

(b) Linux File Systems:

1. Types of Linux File System:

- ext: The ext (extended file system) was the first file system created specifically for Linux. It has undergone several revisions, such as ext2, ext3, and ext4.
- ext2: The second extended file system, providing improvements over the original ext.
- ext3: An extension of ext2 with the addition of journaling, which improves file system recovery in case of a crash.
- ext4: The fourth version of the extended file system, featuring improvements in performance, scalability, and reliability over ext3.

2. Characteristics of a File System:

- Hierarchical Structure: Files and directories are organized in a hierarchical tree structure.
- Permissions: Each file and directory has permission settings determining who can read, write, or execute them.
- File Naming: Files are identified by names, and the file system supports various file attributes.
- Journaling: Some file systems, like ext3 and ext4, use journaling to improve recovery after system crashes.
- Inodes: Inodes store metadata about files, such as ownership, permissions, and location on disk.

3. Journaling, Versioning, and Inode:

- Journaling: File systems like ext3 and ext4 use journaling to keep track of changes before committing them to the main file system. This helps in recovering the file system quickly after a crash.
- Versioning: Some file systems support versioning, where multiple versions of a file can be stored and retrieved.
- Inode (Index Node): Inodes are data structures that store information about files on disk. They contain metadata such as file ownership, permissions, timestamps, and pointers to the actual data blocks.

(c) Linux Directory Structure (File System Hierarchy):

1. `/` (root filesystem):

- Top-level directory where the entire file system hierarchy begins.
- Command : `$ cd`

2. `/root`:

- Home directory for the root user.
- command : `$ ls` at root or `$ cd ../../`

3. `~/home`:`

- Home directories for regular users.
- command : `ls` at root or `$ cd ..`

```

primus@primus:~/Documents/Semester6/Inf... x primus@primus:/ x
[primus@primus ~]$ ls
auto-cpufreq Downloads GNS3 Pictures Public Videos
Documents Fedora-Dockerfiles Music Postman Templates
[primus@primus ~]$ cd ..
[primus@primus home]$ ls
primus
[primus@primus home]$ cd ..
[primus@primus /]$ ls
afs boot etc lib lost+found mnt proc run srv tmp var
bin dev home lib64 media opt root/sbin sys usr
[primus@primus /]$

```

4. `~/boot`:`

- Contains the Linux kernel and files required for the system's initial boot process.
- command :

```

primus@primus:~/Documents/Semester6/Inf... x primus@primus:/boot x
primus
[primus@primus home]$ cd ..
[primus@primus /]$ ls
afs boot etc lib lost+found mnt proc run srv tmp var
bin dev home lib64 media opt root/sbin sys usr
[primus@primus /]$ cd boot
[primus@primus boot]$ ls
config-6.5.11-300.fc39.x86_64
config-6.6.11-200.fc39.x86_64
config-6.6.6-200.fc39.x86_64
efi
grub2
initramfs-0-rescue-cb55580bc30f41fd93c11444259b8d36.img
initramfs-6.5.11-300.fc39.x86_64.img
initramfs-6.6.11-200.fc39.x86_64.img
initramfs-6.6.6-200.fc39.x86_64.img
loader
symvers-6.5.11-300.fc39.x86_64.xz
symvers-6.6.11-200.fc39.x86_64.xz
symvers-6.6.6-200.fc39.x86_64.xz
System.map-6.5.11-300.fc39.x86_64
System.map-6.6.11-200.fc39.x86_64
System.map-6.6.6-200.fc39.x86_64
vmlinuz-0-rescue-cb55580bc30f41fd93c11444259b8d36
vmlinuz-6.5.11-300.fc39.x86_64
vmlinuz-6.6.11-200.fc39.x86_64
vmlinuz-6.6.6-200.fc39.x86_64
[primus@primus boot]$

```

5. `/etc`:

- Configuration files for system-wide settings.
- command : ls at root

```
[primus@primus /]$ cd etc
[primus@primus etc]$ ls
abrt                               init.d                             pulse
adjtime                           inittab                            qemu
aliases                           inputrc                             qemu-ga
alsa                               ipp-usb                            rc0.d
alternatives                       iproute2                            rc1.d
anaconda                           iscsi                               rc2.d
anthy-unicode.conf                 issue                               rc3.d
appstream.conf                     issue.d                             rc4.d
apt                                 issue.net                           rc5.d
asound.conf                        java                                rc6.d
audit                              jvm                                 rc.d
authselect                         jvm-common                         reader.conf.d
avahi                              kdump                              redhat-release
bash_completion.d                 kdump.conf                         request-key.conf
bashrc                             kernel                             request-key.d
bindresvport.blacklist             keys                               resolv.conf
binfmt.d                           krb5.conf                          rhashrc
bluetooth                         krb5.conf.d                       ros
brlapi.key                         ld.so.cache                        rpc
brltty                             ld.so.conf                         rpm
brltty.conf                       ld.so.conf.d                      rsyncd.conf
ceph                               libaudit.conf                     rwtab.d
chkconfig.d                       libblockdev                       rygel.conf
chromium                           libibverbs.d                      samba
chrony.conf                        libnl                              sane.d
cifs-utils                         libreport                          sasl2
common-lisp                        libssh                              sbcl.rc
containerd                         libuser.conf                       security
```

6. `/bin`:

- Essential binary files (commands) required for system recovery.
- command : ls at root

```

vmlinux-6.6.6-200.fc39.x86_64
[primus@primus boot]$ cd ..
[primus@primus /]$ cd bin
[primus@primus bin]$ ls
'[' nl
2to3 nl-addr-add
2to3-3.12 nl-addr-delete
7za nl-addr-list
ab nl-class-add
abrt nl-class-delete
abrt-action-analyze-backtrace nl-classid-lookup
abrt-action-analyze-c nl-class-list
abrt-action-analyze-ccpp-local nl-cls-add
abrt-action-analyze-java nl-cls-delete
abrt-action-analyze-oops nl-cls-list
abrt-action-analyze-python nl-fib-lookup
abrt-action-analyze-vmcore nl-link-enslave
abrt-action-analyze-vulnerability nl-link-ifindex2name
abrt-action-analyze-xorg nl-link-list
abrt-action-check-oops-for-alt-component nl-link-name2ifindex
abrt-action-check-oops-for-hw-error nl-link-release
abrt-action-find-bodhi-update nl-link-set
abrt-action-generate-backtrace nl-link-stats
abrt-action-generate-core-backtrace nl-list-caches
abrt-action-list-dsos nl-list-sockets
abrt-action-notify nl-monitor
abrt-action-save-package-data nl-neigh-add
abrt-action-trim-files nl-neigh-delete
abrt-applet nl-neigh-list
abrt-bodhi nl-neighbtl-list

```

7. `/sbin`:

- System binaries, often used by the system administrator for maintenance tasks.
- command : ls at root

```
primus@primus:~/Documents/Semester6/Inf... x primus@primus:/sbin x
ls
afs boot etc lib lost+found mnt proc run srv tmp var
bin dev home lib64 media opt root sbin sys usr
[primus@primus /]$ cd sbin
[primus@primus sbin]$ ls
abrt-auto-reporting mii-tool
abrt-dbus mkdict
abrt-dbus mkdosfs
abrt-harvest-pstoreoops mkdumpprd
abrt-harvest-vmcore mke2fs
abrt-server mkfs
accessdb mkfs.btrfs
accton mkfs.cramfs
adcli mkfs.exfat
addgnupghome mkfs.ext2
addpart mkfs.ext3
adduser mkfs.ext4
agetty mkfs.f2fs
alsactl mkfs.fat
alsa-info.sh mkfs.hfsplus
alternatives mkfs.minix
anaconda mkfs.msdos
apachectl mkfs.nilfs2
applygnupgdefaults mkfs.ntfs
arp mkfs.udf
arpd mkfs.vfat
arping mkfs.xfs
arptables mkhomedir_helper
arptables-nft mklost+found
```

8. `/usr`:

- Secondary hierarchy containing user-related programs, libraries, and documentation.
- command : ls at root

```
[primus@primus /]$ cd usr
[primus@primus usr]$ ls
bin i686-w64-mingw32 lib libexec sbin src x86_64-w64-mingw32
games include lib64 local share tmp
[primus@primus usr]$
```

9. `/var`:

- Variable files, such as logs, spool files, and temporary files.
- command : ls at root

10. `/dev`:

- Device files representing hardware devices.

```

adm    crash empty games lib    lock mail opt run    tmp    yp
[primus@primus var]$ cd ..
[primus@primus /]$ cd dev
[primus@primus dev]$ ls
acpi_thermal_rel  initctl    port      tty13    tty39    tty7     ttyS31    vcsa4
autofs           input      ppp       tty14    tty4     tty8     ttyS4     vcsa5
block           kmsg      ptmx      tty15    tty40    tty9     ttyS5     vcsa6
bsg             kvm       pts       tty16    tty41    ttyS0     ttyS6     vcsu
btrfs-control   log        random    tty17    tty42    ttyS1     ttyS7     vcsu1
bus            loop-control  rfkill    tty18    tty43    ttyS10    ttyS8     vcsu2
char           lp0       rtc       tty19    tty44    ttyS11    ttyS9     vcsu3
console        lp1       rtc0      tty2     tty45    ttyS12    udmabuf   vcsu4
core           lp2       sda       tty20    tty46    ttyS13    uhid      vcsu5
cpu            lp3       sda1      tty21    tty47    ttyS14    uinput    vcsu6
cpu_dma_latency mapper     sda2      tty22    tty48    ttyS15    urandom   vfio
cuse           mcelog    sda3      tty23    tty49    ttyS16    usb       vga_arbiter
disk           media0    sda4      tty24    tty5     ttyS17    usbmon0   vhci
dma_heap       mei0      sg0       tty25    tty50    ttyS18    usbmon1   vhost-net
dri            mem       shm       tty26    tty51    ttyS19    usbmon2   vhost-vsock
drm_dp_aux0    mqueue    snapshot  tty27    tty52    ttyS2     userfaultfd video0
fb0            net       snd       tty28    tty53    ttyS20    v4l       video1
fd             ng0n1     stderr    tty29    tty54    ttyS21    vcs       watchdog
full          null      stdin     tty3     tty55    ttyS22    vcs1     watchdog0
fuse          nvme0     stdout    tty30    tty56    ttyS23    vcs2     wmi
gpiochip0     nvme0n1   tpm0      tty31    tty57    ttyS24    vcs3     zero
hidraw0       nvme0n1p1 tpmrm0    tty32    tty58    ttyS25    vcs4     zram0
hidraw1       nvme0n1p2 tty        tty33    tty59    ttyS26    vcs5
hidraw2       nvme0n1p3 tty0       tty34    tty6     ttyS27    vcs6
hidraw3       nvme0n1p4 tty1       tty35    tty60    ttyS28    vcsa
hpet          nvme0n1p5 tty10      tty36    tty61    ttyS29    vcsa1
hugepages     nvme0n1p6 tty11      tty37    tty62    ttyS3     vcsa2

```

11. `/lib`:`

- Essential shared libraries and kernel modules.

```

hugepages      nvme0n1p6      tty11      tty37  tty62  ttyS3  vcsa2
hwrng          nvram          tty12      tty38  tty63  ttyS30 vcsa3
[primus@primus dev]$ cd ..
[primus@primus /]$ cd lib
[primus@primus lib]$ ls
abrt-java-connector      libmenu.so.6.4
alsa                     libmenuw.so.6
alsa-lib                 libmenuw.so.6.4
audit                   libmount.so.1
bfd-plugins              libmount.so.1.1.0
binfmt.d                 libmp3lame.so.0
common-lisp              libmp3lame.so.0.0.0
cpp                      libmpg123.so.0
credstore                libmpg123.so.0.47.0
cups                     libm.so.6
debug                    libncurses.so.6
docker                   libncurses.so.6.4
dracut                   libncursesw.so.6
dri                      libncursesw.so.6.4
eclipse                  libnettle.so.8
engines-3                libnettle.so.8.8
environment.d             libnghttp2.so.14
fedora-release            libnghttp2.so.14.24.3
fedora-third-party        libnm.so.0
firewalld                 libnm.so.0.1.0
firmware                  libnspr4.so
fontconfig                libnss3.so
gallium-pipe              libnss_compat.so.2
games                     libnss_dns.so.2
gcc                       libnss_files.so.2
gconv                     libnss_myhostname.so.2

```

12. `/mnt`:`

- Temporary mount points for mounting external file systems.

```

[primus@primus lib]$ cd ..
[primus@primus /]$ cd mnt
[primus@primus mnt]$ ls
[primus@primus mnt]$ ls
[primus@primus mnt]$

```

13. `/media`:`

- Mount points for removable media such as USB drives.

```

[primus@primus mnt]$ ls
[primus@primus mnt]$ cd ..
[primus@primus /]$ cd media/
[primus@primus media]$ ls
[primus@primus media]$

```

14. `/opt`:`

- Optional application software packages.

```
[primus@primus media]$ cd ..  
[primus@primus /]$ cd opt  
[primus@primus opt]$ ls  
auto-cpufreq  containerd  docker-desktop  
[primus@primus opt]$
```

15. `/tmp`:`

- Temporary files, typically cleared on system reboot.

```
[primus@primus /]$ cd tmp  
[primus@primus tmp]$ ls  
dbus-1Rh7AS6u  
dbus-o2F2C4YN  
evince-5592  
hsperfdata_primus  
qemu-console1157508059  
qemu-console1603509223  
qemu-console3385192946  
qemu-console826507703  
qemu-console827752884  
scoped_dirJD5Mjo  
systemd-private-91d842bda91d4144b74b88060438172d-bluetooth.service-tVsNDt  
systemd-private-91d842bda91d4144b74b88060438172d-chronyd.service-vJMoGo  
systemd-private-91d842bda91d4144b74b88060438172d-colord.service-7nyxav  
systemd-private-91d842bda91d4144b74b88060438172d-dbus-broker.service-X7xF2P  
systemd-private-91d842bda91d4144b74b88060438172d-low-memory-monitor.service-QwlIMj  
systemd-private-91d842bda91d4144b74b88060438172d-ModemManager.service-Km5gAl  
systemd-private-91d842bda91d4144b74b88060438172d-polkit.service-oyGKFK  
systemd-private-91d842bda91d4144b74b88060438172d-power-profiles-daemon.service-5yLGAI  
systemd-private-91d842bda91d4144b74b88060438172d-rtkit-daemon.service-UcQUCj  
systemd-private-91d842bda91d4144b74b88060438172d-switcheroo-control.service-m3nf73  
systemd-private-91d842bda91d4144b74b88060438172d-systemd-logind.service-XyXsQB  
systemd-private-91d842bda91d4144b74b88060438172d-systemd-oomd.service-m81YId  
systemd-private-91d842bda91d4144b74b88060438172d-systemd-resolved.service-AIWbkf  
systemd-private-91d842bda91d4144b74b88060438172d-upower.service-vKVSWE  
ubuntu-20.04.6-desktop-amd64.iso-7DORH2  
ubuntu-22.04-latest-desktop-amd64.iso-TBTJH2  
ubuntu-23.10.1-desktop-amd64.iso-5N3VH2  
[primus@primus tmp]$
```