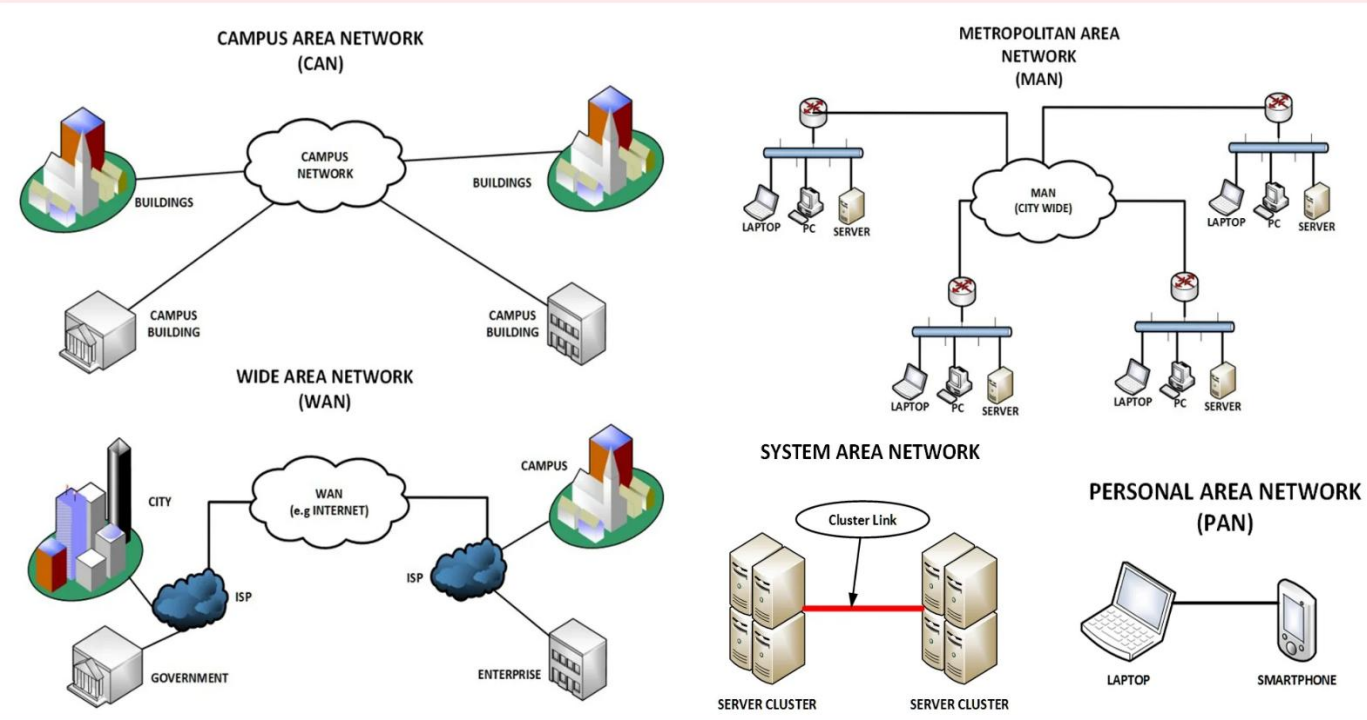
What is a Network?

- Networking is the process of connecting multiple computers and devices together to share resources like files, internet access, and printers, etc and communicate through protocols.
- It is composed of two main aspects
  - Physical connection for ex: wires,cables,wireless media,etc
  - Logical connection

There Are Some Basic Networking Rules

- Data must be delivered uncorrupted. If it is corrupted, it's useless.
- Computers in a network must be capable of determining the origin and destination of a piece of information, i.e., its IP and Mac Address.

Types of Computer Networks



1. **Personal Area Network (PAN)** : Ultra-small networks used for personal use to share data from one device to another. Ex: (smart phone to laptop, smart watch to smart phone,etc)

2. **Local Area Network (LAN)** : A computer network within a small geographical area such as a single room, building or group of buildings. Ex: (Home Network, Small Business or Office Network).
3. **Wireless Local Area Network (WLAN)** : A LAN that's dependent on wireless connectivity or one that extends a traditional wired LAN to a wireless LAN. Most home networks are WLAN's
4. **Campus Area Network (CAN):** A computer network of multiple interconnected LAN's in a limited geographical area, such as a corporate business park, government agency, or university campus. Typically owned or used by a single entity.
5. **Metropolitan Area Network (MAN) :** A computer network that interconnects users with computer resources in a city and it's larger than a campus area network but smaller than a wide area network.
6. **Wide Area Network (WAN) :** A computer network that extends over a large geographical distance, typically multiple cities and countries and typically use leased telecommunications lines from **Internet Service Providers** (ISP). Ex: (The internet and corporate offices in different states).

Network Topologies

1 . Star topology : All devices are connected to a central hub or switch communication passes through this central device

Advantages :

- Easy to install and manage.
- Failure of one cable doesn't affect others.
- Easy to detect faults.

Disadvantages:

- Central hub Failure = entire network down.
- Require more cables means higher cost.

2 . Mesh Topology : Every device connects to every other device directly or partially.

Advantages :

- Highly reliable (no single point of failure).
- Data can take multiple paths.
- Excellent performance and privacy.

Disadvantages :

- Very expensive .
- Difficult to set up and manage.

3 . Ring Topology : Each device connects to two devices forming a ring. Data travels in one or both directions.

Advantages :

- Easy to install and expand
- Equal access for all devices (no collision).

Disadvantages :

- Failure of one device breaks tha ring.
- Difficult to troubleshoot.

4 . Tree Topology : A combination of star and bus topologies, forming a hierachicak structure.

Advantages :

- Easy to expand.
- Supports large networks.
- Fault isolation is easier.

Disadvantages :

- Central hub failure affects entire branch.
- More cable and maintenance cost.

5 . Fully Connected Topology : Every node has a direct link to every other node.

Advantages :

- Maximum reliability.

- No network congestion.
- High security-each connection is private.

Disadvantages :

- Extremely high cost and complexity.
- Not scalable for large networks.

6 . Bus Topology : All devices share a single central cable(bus).

Advantages :

- Cheap and simple setup
- Require less cable.

Disadvantages :

- Entire network fails if backbone breaks.
- Difficult to troubleshoot.
- Performance drops with more devices.

7 . Line Topology : devices are connected in a linear sequence – one after another.

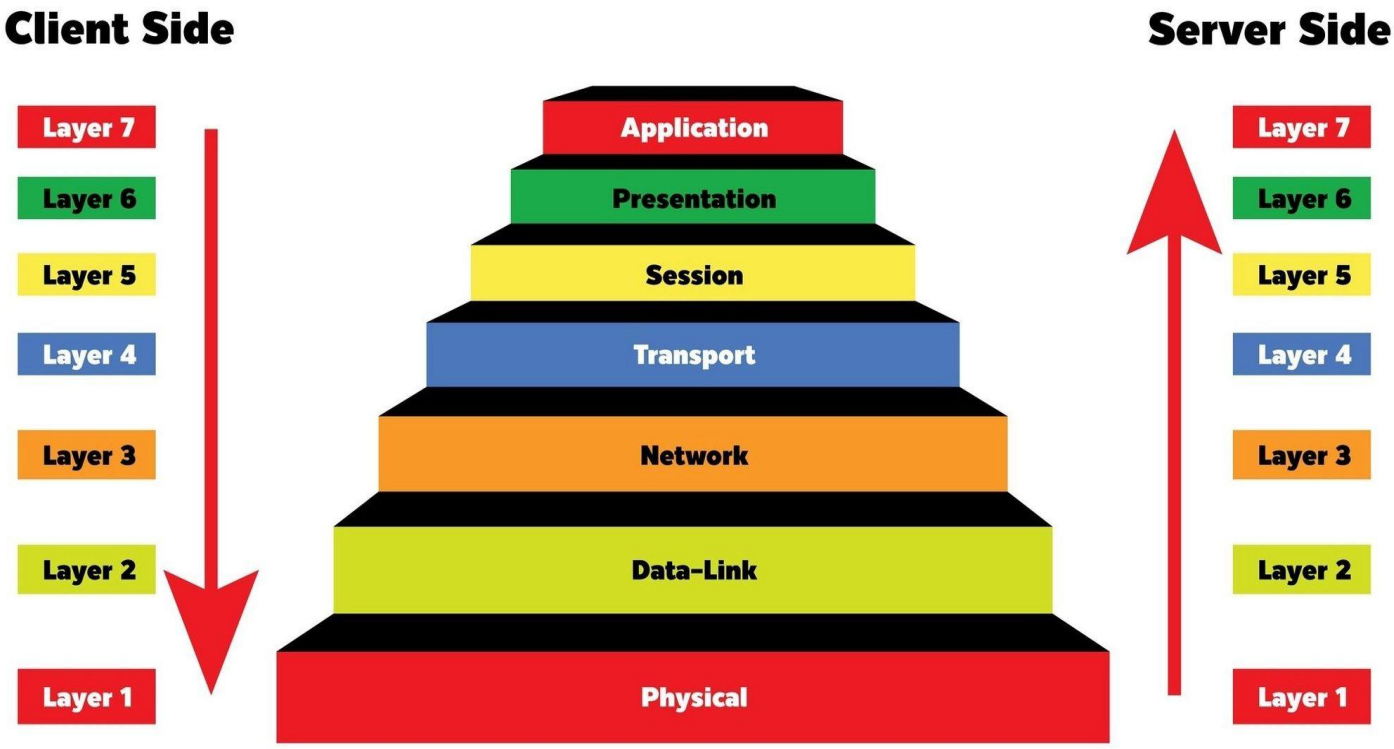
Advantages :

- Simple and inexpensive
- Easy to extend.

Disadvantages :

- If one link fails, communication stops beyond that point.
- Slower as network grows.

OSI Model



1. **Physical Layer :** Deals with hardware transmission – raw bits (0s and 1s) are converted into signals (electrical, optical, or radio).
2. **Data link Layer :** Responsible for error detection, flow control and MAC addressing. It ensures data frames are delivered to the correct device on the same network.
3. **Network Layer :** Handles logical addressing (ip) and routing – decides the best path for data to travel.
4. **Transport Layer :** Provides end-to-end communication, error recovery, and flow control. It Segments large messages into smaller units.
5. **Session Layer :** Manages sessions between applications – opens, maintains, and closes connections.
6. **Presentation Layer** : Ensures that data is in readable format for the application. Handles encryption, compression and data conversion (like ASCII to binary).

7. **Application Layer :** Closest to the user – provides network services directly to applications.

Encapsulation and decapsulation

Encapsulation in OSI Model:

Encapsulation is the process of **adding control information** to data as it moves **down through the OSI layers** from the **Application Layer to the Physical Layer** before being transmitted over the network.

When a user sends data, it starts at the **Application Layer** as simple information. As it passes through each layer, that layer adds its own header (and sometimes a trailer) containing important details needed for communication — such as addressing, routing, or error detection.

Encapsulation = Adding headers as data is prepared for transmission.

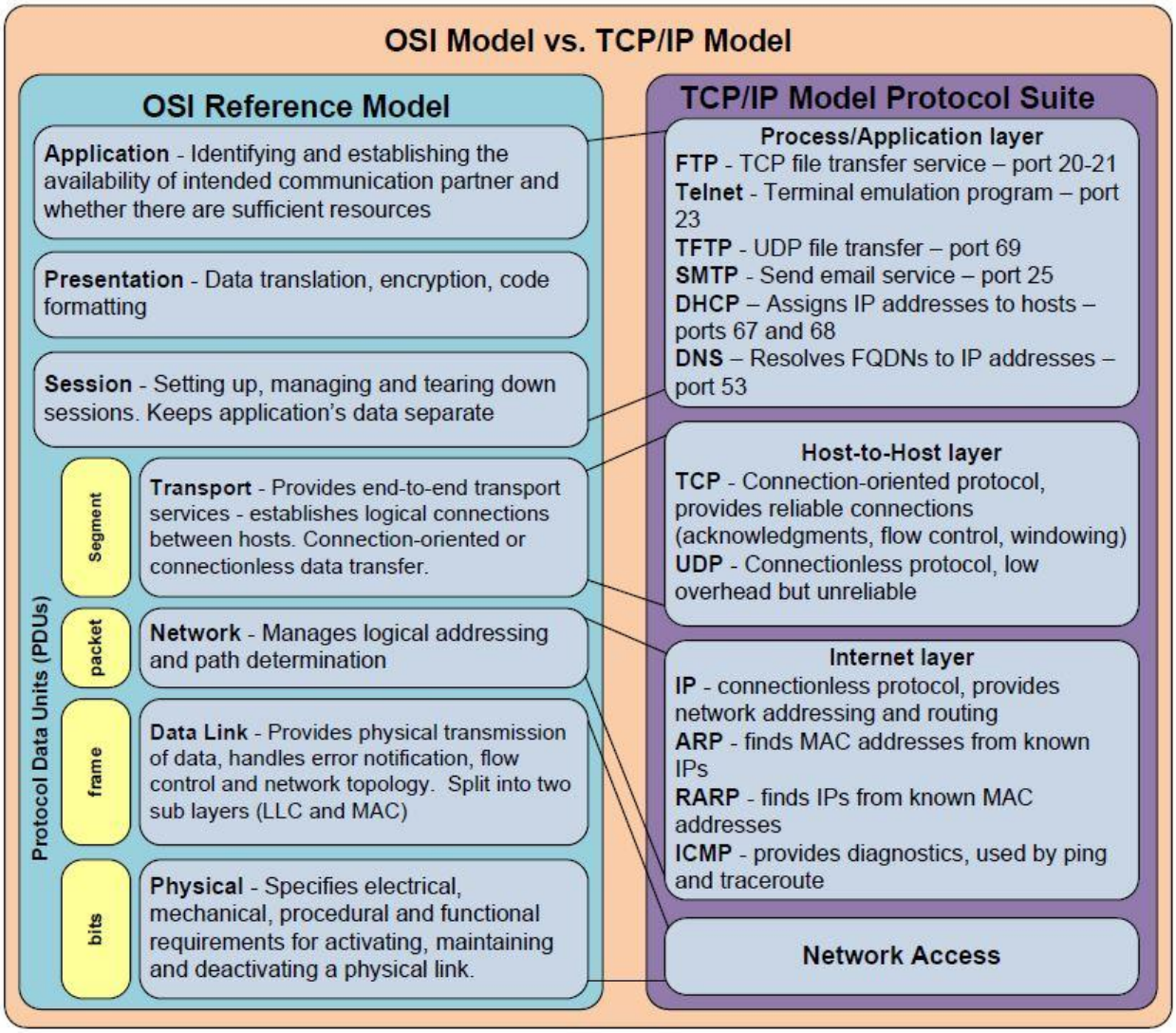
Decapsulation in OSI Model:

Decapsulation is the **reverse process** of encapsulation. It occurs when data is **received** by the destination device and moves **up the OSI layers** from the **Physical Layer to the Application Layer**.

As the data travels upward, each layer **removes its corresponding header and trailer** and processes only the information meant for that layer. The **Physical Layer** converts signals into bits, the **Data Link Layer** verifies frames, the **Network Layer** checks the IP address, and so on — until finally, the **Application Layer** receives the original data in its usable form.

Decapsulation = Removing those headers as data is received and interpreted.

TCP/IP Model



The TCP/IP Model (Transmission Control Protocol / Internet Protocol) is the fundamental framework that defines how data is transmitted over the internet.

It was developed by the U.S Department of Defence (DoD) in the 1970s and is sometimes called the DoD Model.

The TCP/IP model is simpler than the OSI model and has four layers, each performing specific functions to ensure successful data transmission.

1 . Application Layer : The Application Layer is the top layer of the TCP/IP model.

It provides network service directly to users and applications, enabling communication through softwares like web browsers, email clients, and file transfer tools.

This layer combines the OSI model's Application, Presentation, and Session layer into one.

Examples of Protocols :

- HTTP / HTTPS – Web Browsing.
- FTP / SFTP – File transfer
- SMTP / POP3 / IMAP – Email services
- DNS – Domain name resolution
- Telnet / SSH – Remote login

2 . Transport Layer : The Transport layer ensures end-to-end communication between devices. It is responsible for data segmentation, flow control, and error recovery. This layer decides how much data should be sent, checks for errors, and ensures that the data arrives correctly and in order.

It corresponds to the Transport Layer (layer 4) of the OSI model.

Main Protocols :

TCP (Transmission Control Protocol) : Reliable, connection-oriented, ensures all data packets arrive correctly and in sequence. Used for web, email, and file transfer.

UDP (User Datagram Protocol) : Unreliable, Connectionless, faster but does'nt guarantee delivery. Used for streaming , gaming, and voice calls.

3 . Internet Layer Protocols : These protocols handle logical addressing and routing of data packets across different networks.

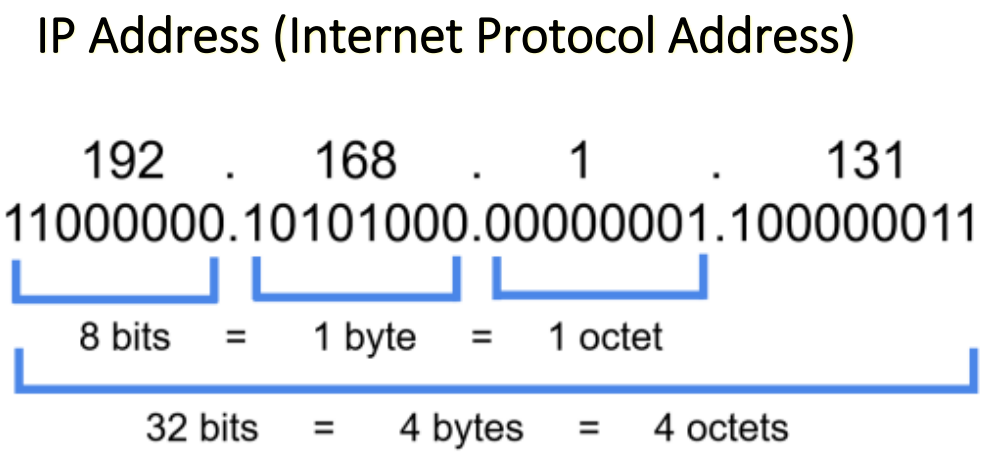
Examples :

- IP (Internet Protocol)
- ICMP (Internet Control Message Protocol)
- ARP (Address Resolution Protocol)
- RARP (Reverse Addresses Resolution Protocol)

4 . Network Access (Data Link And Physical) Layer Protocols : These protocols work at the lowest layers, defining how data is transmitted over physical media such as cables, Wi-Fi, or fiber optics.

Examples :

- Ethernet
- Wi-Fi
- PPP (Point-to-Point Protocols)
- Frame Relay
- HDLC (High-Level Data Link Control)



IP Address : An IP Address is a unique string of number assigned to every device on a network. It identifies where data should be sent and where it came from.

- IPv4 : 32-bit, looks like 192.168.1.1 (4 billion addresses)
- IPv6 : 128-bit, looks like 2001:0db8:85a3:0000:0000:8a2e:0370:7334 (billions of trillions of addresses)

MAC Address (Media Access Control) : A MAC address is a hardware ID assigned to the network interface card (NIC) of a device. It’s permanent and unique like a fingerprint.

Format : 00:1A:2B:3C:4D:5E.

IP Address To Binary

What is the binary IIIIIIII in decimal?

	128		64		32		16		8		4		2		1		
Binary	1		1		1		1		1		1		1		1		
Decimal	128	+	64	+	32	+	16	+	8	+	4	+	2	+	1	=	**255 Decimal**

Add the number where there is a "1".
Add zero, when there is a "0".

Binary to IP Address Examples :

1 . 10101100.01001101.10111000.00011010

Ans : 172.77.184.26

2 . 10110011.01000110.00101011.10101111

Ans : 179.70.43.175

3 . 00100100.10010010.00110011.10010011

Ans : 36.146.51.147

4 . 11100101.01110101.00110010.10001001

Ans : 227.117.50.137

IP Address To Binary :

1 . 184.126.139.72

Ans : 10111000.01111100.10001011.01001000

2 . 112.214.52.142

Ans : 01110000.11010110.00110100.01111011

3 . 129.214.119.123

Ans : 10000001.11010110.01110111.01111011

Common Protocols And Ports

Protocol	Port	Purpose
HTTP	80	Web browsing
HTTPS	443	Secure web browsing
FTP	20, 21	File transfer
SSH	22	Secure remote login
Telnet	23	Remote login (insecure)
SMTP	25	Send emails
POP3	110	Receive emails
IMAP	143	Read emails online
DNS	53	Domain name resolution
DHCP	67, 68	Assign IP addresses
SNMP	161	Network management
NTP	123	Time synchronization
RDP	3389	Remote desktop access
SMB	445	File sharing
MySQL	3306	Database communication

In computer networking, **protocols** are a set of rules that define how data is transmitted and received over a network.
Each protocol uses a **port number** — a virtual doorway that allows data to be directed to the correct service or application on a device.

Ports are divided into:

- **Well-known ports:** 0–1023
- **Registered ports:** 1024–49151
- **Dynamic/private ports:** 49152–65535

Most Common Protocols and Their Port Numbers

1 . HTTP (Hypertext Transfer Protocol) – Port 80

Used for transferring web pages over the Internet.
It's the foundation of data communication on the web (used by websites without encryption).

2 . HTTPS (Hypertext Transfer Protocol Secure) – Port 443

A secure version of HTTP that encrypts data using SSL/TLS, protecting users' information during transmission.
Used for secure websites (those with a 🔒 lock symbol).

3 . FTP (File Transfer Protocol) – Ports 20 & 21

Used to transfer files between computers over a network.

- Port 21 handles control (commands)
- Port 20 handles actual file data transfer

4 . SSH (Secure Shell) – Port 22

Used for secure remote login and command execution on network devices and servers.
It encrypts all data — often used by network administrators.

5 . Telnet – Port 23

Used for remote command-line connections, but **not secure** (transmits data in plain text).
Now mostly replaced by SSH.

6 . SMTP (Simple Mail Transfer Protocol) – Port 25

Used to **send** emails between mail servers.
When you click "Send" on an email, SMTP handles it.

7 . POP3 (Post Office Protocol v3) – Port 110

Used by email clients to **receive** emails from a mail server and download them locally.

8 . IMAP (Internet Message Access Protocol) – Port 143

Also used to **receive** emails, but allows you to view them directly on the server (better for webmail apps like Gmail).

9 . DNS (Domain Name System) – Port 53

Translates **domain names** (like www.google.com) into **IP addresses** so your device can locate the correct server.

10 . DHCP (Dynamic Host Configuration Protocol) – Ports 67 & 68

Automatically assigns **IP addresses** to devices on a network.
This allows devices to connect easily without manual configuration.

11 . SNMP (Simple Network Management Protocol) – Port 161

Used for network monitoring and managing network devices like routers, switches, and servers.

12 . NTP (Network Time Protocol) – Port 123

Synchronizes the time between computers and network devices.

13 . RDP (Remote Desktop Protocol) – Port 3389

Used to remotely access and control Windows computers with a graphical interface.

14 . SMB (Server Message Block) – Port 445

Used for **file and printer sharing** on Windows networks.

15 . MySQL – Port 3306

Used by MySQL database servers for communication.

16 . HTTPS Alternative: SFTP (Secure File Transfer Protocol) – Port 22

An extension of SSH for secure file transfers.

Routing And Switching

1 . What is Switching?

Switching happens inside a **local network (LAN)** — like inside your home, office, or organization.

A **Switch** is a **network device** that connects multiple devices (computers, printers, servers) within the same network and allows them to communicate efficiently.

How it Works :

- A switch receives data packets and looks at their **MAC address** (a unique hardware address).
- It then forwards the data **only to the device** it is meant for — not to every device.
- This makes communication **fast, secure, and reduces congestion**.

Example :
If Computer A sends a file to Computer B within the same office, the **switch** ensures only Computer B gets it — not everyone else.

📡 Protocols Used :

- Ethernet
- VLAN (Virtual LANs)
- Spanning Tree Protocol (STP)

2 . What is Routing?

Routing happens between **different networks** — for example, between your home network and the Internet.

A **Router** is a **network device** that connects multiple networks and directs data from one network to another.

How it Works :

- The router reads the **destination IP address** of each packet.
- It uses a **routing table** to decide the best path to send that packet.
- It forwards the data toward the destination through the most efficient route.

Example :
When you open www.google.com, your router sends your data from your local network to your Internet Service Provider (ISP), and then to Google's server using the best possible route.

📡 Protocols Used:

- RIP (Routing Information Protocol)
- OSPF (Open Shortest Path First)
- BGP (Border Gateway Protocol)
- EIGRP (Enhanced Interior Gateway Routing Protocol)

3 . Key Difference Between Routing and Switching

Feature	Switching	Routing
Purpose	Connects devices within the same network (LAN)	Connects multiple networks (LAN to WAN)
Device Used	Switch	Router
Address Type	MAC Address	IP Address
Works On (OSI Layer)	Layer 2 (Data Link Layer)	Layer 3 (Network Layer)

Feature	Switching	Routing
Protocol Type	Ethernet, VLAN	RIP, OSPF, BGP
Speed	Faster (within local network)	Slightly slower (inter-network)
Example	Sending a file between office PCs	Accessing a website on the Internet

4 . In Simple Terms:

- **Switching** = Directing traffic inside your network
- **Routing** = Finding the best path between networks

Or think of it like this:

🏠 **Switch** = Traffic manager inside your city
🚗 **Router** = GPS that guides cars between cities

---

5 . Why It Matters in Cybersecurity

Understanding routing and switching is crucial for:

- Network design and troubleshooting
- Firewalls and access control
- Packet sniffing and intrusion detection
- Ethical hacking and penetration testing.

Network Security

Network Security is the practice of **protecting computer networks** and the data that travels across them from **unauthorized access, misuse, modification, or cyberattacks**.

It ensures that your network — whether it's a home Wi-Fi, an office LAN, or the Internet — remains **secure, reliable, and available** for legitimate users.

In simple terms:

Network Security = Protecting data *while it moves* from one device to another.

Why Network Security Is Important

Every organization (and even every individual) relies on networks to store, share, and access information.
Without security, hackers can:

- Steal personal or financial data
- Infect systems with malware
- Disrupt services (like websites or servers)
- Spy on network traffic

So, **network security** protects both people and systems from digital threats.

Key Components of Network Security

1. Firewalls

Act as a barrier between trusted internal networks and untrusted external ones (like the Internet).
They filter traffic based on security rules and block suspicious data.

2. Intrusion Detection and Prevention Systems (IDS/IPS)

Monitor network traffic for suspicious activity or known attack patterns and alert or block them.

3. Antivirus and Anti-malware Software

Detect and remove malicious programs that can damage systems or steal data.

4. Virtual Private Network (VPN)

Encrypts data for secure remote connections over public networks.

5. Access Control

Defines who can access what within a network. Uses authentication (passwords, biometrics) and authorization policies.

6. Encryption

Converts data into unreadable form so even if intercepted, it remains private.

7. Network Segmentation

Divides a large network into smaller sections to contain attacks and limit damage.

8. Security Policies

Guidelines and rules that define how users, devices, and data are protected.

How Network Security Works

1. **Monitoring** – Observe all incoming and outgoing data packets.
2. **Detection** – Identify unusual or suspicious behavior.
3. **Prevention** – Block harmful traffic or access.
4. **Response** – Take action (alert admins, isolate systems, etc.).

All this is managed using security tools like **firewalls**, **routers**, **IDS/IPS**, and **security policies**.

In Simple Words:

Network Security is like a multi-layered shield 🛡️ that protects data, devices, and communication from being hacked, stolen, or disrupted.

Useful Linux Commands

1. File and Directory Management

Command	**Use / Description**
ls	Lists all files and directories in the current location.
ls -l	Lists files in long format (permissions, size, owner).
ls -a	Shows hidden files (starting with .).
pwd	Displays the current working directory.

Command	Use / Description
cd [directory]	Changes to the specified directory.
cd ..	Moves one directory up (parent folder).
mkdir [dir_name]	Creates a new directory.
rmdir [dir_name]	Removes an empty directory.
rm [file_name]	Deletes a file.
rm -r [dir_name]	Deletes a directory and all files inside it.
cp [source] [destination]	Copies files or directories.
mv [source] [destination]	Moves or renames files and directories.
touch [file_name]	Creates a new empty file.
cat [file_name]	Displays the content of a file.
head [file_name]	Shows the first 10 lines of a file.
tail [file_name]	Shows the last 10 lines of a file.
nano [file_name]	Opens a file in the Nano text editor.
vim [file_name]	Opens a file in the Vim text editor.

2. System Information

Command	Use / Description
uname -a	Shows system information (kernel version, OS type).
hostname	Displays the system’s hostname.
whoami	Shows the current logged-in username.

Command	Use / Description
date	Displays or sets the system date and time.
uptime	Shows how long the system has been running.
df -h	Displays available disk space in human-readable format.
du -h	Shows the size of files and directories.
top	Displays running processes and system usage in real-time.
htop	Improved version of top with interactive view.
free -h	Shows memory (RAM) usage.
lscpu	Displays CPU architecture information.

3. User Management

Command	Use / Description
adduser [username]	Creates a new user.
passwd [username]	Changes or sets the password for a user.
deluser [username]	Deletes a user.
who	Shows who is currently logged in.
id [username]	Shows the user ID and group information.
su [username]	Switches to another user account.
sudo [command]	Executes a command as the root (admin) user.

4. File Permissions

Command	Use / Description
chmod [permissions] [file]	Changes file or directory permissions.
chown [user]:[group] [file]	Changes the owner and group of a file.
ls -l	Displays permission details of files.

Example:
chmod 755 file.sh → gives read, write, execute permission to the owner, and read+execute to others.

5. Network Commands

Command	Use / Description
ifconfig	Displays network interface configuration. *(use ip a on new systems)*
ip a	Shows all network interface details.
ping [host]	Tests network connection to a host.
netstat -tuln	Shows active listening ports.
ss -tuln	Newer replacement for netstat.
traceroute [host]	Shows the path packets take to reach a destination.
nslookup [domain]	Finds IP address of a domain.
dig [domain]	Performs detailed DNS lookups.
curl [url]	Transfers data from or to a server (downloads webpages or APIs).

Command	Use / Description
wget [url]	Downloads files from the internet.
nmap [target]	Scans open ports on a target (used in cybersecurity).
ssh [user@ip]	Connects securely to a remote machine.
scp [file] [user@host]:[path]	Copies files securely between systems.

6. Package Management (Ubuntu/Debian)

Command	Use / Description
apt update	Updates the package list.
apt upgrade	Installs the latest updates for all packages.
apt install [package_name]	Installs a package.
apt remove [package_name]	Removes a package.
apt autoremove	Removes unused dependencies.
dpkg -l	Lists all installed packages.

7. Process Management

Command	Use / Description
ps	Displays running processes.
ps aux	Shows all running processes with details.
kill [PID]	Terminates a process using its process ID.

Command	Use / Description
killall [process_name]	Kills all processes with the given name.
bg	Sends a job to the background.
fg	Brings a background job to the foreground.

8. Compression and Archiving

Command	Use / Description
tar -cvf file.tar folder/	Creates a tar archive.
tar -xvf file.tar	Extracts a tar archive.
gzip [file]	Compresses a file.
gunzip [file.gz]	Decompresses a gzipped file.
zip [file.zip] [file_name]	Creates a zip file.
unzip [file.zip]	Extracts zip files.

9. Searching and Filtering

Command	Use / Description
grep [text] [file]	Searches for text in a file.
find [path] -name [file_name]	Finds files by name.
locate [file_name]	Quickly finds files (uses database).
history	Shows command history.
clear	Clears the terminal screen.

10. System Control

Command	Use / Description
shutdown now	Shuts down the system immediately.
reboot	Restarts the system.
logout	Logs out of the current session.
systemctl status [service]	Checks the status of a service.
systemctl start [service]	Starts a service.
systemctl stop [service]	Stops a service.

Bonus Tips :

- Use sudo carefully — it gives **root-level access**.
- Combine commands using pipes: | (e.g., ps aux | grep apache).