# 🐧 Introduction to Linux Shell 🖥️

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## 🏆 What is a Shell?

A **shell** is a **command-line interface (CLI)** that allows users to interact with the **operating system** by executing commands. It serves as a bridge 🏗️ between the **user** and the **kernel**.

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## 🔍 Types of Shells

| 🏷️ Shell Type | 📌 Description |
|---|---|
| **Bourne Shell (sh)** | The original Unix shell. |
| **Bash (Bourne Again Shell)** | 🔥 Improved version of Bourne Shell, widely used in Linux. |
| **C Shell (csh)** | 🏗️ Uses C-like syntax. |
| **Korn Shell (ksh)** | 🎭 Combines features of Bourne and C Shell. |
| **Z Shell (zsh)** | ⚡ Extended version of Bash with extra features. |

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## 🏗️ Basic Linux Commands

### 📂 File and Directory Management

| 🔧 Command | 📌 Description |
|---|---|
| `ls` | 📋 List files and directories. |
| `pwd` | 📍 Show current directory. |
| `cd <directory>` | 🚀 Change directory. |
| `mkdir <directory>` | 📁 Create a new directory. |

| | |
|---|---|
| `rmdir <directory>` | 🗑️ Remove an empty directory. |
| `rm <file>` | ❌ Delete a file. |
| `rm -r <directory>` | ❌ Delete a directory and its contents. |
| `cp <source> <destination>` | 📤 Copy files or directories. |
| `mv <source> <destination>` | 🔀 Move or rename files and directories. |

## 📜 File Viewing

| 🔍 Command | 📌 Description |
|---|---|
| `cat <file>` | 📖 Display file contents. |
| `less <file>` | 📜 View file page by page. |
| `head <file>` | 📄 Show the first 10 lines. |
| `tail <file>` | 📑 Show the last 10 lines. |

## 🔒 File Permissions and Ownership

| 🔧 Command | 📌 Description |
|---|---|
| `chmod <permissions> <file>` | 🛡️ Change file permissions. |
| `chown <user>:<group> <file>` | 👤 Change file ownership. |

## ⚙️ Process Management

| 🔍 Command | 📌 Description |
|---|---|
| `ps` | 📋 Show running processes. |
| `top` | 📊 Display system resource usage. |

| | |
|---|---|
| `kill <PID>` | 🔫 Terminate a process by its ID. |
| `pkill <process_name>` | 🛑 Kill a process by name. |

### 🖥️ System Information

| 📌 Command | 📊 Description |
|---|---|
| `uname -a` | 💻 Show system details. |
| `df -h` | 💾 Display disk usage. |
| `free -m` | 🧠 Check memory usage. |

### 🌐 Networking Commands

| 🌍 Command | 📡 Description |
|---|---|
| `ping <host>` | 📡 Check network connectivity. |
| `ifconfig / ip addr show` | 🔎 View network interfaces. |
| `netstat -tulnp` | 🔥 Show active network connections. |
| `curl <URL>` | 🌍 Fetch data from a URL. |

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## 📚 Command Line Help

### 📖 Getting Help on Commands

| 🛠️ Command | 📌 Description |
|---|---|
| `man <command>` | 📕 Show manual for a command. |
| `info <command>` | 📖 View detailed documentation. |

| | |
|---|---|
| `<command> --help` | 📌 Quick command guide. |
| `whatis <command>` | 📌 One-line command summary. |

### 🕵️ Searching for Commands

| 🔍 Command | 📌 Description |
|---|---|
| `apropos <keyword>` | 🔎 Find commands related to a keyword. |
| `which <command>` | 📌 Show full command path. |

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# 🐚 Bash Shell

### 🏆 What is Bash?

**Bash** (**Bourne Again Shell**) is the most commonly used **Linux shell**. It provides powerful **scripting**, **command history**, and **job control** features.

### 🚀 Bash Features

✅ **Command history** – Use `history` or arrow keys to navigate previous commands.
✅ **Auto-completion** – Press `Tab` to autocomplete commands.
✅ **Aliases** – Define shortcuts using `alias name='command'`.

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# 📝 Bash Scripting Basics

### ✍️ Creating a Bash Script

1️⃣ **Create a new script file:**

```
nano script.sh
```

**2️⃣ Add script content:**

```
#!/bin/bash
echo "Hello, World!"
```

**3️⃣ Make it executable:**

```
chmod +x script.sh
```

**4️⃣ Run the script:**

```
./script.sh
```

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## 📦 Variables in Bash

```
name="John"
echo "Hello, $name"
```

---

## 🔁 Conditional Statements

```
if [ "$name" == "John" ]; then
    echo "Name is John"
else
    echo "Name is not John"
fi
```

---

## 🔄 Loops in Bash

```
for i in {1..5}; do
    echo "Number: $i"
done
```

# 🖥️ Linux Core Concepts

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## 🛠️ 1. Linux Kernel

### 🔍 What is the Linux Kernel?

The **Linux Kernel** is the **core** of the operating system. It acts as a **bridge** between **hardware** and **user applications**, managing:
✅ **Processes** 🏃
✅ **Memory** 🧠
✅ **Devices** 🎧📱
✅ **File Systems** 📁
✅ **Networking** 🌐

### 📌 Checking Kernel Information

Use these commands to check kernel details:

```
uname -r        # Display kernel version
uname -a        # Show complete system information
cat /proc/version  # Detailed kernel version info
```

### 📌 Updating the Kernel

To check and upgrade your kernel:

```
sudo apt update && apt list --upgradable | grep linux-image  # Check for kernel updates
sudo apt install linux-image-generic  # Upgrade the kernel
```

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## 💻 2. Working with Hardware

### 🖥️ Device Files in Linux

Linux represents hardware as files in the `/dev/` directory:

🔹 **Character Devices** – Process data **one character at a time** (e.g., `/dev/tty` for terminals).

🔹 **Block Devices** – Process data **in blocks** (e.g., `/dev/sda` for storage).

### 📌 Checking Hardware Information

Use these commands to check system hardware:

```
lscpu        # Display CPU details
lsblk        # Show storage devices and partitions
lspci        # List PCI devices (graphics, network cards, etc.)
lsusb        # List connected USB devices
df -h        # Show disk space usage
free -m      # Display RAM usage in MB
```

### 📌 Managing Devices

**📌 Mount a device:**

```
sudo mount /dev/sdb1 /mnt  # Mount device at /mnt
```

**📌 Unmount a device:**

```
sudo umount /mnt  # Unmount device from /mnt
```

**📌 Load a kernel module:**

```
sudo modprobe <module_name>  # Load a specific kernel module
```

**📌 Remove a kernel module:**

```
sudo rmmod <module_name>  # Remove a kernel module
```

---

## 🚀 3. Linux Boot Sequence

The **Linux Boot Process** consists of:
1️⃣ **BIOS/UEFI** – Initializes hardware and loads bootloader.
2️⃣ **Bootloader (GRUB, LILO, Syslinux, etc.)** – Loads the Linux kernel.
3️⃣ **Kernel Initialization** – Detects hardware and mounts the root filesystem.
4️⃣ **Init System (Systemd, SysVinit, Upstart)** – Starts system processes.
5️⃣ **Runlevel/Target Execution** – Loads user processes and services.

### 📌 Checking Boot Information

```
dmesg | less       # Show boot messages
journalctl -b      # View system logs from the last boot
cat /var/log/syslog  # Check system boot logs
```

---

## 🔄 4. Runlevels (SysVinit) and Systemd Targets

### 📌 Runlevels in SysVinit Systems

| 🏷️ Runlevel | 📌 Description |
|---|---|
| **0** | Shutdown 🔴 |
| **1** | Single-user mode 🔧 |
| **2** | Multi-user (No Networking) 🔌 |
| **3** | Multi-user (With Networking) 🌐 |
| **4** | Unused/Custom ⚙️ |
| **5** | Graphical mode (GUI) 🎨 |
| **6** | Reboot 🔄 |

#### 📌 Check & Change Runlevels:

```
runlevel        # Check current runlevel
sudo init 3     # Change to runlevel 3 (multi-user mode)
```

### 📌 Systemd Targets (Modern Linux Systems)

| Systemd Target | Equivalent Runlevel |
|---|---|

| | |
|---|---|
| **poweroff.target** | Runlevel **0** (Shutdown) |
| **rescue.target** | Runlevel **1** (Single-user mode) |
| **multi-user.target** | Runlevel **3** (Multi-user mode) |
| **graphical.target** | Runlevel **5** (Graphical mode) |
| **reboot.target** | Runlevel **6** (Reboot) |

📌 **Managing Systemd Targets:**

```
systemctl get-default  # Check the current target
sudo systemctl set-default multi-user.target  # Set default target
sudo systemctl isolate graphical.target  # Switch to a specific target
```

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## 📂 5. Linux File Types

| 🏷️ File Type | 📌 Description | 📁 Example |
|---|---|---|
| **Regular File** | Normal text, binary, or script file | `/etc/passwd` |
| **Directory** | Folder containing files | `/home/user/` |
| **Symbolic Link** | Shortcut to another file | `/usr/bin/python -> /usr/bin/python3` |
| **Character Device** | Reads/Writes one character at a time | `/dev/tty` |
| **Block Device** | Reads/Writes data in blocks | `/dev/sda` |
| **Named Pipe** | Inter-process communication | `/tmp/mypipe` |
| **Socket** | Network communication endpoint | `/var/run/docker.sock` |

📌 **Checking File Types:**

```
ls -l  # Display file types
file /dev/sda  # Check type of a specific file
```

📌 **Example output of `ls -l`:**

```
-rw-r--r--  1 user user 1024 Mar 07 12:00 file.txt   # Regular file
drwxr-xr-x  2 user user 4096 Mar 07 12:00 mydir/     # Directory
lrwxrwxrwx  1 user user   10 Mar 07 12:00 link -> file.txt  # Symbolic
link
```

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## 🗂️ 6. Filesystem Hierarchy

📌 The **Filesystem Hierarchy Standard (FHS)** organizes Linux directories:

| 📁 Directory | 📌 Purpose | 🔍 Example Command |
|---|---|---|
| `/` | **Root directory** (everything starts here) | `ls /` |
| `/bin` | Essential binaries (e.g., `ls`, `cat`) | `ls /bin` |
| `/boot` | Boot files (Kernel, GRUB) | `ls /boot` |
| `/dev` | Device files | `ls /dev` |
| `/etc` | Configuration files | `ls /etc` |
| `/home` | User home directories | `ls /home` |
| `/lib` | Shared libraries & kernel modules | `ls /lib` |
| `/media` | Mount points for removable media | `ls /media` |
| `/mnt` | Temporary mount points | `ls /mnt` |
| `/opt` | Optional software packages | `ls /opt` |
| `/proc` | Virtual filesystem (process info) | `ls /proc` |
| `/root` | Home directory for root user | `ls /root` |
| `/sbin` | System binaries (for admin tasks) | `ls /sbin` |
| `/srv` | Data served by the system | `ls /srv` |
| `/tmp` | Temporary files | `ls /tmp` |

| | | |
|---|---|---|
| `/usr` | User applications and libraries | `ls /usr` |
| `/var` | Variable data (logs, caches, databases) | `ls /var` |

📌 **Checking Disk Usage:**

```
df -h  # Show available disk space
du -sh /var/log  # Display the size of the /var/log directory
```

# 📦 Linux Package Management 🛠️

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## 🏗️ 1. Introduction to Package Management

### 🔍 What is Package Management?

Package management is how Linux handles **software installation, updates, and removal**. Different distributions use different package management tools.

### 📌 Types of Package Managers

🔹 **Low-Level Package Managers (work directly with package files):**

- `rpm` → Used in **Red Hat-based** systems
- `dpkg` → Used in **Debian-based** systems

🔹 **High-Level Package Managers (handle dependencies & repositories):**

- `yum` / `dnf` → Used in **Red Hat-based** systems
- `apt` / `apt-get` → Used in **Debian-based** systems

### 📌 Package Manager Categories by Distribution

| 🏷️ Distribution | 📦 Low-Level Package Manager | 📦 High-Level Package Manager |
|---|---|---|
| **Debian-based (Ubuntu, Debian, Mint)** | `dpkg` | `apt`, `apt-get` |
| **Red Hat-based (RHEL, CentOS, Fedora)** | `rpm` | `yum`, `dnf` |

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## 🔴 2. RPM and YUM (For Red Hat-based Systems)

### 📌 RPM (Red Hat Package Manager)

`RPM` is a **low-level package manager** used in Red Hat-based distributions like **CentOS** and **Fedora**.

⚡ **Common RPM Commands**

📌 **Install a package:**

```
sudo rpm -ivh package.rpm
```

📌 **Upgrade a package:**

```
sudo rpm -Uvh package.rpm
```

📌 **Remove a package:**

```
sudo rpm -e package-name
```

📌 **Query installed packages:**

```
rpm -qa | grep package-name
```

📌 **Show package details:**

```
rpm -qi package-name
```

---

## 📌 YUM (Yellowdog Updater, Modified)

`YUM` is a **high-level package manager** that resolves dependencies automatically.

⚡ **Common YUM Commands**

📌 **Install a package:**

```
sudo yum install package-name
```

📌 **Remove a package:**

```
sudo yum remove package-name
```

📌 **Update all packages:**

```
sudo yum update
```

📌 **Check if a package is installed:**

```
yum list installed | grep package-name
```

📌 **Show package info:**

```
yum info package-name
```

🔹 **Note:** `dnf` is the newer version of `yum` used in Fedora and CentOS 8+.

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# 🔵 3. DPKG and APT (For Debian-based Systems)

## 📌 DPKG (Debian Package Manager)

`dpkg` is a **low-level** package manager for **.deb** packages and **does not handle dependencies** automatically.

⚡ **Common DPKG Commands**

📌 **Install a package:**

```
sudo dpkg -i package.deb
```

📌 **Remove a package:**

```
sudo dpkg -r package-name
```

📌 **Reconfigure a package:**

```
sudo dpkg-reconfigure package-name
```

📌 **List installed packages:**

```
dpkg -l | grep package-name
```

---

### 📌 APT (Advanced Package Tool)

`APT` is a **high-level package manager** for **Debian-based** systems that resolves dependencies automatically.

#### ⚡ Common APT Commands

**📌 Update package lists:**

```
sudo apt update
```

**📌 Install a package:**

```
sudo apt install package-name
```

**📌 Remove a package:**

```
sudo apt remove package-name
```

**📌 Upgrade all packages:**

```
sudo apt upgrade
```

**📌 Show package details:**

```
apt show package-name
```

**📌 Search for a package:**

```
apt search package-name
```

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## ⚖️ 4. APT vs APT-GET

🔹 **Both `apt` and `apt-get` are used in Debian-based distributions, but `apt` is newer and more user-friendly.**

### 📌 Key Differences

| 🏷️ Feature | 📦 `apt-get` | 📦 `apt` |
|---|---|---|
| **Introduced in** | **Debian** | **Ubuntu 16.04+** |
| **Handles package management** | ✅ Yes | ✅ Yes |
| **Displays progress bar** | ❌ No | ✅ Yes |
| **Simplified syntax** | ❌ No | ✅ Yes |

### 📌 Example Commands Comparison

| **Task** | **`apt-get` (Old)** | **`apt` (New)** |
|---|---|---|
| **Update package lists** | `sudo apt-get update` | `sudo apt update` |
| **Install a package** | `sudo apt-get install package-name` | `sudo apt install package-name` |
| **Upgrade all packages** | `sudo apt-get upgrade` | `sudo apt upgrade` |

🔹 **Note:** `apt-get` is still available for **backward compatibility**, but `apt` is recommended for newer systems.

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## 🚀 Conclusion

✅ **Red Hat-based systems** use `rpm` (low-level) and `yum/dnf` (high-level).
✅ **Debian-based systems** use `dpkg` (low-level) and `apt/apt-get` (high-level).
✅ **High-level package managers** (`apt`, `yum`, `dnf`) **handle dependencies automatically**.
✅ **Low-level package managers** (`rpm`, `dpkg`) **work directly with package files**.

📌 **Choosing the Right Package Manager:**

- If you're on **Ubuntu/Debian**, use `apt`.
- If you're on **Fedora/CentOS**, use `dnf`.
- If you want **manual control**, use `dpkg` or `rpm`.

# 🐚 Working with Shell in Linux

## 1. File Compression and Archival

### 📌 What is File Compression and Archival?

- **Compression** reduces file sizes, making them easier to store or transfer.
- **Archiving** bundles multiple files into a single file.

### 🛠️ Common Compression and Archival Commands

| Command | Description |
|---|---|
| `tar` | Archive multiple files into one file |
| `gzip` | Compress files using the Gzip algorithm |
| `bzip2` | Compress files using the Bzip2 algorithm |
| `xz` | Compress files using the XZ algorithm |
| `zip` | Compress files into a `.zip` format |
| `unzip` | Extract `.zip` archives |

---

### 📦 Archiving with tar

**Create an archive (without compression):**

```
tar -cvf archive.tar file1 file2 directory/
```

**Extract an archive:**

```
tar -xvf archive.tar
```

**List contents of an archive:**

```
tar -tvf archive.tar
```

---

## 🗜️ Compressing with gzip, bzip2, and xz

**Compress a file using gzip:**

```
gzip file.txt  # Produces file.txt.gz
gunzip file.txt.gz  # Decompress
```

**Compress a file using bzip2:**

```
bzip2 file.txt  # Produces file.txt.bz2
bunzip2 file.txt.bz2  # Decompress
```

**Compress a file using xz:**

```
xz file.txt  # Produces file.txt.xz
unxz file.txt.xz  # Decompress
```

---

## 📁 Combining tar with Compression

**Create a gzip-compressed archive:**

```
tar -czvf archive.tar.gz file1 file2 directory/
```

**Create a bzip2-compressed archive:**

```
tar -cjvf archive.tar.bz2 file1 file2 directory/
```

**Create an xz-compressed archive:**

```
tar -cJvf archive.tar.xz file1 file2 directory/
```

**Extract compressed archives:**

```
tar -xzvf archive.tar.gz  # For gzip
tar -xjvf archive.tar.bz2  # For bzip2
tar -xJvf archive.tar.xz  # For xz
```

---

### 📌 Working with Zip Files

**Create a zip archive:**

```
zip archive.zip file1 file2 directory/
```

**Extract a zip archive:**

```
unzip archive.zip
```

---

## 2. Searching for Files and Patterns

### 🔍 Why Search for Files?

Searching for files and text patterns is **essential for managing a Linux system** effectively.

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### 🔎 Finding Files with find

**Find a file by name:**

```
find /home -name "file.txt"
```

**Find files larger than 100MB:**

```
find / -size +100M
```

**Find all `.log` files in `/var/log`:**

```
find /var/log -name "*.log"
```

**Find and delete files older than 7 days:**

```
find /tmp -type f -mtime +7 -exec rm {} \;
```

---

### 📌 Searching for Text in Files with grep

**Find a pattern in a file:**

```
grep "error" /var/log/syslog
```

**Case-insensitive search:**

```
grep -i "warning" /var/log/syslog
```

**Recursive search in a directory:**

```
grep -r "TODO" /home/user/projects/
```

**Show line numbers for matches:**

```
grep -n "failed" /var/log/auth.log
```

---

### ⚡ Searching Faster with locate

**Find files using `locate` (requires `updatedb` first):**

```
locate bashrc
```

**Update the locate database:**

```
sudo updatedb
```

---

## 3. I/O Redirection

## 🔄 What is I/O Redirection?

I/O redirection allows you to control where input and output streams go in the shell.

| Stream | Description | File Descriptor |
| --- | --- | --- |
| `stdin` | Standard input | `0` |
| `stdout` | Standard output | `1` |
| `stderr` | Standard error | `2` |

---

## 📤 Redirecting Output to a File

**Redirect `stdout` to a file (overwrite):**

```
ls > output.txt
```

**Redirect `stdout` to a file (append):**

```
ls >> output.txt
```

**Redirect `stderr` to a file:**

```
ls non_existing_file 2> error.txt
```

**Redirect both `stdout` and `stderr`:**

```
ls non_existing_file > output.txt 2>&1
```

**Suppress error messages:**

```
command 2>/dev/null
```

---

## 📥 Redirecting Input from a File

**Read from a file instead of standard input:**

```
sort < unsorted.txt
```

---

### 🔗 Using Pipes (`|`) to Redirect Output Between Commands

**Count lines in a file:**

```
cat file.txt | wc -l
```

**Find all `.log` files and search for "error":**

```
find /var/log -name "*.log" | xargs grep "error"
```

---

## 4. Vi Editor

### 📝 What is the Vi Editor?

`vi` is a **powerful text editor** used in Unix/Linux systems.

---

### 📂 Opening and Closing Files

**Open a file in vi editor:**

```
vi filename
```

**Exit without saving:**

```
:q!
```

**Save and exit:**

```
:wq
```

---

## 🛠️ Vi Modes

| Mode | Description |
| --- | --- |
| **Normal Mode** | Default mode for navigation and commands |
| **Insert Mode** | Used for text editing (press `i` or `a` to enter) |
| **Command Mode** | Used for executing commands (`:` followed by command) |

---

## 📌 Basic Navigation

- **Move left:** `h`
- **Move right:** `l`
- **Move down:** `j`
- **Move up:** `k`

---

## ✏️ Editing in Insert Mode

- **Insert before cursor:** `i`
- **Append after cursor:** `a`
- **Open a new line below:** `o`
- **Return to Normal mode:** `ESC`

---

## 📑 Copy, Cut, and Paste

- **Copy a line:** `yy`
- **Cut (delete) a line:** `dd`
- **Paste after the cursor:** `p`
- **Paste before the cursor:** `P`

---

## 🔍 Searching in Vi

- **Search forward for "word":** `/word`
- **Search backward for "word":** `?word`

- **Repeat last search forward:** `n`
- **Repeat last search backward:** `N`

---

## 💾 Saving and Exiting

- **Save:** `:w`
- **Quit:** `:q`
- **Save and quit:** `:wq`
- **Quit without saving:** `:q!`

# 🐧 Linux Networking

## 1️⃣ Network Issues

### 📌 Overview

Networking issues in Linux can arise due to misconfigurations, hardware failures, or connectivity problems. Below are **common network issues, their causes, and solutions**.

### 🛠️ Common Network Issues

| Issue | Cause | Solution |
|---|---|---|
| **No Internet** | Missing IP address, no default gateway | Check with `ip a`, `route -n` |
| **Slow Connection** | High network traffic, DNS issues | Test with `ping`, `traceroute` |
| **Cannot Reach Host** | Firewall, incorrect routes | Check `iptables`, `firewalld`, `netstat -r` |
| **Hostname Not Resolving** | DNS issues | Verify `/etc/resolv.conf`, use `nslookup`, `dig` |
| **No Network Interface** | Driver issue | Use `lspci`, `lsmod`, reinstall drivers |

### 📌 Basic Network Commands

```
ip a                    # Show network interfaces
ip r                    # Display routing table
ping 8.8.8.8            # Test connectivity
traceroute google.com   # Trace route to a host
nslookup google.com      # Resolve domain to IP
netstat -tulnp          # Show open ports and listening services
```

---

# 2️⃣ DNS (Domain Name System)

## 📌 Overview

DNS translates domain names (e.g., `google.com`) into IP addresses.

## 🛠️ Checking DNS Configuration

**View DNS servers in use:**

```
cat /etc/resolv.conf
```

**Test domain resolution:**

```
nslookup google.com
dig google.com
host google.com
```

---

## 📌 Flushing DNS Cache

**If using `systemd-resolved`:**

```
sudo systemctl restart systemd-resolved
```

**For `nscd` (Name Service Cache Daemon):**

```
sudo systemctl restart nscd
```

---

## 📌 Manually Setting DNS

**Edit `/etc/resolv.conf` (temporary change):**

```
nameserver 8.8.8.8
nameserver 1.1.1.1
```

**For permanent changes, modify `/etc/systemd/resolved.conf`:**

```
[Resolve]
DNS=8.8.8.8 1.1.1.1
```

**Then restart the service:**

```
sudo systemctl restart systemd-resolved
```

---

# 3️⃣ Networking Basics

## 📌 Overview

Linux networking follows a layered approach similar to the **OSI model**.

## 🛠️ Key Networking Components

| Component | Description |
|---|---|
| **IP Addressing** | Identifies a device in a network (e.g., `192.168.1.1`) |
| **Subnet Mask** | Defines the network range (e.g., `255.255.255.0`) |
| **Gateway** | Router address for external traffic |
| **DNS Server** | Resolves domain names (e.g., `8.8.8.8` for Google DNS) |
| **MAC Address** | Unique hardware address of a network interface |

---

## 📌 Viewing Network Configuration

```
ip a        # Show IP addresses
ip r        # Show routing table
ip link     # Show network interfaces
```

---

## 📌 Assigning a Static IP (Temporary)

```
sudo ip addr add 192.168.1.100/24 dev eth0
sudo ip route add default via 192.168.1.1
```

---

### 📌 Assigning a Static IP (Permanent - Ubuntu)

**Edit `/etc/netplan/*.yaml`:**

```
network:
  ethernets:
    eth0:
      addresses:
        - 192.168.1.100/24
      gateway4: 192.168.1.1
      nameservers:
        addresses:
          - 8.8.8.8
          - 1.1.1.1
  version: 2
```

**Apply the changes:**

```
sudo netplan apply
```

---

## 4️⃣ Network Troubleshooting

### 📌 Overview

Troubleshooting involves diagnosing and resolving network issues **systematically**.

---

### 🛠️ Step-by-Step Troubleshooting

#### 🟢 Step 1: Check Network Interfaces

```
ip a          # List all interfaces
ifconfig -a   # Show interface details
```

#### 🟢 Step 2: Check Connectivity

```
ping 8.8.8.8            # Test internet access
ping -c 5 google.com    # Test DNS resolution
```

### 🟢 Step 3: Verify Routing Table

```
ip r       # Show routing table
route -n   # Display routes
```

### 🟢 Step 4: Check DNS Resolution

```
nslookup google.com
dig google.com
host google.com
```

### 🟢 Step 5: Check Open Ports

```
netstat -tulnp  # Show listening ports
ss -tulnp       # Alternative to netstat
```

### 🟢 Step 6: Restart Networking Services

```
sudo systemctl restart networking         # Restart networking service
sudo systemctl restart systemd-resolved   # Restart DNS resolver
```

### 🟢 Step 7: Inspect Logs

```
journalctl -u networking --no-pager  # View networking logs
dmesg | grep eth0                     # Check for interface errors
```

---

## ✅ Summary of Key Commands

| Action | Command |
|---|---|
| Show network interfaces | `ip a` |
| Display routing table | `ip r` |
| Test connectivity | `ping 8.8.8.8` |
| Trace route to a host | `traceroute google.com` |

| | |
|---|---|
| Check DNS resolution | `nslookup google.com` |
| Restart networking service | `sudo systemctl restart networking` |
| Assign a static IP (temporary) | `sudo ip addr add 192.168.1.100/24 dev eth0` |
| Set a static IP permanently (Ubuntu) | Edit `/etc/netplan/*.yaml` and run `sudo netplan apply` |
| Show open ports | `netstat -tulnp` or `ss -tulnp` |
| View networking logs | `journalctl -u networking --no-pager` |

# 🔒 Linux Security and File Permissions

---

## 1️⃣ Security Incidents

### 📌 Overview

A security incident in Linux refers to unauthorized access, malware, data breaches, or misconfigurations that compromise system integrity.

### 🛠️ Common Security Incidents in Linux

| Incident Type | Description | Detection Method |
|---|---|---|
| **Unauthorized Access** | An attacker gains unauthorized system access | Check `/var/log/auth.log`, `last`, `w` |
| **Privilege Escalation** | User gains unauthorized root access | Audit sudo logs (`cat /var/log/auth.log`) |
| **Malware Infection** | Malicious software compromises the system | Scan with `chkrootkit`, `clamav` |
| **File Integrity Breach** | Unauthorized modification of files | Use `tripwire` or `aide` for integrity checking |
| **Denial of Service (DoS)** | Overloading services to cause downtime | Monitor `netstat`, `top`, `fail2ban` |

### 📌 Basic Security Audit Commands

```
last                          # Show last logins
who                           # Show logged-in users
ps aux --sort=-%mem           # Find processes using high memory
netstat -tulnp                # Check open ports
```

---

## 2️⃣ Linux Accounts

### 📌 Overview

Linux has different types of accounts to manage access and permissions.

### 🛠️ Types of Linux Accounts

| Account Type | Description |
| --- | --- |
| **Root User (UID=0)** | Full system access |
| **Regular User** | Restricted access, used for daily tasks |
| **System Accounts (UID<1000)** | Used by services (e.g., `www-data`, `mysql`) |

### 📌 Managing User Accounts

```
whoami                  # Show current user
id user1                # Show user ID and group ID
cat /etc/passwd         # List all users
```

---

## 3️⃣ Access Control Files

### 📌 Overview

Linux uses access control files to manage permissions for users and groups.

### 🛠️ Important Access Control Files

| File | Description |
| --- | --- |
| `/etc/passwd` | Stores user account details |
| `/etc/shadow` | Stores encrypted passwords |
| `/etc/group` | Manages group memberships |
| `/etc/sudoers` | Controls sudo access |

### 📌 Checking User Access

```
cat /etc/passwd | grep user1   # View user account details
cat /etc/group | grep sudo     # Check if a user is in the sudo group
```

---

## 4️⃣ User Management

### 📌 Creating and Managing Users

```
# Create a new user
sudo useradd -m user1

# Set a password for the user
sudo passwd user1

# Add a user to a group
sudo usermod -aG sudo user1

# Delete a user
sudo userdel -r user1
```

### 📌 Group Management

```
# Create a new group
sudo groupadd developers

# Add a user to a group
sudo usermod -aG developers user1

# Remove a user from a group
sudo gpasswd -d user1 developers
```

---

## 5️⃣ File Permissions and Ownership

### 📌 Overview

Linux file permissions determine who can read, write, and execute files.

### 🛠️ Understanding File Permissions

To view file permissions, use:

```
ls -l file.txt
```

Example output:

```
-rwxr-xr-- 1 user1 group1 1024 Mar 7 10:00 file.txt
```

| Permission Symbol | Meaning |
|---|---|
| **r (read)** | Can read the file |
| **w (write)** | Can modify the file |
| **x (execute)** | Can run the file as a program |

- **First three characters:** Owner permissions
- **Next three:** Group permissions
- **Last three:** Others' permissions

### 📌 Changing Permissions

```
chmod 755 file.txt        # Owner: rwx, Group: r-x, Others: r-x
chmod u+r file.txt        # Add read permission for owner
```

### 📌 Changing Ownership

```
chown user1 file.txt      # Change file owner
chgrp group1 file.txt     # Change file group
```

---

## 6️⃣ SSH and SCP

### 📌 Secure Shell (SSH)

SSH allows secure remote login:

```
ssh user@remote-server
```

### 📌 Copying Files Securely with SCP

```
# Copy file to a remote server
scp file.txt user@remote-server:/home/user/

# Copy file from a remote server
scp user@remote-server:/home/user/file.txt .
```

---

## 7️⃣ IPTables Introduction

### 📌 Overview

iptables is a firewall used to filter traffic.

### 🛠️ Basic IPTables Commands

```
# List current rules
sudo iptables -L -v

# Block an IP address
sudo iptables -A INPUT -s 192.168.1.10 -j DROP

# Allow SSH (port 22)
sudo iptables -A INPUT -p tcp --dport 22 -j ACCEPT

# Save rules
sudo iptables-save > /etc/iptables.rules
```

---

## 8️⃣ Securing the Environment with IPTables

### 📌 Securing Common Services

```
# Allow web traffic (HTTP and HTTPS)
sudo iptables -A INPUT -p tcp --dport 80 -j ACCEPT
sudo iptables -A INPUT -p tcp --dport 443 -j ACCEPT

# Allow internal network access
sudo iptables -A INPUT -s 192.168.1.0/24 -j ACCEPT

# Block all other incoming traffic
sudo iptables -P INPUT DROP
```

### 📌 Saving and Reloading Rules

```
sudo iptables-save > /etc/iptables.rules
sudo iptables-restore < /etc/iptables.rules
```

---

## 9️⃣ Cron Jobs

### 📌 Overview

Cron jobs automate scheduled tasks in Linux.

### 📌 Creating a Cron Job

```
crontab -e  # Edit cron jobs
```

### 🛠️ Example Cron Jobs

| Task | Cron Expression |
| --- | --- |
| Run a script every minute | `* * * * * /path/to/script.sh` |
| Run a script daily at midnight | `0 0 * * * /path/to/script.sh` |

| | |
|---|---|
| Run a script every Sunday at 2 AM | `0 2 * * 0 /path/to/script.sh` |

### 📌 List and Remove Cron Jobs

```
crontab -l  # List scheduled jobs
crontab -r  # Remove all cron jobs
```

---

## ✅ Summary of Key Security Commands

| Action | Command |
|---|---|
| Show last logins | `last` |
| Show logged-in users | `who` |
| Check open ports | `netstat -tulnp` |
| Change file permissions | `chmod` |
| Change file ownership | `chown` |
| Securely copy files | `scp` |
| List current firewall rules | `sudo iptables -L -v` |
| Block an IP address | `sudo iptables -A INPUT -s <IP> -j DROP` |
| Restart SSH service | `sudo systemctl restart sshd` |

# 📌 Linux System Management: systemd Services

## 🔥 1. Creating a systemd Service

### 🛠️ What is systemd?

`systemd` is an init system that manages services, processes, and system states. It uses **unit files** to control how services are started, stopped, and restarted.

---

### 🚀 Steps to Create a Custom systemd Service

#### 📝 1. Create the Service File

systemd service files are stored in `/etc/systemd/system/`.

```
sudo nano /etc/systemd/system/myservice.service
```

---

#### ⚙ 2. Define the Service Configuration

A basic **systemd** service file has three sections:
✅ **[Unit]** – Describes the service and dependencies
✅ **[Service]** – Defines how the service runs
✅ **[Install]** – Specifies when to start the service

#### 📜 Example systemd Service File

```
[Unit]
Description=My Custom Service
After=network.target

[Service]
ExecStart=/usr/bin/python3 /home/user/myscript.py
Restart=always
User=user
```

```
Group=user
WorkingDirectory=/home/user
StandardOutput=journal
StandardError=journal

[Install]
WantedBy=multi-user.target
```

---

### 🔄 3. Reload systemd to Recognize the New Service

```
sudo systemctl daemon-reload
```

---

### ▸ 4. Enable and Start the Service

```
sudo systemctl enable myservice
sudo systemctl start myservice
```

---

### 📌 5. Check Service Status

```
sudo systemctl status myservice
```

---

### ⛔ 6. Stop and Disable the Service

```
sudo systemctl stop myservice
sudo systemctl disable myservice
```

---

# 🛠️ 2. systemd Service Management and Tools

## 🎛️ Managing Services

| Action | Command |
| --- | --- |
| Start a service | `sudo systemctl start myservice` |

| | |
|---|---|
| Stop a service | `sudo systemctl stop myservice` |
| Restart a service | `sudo systemctl restart myservice` |
| Reload a service | `sudo systemctl reload myservice` |
| Enable at boot | `sudo systemctl enable myservice` |
| Disable at boot | `sudo systemctl disable myservice` |
| Check service status | `sudo systemctl status myservice` |
| View service logs | `journalctl -u myservice` |

---

### 📋 Checking System Services

```
systemctl list-units --type=service     # List all active services
systemctl list-unit-files --type=service  # List all installed services
```

---

## ⚡ 3. Service Unit File Options

### 🏗️ [Unit] Section (Describes the service)

| Option | Description |
|---|---|
| `Description=` | Short description of the service |
| `After=` | Services that should start **before** this one |
| `Before=` | Services that should start **after** this one |
| `Requires=` | **Hard dependency** – If this service fails, dependent services fail too |

| | |
|---|---|
| `Wants=` | **Soft dependency** – If this service fails, dependent services may continue |

---

### 🔧 [Service] Section (Defines how the service runs)

| Option | Description |
|---|---|
| `ExecStart=` | Command to start the service |
| `ExecStop=` | Command to stop the service |
| `ExecReload=` | Command to reload the service |
| `Restart=` | Restart policy (`always`, `on-failure`, `no`, `on-success`) |
| `User=` | Specifies which user runs the service |
| `Group=` | Specifies which group runs the service |
| `WorkingDirectory=` | Specifies the working directory |
| `Environment=` | Sets environment variables |

---

### 🎯 [Install] Section (Specifies startup behavior)

| Option | Description |
|---|---|
| `WantedBy=` | Defines target where the service should start (e.g., `multi-user.target`) |
| `RequiredBy=` | Services that depend on this service |

---

## 🛠️ 4. systemctl Command Options

| Command | Description |
|---|---|

| | |
|---|---|
| `systemctl start <service>` | Starts a service |
| `systemctl stop <service>` | Stops a service |
| `systemctl restart <service>` | Restarts a service |
| `systemctl reload <service>` | Reloads the configuration of a running service |
| `systemctl enable <service>` | Enables a service at boot |
| `systemctl disable <service>` | Disables a service at boot |
| `systemctl status <service>` | Shows service status |
| `systemctl is-active <service>` | Checks if a service is running |
| `systemctl is-enabled <service>` | Checks if a service is enabled |
| `systemctl mask <service>` | Prevents a service from starting |
| `systemctl unmask <service>` | Allows a masked service to start |

---

## 📜 5. Checking systemd Logs

```
journalctl -xe   # Show detailed logs
journalctl -u myservice --since "1 hour ago"  # View logs for a specific service
journalctl --boot -1  # Show logs from the previous boot
```

---

## ✏️ 6. Editing and Reloading Services

```
sudo systemctl edit myservice  # Edit service configuration
sudo systemctl daemon-reexec    # Restart systemd itself
sudo systemctl reset-failed     # Clear failed services list
```

---

## ✅ Conclusion

- `systemd` provides a powerful way to manage services in Linux.
- You can create, enable, disable, start, stop, and monitor services with `systemctl`.
- Logs can be viewed with `journalctl` to debug issues.
- Understanding systemd helps in automating processes, running background jobs, and optimizing system performance.

🚀 **Mastering systemd = Better Linux System Administration!** 🔥💻

# 💾 Linux Storage Management

## 🔥 1. Disk Partitions

A **disk partition** is a logical division of a physical storage device that allows better management of data. In Linux, partitions are managed using tools like `fdisk`, `parted`, and `lsblk`.

### 🗂️ Types of Partitions

| Partition Type | Description |
|---|---|
| **Primary** | Can contain a bootable OS, limited to 4 partitions |
| **Extended** | Used to create more than 4 partitions, acts as a container |
| **Logical** | Partitions inside an extended partition |

---

### 📋 Checking Disk Partitions

```
lsblk      # List block devices and partitions
fdisk -l   # Display partition details
parted -l  # Show partition table info
```

---

### 🛠️ Creating a New Partition with fdisk

```
sudo fdisk /dev/sdb
# Press 'n' → Create a new partition
# Press 'p' → Make it a primary partition
# Enter partition number and size
# Press 'w' → Write changes
```

---

### 🔧 Formatting a Partition

```
sudo mkfs.ext4 /dev/sdb1   # Format as ext4
```

---

### 📂 Mounting a Partition

```
sudo mount /dev/sdb1 /mnt/data
```

To make it permanent, add to `/etc/fstab`:

```
/dev/sdb1  /mnt/data  ext4  defaults  0  2
```

---

## 🗄️ 2. File Systems in Linux

A **file system** defines how data is stored and accessed on a disk.

### 🔍 Common File Systems

| File System | Description |
|---|---|
| **ext4** | Default Linux file system, supports journaling |
| **xfs** | High-performance file system, used in RHEL |
| **btrfs** | Supports snapshots and RAID features |
| **vfat** | Used for USB drives, compatible with Windows |
| **ntfs** | Windows file system, needs `ntfs-3g` to write |

---

### 🛠️ Checking File System Type

```
df -T /mnt/data   # Check file system type of a mount point
lsblk -f          # Show file system type of all partitions
```

---

### 🔄 Converting File Systems

```
sudo mkfs.xfs /dev/sdb1   # Convert to XFS
sudo mkfs.btrfs /dev/sdb1 # Convert to Btrfs
```

---

# 💾 3. DAS, NAS, and SAN

Linux storage can be categorized into:
✔ **Direct-Attached Storage (DAS)**
✔ **Network-Attached Storage (NAS)**
✔ **Storage Area Network (SAN)**

---

## 🖥️ 3.1 Direct-Attached Storage (DAS)

**DAS** refers to storage devices that are directly connected to a single computer without a network.

**Examples of DAS**

- **Internal Hard Drives (HDDs & SSDs)**: SATA, NVMe
- **External USB Drives**: USB hard drives, flash drives
- **RAID**: Locally attached RAID controllers

### ✅ Advantages of DAS

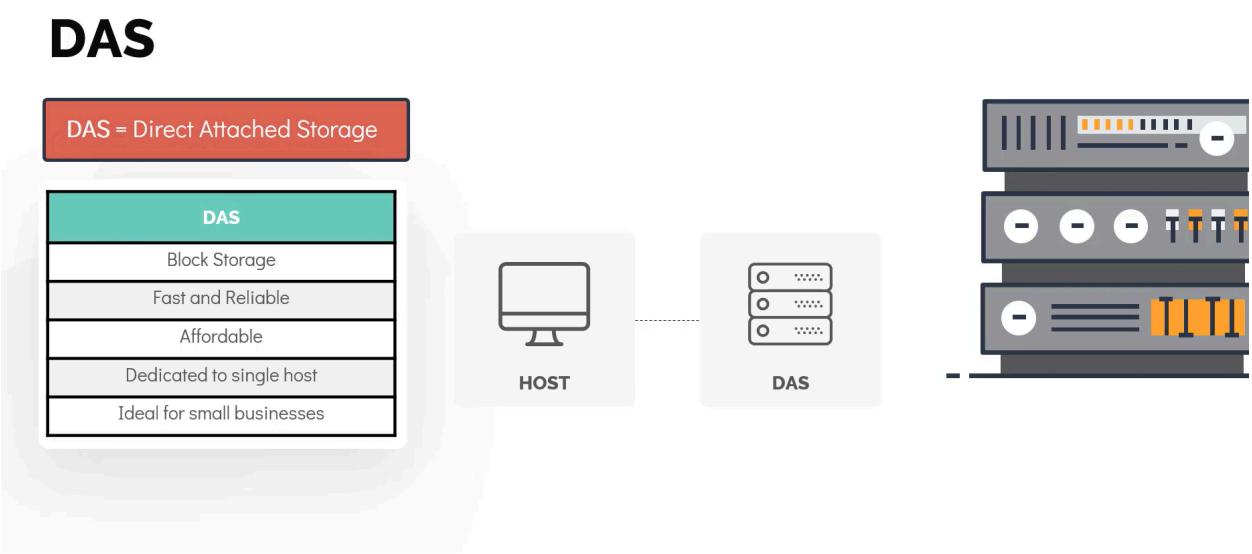
✔ High speed (direct connection)
✔ No network dependency
✔ Lower cost

### ❌ Disadvantages of DAS

✖ Limited to a single machine
✖ Not easily shareable

### 🛠️ Checking DAS Devices in Linux

```
lsblk      # Show block devices
fdisk -l   # List partitions
df -h      # Show mounted file systems
```




---

## 🌐 3.2 Network-Attached Storage (NAS)

**NAS** is a storage device connected to a network, accessible by multiple clients over protocols like **NFS (Linux/Unix)** and **SMB (Windows)**.

**Examples of NAS**

- **Dedicated NAS appliances** (e.g., Synology, QNAP)
- **Linux-based file servers**

### ✅ Advantages of NAS

✔ Centralized storage
✔ Multiple users can access files
✔ Easy to scale

### ❌ Disadvantages of NAS

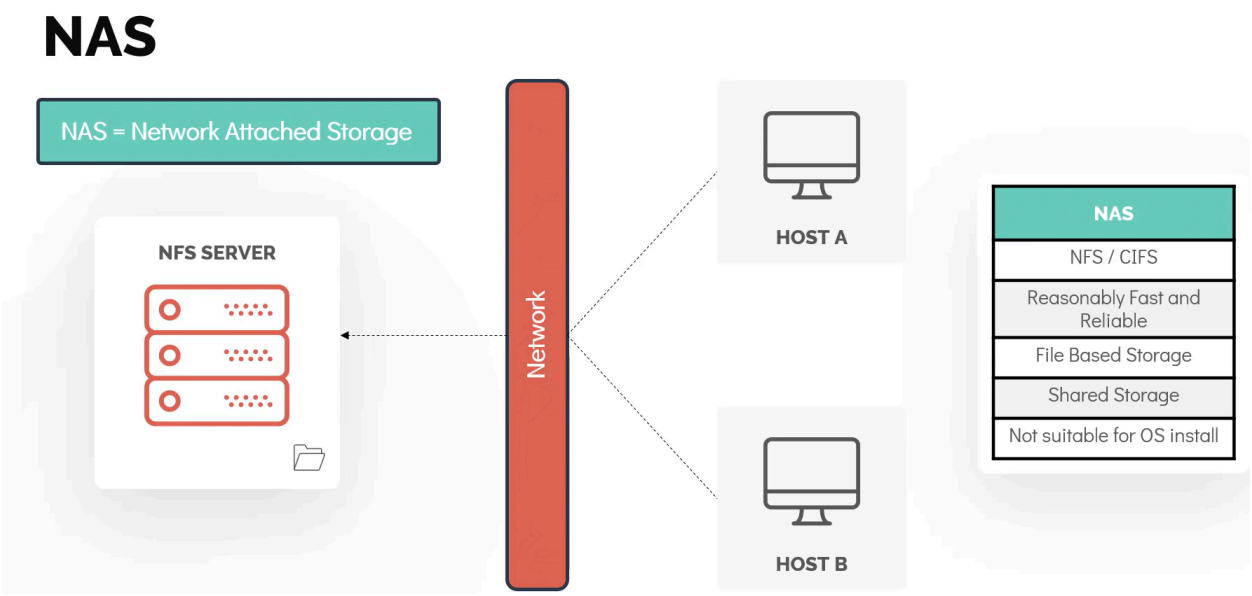
✖ Slower than local DAS
✖ Dependent on network performance

### 🛠️ Mounting a NAS Share via NFS

```
sudo mount -t nfs 192.168.1.100:/shared_folder /mnt/nas
```

To make it persistent, add to `/etc/fstab`:

```
192.168.1.100:/shared_folder  /mnt/nas  nfs  defaults  0  0
```




---

## ⚡ 3.3 Storage Area Network (SAN)

**SAN** is a high-speed network dedicated to providing block-level storage to multiple machines, often used in data centers.

**Examples of SAN Technologies**

- **Fibre Channel (FC)** – High-speed storage networking
- **iSCSI (Internet Small Computer System Interface)** – Block storage over TCP/IP

### ✅ Advantages of SAN

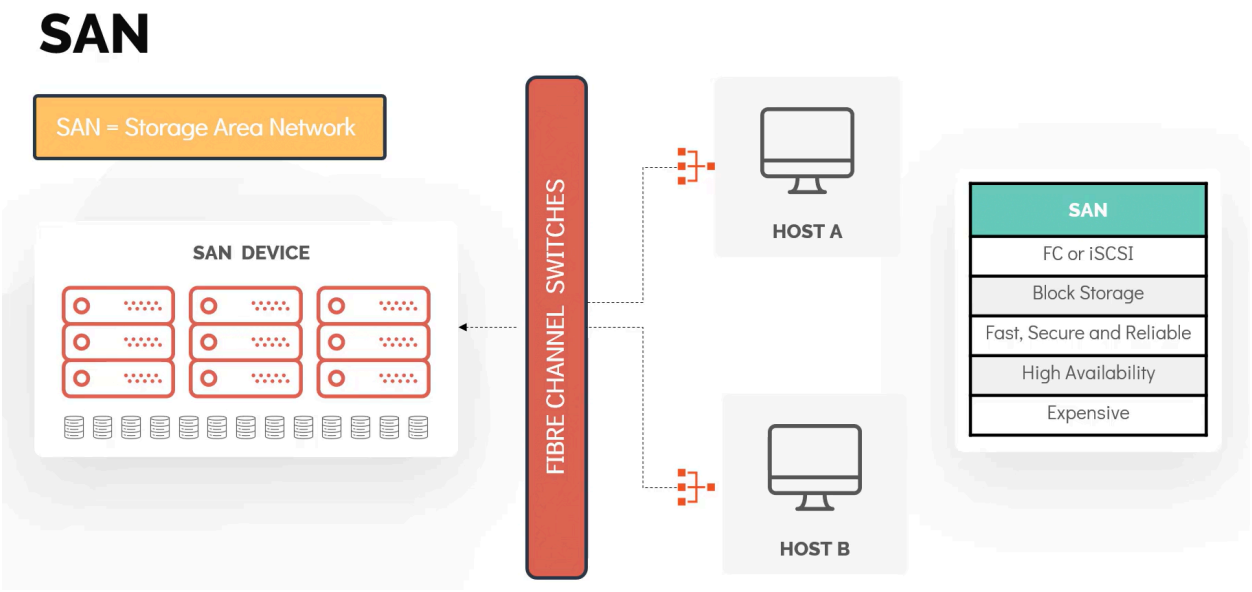
✔ High-speed performance
✔ Redundancy and fault tolerance
✔ Supports virtualization

### ❌ Disadvantages of SAN

✖ Expensive setup
✖ Requires specialized hardware

### 🛠️ Checking SAN/iSCSI Devices in Linux

```
iscsiadm -m session  # List active iSCSI sessions
lsblk                # Show block devices
multipath -ll        # Show multi-path storage devices
```




---

## 📡 4. NFS (Network File System) in Linux

**NFS** allows Linux systems to share files over a network using a **client-server architecture**.

---

### 🔧 4.1 Installing NFS

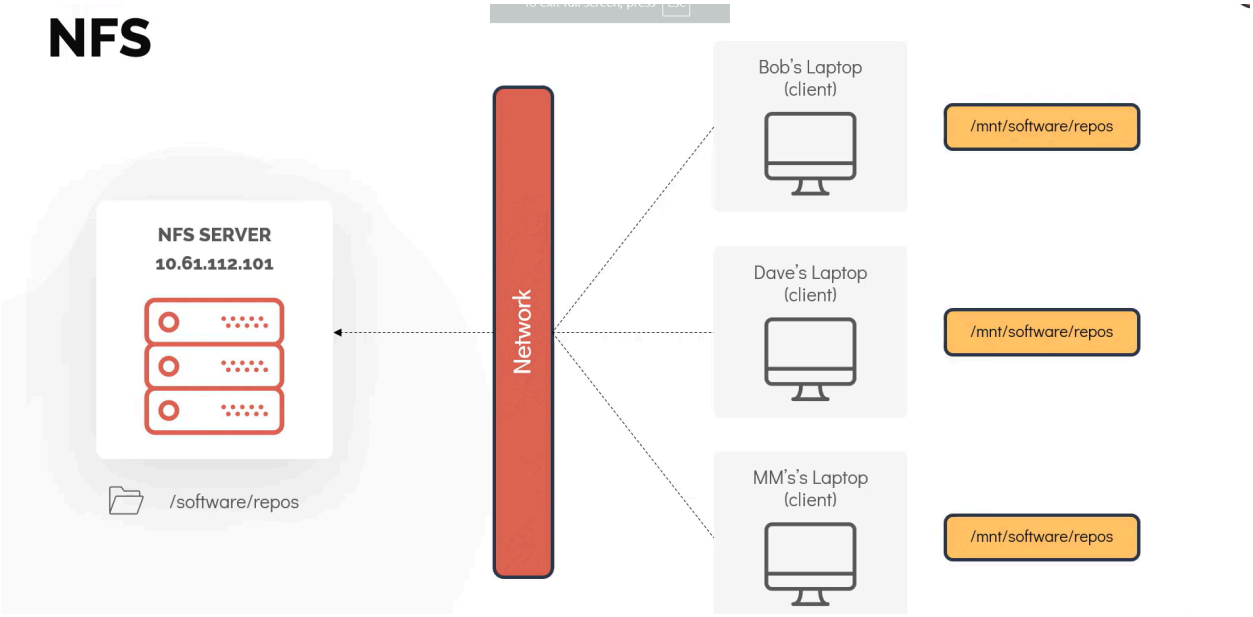
**On the NFS Server:**

```
sudo apt install nfs-kernel-server   # Debian-based

sudo yum install nfs-utils           # RHEL-based
```

**On the NFS Client:**

```
sudo apt install nfs-common   # Debian-based
sudo yum install nfs-utils    # RHEL-based
```




---

## 🛠️ 4.2 Configuring an NFS Server

**Create a Shared Directory:**

```
sudo mkdir -p /mnt/shared
sudo chmod 777 /mnt/shared
```

**Edit the NFS Exports File:**

```
sudo nano /etc/exports
```

Add:

```
/mnt/shared  192.168.1.0/24(rw,sync,no_root_squash)
```

**Restart NFS Service:**

```
sudo systemctl restart nfs-server
```

---

### 📂 4.3 Mounting an NFS Share on a Client

```
sudo mount -t nfs 192.168.1.100:/mnt/shared /mnt/client
```

To make it persistent, add to `/etc/fstab`:

```
192.168.1.100:/mnt/shared  /mnt/client  nfs  defaults  0  0
```

---

### 📊 4.4 Checking NFS Status

```
showmount -e 192.168.1.100  # Show available NFS shares
systemctl status nfs-server  # Check NFS service status
```

---

## 📦 5. LVM (Logical Volume Manager)

LVM allows **flexible disk management**, enabling resizing and snapshots.

### 📜 5.1 LVM Components

| Component | Description |
|---|---|
| **Physical Volume (PV)** | Raw storage device (e.g., `/dev/sdb`) |
| **Volume Group (VG)** | Collection of physical volumes |
| **Logical Volume (LV)** | Partition inside a volume group |

---

### 5.2 Creating an LVM Partition

#### Step 1: Initialize the Physical Volume

```
sudo pvcreate /dev/sdb
```

---

### Step 2: Create a Volume Group

```
sudo vgcreate my_vg /dev/sdb
```

---

### Step 3: Create a Logical Volume

```
sudo lvcreate -L 10G -n my_lv my_vg
```

---

### Step 4: Format and Mount the LVM Volume

```
sudo mkfs.ext4 /dev/my_vg/my_lv

sudo mkdir /mnt/lvm

sudo mount /dev/my_vg/my_lv /mnt/lvm
```

**To make the mount persistent, add it to `/etc/fstab`:**

```
/dev/my_vg/my_lv  /mnt/lvm  ext4  defaults  0  2
```

---

## 🔄 5.3 Resizing an LVM Volume

### Increase LVM Size

```
sudo lvextend -L +5G /dev/my_vg/my_lv  # Increase by 5GB

sudo resize2fs /dev/my_vg/my_lv        # Resize file system
```

---

### Reduce LVM Size (Unmount First!)

```
sudo umount /mnt/lvm

sudo lvreduce -L -5G /dev/my_vg/my_lv

sudo resize2fs /dev/my_vg/my_lv

sudo mount /dev/my_vg/my_lv /mnt/lvm
```

---

## 📸 5.4 Creating LVM Snapshots

### Create a Snapshot

```
sudo lvcreate -L 1G -s -n my_snapshot /dev/my_vg/my_lv
```

---

### Restore from a Snapshot

```
sudo lvconvert --merge /dev/my_vg/my_snapshot
```

---

## 📊 5.5 Checking LVM Status

### Show Physical Volumes

```
sudo pvs
```

### Show Volume Groups

```
sudo vgs
```

### Show Logical Volumes

```
sudo lvs
```