

# LINUX FUNDAMENTALS

# OVERVIEW

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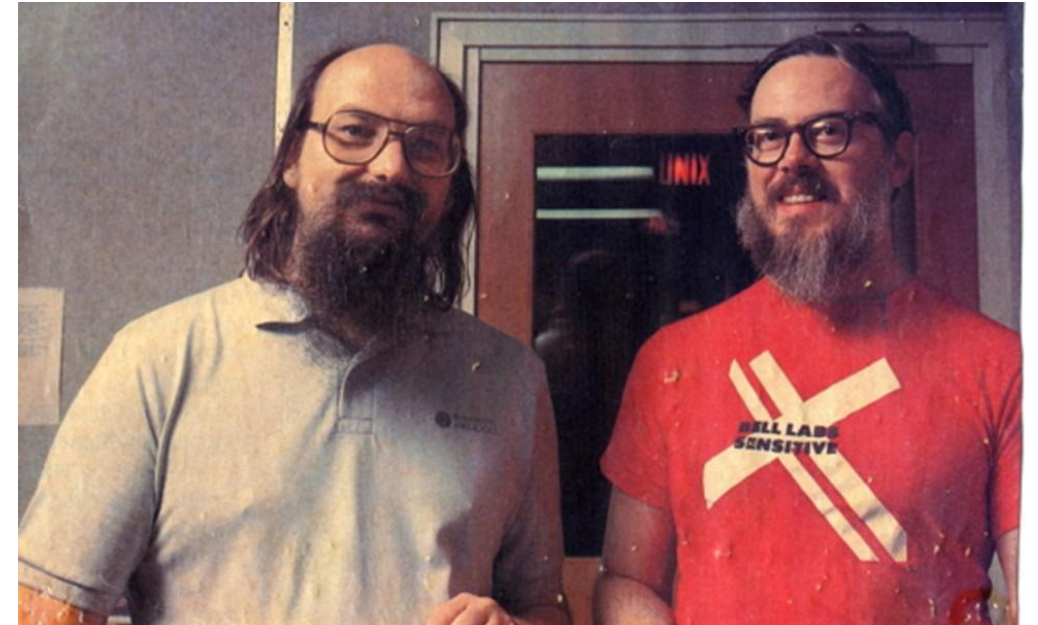
File Permissions

# History of Linux

- Before talking of Linux, we first have to go back in time to learn about another name, which is Unix.

## 1969 -Ken Thompson and Dennis Ritchie

- Unix is an operating system that has been around for a long time, at AT&T Bell Labs. The project was led by Ken Thompson and Dennis Ritchie, two famous computer scientists.
- **Motivation**-That time there were very few operating systems those that were available often highly specific to particular hardware architectures.
- Unix is multi-tasking, multi-user operating system but is not free to use and is not open source.



## 1983-Richard Stallman ,GNU (GNU's Not Unix) project

- Main Goal-create a free, Unix-like operating system, where people have the freedom to copy, develop, modify and distribute software

## Linus and Linux

- Linus Torvalds, he was a computer science at the university of Helsinki, he wanted to make a free and open source operating system that anyone could use and improve .

## 1991

- Finally Linus Torvalds introduced a personal product, which later became the Linux Kernel.
- The combination of the Linux kernel and the GNU(**GNU's Not Unix**) software created the first completely free operating system. It is named **GNU/Linux**.



## Important things of Linux

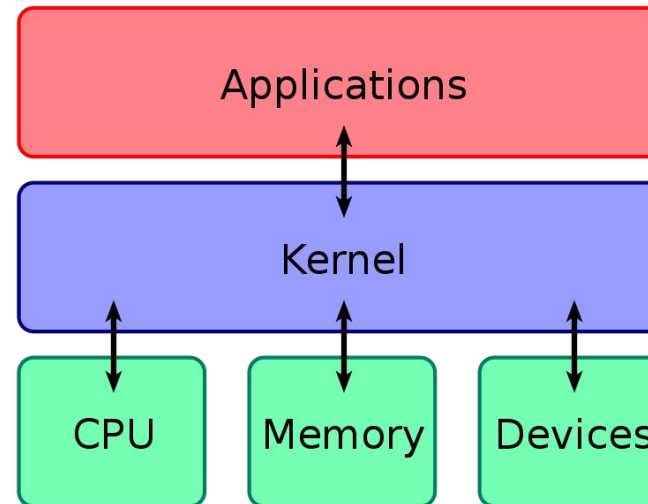
- Linux itself is just a kernel, it is not a complete operating system.
- 
- The operating system that we still using on our computer is called GNU / Linux,
- Linux operating system does not use or share any part of Unix,It was built entirely new by Linus and the GNU Project .

# What is Kernel

A kernel is the core component of an operating system. It is also a system program. It is the part of Operating System which translates the application commands in to hardware command

It provides an interface between application and hardware.

The main purpose of a kernel is to manage memory, disk and task.



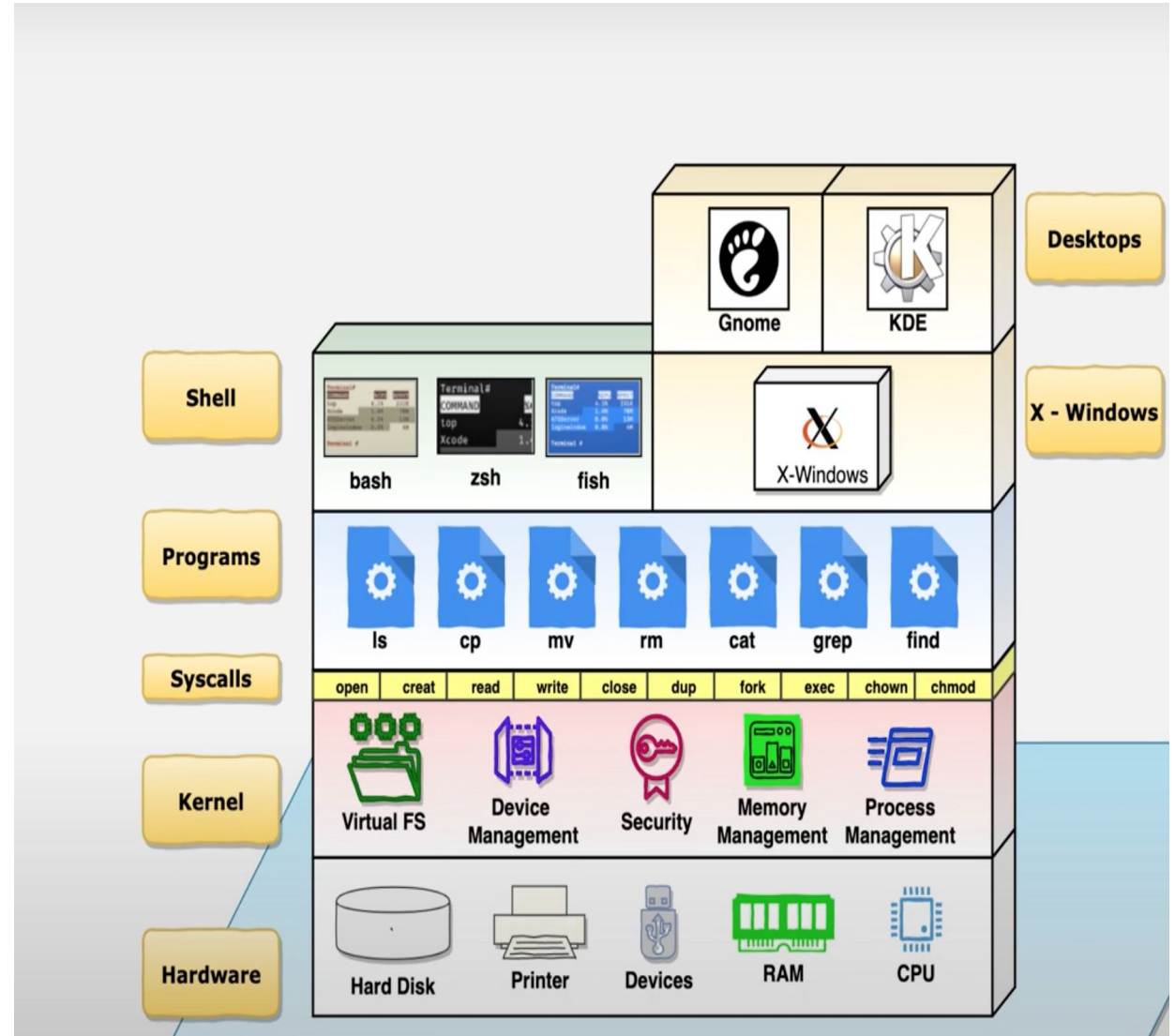
# Linux System Architecture

Divided in to two levels

- User space
- Kernel space

user space is the area of memory where applications and user-level programs run. It contains the code and data that are executed by user-level processes, and it provides access to system resources through **system calls**.

Kernel space It is responsible for managing hardware resources and providing services to user-level programs through **system calls**.



system calls-It is a **request for the kernel to access a resource**

open() - opens a file and returns a file descriptor

read() - reads data from a file descriptor

write() - writes data

close() - closes a file descriptor

System calls provide an interface between the user-level application and the kernel

Programs-This includes the user application and utilities(commands that are used to perform various tasks on the system)

Shell-This is a program that provides a command-line interface for users to interact with the operating system

Gnome-It is a desktop environment in Linux. It is a graphical user interface (GUI) that provides an user-friendly interface for users to interact with the operating system



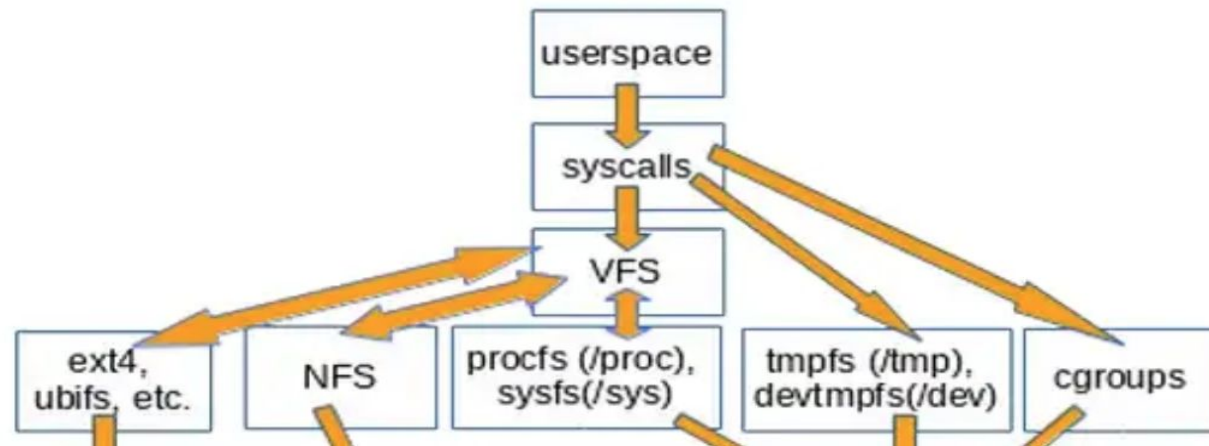
When a user types a command like **cat example.txt** in the terminal, the shell decodes the command and uses **system calls** to send this to kernel, In this case, the shell would use the **open() ,read() ,write() and close()** system calls to perform this task(**cat example.txt**)

# Linux File System

In Linux, a file system is a way of organizing and storing files and folders on a storage device such as hard disk drive (HDD) .

Linux abstracts file systems operations through the Virtual File System (VFS),This provides a standard way of interacting with different file systems

It provides a uniform view of the file system to user applications.



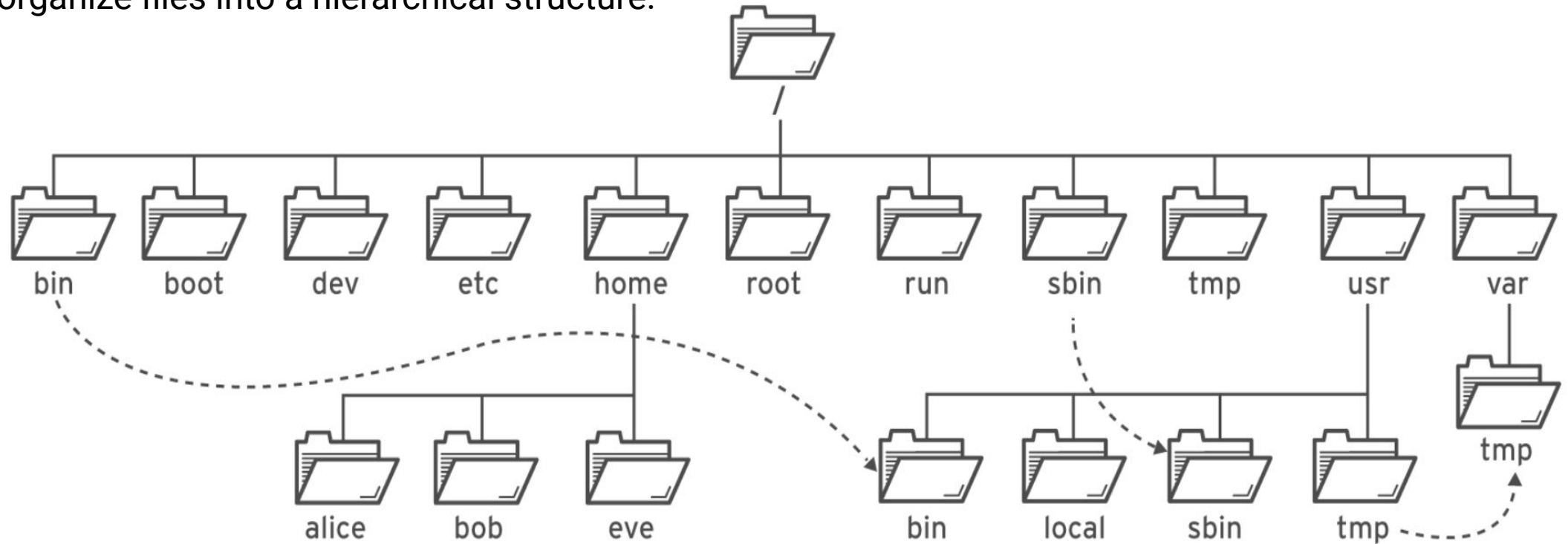
So a user program which uses the **write()** **syscall** doesn't execute a **syscall** in the kernel immediately, the VFS handles the request to the appropriate file system based on the file descriptor,

Each file system has its own features and limitations, and the choice of file system depends on factors such as the type of storage device

- Ext
- Ext2
- Ext3
- Ext4
- JFS
- XFS
- btrfs
- swap

# Folder/Directory Structure

In Linux, a folder is a special type of file that is used to organize files into a hierarchical structure.



- (/) folder: also known as the root directory, is the top-level directory in the file system hierarchy. All other directories and files in the file system are located within the root directory or one of its subdirectories

```
mercy@mercy:/$ cd /
mercy@mercy:/$ ls
bin  dev  home  lib32  libx32  media  opt  root  sbin  srv  sys  usr
boot  etc  lib  lib64  lost+found  mnt  proc  run  snap  swap.img  tmp  var
mercy@mercy:/$
```

**/bin** : binary files and executable programs that are required for basic system functionality, such as the **shell** (**ls, cp, mkdir, rm** and **etc**) commands.

```
root@mercy:/bin# ls l*
landscape-sysinfo  lessfile          linux-version     loginctl          lsipc             lzcmp
last               lesskey           ln                logname           lslocks           lzdiff
lastb             lesspipe          lnstat            look              lslogins          lzegrep
lastlog           lexgrog           loadkeys          lowntfs-3g        lsmem             lzfgrep
lcf               libnetcfg         loadunimap        ls                 lsmod             lzgrep
ld                link              locale            lsattr            lsns              lzless
ld.bfd            linux32           locale-check      lsblk             lsof              lzma
ldd               linux64           localectl         lsb_release       lspci             lzmainfo
ld.gold           linux-boot-prober localedef          lscpu             lspgpot           lzmore
less              linux-check-removal  logger           lshw              lsusb
lessecho          linux-update-symlinks  login            lsinitramfs       lzcat
```

- **/boot** : contains files required for booting the system, including the kernel, initial ramdisk, and boot loader configuration files..

```
root@mercy:/boot# ls
config-5.15.0-69-generic  initrd.img-5.15.0-69-generic  System.map-5.15.0-69-generic  vmlinuz.old
grub                    initrd.img.old                vmlinuz
initrd.img             lost+found                    vmlinuz-5.15.0-69-generic
```

- **/dev** : contains device files that represent physical and virtual devices connected to the system, such as disks, terminals, and printers.

```
mercy@mercy:/tmp$ cd ../dev
mercy@mercy:/dev$ ls
autofs          hugepages      port           stdin          tty27         tty49         ttyS11        ttyS5         vcsa4
block          hwrng         ppp           stdout         tty28         tty5          ttyS12        ttyS6         vcsa5
bsg            i2c-0         psaux         test           tty29         tty50         ttyS13        ttyS7         vcsa6
btrfs-control  initctl       ptmx          tty           tty3          tty51         ttyS14        ttyS8         vcsu
bus            input         pts           tty0          tty30         tty52         ttyS15        ttyS9         vcsu1
cdrom          kmsg         random        tty1          tty31         tty53         ttyS16        ubuntu-vg    vcsu2
char           kvm           rfkill        tty10         tty32         tty54         ttyS17        udmabuf      vcsu3
console        log           rtc           tty11         tty33         tty55         ttyS18        uhid         vcsu4
core           loop0         rtc0          tty12         tty34         tty56         ttyS19        uinput       vcsu5
cpu            loop1         sda           tty13         tty35         tty57         ttyS2         urandom      vcsu6
cpu_dma_latency loop2         sda1         tty14         tty36         tty58         ttyS20        userio       vfio
cuse           loop3         sda2         tty15         tty37         tty59         ttyS21        vboxguest   vga_arbiter
disk           loop4         sda3         tty16         tty38         tty6          ttyS22        vboxuser    vhci
dm-0           loop5         sdb           tty17         tty39         tty60         ttyS23        vcs         vhost-net
dm-1           loop6         sdb1         tty18         tty4          tty61         ttyS24        vcs1         vhost-vsock
dma_heap       loop7         sdb2         tty19         tty40         tty62         ttyS25        vcs2         zero
dri            loop-control sg0           tty2          tty41         tty63         ttyS26        vcs3         zfs
ecryptfs       mapper        sg1           tty20         tty42         tty7          ttyS27        vcs4
fb0            mcelog        sg2           tty21         tty43         tty8          ttyS28        vcs5
fd             mem           shm           tty22         tty44         tty9          ttyS29        vcs6
full           mqueue       snapshot     tty23         tty45         ttyprintk    ttyS3         vcsa
fuse           net           snd           tty24         tty46         ttyS0         ttyS30        vcsa1
hidraw0        null          sr0           tty25         tty47         ttyS1         ttyS31        vcsa2
hpet           nvram         stderr        tty26         tty48         ttyS10        ttyS4         vcsa3
```

- **/etc** : Most important system configuration files are in /etc, this directory contains data similar to those in the Control Panel in Windows.

```

alternatives          fuupd                login.defs            passwd                subgid
apparmor              gai.conf             logrotate.conf       passwd-              subgid-
apparmor.d            groff                logrotate.d           perl                 subuid
appport               group               lsb-release           pki                  subuid-
apt                   group-              lvm                   pm                    sudo.conf
bash.bashrc           grub.d              machine-id            polkit-1             sudoers
bash_completion       gshadow             magic                 pollinate            sudoers.d
bash_completion.d     gshadow-            magic.mime            profile              sudo_logsrvd.conf
bindresvport.blacklist gss                  manpath.config       profile.d            sysctl.conf
binfmt.d              hdparm.conf         mdadm                 mime.types           sysctl.d
byobu                  host.conf           mke2fs.conf          ModemManager        systemd
ca-certificates       hostname            modprobe.d           modules              terminfo
ca-certificates.conf hosts                 modules-load.d       nanorc               thermald
cloud                  hosts.allow         modules               network               timezone
console-setup         hosts.deny          mtab                  netconfig            tmpfiles.d
cron.d                 init.d              multipath             netplan              ubuntu-advantage
cron.daily             initramfs-tools    multipath.conf       networkd-dispatcher ucf.conf
cron.hourly           inputrc             multipath             NetworkManager      udev
cron.monthly          iproute2            nanorc               networks             udisks2
crontab                iscsi               needrestart          nftables.conf       ufw
cron.weekly           issue               netconf              nsswitch.conf       update-manager
cryptsetup-initramfs issue.net            netplan              os-release           update-motd.d
crypttab              kernel              network              overlayroot.conf   update-notifier
dbus-1                 landscape           networkd             PackageKit           UPower
debconf.conf          ldap                networkd-dispatcher rmt                  usb_modeswitch.conf
debian_version        ld.so.cache         NetworkManager      rpc                  usb_modeswitch.d
default               ld.so.conf          newt                  rsyslog.conf        vim
deluser.conf          legal               nftables.conf       rsyslog.d           vmware-tools
depmod.d              libaudit.conf      nsswitch.conf       security             vtrgb
dhcp                  libblockdev         opt                   shadow               wgetrc
dpkg                  libn1-3             os-release           shadow-              X11
e2scrub.conf          locale.alias        overlayroot.conf     shells               xattr.conf
environment           locale.gen          PackageKit           skel                  xdg
ethertypes            localtime          pam.conf              sos                   zsh_command_not_found
fstab                  localtime           passwd                ssh

```

- **/home** : Home folders of the common users.

```

mercy@mercy:~$ pwd
/home/mercy

```

/lib: Library files, includes files for all kinds of programs needed by the system and the users.

```
mercy@mercy:~$ cd /lib
mercy@mercy:/lib$ ls
apparmor          klibc-K8e6D0mVI9JpyGMLR7qNe5iZeBk.so  pkgconfig
apt               libdmmp.so                               pm-utils
binfmt.d         libdmmp.so.0.2.0                         policykit-1
pyobu            libhandle.so.1                           polkit-1
cloud-init       libhandle.so.1.0.3                       python2.7
cnf-update-db   libmpathcmd.so                           python3
command-not-found libmpathcmd.so.0                         python3.10
compat-ld       libmpathpersist.so                       python3.11
console-setup   libmpathpersist.so.0                     recovery-mode
crda            libmultipath.so                           rsyslog
cryptsetup      libmultipath.so.0                         sasl2
dbus-1.0        linux                                     sftp-server
dpkg            linux-boot-probes                         snapd
dracut          locale                                   software-properties
environment.d   lsb                                       ssl
file           man-db                                   sysctl.d
finalrd        mime                                     systemd
libuser       redhatcpd.d                             xuserns.d
```

- /usr : directory in Linux contains user-related programs, libraries, documentation

```
mercy@mercy:/usr/lib$ cd ../
mercy@mercy:/usr$ ls -ll
total 92
drwxr-xr-x  2 root root 36864 Apr 16 16:20 bin
drwxr-xr-x  2 root root  4096 Apr 18 2022 games
drwxr-xr-x  5 root root  4096 Apr 16 16:20 include
drwxr-xr-x 83 root root  4096 Apr 16 16:17 lib
drwxr-xr-x  2 root root  4096 Feb 17 17:19 lib32
drwxr-xr-x  2 root root  4096 Feb 17 17:22 lib64
drwxr-xr-x  9 root root  4096 Apr 16 16:17 libexec
drwxr-xr-x  2 root root  4096 Feb 17 17:19 libx32
drwxr-xr-x 10 root root  4096 Feb 17 17:19 local
drwxr-xr-x  2 root root 16384 Apr 16 16:21 sbin
drwxr-xr-x 110 root root  4096 Apr 16 16:17 share
drwxr-xr-x  4 root root  4096 Apr 16 16:17 src
```



- /tmp: contains temporary files that are created by applications and the system, and are typically deleted when system reboot.

```
mercy@mercy:/usr$ cd ../tmp
mercy@mercy:/tmp$ ls
snap-private-tmp
systemd-private-b145a234a24d4a4aae68e43acfd88689-ModemManager.service-XTVKEe
systemd-private-b145a234a24d4a4aae68e43acfd88689-systemd-logind.service-587CgA
systemd-private-b145a234a24d4a4aae68e43acfd88689-systemd-resolved.service-XAn0V3
systemd-private-b145a234a24d4a4aae68e43acfd88689-systemd-timesyncd.service-aqIoWq
mercy@mercy:/tmp$
```

## Common Commands

- **Useradd**- add a new user
- **Passwd**-change the current password or add a password for new user
- **ls** : List the contents of a directory
- **pwd** : Present working directory
- **cd** : Change directory
- **mkdir** : Make a directory
- **cp** : Copy
- **cp -r** :Copy a directory and its contents

## Common Commands

**mv** : Move

**rm** : Remove

**rm -r** directory: Remove a directory containing files

**rmdir** directory: Remove an empty directory

### Shell Shortcuts for bash

Ctrl-A (jump to start of line)

Ctrl-E (jump to end of line)

Ctrl-K (delete (kill) everything from the cursor onwards)

Ctrl-W (delete the previous word only)

Ctrl-Y (paste whatever was just deleted)

Ctrl-C (kill/exit a running process)

Ctrl-L (clear the screen)

Ctrl-R (search for previously executed commands)

Tab (auto-complete command or file/directory name)

↑ / ↓ (scroll back / forwards through previously entered commands)

# Types of Users

Root User-The root user is also known as the superuser and has complete control over the system

System users: System users are created by the system for running specific services or processes. These users do not have login privileges, and their accounts are locked by default.

Regular users: Regular users are created by the system administrator or by other regular users. These users have limited privileges and cannot perform tasks that require root access, such as modifying system files or installing software

```
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
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
irc:x:39:39:ircd:/run/ircd:/usr/sbin/nologin
gnats:x:41:41:Gnats Bug-Reporting System (admin):/var/lib/gnats:/usr/sbin/nologin
nobody:x:65534:65534:nobody:/nonexistent:/usr/sbin/nologin
_apt:x:100:65534::/nonexistent:/usr/sbin/nologin
systemd-network:x:101:102:systemd Network Management,,,:/run/systemd:/usr/sbin/nologin
systemd-resolve:x:102:103:systemd Resolver,,,:/run/systemd:/usr/sbin/nologin
messagebus:x:103:104::/nonexistent:/usr/sbin/nologin
systemd-timesync:x:104:105:systemd Time Synchronization,,,:/run/systemd:/usr/sbin/nologin
pollinate:x:105:1::/var/cache/pollinate:/bin/false
sshd:x:106:65534::/run/sshd:/usr/sbin/nologin
syslog:x:107:113::/home/syslog:/usr/sbin/nologin
uidd:x:108:114::/run/uidd:/usr/sbin/nologin
tcpdump:x:109:115::/nonexistent:/usr/sbin/nologin
tss:x:110:116:TPM software stack,,,:/var/lib/tpm:/bin/false
landscape:x:111:117::/var/lib/landscape:/usr/sbin/nologin
fwupd-refresh:x:112:118:fwupd-refresh user,,,:/run/systemd:/usr/sbin/nologin
usbmux:x:113:46:usbmux daemon,,,:/var/lib/usbmux:/usr/sbin/nologin
mercy:x:1000:1000:mercy:/home/mercy:/bin/bash
ixd:x:999:100::/var/snap/ixd/common/ixd:/bin/false
```

# File Permission

```

shum@sol:~$ ls -l
total 20
drwx----- 2 shum      staff    4096 Jan 16 22:04 Mail
drwx----- 3 shum      staff    4096 Jan 16 14:15 csc128
drwxr-xr-x  2 shum      staff    4096 Jan 13 16:42 public
drwxr-xr-x  2 shum      staff    4096 Jan 16 14:07 public_html
-rw-r--r--  1 shum      staff    628  Jan 15 20:04 verse
  
```

The diagram illustrates the components of the `ls -l` command output. The output is as follows:

```

drwx----- 2 shum      staff    4096 Jan 16 22:04 Mail
drwx----- 3 shum      staff    4096 Jan 16 14:15 csc128
drwxr-xr-x  2 shum      staff    4096 Jan 13 16:42 public
drwxr-xr-x  2 shum      staff    4096 Jan 16 14:07 public_html
-rw-r--r--  1 shum      staff    628  Jan 15 20:04 verse
  
```

The components are labeled as follows:

- file type**: Indicated by the first character of the permission string (e.g., `d` for directory, `-` for regular file).
- number of hard links**: The number following the permission string (e.g., `2`, `3`, `2`, `2`, `1`).
- user (owner) name**: The name following the number of hard links (e.g., `shum`).
- group name**: The name following the user name (e.g., `staff`).
- size**: The size of the file in bytes (e.g., `4096`, `628`).
- date/time last modified**: The date and time the file was last modified (e.g., `Jan 16 22:04`).
- filename**: The name of the file (e.g., `Mail`, `csc128`, `public`, `public_html`, `verse`).

The permissions are further detailed as follows:

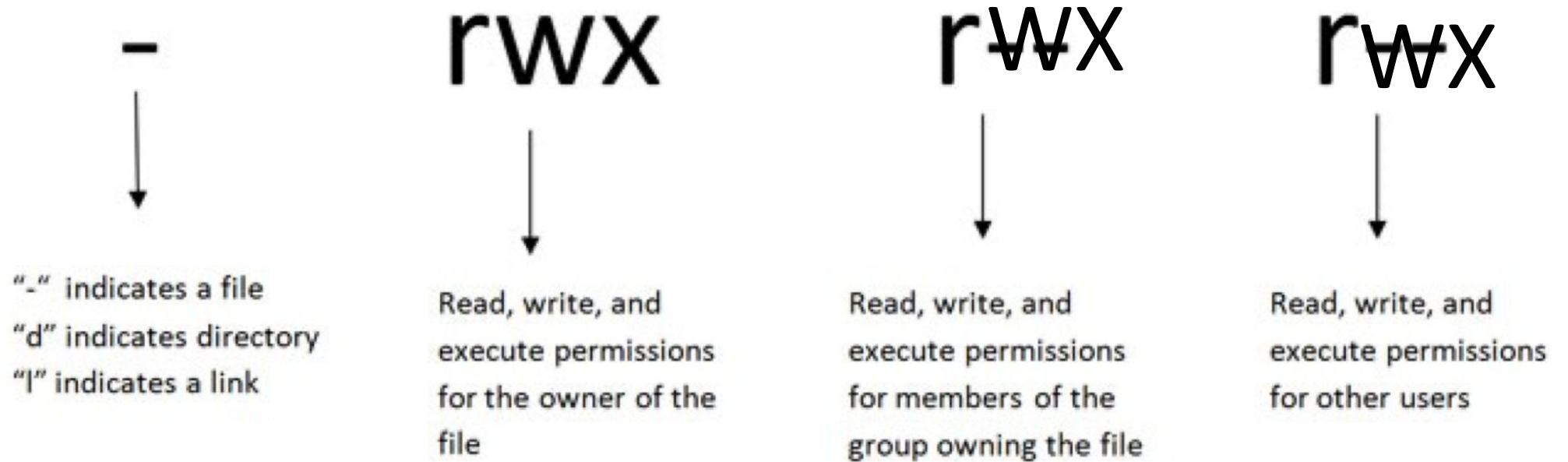
**rwx**

- r**: readable
- w**: writeable
- x**: executable

The permissions are also categorized as follows:

- user permissions**: The first three characters of the permission string (e.g., `drwx`).
- group permissions**: The next three characters of the permission string (e.g., `-----`).
- other (everyone) permissions**: The last three characters of the permission string (e.g., `-----`).

# File Permission in Detail



# Access Rights

- Files are owned by a user and a group (ownership)
- Files have permissions for the user, the group, and other
- “Other” permission is often referred to as “world”
- The permissions are Read, Write and Execute (r, w, x)
- The user who owns a file is always allowed to change its permissions

## Changing File Permissions

File permissions can be change using “**chmod**” command There are two ways to use this command

- *Symbolic mode*
- *Absolute mode*



# Symbolic Mode

Uses letters and “+” , ”-” to give permissions

- Letters are used as following

u	User
g	Group
o	Other
r	Read
w	Write
e	Execute
+	To add permission
-	To remove a permission

# Symbolic mode (Examples)

- `$ chmod g+x testfile`
- `$ chmod u+wx testfil`
- `$ chmod ug-x testfile`

u=user, g=group, o=other (world)

# Absolute Mode

We use octal (base eight) values represented like this

For each column, User, Group or Other you can set values from 0 to 7

<b>Number</b>	<b>Permission Type</b>
0	No Permissions
1	Execute
2	Write
3	Execute+Write
4	Read
5	Read+Execute
6	Read+Write
7	Read+Write+Execute

# Symbolic Mode (Example)

- \$ chmod 445 testfile ==> -r--r-xr—
- \$ chmod 754 testfile ==> -rwxr-xr—
- \$ chmod 644 testfile ==> -rw--r--r—