverse	Display the results in reverse order. Normally, ls displays its results in ascending alphabetical order.
-S		Sort results by file size.
-t		Sort by modification time.

ls Command

- *ls -a*

```
lvl3@lvl3-vm:~$ ls -a
.      .bash_history  b.txt    Desktop    .gnupg    Pictures  Templates
..     .bash_logout   .cache   Documents  .local    .profile  Videos
a.txt  .bashrc       .config  Downloads  Music     Public
```

- *ls -A*

```
lvl3@lvl3-vm:~$ ls -A
a.txt      .bashrc  .config  Downloads  Music    Public
.bash_history b.txt    Desktop  .gnupg    Pictures  Templates
.bash_logout .cache   Documents .local     .profile  Videos
```

- *ls -ld*: see details about the directory rather than its contents.

```
lvl3@lvl3-vm:~$ ls -ld
drwxr-xr-x 14 lvl3 lvl3 4096 00:26 27 فبر .
```

ls Command

- *ls -F*

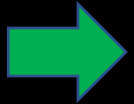
```
lvl3@lvl3-vm:~$ ls -F
a.txt Desktop/ Downloads/ Pictures/ Templates/
b.txt Documents/ Music/ Public/ Videos/
```

- *ls -lh*: to show file size in human readable formats rather than bytes

```
lvl3@lvl3-vm:~$ ls -lh
total 32K
-rw-rw-r-- 1 lvl3 lvl3 0 00:26 27 فبر a.txt
-rw-rw-r-- 1 lvl3 lvl3 0 00:26 27 فبر b.txt
drwxr-xr-x 2 lvl3 lvl3 4.0K 17:23 24 فبر Desktop
drwxr-xr-x 2 lvl3 lvl3 4.0K 00:41 27 فبر Documents
drwxr-xr-x 2 lvl3 lvl3 4.0K 17:23 24 فبر Downloads
drwxr-xr-x 2 lvl3 lvl3 4.0K 17:23 24 فبر Music
drwxr-xr-x 2 lvl3 lvl3 4.0K 17:23 24 فبر Pictures
drwxr-xr-x 2 lvl3 lvl3 4.0K 17:23 24 فبر Public
drwxr-xr-x 2 lvl3 lvl3 4.0K 17:23 24 فبر Templates
drwxr-xr-x 2 lvl3 lvl3 4.0K 17:23 24 فبر Videos
```

Content

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Manual and Help

- Display commands' manual in Linux: *man [command name]*

```
lvl3@lvl3-vm:~$ man ls
```

```
LS(1)                                User Commands                                LS(1)

NAME
    ls - list directory contents

SYNOPSIS
    ls [OPTION]... [FILE]...

DESCRIPTION
    List information about the FILES (the current directory by default).
    Sort entries alphabetically if none of -cftuvSUX nor --sort is specified.

    Mandatory arguments to long options are mandatory for short options too.

    -a, --all
        do not ignore entries starting with .

    -A, --almost-all
        do not list implied . and ..

    --author

Manual page ls(1) line 1 (press h for help or q to quit)
```

Manual and Help

- Display a short help about a command: *help* [*command*]

```
lvl3@lvl3-vm:~$ help pwd
pwd: pwd [-LP]
    Print the name of the current working directory.

Options:
  -L      print the value of $PWD if it names the current working
          directory
  -P      print the physical directory, without any symbolic links

By default, `pwd' behaves as if `-L' were specified.

Exit Status:
Returns 0 unless an invalid option is given or the current directory
cannot be read.
```

Manual and Help

- Display a help about *help* command: *help help*

```
lvl3@lvl3-vm:~$ help help
help: help [-dms] [pattern ...]
    Display information about builtin commands.

Displays brief summaries of builtin commands.  If PATTERN is
specified, gives detailed help on all commands matching PATTERN,
otherwise the list of help topics is printed.

Options:
  -d      output short description for each topic
  -m      display usage in pseudo-manpage format
  -s      output only a short usage synopsis for each topic matching
          PATTERN

Arguments:
  PATTERN  Pattern specifying a help topic

Exit Status:
Returns success unless PATTERN is not found or an invalid option is given.
```

Manual and Help

- Display information about a command: *info* [command]

```
lvl3@lvl3-vm:~$ info cal
```

```
CAL(1) BSD General Commands Manual CAL(1)

NAME
    cal, ncal - displays a calendar and the date of Easter

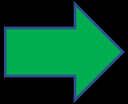
SYNOPSIS
    cal [-31jy] [-A number] [-B number] [-d yyyy-mm] [[month] year]
    cal [-31j] [-A number] [-B number] [-d yyyy-mm] -m month [year]
    ncal [-C] [-31jy] [-A number] [-B number] [-d yyyy-mm] [[month] year]
    ncal [-C] [-31j] [-A number] [-B number] [-d yyyy-mm] -m month [year]
    ncal [-31bhjJpwySM] [-A number] [-B number] [-H yyyy-mm-dd] [-d yyyy-mm]
        [-s country_code] [[month] year]
    ncal [-31bhJeoSM] [-A number] [-B number] [-d yyyy-mm] [year]

DESCRIPTION
    The cal utility displays a simple calendar in traditional format and ncal
    offers an alternative layout, more options and the date of Easter. The
    new format is a little cramped but it makes a year fit on a 25x80 termi-
    nal. If arguments are not specified, the current month is displayed.

    The options are as follows:
```

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File Type and File Content

- Use the *file* command to determine a file's type.

```
file filename
```

```
lvl3@lvl3-vm:~$ file a.jpg
a.jpg: JPEG image data, JFIF standard 1.01, resolution (DPI), density 300x300, segment length 16, Exif Standard: [TIFF image data, little-endian, direntries=1, description=Picturesque morning in Plitvice National Park. Colorful spring scene of green forest with pure ], progressive, precision 8, 612x408, components 3
```

```
lvl3@lvl3-vm:~$ file a.txt
a.txt: empty
```

```
lvl3@lvl3-vm:~$ file a
a: cannot open `a' (No such file or directory)
```

File Type and File Content

- The *less* command is a program to view text files.

```
less filename
```

- The *passwd* file defines all the system's user accounts

- Start the directory with “/”

```
lvl3@lvl3-vm:~$ less etc/passwd
etc/passwd: No such file or directory
lvl3@lvl3-vm:~$ less /etc/passwd
```

- To exit less, press the q key.

File Type and File Content

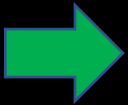
- The *more* command like *less* command, but it shows fewer data
 - Press enter to show more data.

```
lvl3@lvl3-vm:~$ more /etc/passwd
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
bin:x:2:2:bin:/bin:/usr/sbin/nologin
sys:x:3:3:sys:/dev:/usr/sbin/nologin
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/usr/sbin/nologin
man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
lp:x:7:7:lp:/var/spool/lpd:/usr/sbin/nologin
mail:x:8:8:mail:/var/mail:/usr/sbin/nologin
```

- The *less* command shows all the data, but you need to scroll.
- When exiting *more* command, the text remains in the console, but when exiting *less* command the text disappears from console.

Content

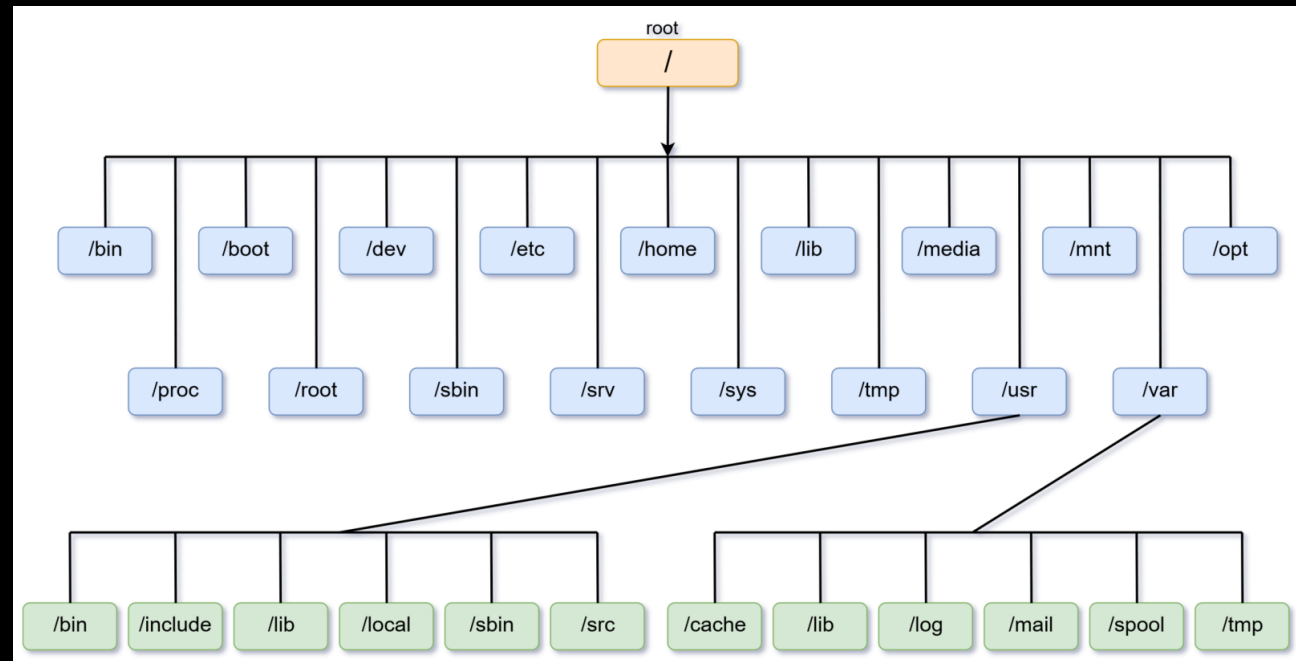
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Linux Filesystem

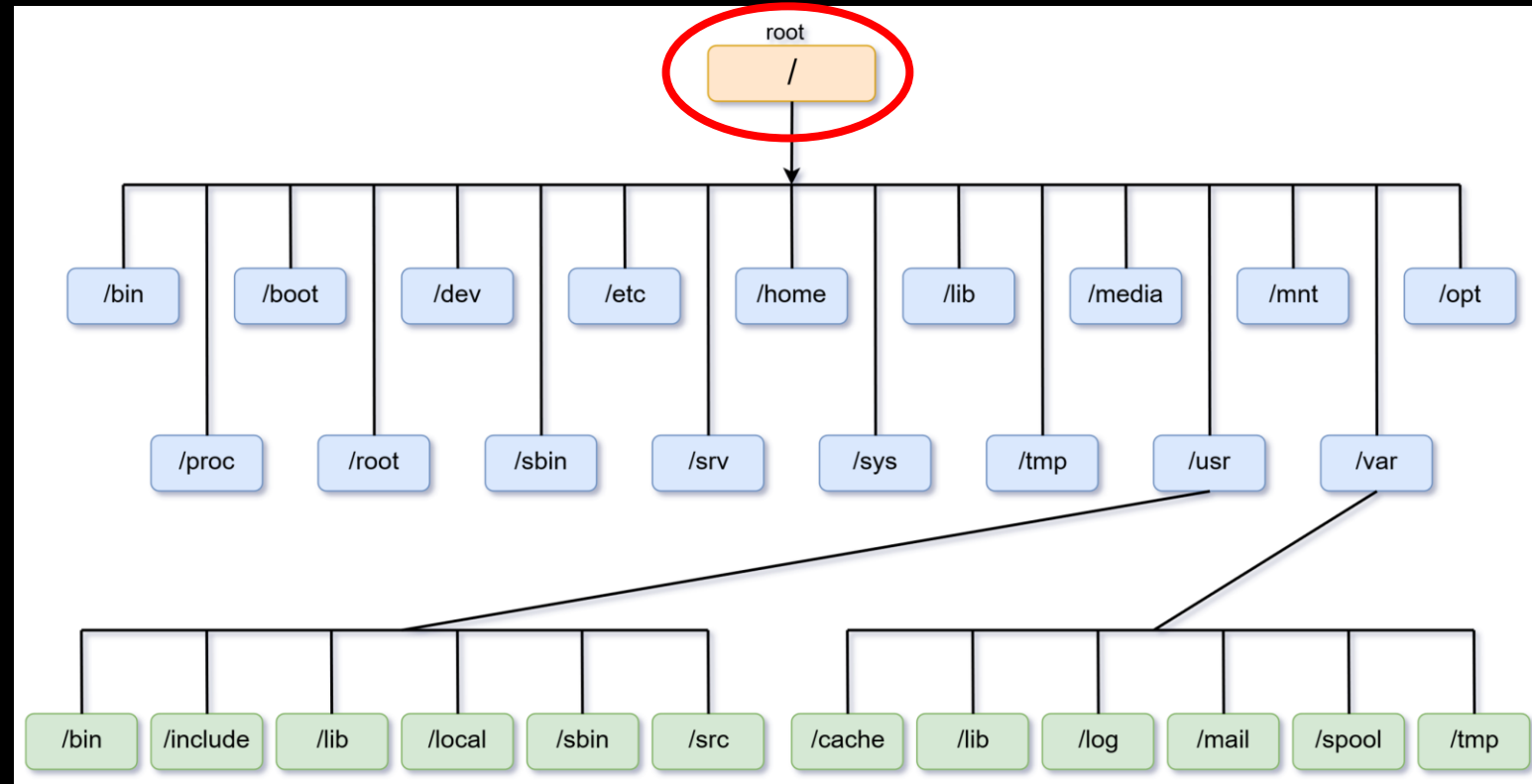
- Linux file system is a built-in layer of a Linux used to handle the data management of the storage. It helps to arrange the file on the disk storage.
 - It manages the file name, file size, creation date, and much more information about a file.

```
lvl3@lvl3-vm:~/Desktop$ cd /  
lvl3@lvl3-vm:/$ ls  
bin      dev      lib      libx32  mnt      root     snap     sys      var  
boot     etc      lib32    lost+found  opt      run      srv      tmp  
cdrom    home     lib64    media    proc     sbin     swapfile usr
```



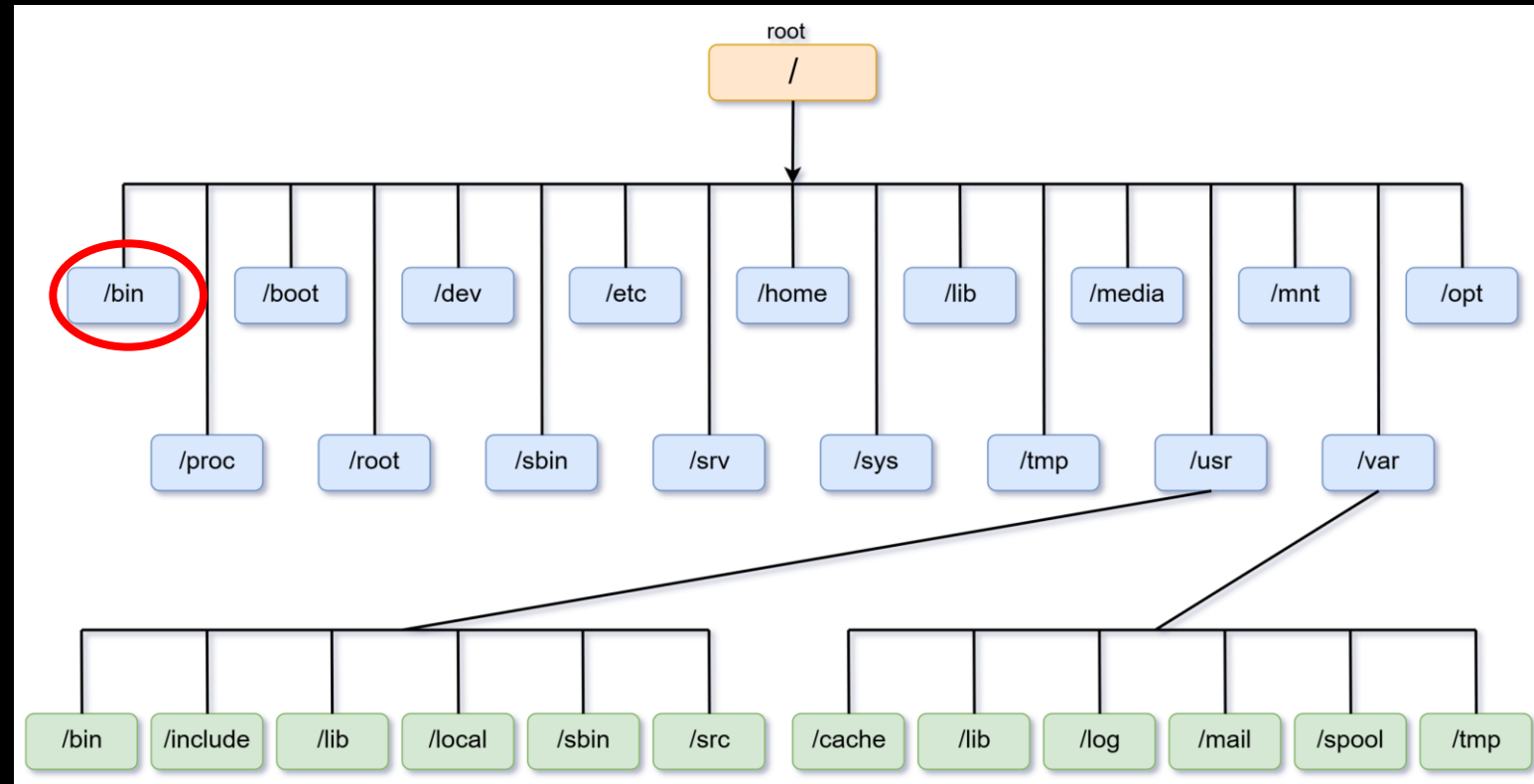
Linux Filesystem

- The root directory.
Where everything begins.



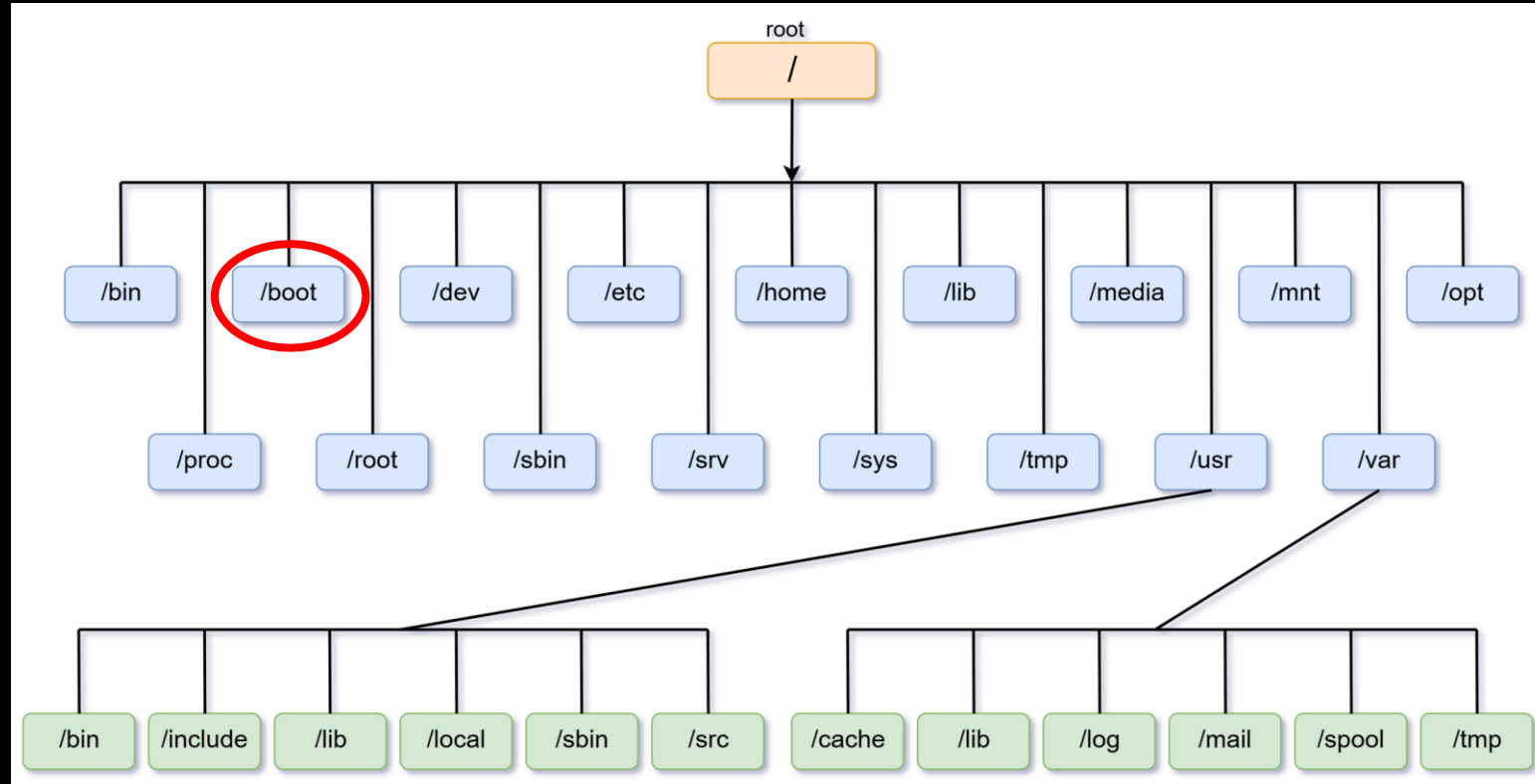
Linux Filesystem

- Contains binaries (programs) that must be present for the system to boot and run.



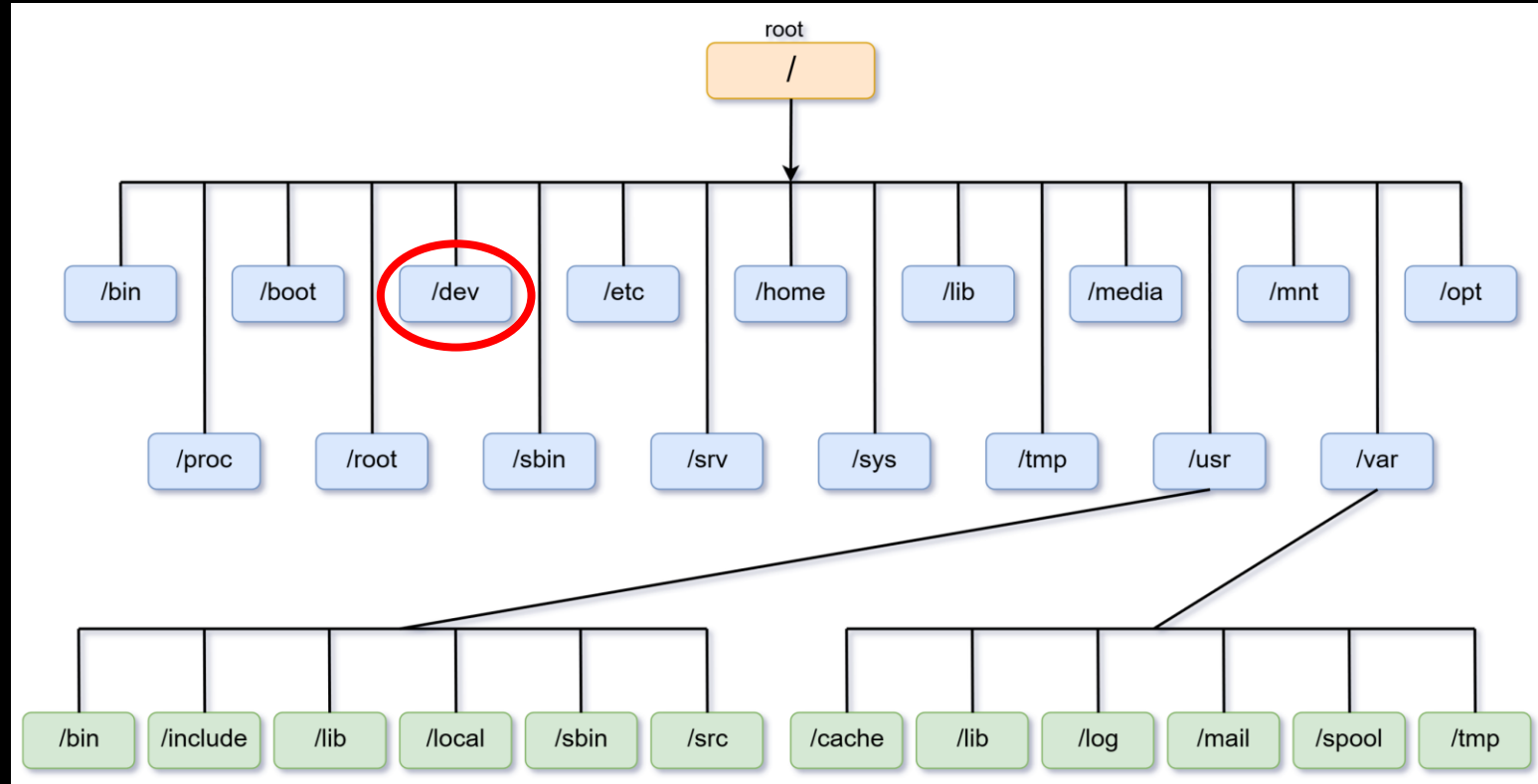
Linux Filesystem

- Contains the Linux kernel, initial RAM disk image and the boot loader.
- Interesting files:
 - /boot/grub/grub.conf or menu.lst, which are used to configure the boot loader.
 - /boot/vmlinuz the Linux kernel



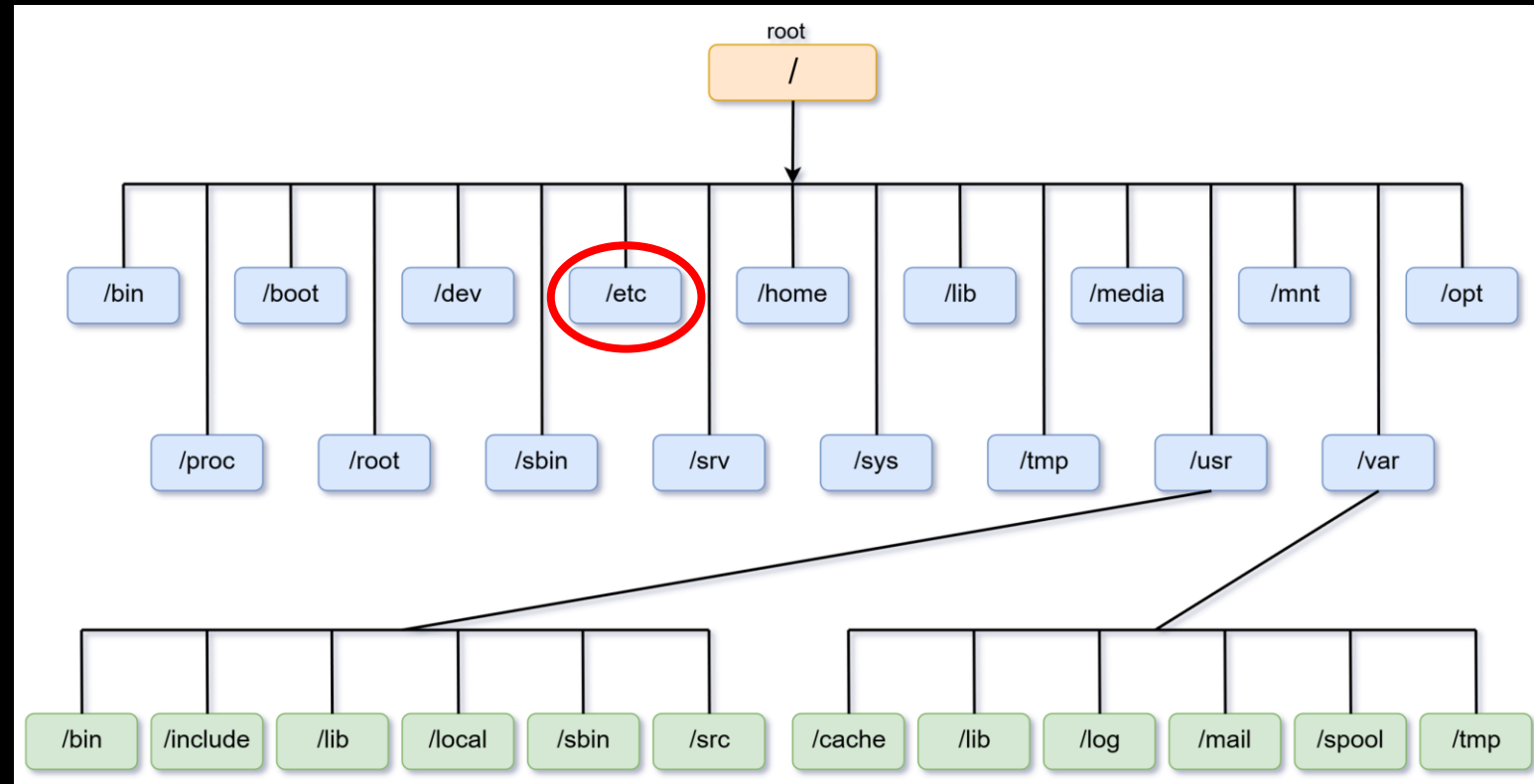
Linux Filesystem

- This is a special directory that contains device nodes.
- “Everything is a file” also applies to devices.
- Here is where the kernel maintains a list of all the devices it understands.



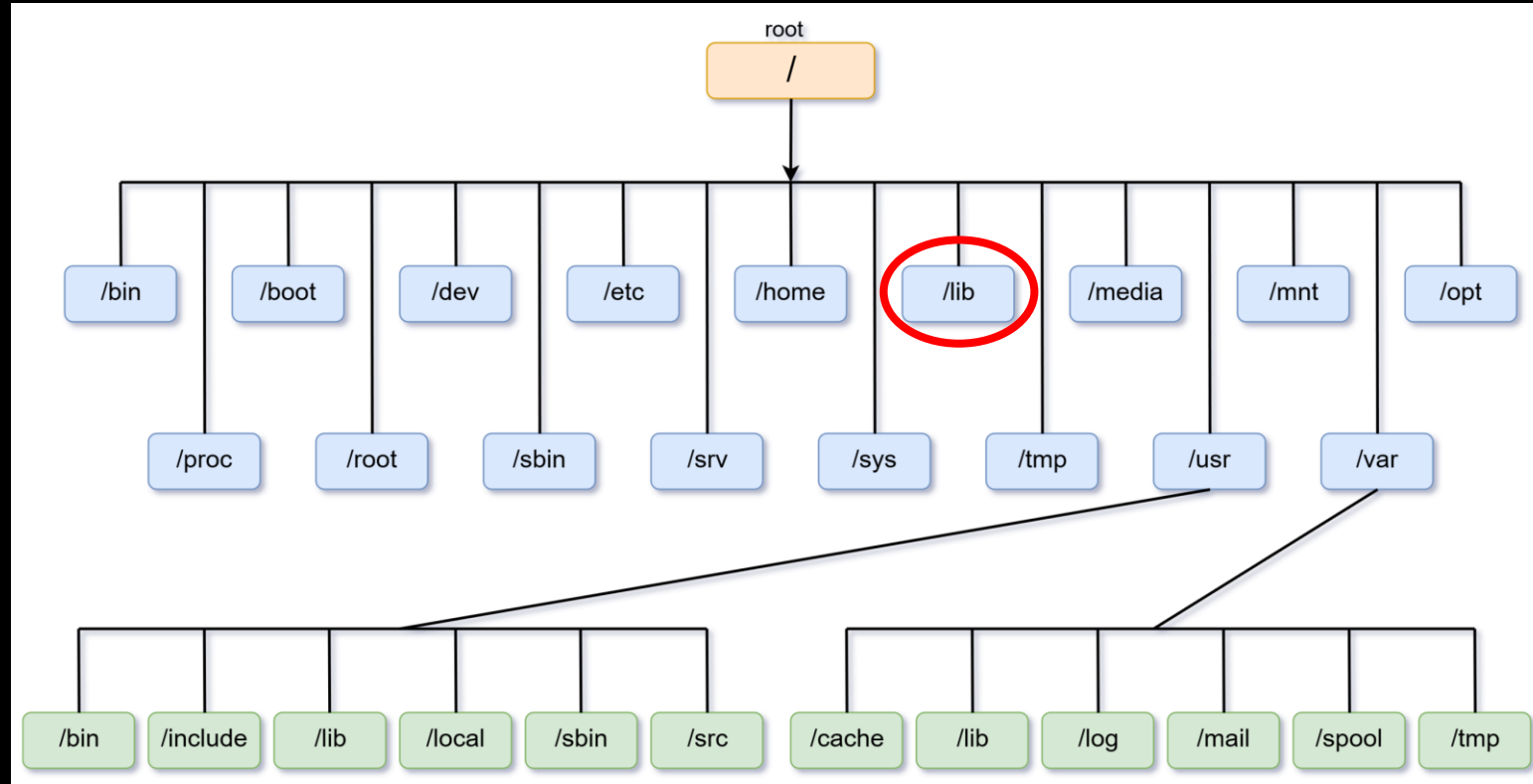
Linux Filesystem

- Contains:
 - Configuration files.
 - Shell scripts that start the system services at boot time.
- Interesting files:
 - `/etc/passwd`, a list of the user accounts.



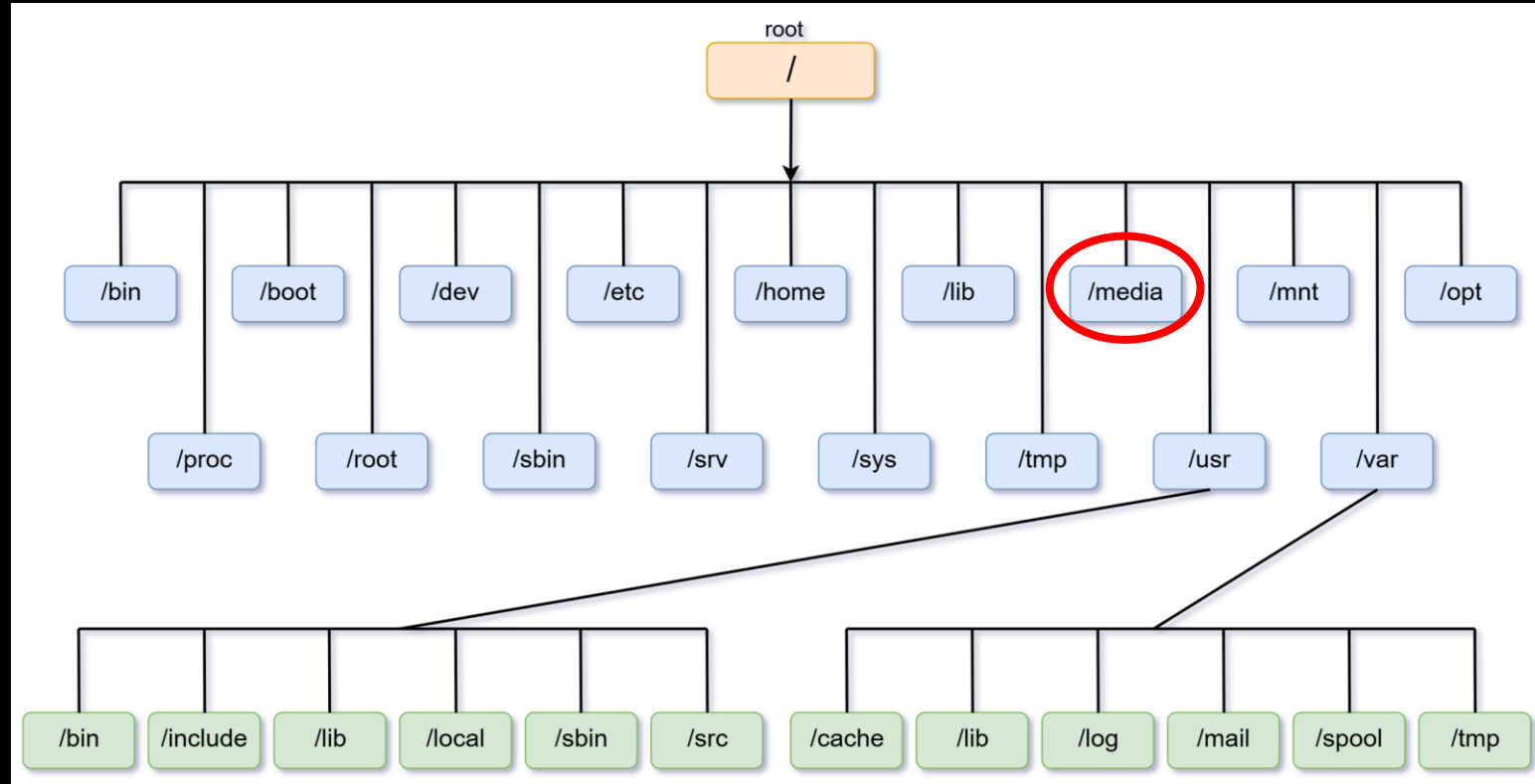
Linux Filesystem

- Contains shared library files used by the core system programs.
 - These are similar to dynamic link libraries (DLLs) in Windows.



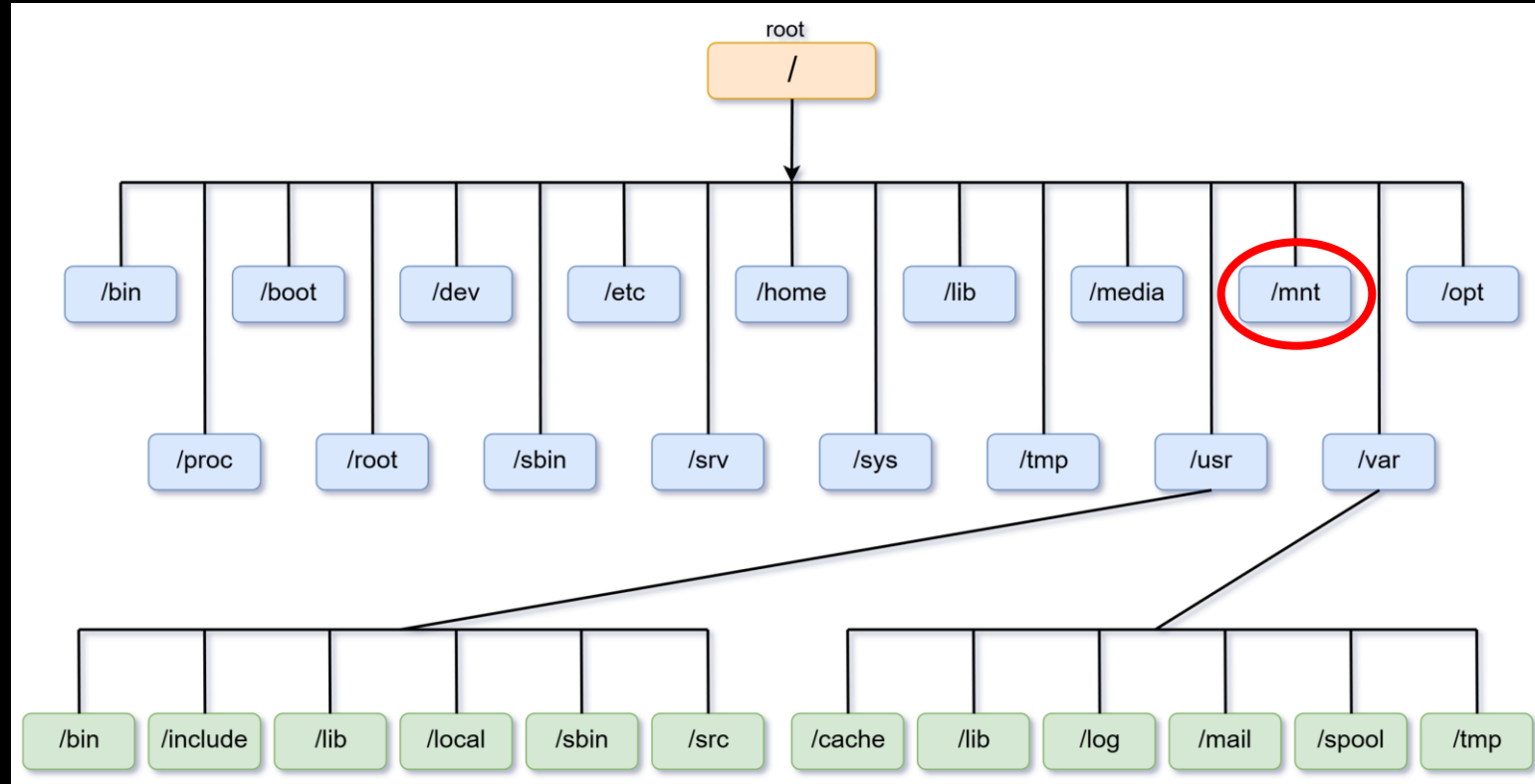
Linux Filesystem

- Contain the mount points for removable media such as USB drives, CD-ROMs, etc. that are mounted **automatically** at insertion.
 - Used in modern Linux systems.



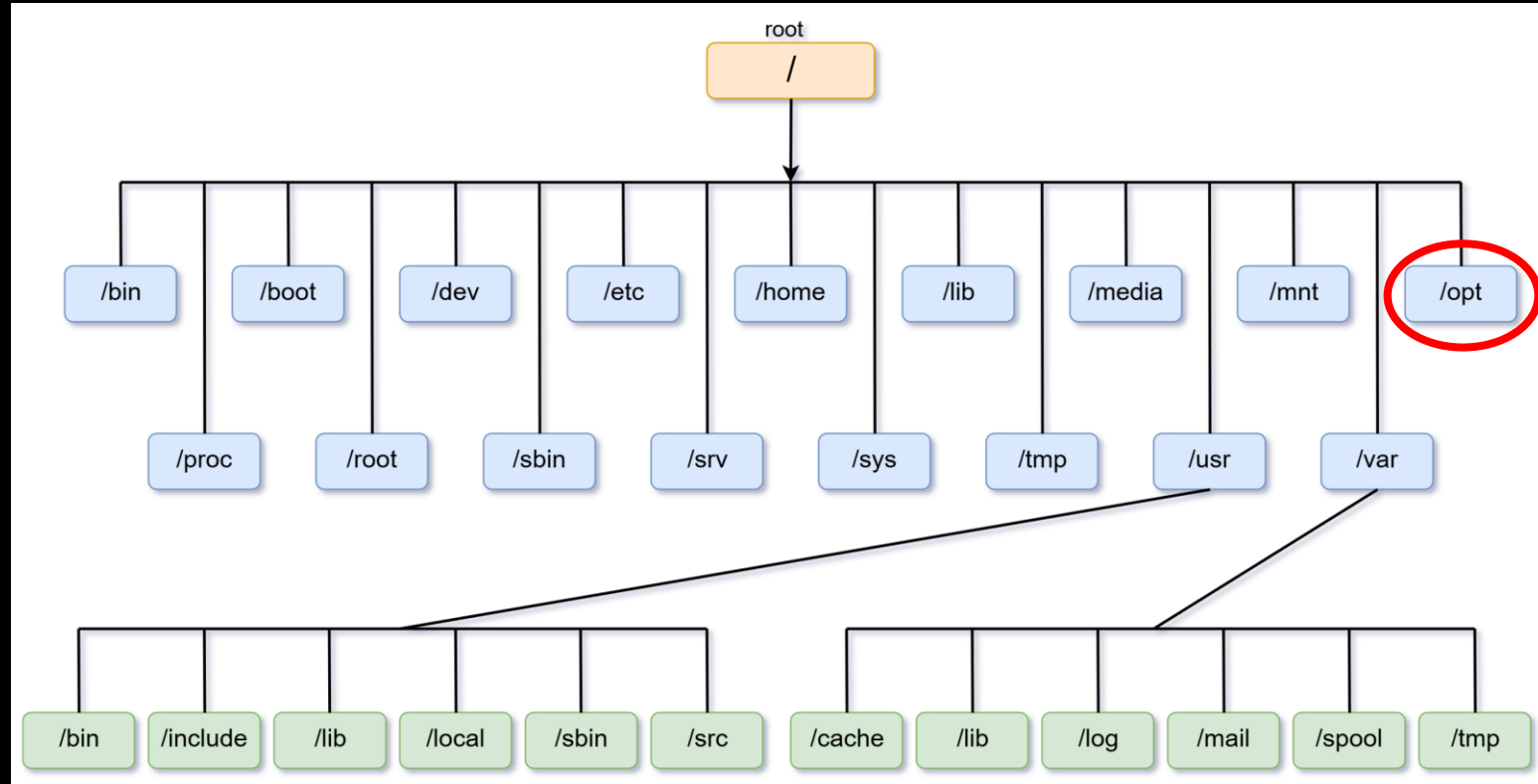
Linux Filesystem

- Contains mount points for removable devices that have been mounted **manually**.
 - Used in older Linux systems.



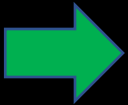
Linux Filesystem

- Used to install “optional” software.
- This is mainly used to hold commercial software products that might be installed on the system.



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Symbolic Links and Hard Links



Symbolic Links and Hard Links

- **Symbolic link (soft link)** is a type of file in Linux that points to another file or a folder on your computer.
 - Similar to shortcuts in Windows
- Let's explore the attributes of /lib directory

```
lvl3@lvl3-vm:/$ ls -l /lib  
lrwxrwxrwx 1 root root 7 16:58 24 فبر /lib -> usr/lib
```

- The first letter is “l”, not “d” or “-”. This means that it is a symbolic link.
- The last value indicates that the file “/lib” points to a shared directory “/usr/lib”.

Symbolic Links and Hard Links

- **Why use symbolic links?** (<https://stackoverflow.com/questions/58314491/what-is-the-purpose-of-creating-a-symbolic-link-between-files>)
 - This allows you to have multiple "access points" to a file, without having excess copies (that remain up to date, since they always access the same file).
- Imagine this scenario: suppose that there is a shared file "foo 1" that accessed by many processes/users. This file always updated.
 - When updating the file to version "foo 2", we need to change every process that access the file.
 - But, when we use symbolic links, we create a symbol link "foo" that points to "foo 1". The process/users now refer to the symbolic link "foo" that points to "foo 1".
 - When we update "foo 1" to "foo 2", we change its symbolic link only to point to "foo 2", the processes/users don't need to change the filename.
 - Also, it is easier to revert to the older version.

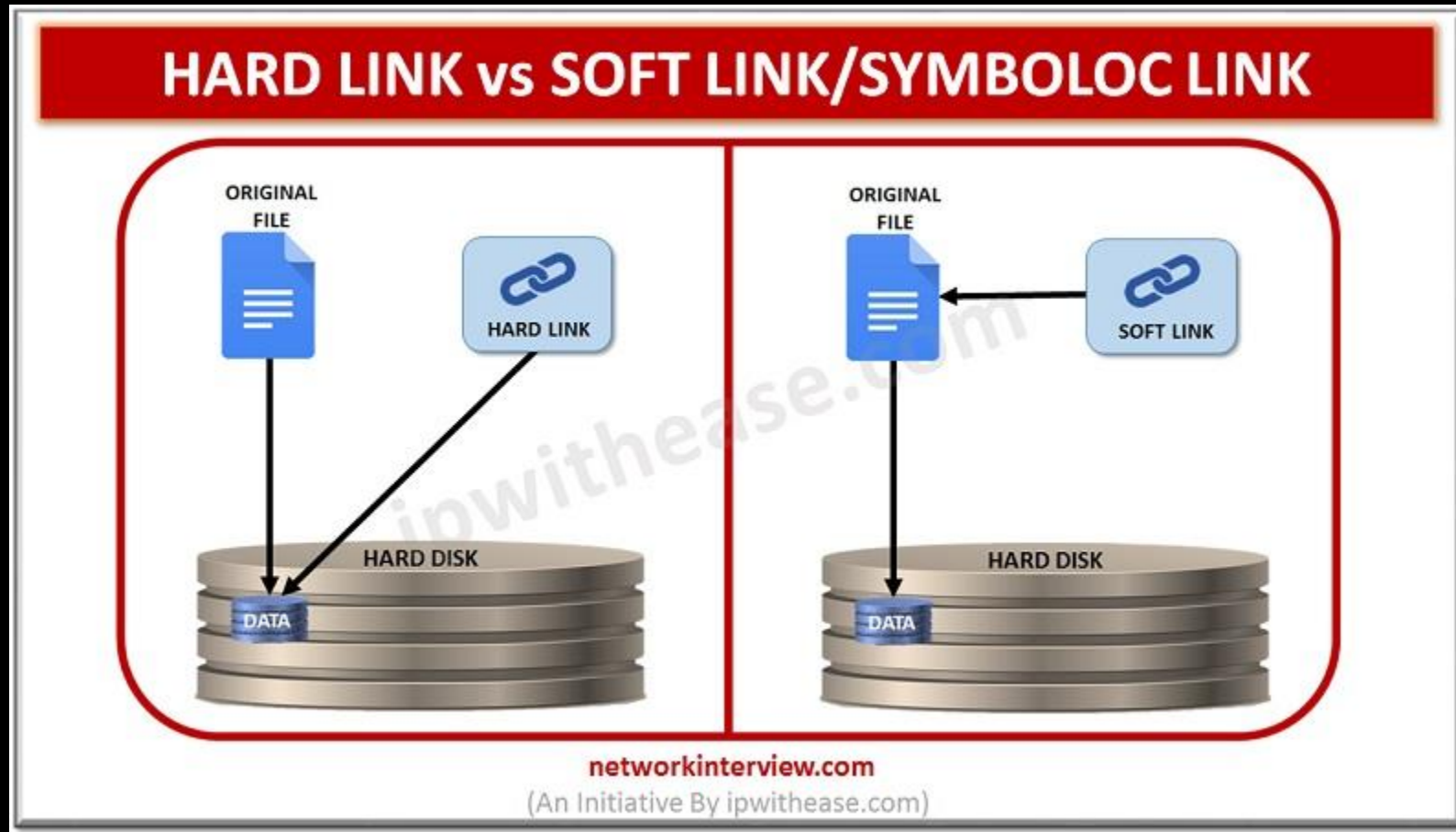
Symbolic Links and Hard Links

- A hard link is a file all its own, and the file references or points to the exact spot on a hard drive where the node stores the data.
- By default, every file has a single hard link that gives the file its name.
 - When we create a hard link, we create an additional directory entry for a file.
- When a hard link is deleted, the link is removed but the contents of the file itself continue to exist (that is, its space is not deallocated) until all links to the file are deleted.

Symbolic Links and Hard Links

- Imagine this scenario: we have a file “foo 1” that points to a location on the hard drive, where the data is stored.
 - When you open the file and change it, the data on the hard are changed too.
 - When we create a hard link to “foo”, we create a new file (“foo 2”) that points the same location of “foo 1” (the same content)
 - A change in the content of a file through any hard link, applies to the other hard link.

Symbolic Links and Hard Links



Exercise

- Open the manual of *ls* command
- What is “--color” option. How it works?
- How list the files without listing the owner?
- Print the index number of each file on the hard disk.
- What is the difference between *-r* and *-R* options.

Exercise

- Open the manual of *ls* command
 - *man ls*
- What is “--color” option. How it works?
 - Colorize the output; *ls --color = 'never'; ls --color = 'auto'*
- How list the files without listing the owner?
 - *ls -g*
- Print the index number of each file on the hard disk.
 - *ls -i*
- What is the difference between *-r* and *-R* options.
 - *-r* displays the files in reverse order, *-R* recursively displays directories and its content.

Summary

- *ls* with options
- *help*
- *info*
- *man*
- *file*
- *less*
- *more*

TASK

- List files by sorting them by file size.
- Display the calendar without highlighting of today.
- Display the calendar of May and October months.
- How to print the size of the current directory?
- What the command “*du ~ -h*” does?