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Unit-1 Introductory Concepts & Physical Layer

I	**Introductory Concepts**: Goals and applications of networks, Categories of networks, Organization of the Internet, ISP, Network structure and architecture (layering principles, services, protocols and standards), The OSI reference model, TCP/IP protocol suite, Network devices and components. **Physical Layer:** Network topology design, Types of connections, Transmission media, Signal transmission and encoding, Network performance and transmission impairments, Switching techniques and multiplexing.

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❖ What is Computer Network :

- A **computer network** is a collection of interconnected devices—such as computers, smartphones, printers, and servers—that communicate and share resources with each other. These connections can be established through physical cables (like Ethernet) or wireless signals (such as Wi-Fi). The primary purpose of a computer network is to enable data exchange and resource sharing among multiple devices.
- Computer Network means where no of computers are connected to each other.
- Two Computers are said to be interconnected if they are able to exchange information.

Now let discuss first basic terminology which you should know before studying Computer Network →

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❖ Basic Terminologies of Computer Networks

1. **Network:** A network is a collection of computers and devices that are connected together to enable communication and data exchange.
2. **Nodes:** Nodes are devices that are connected to a network. These can include computers, Servers, Printers, Router, and other devices.
3. **Protocol:** A protocol is a set of rules and standards that govern how data is transmitted over a network. Examples of protocols include TCP/IP, HTTP, and FTP
4. **Topology:** Network topology refers to the arrangement of various elements (links, nodes, etc.) in a computer network. It defines how different devices (like computers, printers, and servers) are connected and how data flows between them.
5. **Service Provider Networks:** These types of Networks give permission to take Network Capacity and Functionality on lease from the Provider. Service Provider Networks include Wireless Communications, Data Carriers, etc.

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6. IP Address: An IP address is a unique numerical identifier that is assigned to every device on a network. IP addresses are used to identify devices and enable communication between them.

7. DNS: The Domain Name System (DNS) is a protocol that is used to translate human-readable domain names (such as www.google.com) into IP addresses that computers can understand.

8. Firewall: A firewall is a security device that is used to monitor and control incoming and outgoing network traffic. Firewalls are used to protect networks from unauthorized access and other security threats.

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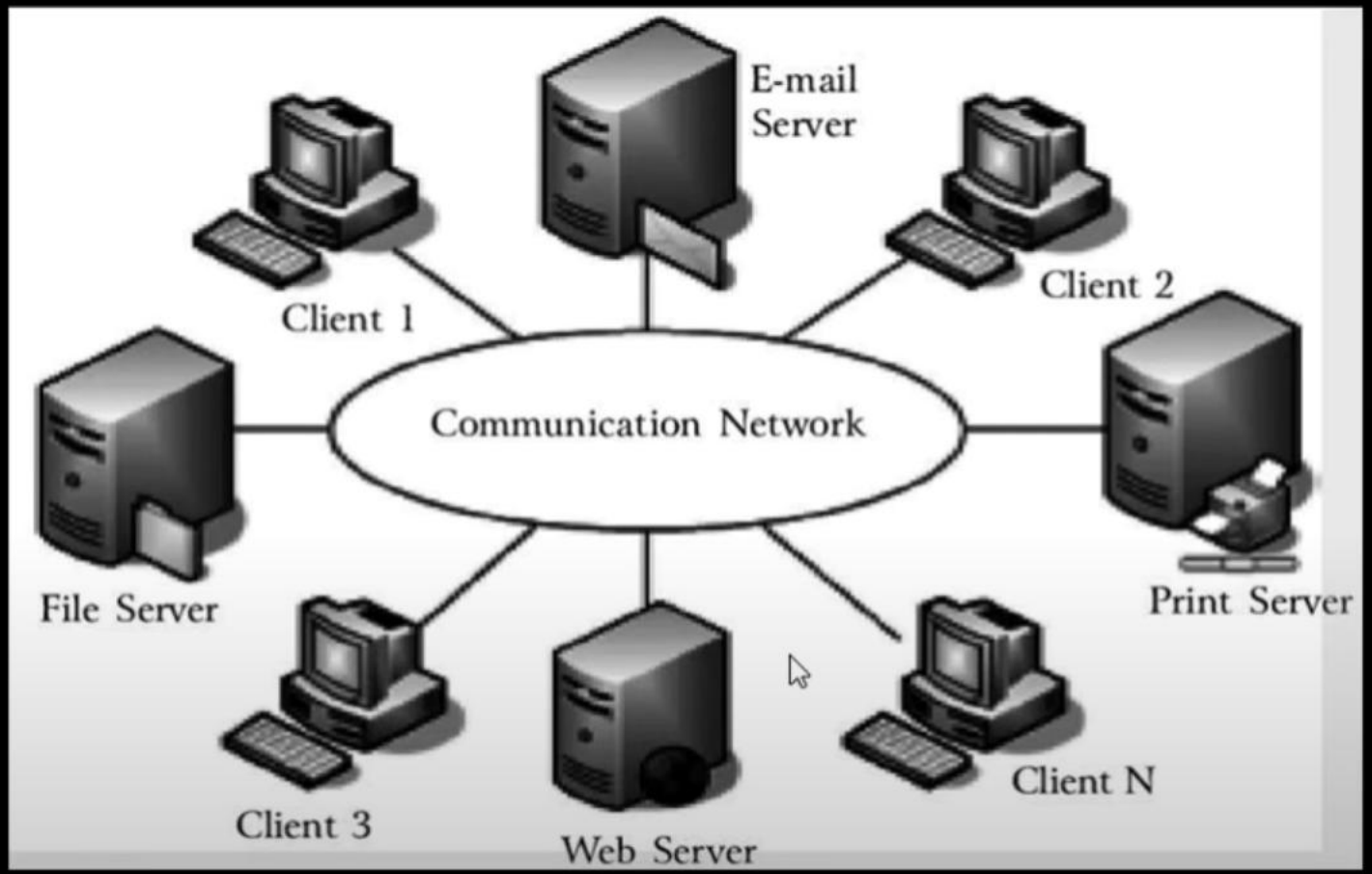

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❖ **Goals of Computer Networks:**

i. **Resource Sharing:** Enable multiple users to access shared resources like files, printers, and internet connections.

ii. **Reliability:** Provide backup systems and alternative pathways to ensure continuous operation even if one part fails.

iii. **Scalability:** Allow the network to grow by adding new devices without significant changes to the existing setup.

iv. **Cost Efficiency:** Share resources to reduce the need for individual equipment, lowering overall costs.

v. **Communication:** Facilitate various forms of communication, such as emails, instant messaging, and video conferencing.

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❖ Applications of Computer Networks:

i. Business Applications:

- *i. Email and Instant Messaging:* Quick communication among employees.
- *ii. Shared Databases:* Access to centralized information for all team members.
- *iii. Remote Work:* Employees can work from anywhere by accessing the company's network.

ii. Home Applications:

- *i. Internet Access:* Connect multiple devices to the internet simultaneously.
- *ii. File Sharing:* Share photos, videos, and documents between family members.
- *iii. Smart Home Devices:* Control devices security cameras remotely.

iii. Educational Applications:

- *i. Online Learning Platforms:* Attend virtual classes and access course materials.
- *ii. Research Collaboration:* Share data and work together on projects in real-time.

iii. Access to Digital Libraries: Utilize e-books, journals, and educational videos.

iv. Healthcare Applications:

i. *Telemedicine:* Consult with doctors via video calls.
ii. *Electronic Health Records (EHRs):* Access and update patient records in a centralized system.

v. Entertainment Applications:

i. *Streaming Services:* Watch movies and listen to music online.
ii. *Online Gaming:* Play games with others over the internet.
iii. *Social Networking:* Connect with friends and family through platforms like Facebook and Twitter.

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❖ Different Categories of Network

Networks are classified based on their size, coverage area, and purpose. Here's a simple explanation of each type:

1. Personal Area Network(PAN)
2. Local Area Network(LAN)
3. Campus Area Network(CAN)
4. Metropolitan Area Network (MAN)
5. Wide Area Network

Now let discuss in detail -→

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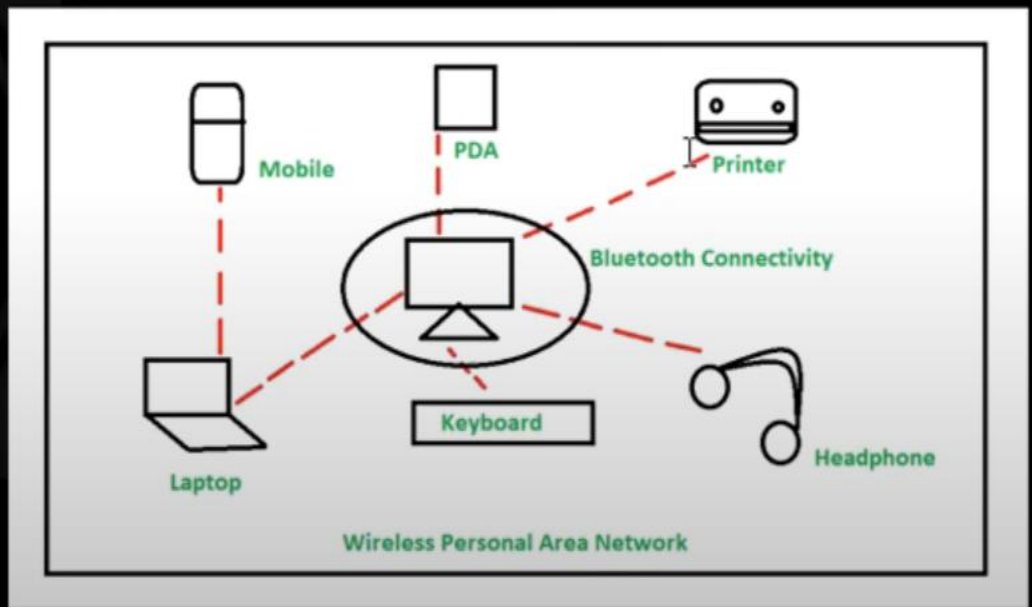
1. Personal Area Network (PAN)

- **Definition:** A small network used for personal devices like mobile phones, laptops, and smartwatches.
- **Range:** About **1 to 100 meters**.
- **Example:** Bluetooth connections, wireless mouse & keyboard, or a hotspot created by a mobile phone.
- **Best For:** Personal use in a small area.
- **Speed :** Very High
- **Cost :** Lower Cost



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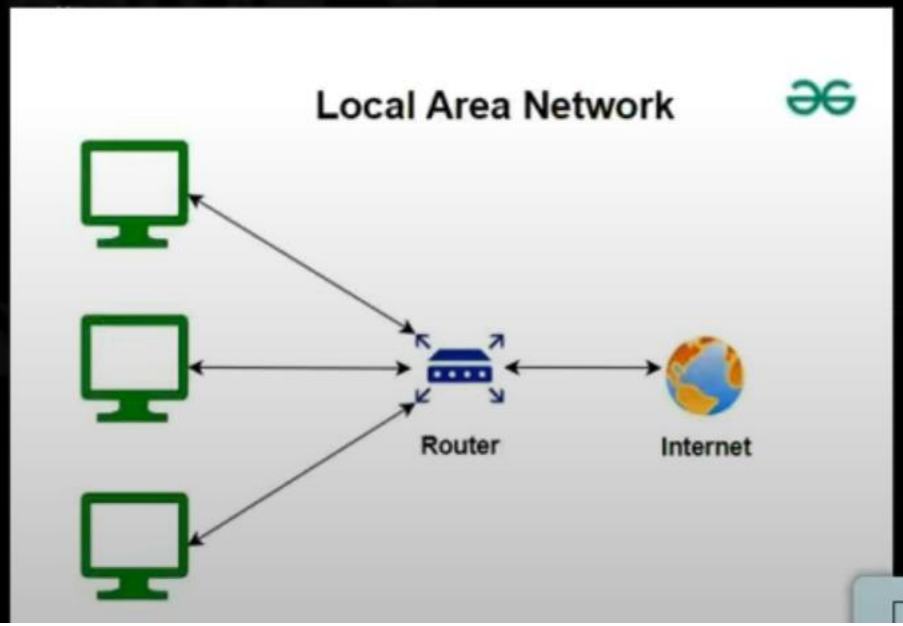
2. Local Area Network (LAN)

- **Definition:** A network that connects computers and devices within a limited area like a home, office, or school.
- **Range:** **Up to a few kilometers**.
- **Example:** Computers in a school lab connected through LAN, an office network.
- **Best For:** Organizations, schools, and small businesses.
- **Speed :** Very High
- **Cost :** Lower in Cost



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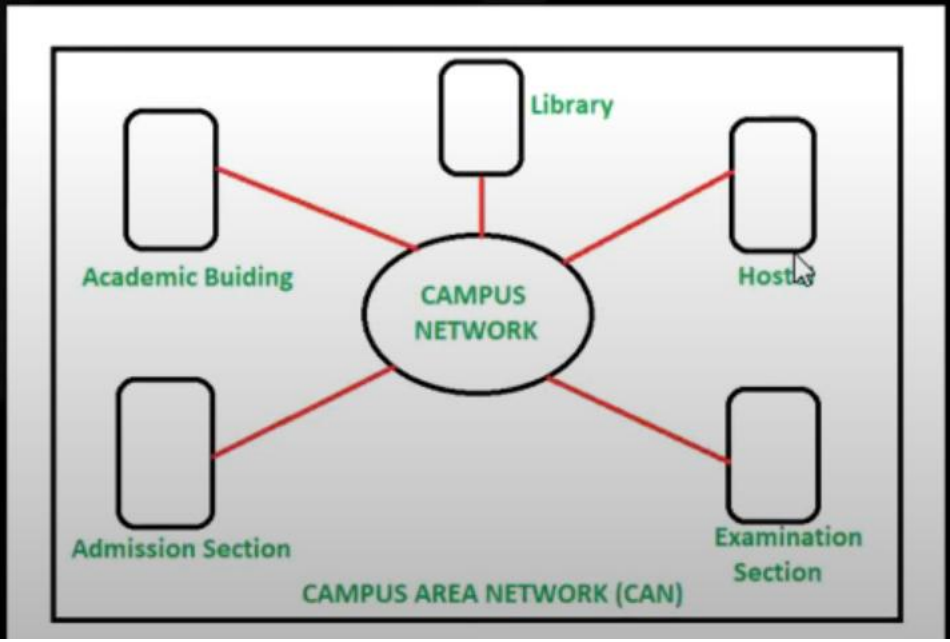
3. Campus Area Network (CAN)

- **Definition:** A network that connects multiple LANs within a campus, such as a university or company campus.
- **Range:** **Covers a larger area than LAN but is smaller than MAN.**(1-5KM)
- **Example:** A university with different departments having interconnected networks.
- **Best For:** Educational institutes, large offices, and company campuses.
- **Speed :** Average
- **Cost :** Little high



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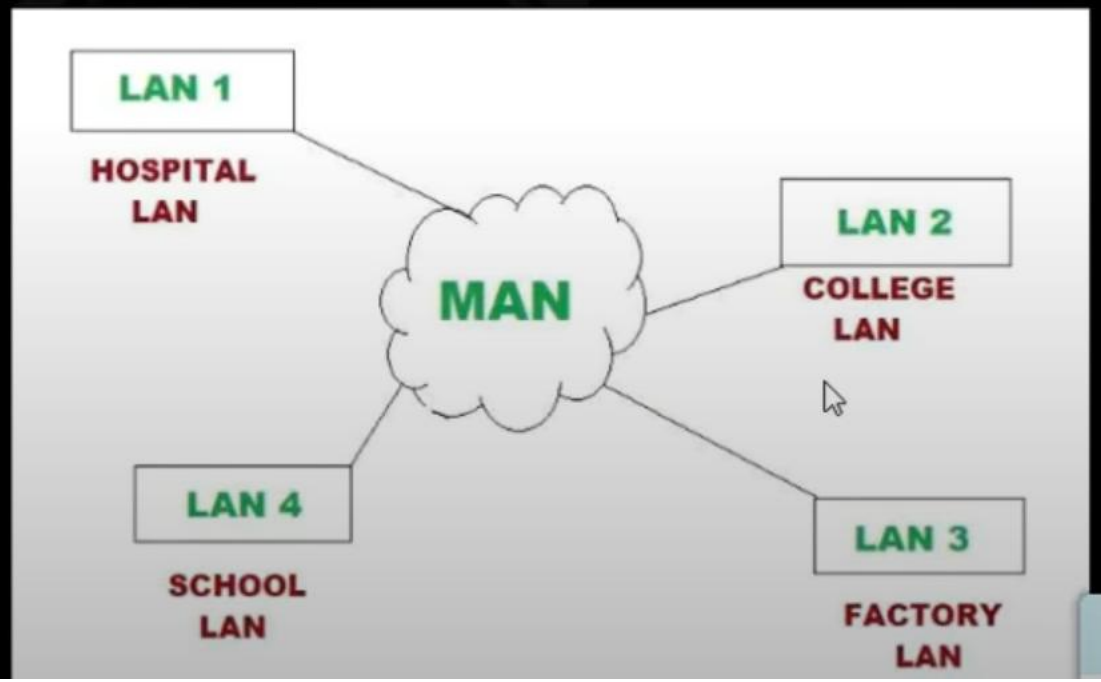
4. Metropolitan Area Network (MAN)

- **Definition:** A network that covers a city or a large town. It connects multiple LANs and CANs.
- **Range:** **Up to 50 km**.
- **Example:** Internet services provided by telecom companies in a city.
- **Best For:** Government agencies, large businesses, or city-wide internet providers.
- **Speed :** Slow
- **Cost :** High



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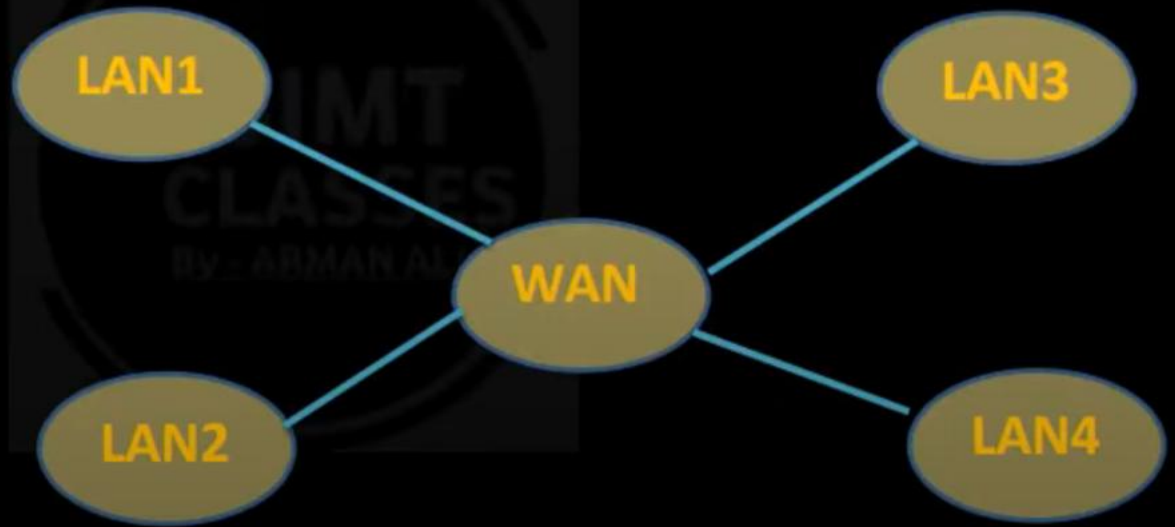
5. Wide Area Network (WAN)

- **Definition:** A large network that covers a **country or even the entire world**.
- **Range:** **Unlimited (Global reach)**.
- **Example:** The Internet, bank networks across different countries.
- **Best For:** International businesses, online services, and global communication.
- **Speed :** Slow
- **Cost :** Very High



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Comparison Table:

Network Type	Full Form	Coverage Area	Example	Best For
PAN	Personal Area Network	1-10 meters	Bluetooth, Hotspot	Personal Use
LAN	Local Area Network	A few kilometers	Office, School Lab	Offices, Schools
CAN	Campus Area Network	A university campus	University network	Large Institutes
MAN	Metropolitan Area Network	Up to 50 km	City-wide Internet	Large Businesses, Government
WAN	Wide Area Network	Unlimited	Internet, Bank Networks	Global Communication

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❖ Organization of the Internet :

The **Internet** is a global network that connects millions of computers, devices, and users worldwide. It is structured in a way that ensures smooth communication between different systems. Let's break it down into **different layers** of organization:

1. Internet Service Providers (ISPs) - The Backbone –

- Think of **ISPs** as companies that **sell internet connections** to people.

Just like electricity providers give you power at home, ISPs give you the Internet.

Examples: Jio, Airtel, BSNL, ACT Fibernet

❖ Types of ISPs:

i. **Global ISPs (Tier 1)** → Connect entire countries (**Example:** Tata Communications)
ii. **Regional ISPs (Tier 2)** → Connect big cities or regions (**Example:** Airtel, BSNL)
iii. **Local ISPs (Tier 3)** → Provide internet to homes (**Example:** ACT, Hathway)

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2. Internet Exchange Points (IXPs) - The Connection Points

- IXPs are places where different ISPs connect to exchange data.
- They help in **faster data transfer** between networks.
- **Example:** **DE-CIX Mumbai** (One of India's largest IXPs).
- If Amazon wants to send a package to a Flipkart warehouse, they can **meet at a central hub** to exchange goods instead of taking long routes.
- Similarly, **ISPs use IXPs** to send data quickly instead of taking long paths across the world.

3. Servers & Data Centers - Store Information

- Websites, emails, and apps are stored in **servers** inside large **data centers**.
- **Example:** Google Cloud, Amazon Web Services (AWS), Microsoft Azure.

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4. Domain Name System (DNS) - The Address Book of the Internet

- Every website has an IP address, but humans use easy names like **google.com**.
- DNS converts domain names into IP addresses.
- Example: When you type www.youtube.com, DNS finds the correct server and connects you.

5. End Users - You & Me

- We connect to the internet using **phones, laptops, or smart devices**.
- The data we send (like messages, videos, or web searches) travels through **routers, ISPs, and servers** before reaching the destination.

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✓ How the Internet Works? (Simple Example)

- You type www.facebook.com in your browser.
- Your request goes to your **ISP**.
- **DNS** finds Facebook's server.
- Data travels through different networks and reaches the Facebook server.
- Facebook sends back the webpage to your device.
- You see Facebook on your screen! 🎉

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❑ Network Structure & Architecture :

❖ What is Network Architecture?

- Network architecture is the **design or structure of a computer network** that defines how devices (computers, routers, servers) communicate with each other.
- Think of it as a **blueprint for building a network**, just like an architect makes a blueprint for a house.

❖ Types of Network Architecture

There are **two main types** of network architecture:

1. Client-Server Architecture -

📌 **Definition:** In this model, **one central computer (server)** manages and provides services to **multiple user computers (clients)**.

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📌 How it Works:

- The **server** stores data, applications, and resources.
- **Clients** (users) send requests to the server for data or services.
- The server processes the request and sends back the response.

📌 Example:

- **Google Search** – When you search something on Google, your computer (client) sends a request to Google's **server**, and the server gives you search results.
- **Banking System** – ATMs (clients) connect to a central bank server.

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📌 Advantages:

✓ Centralized control (easy to manage).
✓ High security.
✓ Efficient for large organizations.

📌 Disadvantages:

✗ Expensive to set up.
✗ If the server fails, all clients are affected.

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2. Peer-to-Peer (P2P) Architecture

📌 **Definition:** In this model, **all computers are equal** and can act as both a **client and a server**.

📌 **How it Works:**

- Any computer in the network can **share data and resources** directly with another.
- No need for a central server.

📌 **Example:**

- **Torrent Downloads** – When you download a file using torrents, you are getting data from many users (peers), not a single server.
- **Bluetooth File Sharing** – When you send files between two phones using Bluetooth.

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📌 Advantages:

✓ Cheap and easy to set up.

✓ No dependency on a single server.

📌 Disadvantages:

✗ Less security.

✗ Slower for large networks.

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❖ **Other Important Network Architectures**

3. Hybrid Architecture (Combination of Client-Server & P2P)

- Some networks **use both models together** for better performance.
- **Example:** **Online gaming** (players communicate directly, but the game server manages the main data).

4. Cloud-Based Architecture

- Data and applications are stored **in the cloud (online)** instead of physical servers.
- **Example:** **Google Drive, Dropbox, AWS (Amazon Web Services)**.

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❖ Need for Layered Architecture & Layering Principle :

✓ What is Layered Architecture?

Layered architecture is a **design approach** in networking where the communication process is divided into **multiple layers**. Each layer has a **specific role** and works with the layers above and below it.

Example:

Think of a **postal system**:

1. You **write a letter** (message).
2. You **put it in an envelope** (formatting).
3. The post office **sorts and delivers it** (routing).
4. The receiver **opens and reads it** (receiving data).

Similarly, in a **computer network**, data passes through different **layers** before reaching its destination.

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❖ Why Do We Need Layered Architecture?

✓ 1. Simplifies Network Design

Breaking the communication into smaller **manageable** parts makes it easier to design and understand.

✓ 2. Standardization (Easy Communication)

Different companies (Cisco, Microsoft, Google) follow the same layered model, making their networks **work together smoothly**.

✓ 3. Easier Troubleshooting (Finding Errors)

If a network has a problem, we can **check one layer at a time** instead of the whole system.

✓ 4. Flexible Upgrades & Modifications

We can **improve one layer** (like security or speed) without changing the entire system.

✓ 5. Reusability

Common functions like **error checking** can be used at different layers, reducing extra work.

❖ What is the Layering Principle?

The **layering principle** means that:

1. Each layer should **do only one specific job** (e.g., sending data, error checking).
2. Each layer should **communicate only with the layers directly above or below it**.
3. Each layer should be **independent**, so changes in one layer don't affect others.

Example:

Think of a **burger** 🍔:

- **Bottom bun (Layer 1)** → Holds everything together.
- **Patty (Layer 2)** → Provides main content.
- **Cheese & veggies (Layer 3)** → Adds extra features.

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- **Top bun (Layer 4)** → Completes the burger.

Each layer has a **specific role** and works together **without mixing** functions.

4 Example of Layered Architecture in Networking

The **OSI Model (Open Systems Interconnection)** follows the layering principle:

Layer No.	Layer Name	Function
7	Application Layer	User interaction (e.g., web browsers, email).
6	Presentation Layer	Formats data (e.g., encryption, compression).
5	Session Layer	Manages communication sessions.
4	Transport Layer	Ensures data reaches correctly (e.g., TCP, UDP).
3	Network Layer	Finds the best route (e.g., IP address).
2	Data Link Layer	Controls data transfer (e.g., MAC address).
1	Physical Layer	Deals with hardware (e.g., cables, signals).

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❖ Protocol and Standard in Computer Networks :

In computer networks, **protocols** and **standards** help devices communicate with each other smoothly.

◆ What is a Protocol?

A **protocol** is a **set of rules** that defines **how data should be sent and received** in a network.

📌 Why is a protocol needed?

- Just like people follow **rules in a conversation** (e.g., one speaks, the other listens), computers need rules to communicate.
- Different devices (like a laptop, mobile, and server) can understand each other **only if they follow the same protocol**.

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📌 Example of Protocols:

Protocol Name	Purpose	Example Use
HTTP (HyperText Transfer Protocol)	Used for websites	When you open a webpage
HTTPS (Secure HTTP)	Secure website communication	Online banking, shopping
TCP/IP (Transmission Control Protocol/Internet Protocol)	Helps send and receive data	Browsing, downloading
FTP (File Transfer Protocol)	Transfers files	Uploading files to a website
SMTP (Simple Mail Transfer Protocol)	Sends emails	Sending an email
POP3/IMAP	Receives emails	Reading an email

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◆ What is a Standard?

A **standard** is a **set of guidelines** created by organizations to ensure that different devices and networks work together.

📌 Why are standards needed?

- If every company used its own **networking rules**, their devices wouldn't work with others.
- Standards ensure that **all devices, software, and networks can communicate** properly.

📌 Example:

- Your **Wi-Fi router follows IEEE 802.11 standards**, so any laptop or phone can connect to it.
- Websites follow **TCP/IP standards**, so they work on all browsers and devices.

📌 Examples of Standards:

Standard Name	Purpose	Developed By
IEEE 802.3	Ethernet (Wired Network)	IEEE (Institute of Electrical and Electronics Engineers)
IEEE 802.11	Wi-Fi (Wireless Network)	IEEE
IPv4 / IPv6	Internet Addressing	IETF (Internet Engineering Task Force)
OSI Model	Networking framework	ISO (International Organization for Standardization)

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Difference Between Protocol and Standard

Feature	Protocol	Standard
Definition	Set of **rules** for communication	Set of **guidelines** to ensure compatibility
Purpose	Controls **how data is sent and received**	Ensures different devices and networks work together
Example	HTTP, TCP/IP, FTP, SMTP	IEEE 802.11 (Wi-Fi), IPv4/IPv6, OSI Model
Who Creates It?	Organizations like **IETF, W3C**	Organizations like **IEEE, ISO**

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❖ OSI Model : (V.V.V.V.VIMP)

The **OSI Model (Open Systems Interconnection Model)** is a framework that helps us understand **how data moves in a network**. It divides the network communication into **7 layers**, where each layer has a specific job.

Think of it like sending a **parcel** by courier:

1. You **pack the item** (data formatting).
2. You **write the address** (source & destination).
3. The courier **transports it safely** (network transmission).
4. The receiver **unpacks the item** (data retrieval).

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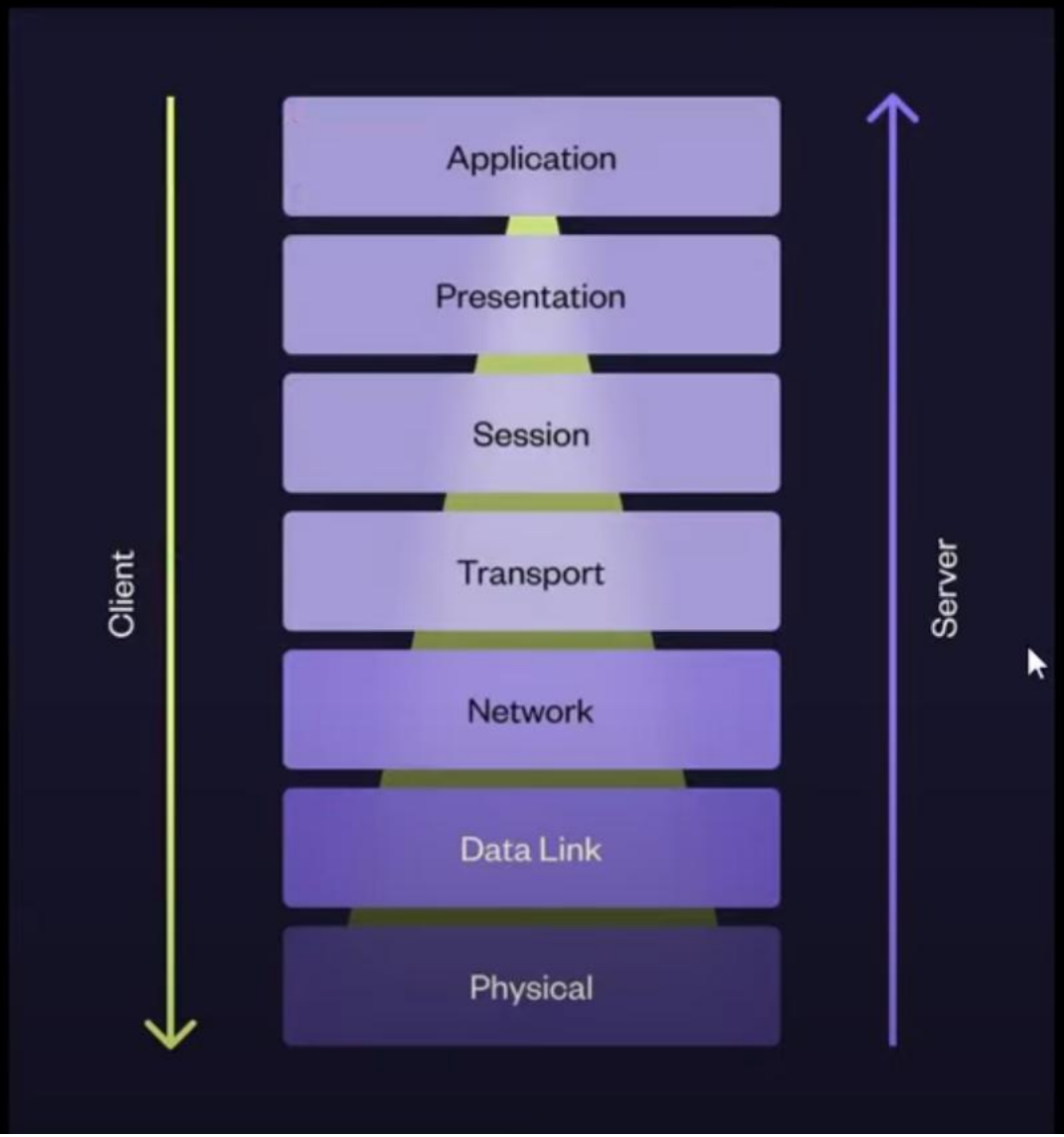

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❖ Understanding OSI Model with an Example:

Example: Sending a WhatsApp Message

Let's say **you send a "Hello" message on WhatsApp** from your phone (Client) to your friend's phone (Server). The OSI model explains how this message travels through different layers.

1. Application Layer (You type the message)

- You **open WhatsApp** and type “Hello” in the chat.
- WhatsApp is an **application** that allows communication.
- The layer that **users interact with** (like websites, emails, chat apps).
- Sends and receives **files, emails, and messages**.
- 📌 **Protocols Used:**
- **HTTP/HTTPS** - Websites.
- **FTP** - File transfer.
- **SMTP/POP3/IMAP** - Emails.

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2. Presentation Layer (Message gets formatted)

- WhatsApp **converts "Hello" into a format** (encryption, compression, encoding).
- Ensures that the receiver understands the data format.
- **Converts data** into a format that both sender and receiver can understand.
- The presentation layer is also called the **Translation layer**. The data from the application layer is extracted here and manipulated as per the required format to transmit over the network.

- **Example Protocols**: JPEG, MP3, MP4, SSL/TLS encryption, File compression.

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3. Session Layer (Maintains the connection)

- A **session** (connection) is created between **you and your friend**.
- Ensures smooth communication.
- **Establishes, manages, and ends** communication sessions.
- Keeps track of **multiple conversations happening at the same time**.
- Ensures that **data is exchanged only when both sender and receiver are ready**.
- **Example Protocols**: NetBIOS, RPC.

How it works?

When you **log in** to a website, the session layer maintains your connection until you **log out** or close the browser.

Examples:

Online banking sessions, Video calls, Remote desktop access.

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4. Transport Layer (Breaks message into small packets)

- The message **"Hello" is broken into small packets** and assigned numbers.
- Ensures **reliable** delivery and reassembles packets at the receiver's end.
- **Example Protocols**: TCP (reliable), UDP (faster but no reliability).

❖ **At Sender's Side:**

- The message **"Hello"** is broken into **small packets** for easy transmission.
- Each packet is assigned a number so they can be reassembled correctly.
- If TCP is used: It ensures all packets arrive safely.
- If UDP is used: It sends packets quickly but doesn't check if all arrived.

❖ **At Receiver's Side:**

- All the **packets are reassembled** in the correct order to form the original message.
- If a packet is missing, TCP requests a **retransmission**.
- **Example Protocols:** TCP (reliable), UDP (faster but no reliability).

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5. Network Layer (Finds the best path to the receiver)

- Adds the **IP addresses** (your phone's IP and your friend's phone's IP).
- Finds the best route to deliver the message.
- Finds the best path for data to travel.
- Uses IP addresses (like home addresses) to identify the sender & receiver.
- 📌 **Example in Real Life:** A Google Maps route finds the best way to reach your destination. When you search Google, your request travels across many networks using routers.
- 📌 **Protocols Used:** IP (Internet Protocol) - Assigns addresses (IPv4, IPv6). ICMP - Helps check if a connection is working (Ping command).
- **Example Protocols:** IP, ICMP, ARP.

6. Data Link Layer (Adds MAC Address & Error Checking)

- Adds **MAC (Physical) address** of your device and your friend's device.
- Checks for errors in transmission.

📌 **Example in Real Life:**

• You send a letter to a building, but it needs to go to the right apartment (MAC address = apartment number).

• Your Wi-Fi routersends data to the correct device (laptop, phone).

📌 Technologies Used:

• Ethernet, Wi-Fi, MAC Addresses

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7. Physical Layer (Data travels as signals)

- Converts data into **electrical signals (Wi-Fi, Bluetooth, cable)** and sends them through the network.
- The data **physically travels** to your friend's phone.
- Sends data as signals through wires, fiber optics, or Wi-Fi.
- It'slike sending a message through a wire or air.
- 📌 **Example in Real Life:**
- When you send a letter, the postman carries it (like signals carrying data).
- A Wi-Fi router sending internet signals.
- 📌 **Technologies Used:**
- Ethernet cables, Fiber optics, Bluetooth, Wi-Fi.

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❑ Simple Trick to Remember OSI Model Layers

- "Aaj fir se tumne dudh piya"

- **P**hysical
- **D**ata Link
- **N**etwork
- **T**ransport
- **S**ession
- **P**resentation
- **A**pplication

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❖ TCP/IP Protocol Suite : (Practical Model)

The **TCP/IP Protocol Suite** is a set of rules (protocols) that help computers and devices communicate over the internet. It is the foundation of how data is sent and received across networks like the internet.

❖ What is TCP/IP?

- **TCP/IP stands for** Transmission Control Protocol / Internet Protocol.
- It is a collection of communication rules that allow devices to **send and receive data** smoothly.
- It ensures that the data sent from one device reaches the correct destination **without errors**. It is simpler than the OSI Model and has only 4 layers instead of 7.

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📦 The 4 Layers of the TCP/IP Model (With Super Simple Examples!)

Layer Number	Layer Name	What It Does?	Example in Real Life
4	**Application Layer**	The layer users interact with, like apps & websites.	✉️ Email, 🌍 Browsing, 📞 WhatsApp
3	**Transport Layer**	Splits big data into small parts & ensures delivery.	📦 Breaking a big parcel into small boxes
2	**Internet Layer**	Finds the best route for data (IP addressing).	🚚 Choosing the fastest delivery route
1	**Network Access Layer**	Sends data through cables, Wi-Fi, or radio signals.	📡 Internet cables, Wi-Fi signals

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1. Application Layer (User Interaction Layer)

- This is the **topmost** layer where users interact with applications like WhatsApp, Google, and Email.
- It helps software applications communicate with the network.
- **Example:** When you send a message on WhatsApp, this layer prepares the data.

💡 Common Protocols:

- **HTTP/HTTPS** → Used for web browsing.
- **FTP** → Used for file transfers.
- **SMTP** → Used for sending emails.
- **POP3/IMAP** → Used for receiving emails.

2. Transport Layer (Reliable Data Transfer)

- This layer **ensures that data is delivered correctly** and without errors.
- It **breaks large messages into smaller packets** before sending them.
- It **reassembles** the packets at the receiver's end.

💡 **Main Protocols:**

- **TCP (Transmission Control Protocol)** → Reliable, ensures all packets are received correctly.
- **UDP (User Datagram Protocol)** → Faster, but does not guarantee packet delivery.
- ✅ **Example:** When you download a file, TCP ensures the whole file is received correctly.

3. Internet Layer (Finding the Best Path)

- This layer **decides the best route** for data to travel from the sender to the receiver.
- It adds **IP addresses** to identify the sender and receiver.

💡 **Main Protocols:**

- **IP (Internet Protocol)** → Assigns addresses to devices.
- **ICMP (Internet Control Message Protocol)** → Used for error reporting.
- **ARP (Address Resolution Protocol)** → Translates IP addresses into MAC addresses.
- ✅ **Example:** When you type "www.google.com," the Internet Layer helps find the fastest path to reach Google's servers.

4. Network Access Layer (Sending Data Physically)

- This is the **lowest** layer, responsible for **transmitting data** through physical cables or wireless signals.
- It converts data into **electrical signals, radio waves, or light signals**.

💡 **Common Protocols & Technologies:**

- **Ethernet** → Used in wired networks.
- **Wi-Fi** → Used in wireless networks.
- **PPP (Point-to-Point Protocol)** → Used for direct communication between two devices.
- ✅ **Example:** When you connect to Wi-Fi, this layer manages the physical connection.

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❖ How TCP/IP Works with an Example (Sending a WhatsApp Message)

📲 You send a "Hello" message on WhatsApp:

1. **Application Layer:** WhatsApp prepares the message.
2. **Transport Layer:** The message is broken into small packets.
3. **Internet Layer:** Each packet is assigned an IP address and sent through the network.
4. **Network Access Layer:** The packets travel through Wi-Fi or mobile data.

📥 Your friend receives the message:

1. **Network Access Layer:** The message arrives via Wi-Fi/mobile data.
2. **Internet Layer:** The message finds your friend’s IP address.
3. **Transport Layer:** The packets are reassembled into the original message.
4. **Application Layer:** WhatsApp displays "Hello" on your friend’s screen.

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Difference Between OSI Model & TCP/IP Model

Feature	OSI Model	TCP/IP Model
Number of Layers	7	4
Developed By	ISO (International Organization for Standardization)	DoD (Department of Defense, USA)
Usage	Conceptual Model	Practical Model used on the internet
Protocols Used	More protocols (e.g., FTP, SMTP, etc.)	Fewer but essential protocols (e.g., TCP, IP)
Reliability	More structured but complex	Simpler and widely used

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❖ Network Devices and Components of a Network :

A **network** is a group of connected computers and devices that share information. To make this connection work, we need different **network devices** that help in sending, receiving, and managing data.

1. Network Devices (Hardware Components)

These are physical devices that help in communication within a network.

i. Router :

A **router** is a device that helps connect multiple networks, such as your home Wi-Fi and the internet.

☞ Imagine a **router as a traffic police officer** who directs cars (data) to the correct road (device). It ensures that data from the internet reaches the right device, whether it's your mobile phone, laptop, or smart TV.

Without a **router**, your devices wouldn't know where to send or receive internet data.

Example: Your home Wi-Fi router connects your mobile phone to the internet.

2. Switch – The Manager of Local Networks

A **switch** is used inside a network (like an office or home) to connect multiple devices.

☞ Think of a **switch like a telephone operator** in an office. When an employee wants to call another employee, the operator connects them directly instead of disturbing everyone.

- A **switch sends data only to the intended device**, making communication faster and more secure.
- **Example:** In an office, a switch connects all computers, allowing them to share files without using the internet.

3. Hub – The Loudspeaker of a Network 📢

A **hub** is similar to a switch but less advanced.

☞ Imagine a **hub as a loudspeaker** in a room. If one person speaks, everyone hears it—even if the message is meant for only one person.

- A **hub sends data to all devices in a network**, even if only one device needs it.
- **Disadvantage:** This makes the network slower and less secure.
- **Example:** Small offices used hubs in older networks, but today, switches are preferred.

4. Modem – The Internet Connector 🌍

A **modem** connects your home or office to the internet.

☞ Think of a **modem as a translator** that helps two people who speak different languages communicate.

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- Your computer understands **digital signals (0s and 1s)**, but telephone lines use **analog signals**.
- A **modem converts digital signals into analog signals** (so they can travel through telephone lines) and vice versa.
- **Example:** Your internet provider (like Jio, Airtel) gives you a modem to connect to the internet.

5. Network Interface Card (NIC) – The Passport to a Network

A **NIC (Network Adapter)** is a small component inside a computer that allows it to connect to a network.

☞ Think of a **NIC as a passport** that lets a person enter another country. Without a passport, you cannot travel internationally. Similarly, without a NIC, a computer cannot connect to a network.

- Every device, like **laptops, desktops, and mobile phones**, has a NIC to connect to Wi-Fi or wired internet.
- **Example:** Your laptop's Wi-Fi adapter is a type of NIC.

6. Access Point (AP) – The Wi-Fi Booster 📶

An **Access Point (AP)** helps extend Wi-Fi signals in large areas.

👉 Imagine an **Access Point as a speaker in a big hall**. If the main speaker's voice is too low for people sitting far away, additional speakers help everyone hear clearly.

- If your Wi-Fi signal is weak in one room, an **Access Point boosts the signal** to reach that area.
- **Example:** Hotels, shopping malls, and big offices use Access Points to provide internet in every corner.

7. Repeater – The Signal Strengthener 🔁

A **Repeater** is used to strengthen weak network signals.

👉 Think of a **Repeater as a relay runner** in a long marathon. If the first runner gets tired, the second runner continues the race, ensuring the baton reaches the finish line.

- If your Wi-Fi signal becomes weak in distant rooms, a **Repeater amplifies the signal** to keep it strong.
- **Example:** Used in large buildings to extend internet coverage.

8. Gateway – The Bridge Between Different Networks 🌉

A **Gateway** connects different types of networks, ensuring they can communicate properly.

👉 Think of a **Gateway as a tourist guide** who helps visitors understand a new culture and language.

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- If two different networks use different communication methods, a **Gateway acts as a translator**, helping them communicate.
- **Example:** A company's internal network and an external cloud system use a Gateway to exchange data.

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❖ Components of a Network (Basic Elements in Any Network)

Now that we understand the devices used in a network, let's look at the **basic components** that make a network function properly.

1. Sender (The Person Sending the Message)

- The **sender** is the device that sends data.
- **Example:** Your phone when you send a WhatsApp message.

2. Receiver (The Person Receiving the Message)

- The **receiver** is the device that receives data.
- **Example:** Your friend's phone when they receive the WhatsApp message.

3. Transmission Media (The Path for Data Travel)

- This is the medium through which data travels.
- It can be **wired (cables like Ethernet, fiber optics)** or **wireless (Wi-Fi, Bluetooth, mobile networks)**.

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4. Network Protocols (The Language of Communication)

- **Protocols** are rules that decide how data is sent and received in a network.
- Examples:
  - **TCP/IP** – Used for the internet.
  - **HTTP/HTTPS** – Used for websites.
  - **FTP** – Used for file transfers.

5. Server (The Data Provider)

- A **server** is a powerful computer that stores and manages network data.
- **Example:** Google's servers store Gmail and YouTube videos.

6. Client (The User's Device)

- A **client** is a device that requests data from a server.
- **Example:** Your laptop when browsing Google.

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🌐 Different Network Devices & Their Functions

Device	Function (What It Does?)	Example in Real Life
Modem	Connects your home to the internet by converting signals.	📞 Like a translator between two languages (converts signals between internet & home devices).
Router	Directs internet traffic between your modem and devices.	🚦 Like a traffic police officer directing cars to different roads.
Switch	Connects multiple devices in a network and allows them to share data.	🏢 Like an office receptionist directing messages to employees.
Hub	Connects multiple devices but sends data to all devices, not just the required one.	📢 Like a loudspeaker announcing messages to everyone.
Repeater	Boosts and extends weak signals in a network.	📡 Like a signal booster for weak mobile networks.
Bridge	Connects two different networks and allows them to communicate.	🌉 Like a bridge connecting two cities.
Gateway	Acts as a translator between two different types of networks.	🌐 Like Google Translate, converting one language to another.
Firewall	Protects the network from hackers and cyber threats.	🛡️ Like a security guard checking who enters a building.

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❖ Understanding Topology and Network Topology

When we talk about "topology," we mean **how things are arranged or structured**. This concept applies to many things, like **how houses are arranged in a city, how desks are arranged in a classroom, or how roads are connected in a city.**

Now, when we apply this concept to **computer networks**, we get **Network Topology**, which means **how computers and devices are connected in a network**.

❖ What is Network Topology?

☞ **Network topology is the way computers and devices are connected in a network.**

Different network topologies exist, each with its own advantages and disadvantages. Some networks are simple (like home Wi-Fi), while others are complex (like internet service provider networks).

Let's now learn about the **types of network topology in detail with easy examples.**

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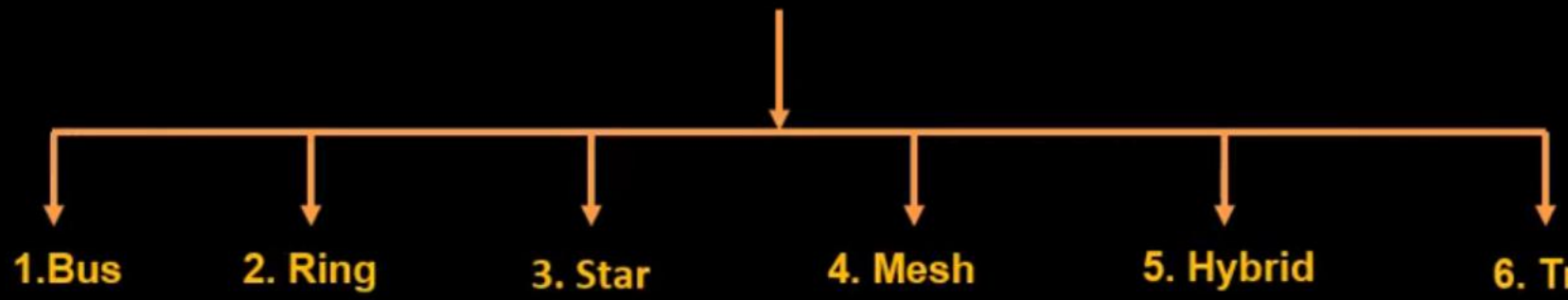
❖ Types of Network Topology



1.Bus Topology :

In bus Topology one single bus acts as a Single communication Channel & all the devices are connected to this cable.

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❖ **Advantages :**

- Easy to add/Remove Node in a network.
- Requires only Cable
- It is less expensive
- It Broadcast the message to each device which are connected through the cable
- It is easy to maintain
- In case of any computer failure other computer will not be affected

❖ **Disadvantages :**

- If Cable is fail then the entire network will be failed.
- The message is Brodcasts so we can't send private messages.
- It takes more time to pass the message from one place to another place.
- The length of Cable is limited.
- In this topology data is transmitted only one direction.

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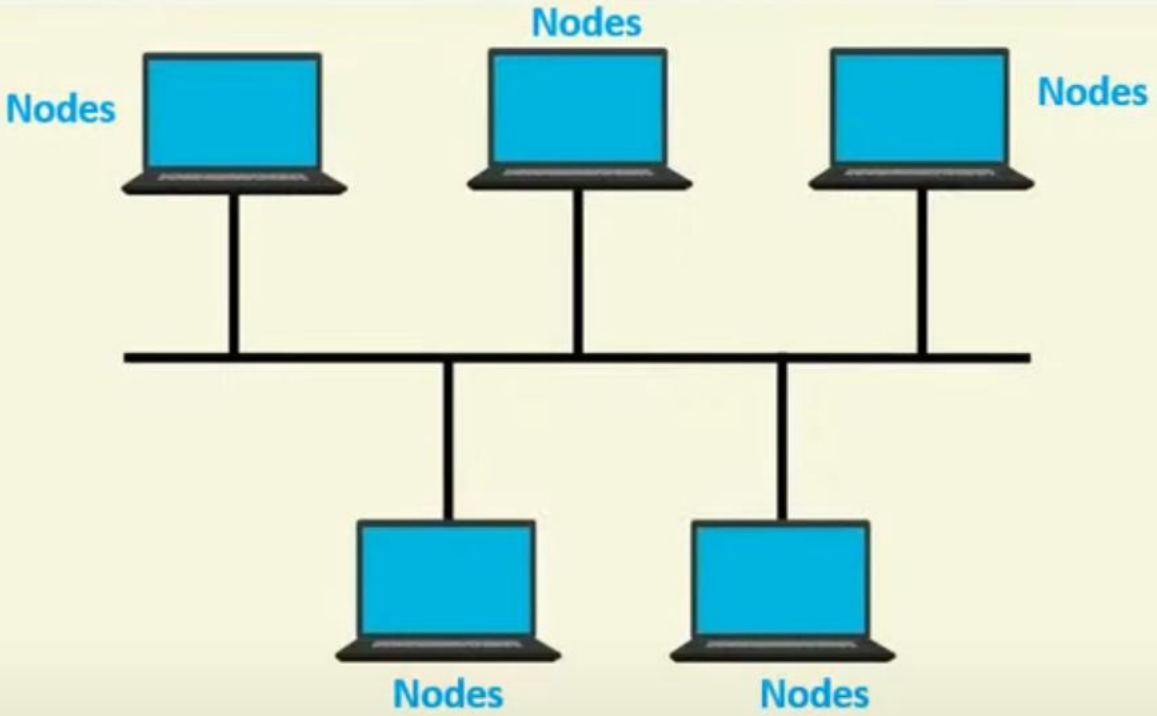


What is a Bus Topology?

2. Ring Topology :

It is Called Ring Topology because it forms a ring. In this Topology each node is Strongly Connected with its adjacent node.

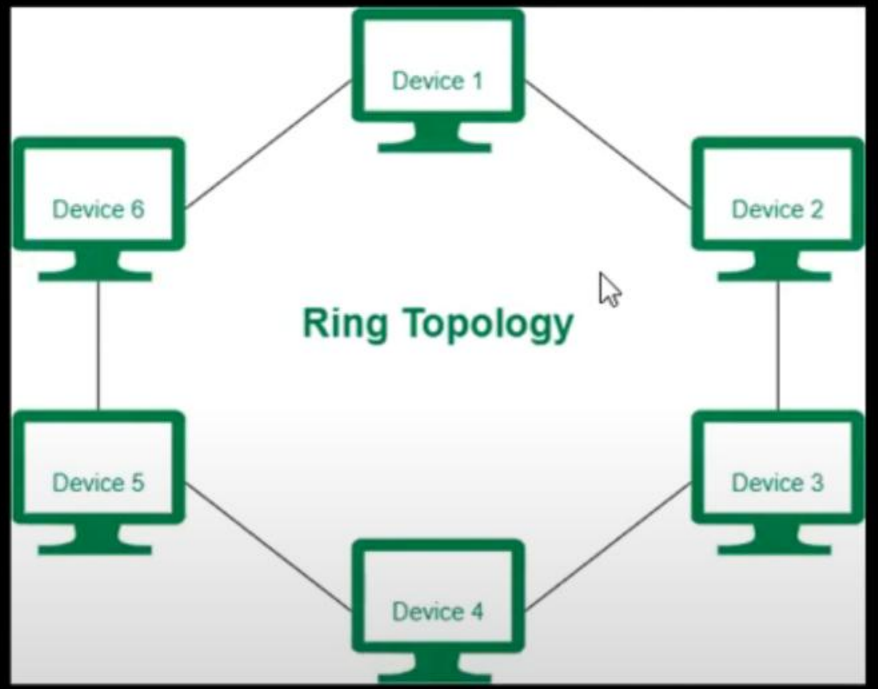
❖ Advantages :

- It Forms a Strong Network.
- Each an every node can share data with another node connected through ring topology.
- Transmission rate of data is very high.
- The data send through this topology will be brodcasts.

❖ Disadvantages :

- It is very difficult task to add some other nodes in network.
- If we want to send data from source to destination machine then data will be passed to all other nodes.

- Single Point of Failure, that means if a node goes down entire network goes down.
- It is very difficult to recover the ring topology if any particular machine is not working properly.
- We can't send private Messages.



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3. Star Topology :

In Star topology all the nodes are connected with a central device Called HUB. And The sharing of data is only possible through HUB.

❖ Advantages :

- It brodcasts the messages.
- It is less expensive due to less cable.
- Easy to connect new nodes without affecting rest of network.
- If one node failed then it would not be failure of entire network.

❖ Disadvantages :

In start topology We must required a network device like – Switch, HUB etc.

- If two nodes want to share data then it is only possible through HUB.
- If HUB is failed then entire network in failed
- We can't send Private Data.

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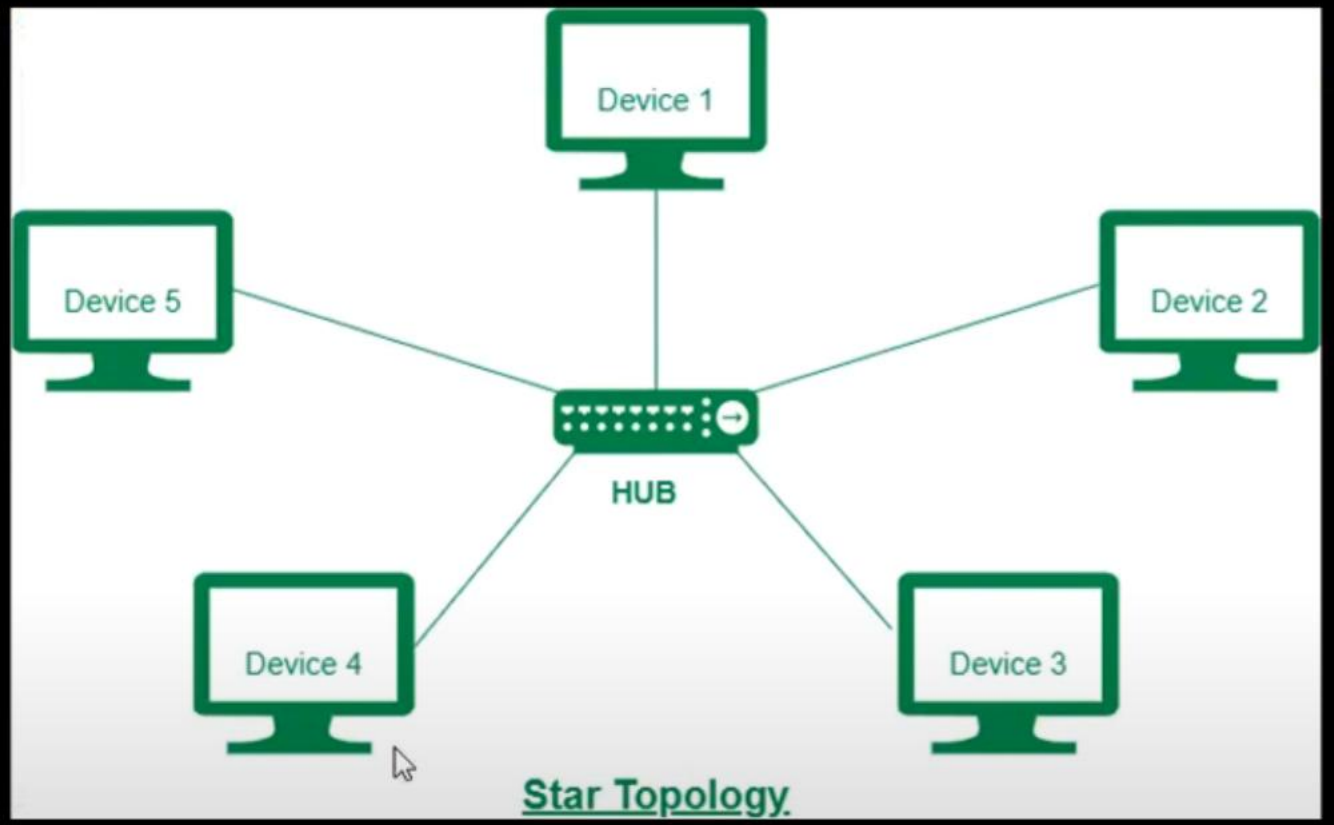


4. Mesh Topology :

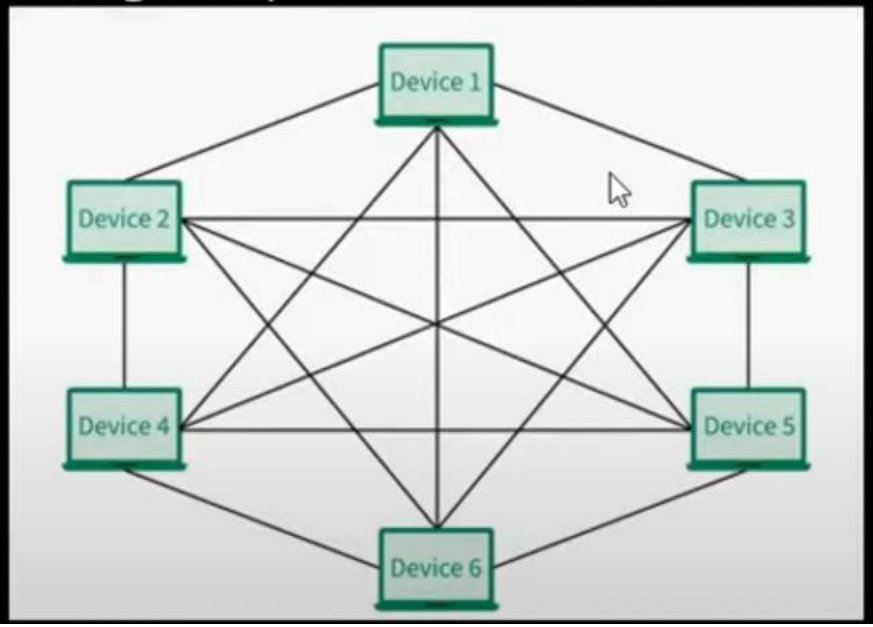
In this topology each an every Computer is directly connected with each other, So we can directly send the data to the destination machine without going to intermediate machine.

❖ Advantages :

- It is Vey good topology because we can send Private messages.
- All nodes are directly associated with another node so it Provide point to point connection.
- Unlike ring topology if a particular machine is failed then entire network will not be failed.
- Multiple Device can send or receive data Simultaneously.

❖ Disadvantages :

- It is very difficult to add some new node because each an every Computer directly connected with another one.
- If a particular machine not working then, we can't send or receive data from the failure machine.



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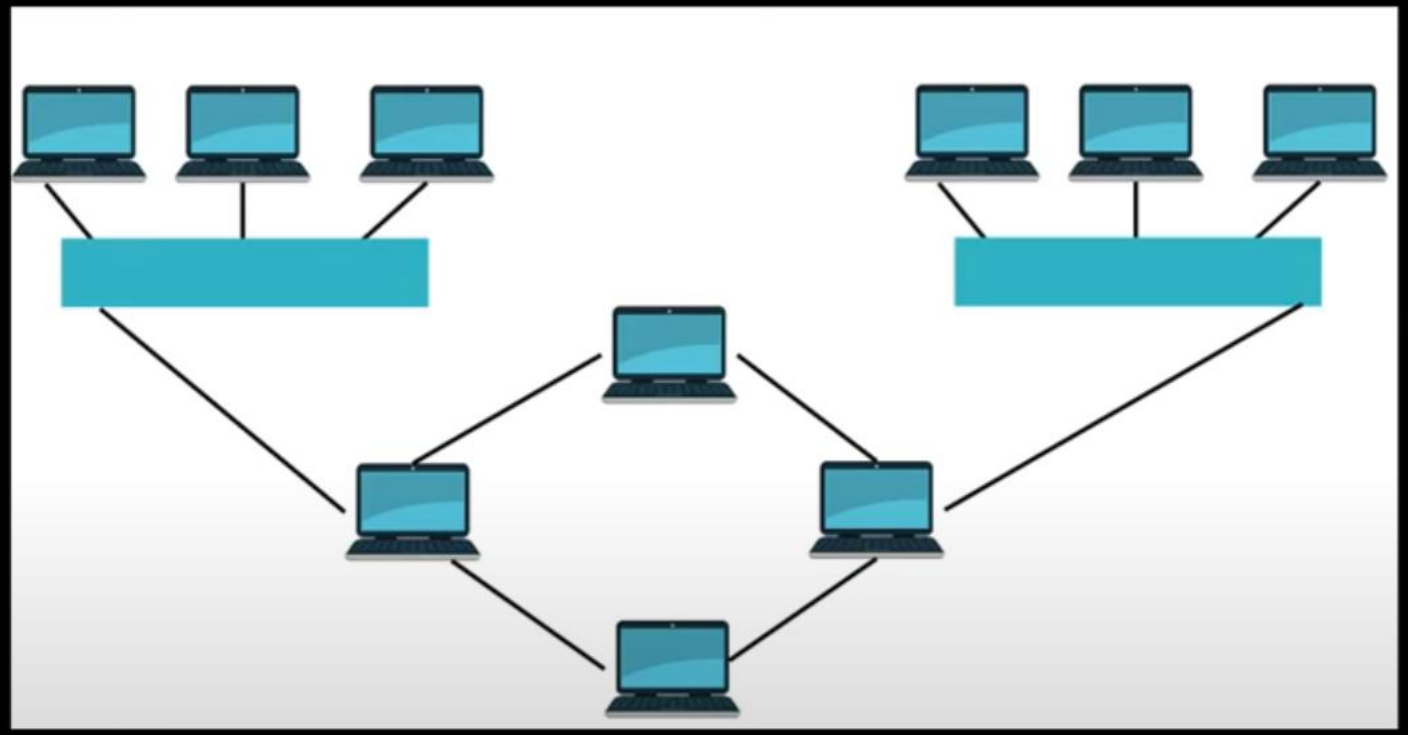
5. Hybrid Topology :

Combination of various different topology is called hybrid topology.



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❖ Types of Connections in Computer Networks :

In computer networks, devices (like computers, routers, and servers) **connect** to share data. These connections can be categorized into two main types:

1. Wired Connections

2. Wireless Connections

3. Wired Connections

In **wired connections**, devices are connected using physical cables. These cables carry signals and provide a **stable and fast** network connection.

Types of Wired Connections

◆ Twisted Pair Cable

- Used in **LAN networks** (Local Area Networks).
- Made of **two twisted copper wires** to reduce signal interference.
- Example: Ethernet cables used in offices and homes.

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Coaxial Cable

- Used in **cable TV and older networks**.
- Contains a **copper core with shielding** to prevent interference.
- Example: Used in **cable broadband connections**.

Fiber Optic Cable

- Uses **light signals** instead of electrical signals.
- **Very fast** and **long-distance** data transmission.
- Example: Used in **high-speed internet connections** like JioFiber.

2. Wireless Connections

In **wireless connections**, data is transmitted without cables using **radio waves** or **infrared signals**.

Types of Wireless Connections

Wi-Fi (Wireless Fidelity)

- Used in homes, offices, and public places.
- Connects devices like laptops, smartphones, and smart TVs.

Bluetooth

- Used for **short-range** connections.
- Example: Wireless headphones, keyboards, and file transfers between mobile devices.

Infrared (IR)

- Used in **remote controls** (TV, AC remotes).
- Works only within **a short range** and requires **direct line of sight**.

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Satellite Communication

- Used for **global communication** via satellites.
- Example: GPS, satellite internet like Starlink.

Mobile Networks (3G, 4G, 5G)

- Used in smartphones for internet and calling.
- **5G is the fastest** and supports IoT devices.

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Comparison: Wired vs Wireless Connection

Feature	Wired Connection 🔌	Wireless Connection 📡
Speed	Faster ⚡	Slower (but improving)
Reliability	Very stable ✅	Can be affected by obstacles 🚧
Mobility	Limited (fixed location) 📍	High mobility (use anywhere) 📱
Cost	Higher 💰 (cables, installation)	Lower (no cables needed)
Security	More secure 🔒	Less secure (needs encryption) 🔐

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❖ What is Transmission Media? :

Transmission media is the **path or channel** through which data (information) travels from one device to another. It is like a **road** that connects computers, phones, or any other network devices.

For example, when you send a message on WhatsApp, the message travels through a **transmission medium** (like Wi-Fi, mobile network, or cables) to reach your friend.

❖ Types of Transmission Media

Transmission media is divided into **two categories**:

1. **Wired (Guided) Media** – Uses physical cables.
2. **Wireless (Unguided) Media** – Uses air, radio waves, or light.

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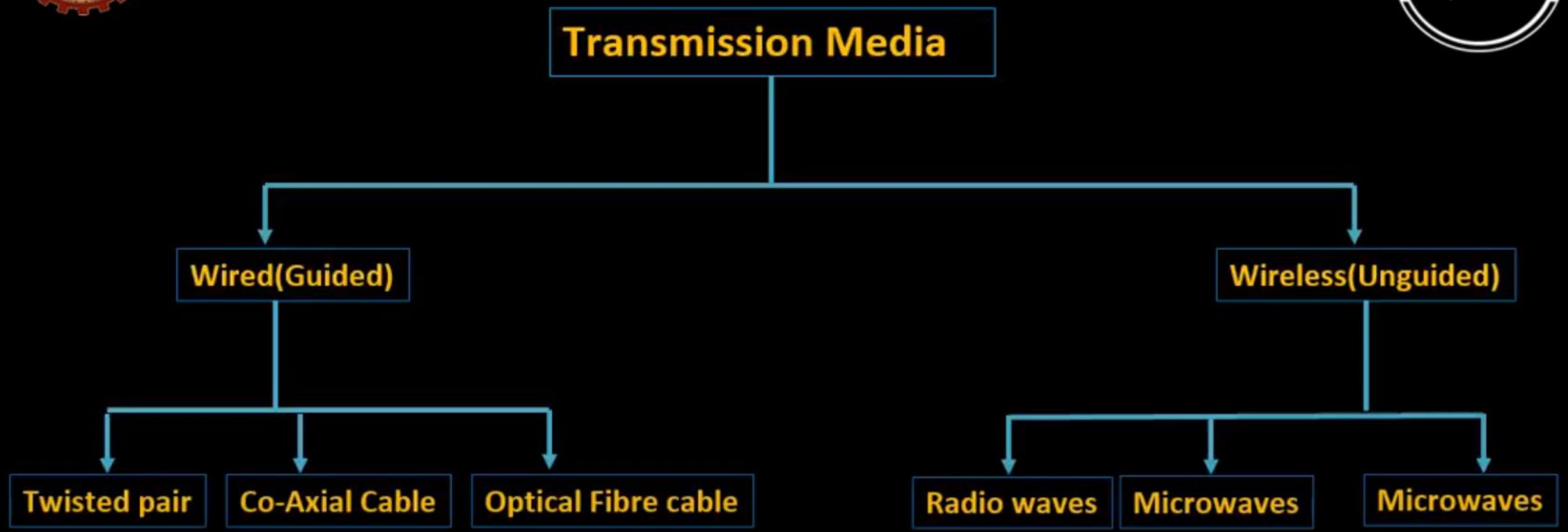

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1. Wired Transmission Media (Guided Media) 🔌

➞ **Data moves through a physical cable.**

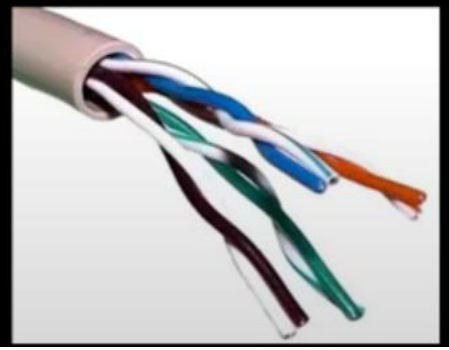
➞ Provides a **fast and stable** connection.

In **wired media**, data travels through **physical cables**, just like electricity travels through wires.

Types of Wired Transmission Media

🔑 1. Twisted Pair Cable

- 👉 It consists of **two copper wires twisted together** to reduce signal loss.
  👉 Used in **telephone lines and LAN connections**.
  👉 **Example:** Like a landline phone cable.



🔑 2. Coaxial Cable

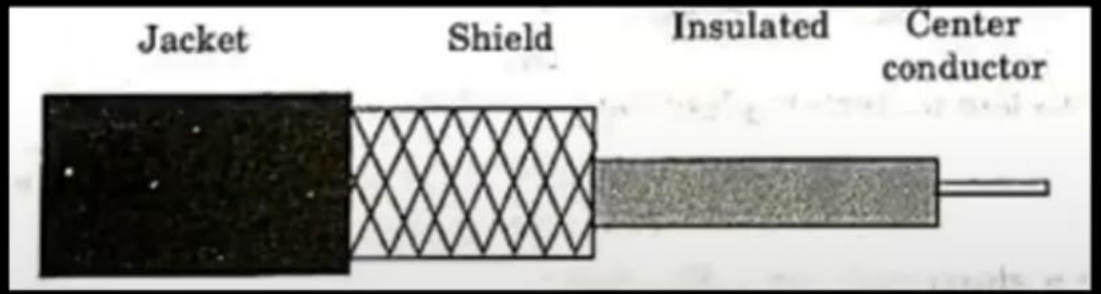
- Has a copper core and shielding to protect against interference.
- Used in cable TV and broadband internet.

☞ It has a **central conductor**, an insulating layer, and a metal shield.

☞ Used in **TV cables, internet connections**.

☞ **Example:** The cable used for **DTH TV (Dish TV, Tata Sky)**.

- **Example:** Internet connections via cable modems.



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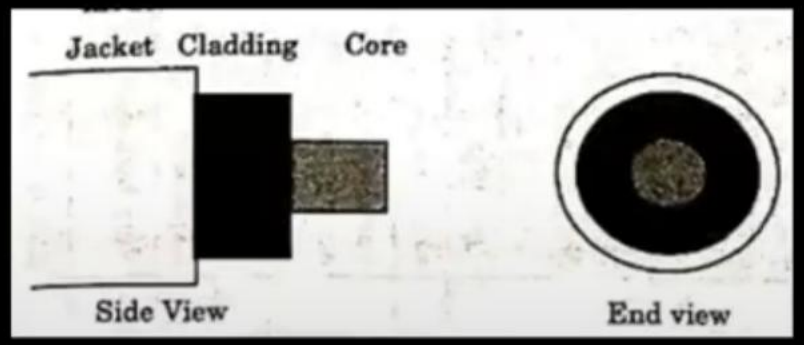
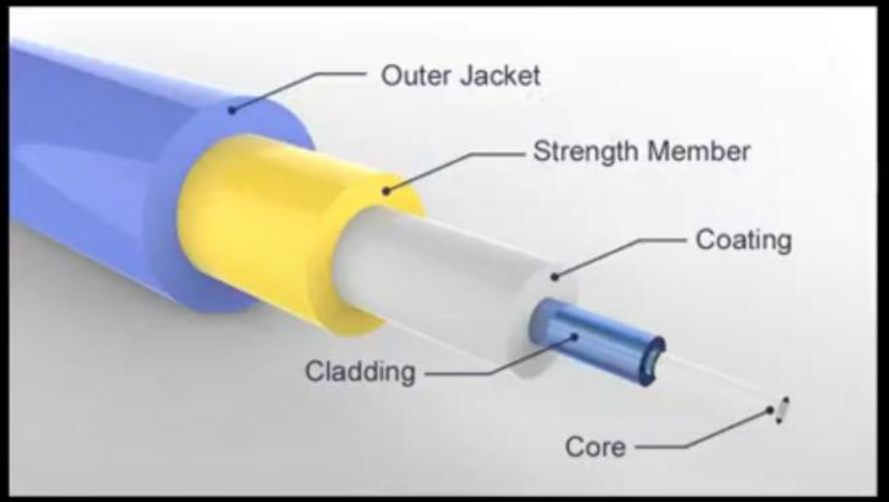
3. Fiber Optic Cable 💡

- It uses **light signals** instead of electricity for fast data transmission.
- Provides **high speed and long-distance communication**.
- Used in **high-speed internet and telecom networks**.
- **Example: Airtel Fiber, Jio Fiber** use fiber optic cables.





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2. Wireless Transmission Media (Unguided Media) 📡

➞ Data moves through air using waves or signals.

➞ Provides mobility but can be affected by interference.

In **wireless media**, data travels through **air, space, or water** using electromagnetic waves.

Types of Wireless Transmission Media 🔑

1. Radio Waves

👉 Used for **long-distance communication** like FM radio, Wi-Fi, and Bluetooth.

👉 **Example:** Listening to **FM radio** or using **Wi-Fi on a mobile phone.**•

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🔑 2. Microwaves

- 👉 Used for **long-distance communication** without cables.
- 👉 Used in **mobile networks and satellite communications**.
- 👉 **Example:** Your **mobile phone signal** uses microwaves to connect to towers.

🔑 3. Infrared (IR) Waves

- Used for **short-range communication**.
- 👉 Used for **short-distance communication** like remote controls.
- 👉 **Example:** Your **TV remote** uses infrared

🔑 4. Satellite Communication

- Data is sent **to a satellite** in space and then sent back to earth.
- Used in **GPS, satellite internet (Starlink), and weather forecasting**.

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❖ What is Signal Transmission? :

Signal transmission means **sending data or information from one device to another** in the form of signals. These signals can be in the form of **electrical waves, light waves, or radio waves** and are used to communicate over a network.

📌 Example:

- When you talk on a mobile phone, your voice is converted into signals and sent to the receiver.
- When you use Wi-Fi, data is transmitted using radio signals.

✓ How Can We Transmit a Digital Signal?

A **digital signal** is a type of signal that has only two values: **0s and 1s (binary format)**.
This type of signal is used in computers and digital devices for communication.
There **are two main ways to transmit digital signals:**

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1. Transmission Through Wired Media (Physical Connection)

Digital signals can be sent using **wires or cables**.

There are three main types:

- ✓ **Twisted Pair Cable** – Used in telephone lines and LAN networks.
- ✓ **Coaxial Cable** – Used in cable TV and internet connections.
- ✓ **Fiber Optic Cable** – Uses light signals, very fast, used in high-speed internet.

📌 **Example:** When you connect your computer to the internet using an Ethernet cable, digital signals travel through the cable.

2. Transmission Through Wireless Media (No Physical Connection)

Digital signals can also be transmitted without wires using different types of wireless technology:

✓ **Radio Waves** – Used in Wi-Fi, Bluetooth, and FM radio.
✓ **Microwaves** – Used in satellite communication and mobile networks.
✓ **Infrared (IR)** – Used in remote controls for TVs and ACs.

📌 **Example:** When you send a message on WhatsApp, the data is transmitted wirelessly using radio waves through mobile towers.

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❖ What is Digital Encoding?

Digital Encoding is the process of converting **data (text, images, sound, etc.) into digital signals (0s and 1s)** so that computers and digital devices can understand and transmit the information.

📌 Example:

- When you type on a keyboard, each letter is converted into **binary code** (0s and 1s).
- When you send a message on WhatsApp, your text is **encoded** into a digital format before being transmitted over the internet.

Why is Digital Encoding Needed?

🔹 Computers and digital devices **only understand binary numbers (0s and 1s)**.

🔹 To **store, process, and transmit data** efficiently, we need to **convert** it into a digital form.

🔹 Helps in **error detection and correction**, making communication **more reliable**.

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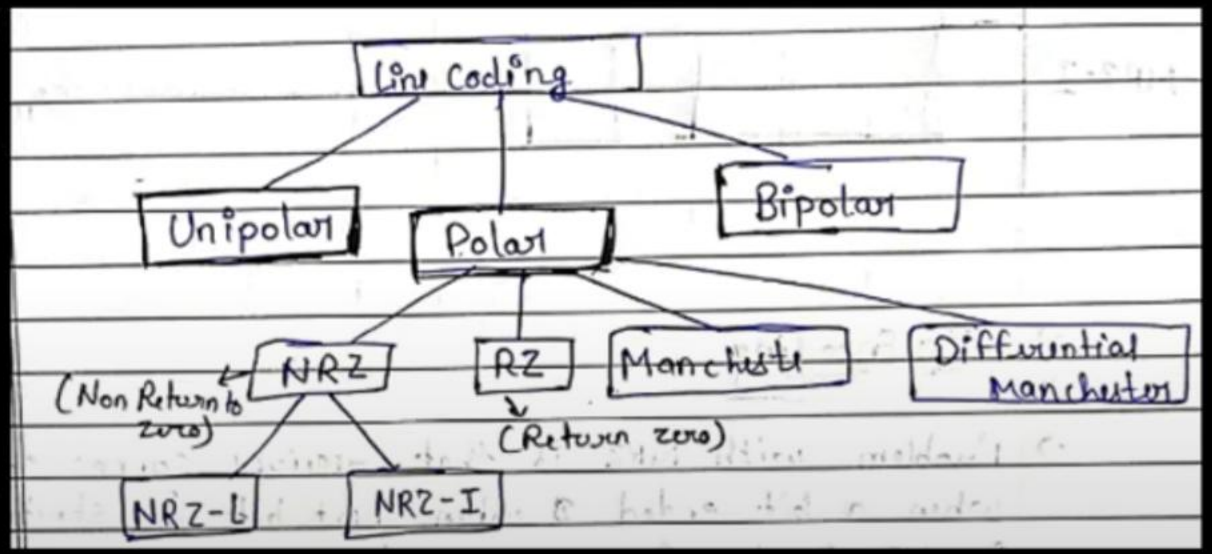

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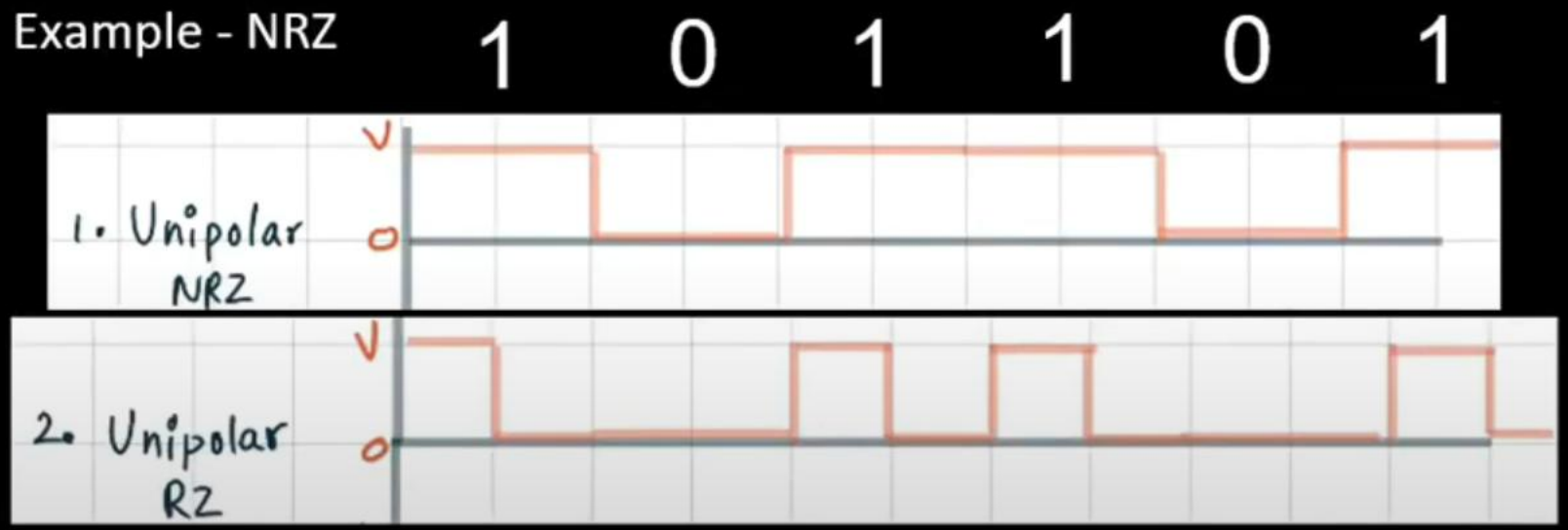
1. Unipolar Encoding

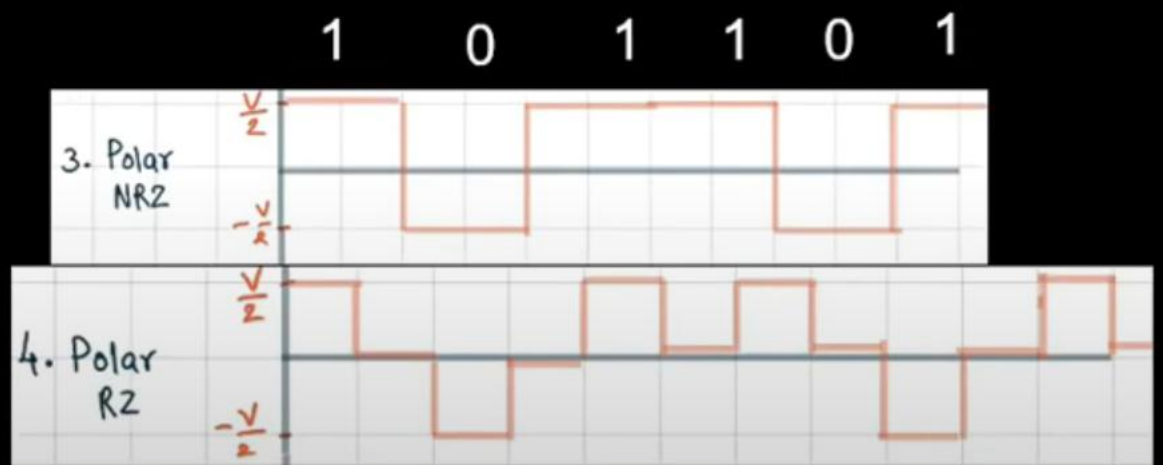
- Unipolar encoding is very simple and primitive.
- Unipolar encoding uses only one polarity.
- In unipolar encoding, all the signal levels are on one side of the time axis, either above or below.

Example - NRZ



2. Polar Encoding :

- Polar encoding uses two voltage levels: one positive and one negative.
- By using both levels, in most polar encoding methods the average voltage level on the line is reduced.
- NRZ encoding includes two methods: non return to zero, level (NRZ-L), and non return to zero, invert (NRZ-I)



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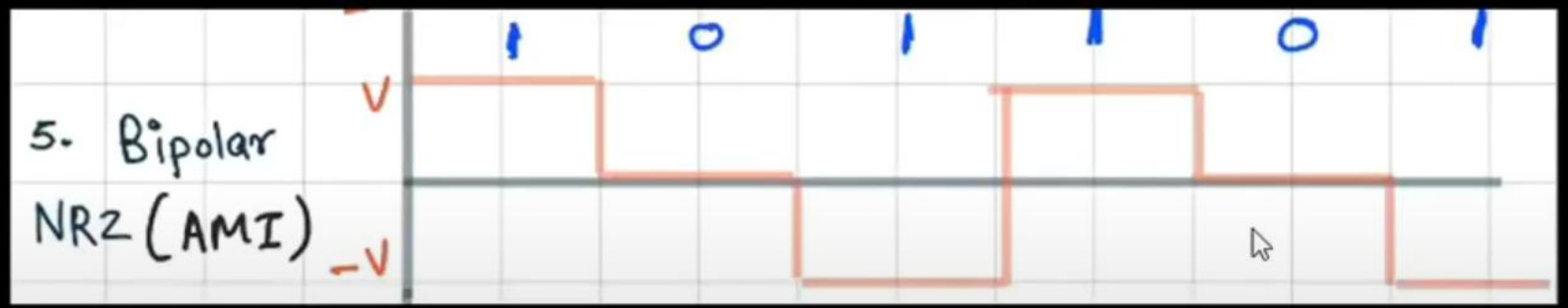
3. Bipolar Encoding

- Uses **three voltage levels**: **Positive (+V), Zero (0V), and Negative (-V)**.
- **1s are sent alternately as +V and -V**, while **0 is always 0V**.
- ✓ **Advantage:** Reduces power usage and avoids signal loss.
- ✗ **Disadvantage:** More complex than Polar encoding.



Computer Network (BCS603)

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✓ Network Performance :

Network Performance means how well a computer network is working. It measures how fast and efficiently data can be sent and received between devices.

✓ Factors Affecting Network Performance

1. Bandwidth (Speed of Data Transfer) - Bandwidth is the **maximum amount of data** that can be transferred in one second, measured in **Mbps (Megabits per second) or Gbps (Gigabits per second)**.

Example: If you have a **100 Mbps internet connection**, it means you can transfer **100 megabits of data every second**.

Real-life Example:

- A **higher bandwidth** allows you to watch a **4K video** on YouTube without buffering.
- A **low bandwidth** can make a video **buffer a lot** while playing.

2. Latency (Delay in Data Transmission) - Latency is the time it takes for data to travel from sender to receiver, measured in milliseconds (ms).

Example: A delay of 100 ms means it takes 100 milliseconds for a message to reach the other person.

Real-life Example:

- In an online game, if there is high latency (like 300ms), the player's actions will be delayed.
- In video calls, high latency can cause a lag where one person speaks, but the other hears it later.

3. Throughput (Actual Data Speed You Get)

Throughput is the **real speed** of data transfer, which can be lower than bandwidth due to **network congestion** or **device limitations**.

Example: If your internet plan is **100 Mbps**, but due to congestion, you get **50 Mbps**, that is your actual **throughput**.

Real-life Example:

- You have a **1 Gbps fiber connection**, but during peak hours, your internet slows down.
- Downloading a file at **50 Mbps speed** means you get **50 megabits per second** in real-time.

4. Jitter (Variation in Latency)

Jitter is the **variation** in the delay (latency) of data packets reaching the destination. It causes **uneven** network performance.

Example: If one data packet arrives in **20ms**, the next in **50ms**, and another in **30ms**, the delay is inconsistent, which is called **jitter**.

Real-life Example:

- During a **Zoom call**, if there is high jitter, you might see **choppy video or hear broken audio**.
- **Online gaming** feels **laggy** when jitter is high, even if the internet is fast.

5. Packet Loss (Missing Data Packets)

Packet loss happens when **some data packets do not reach their destination**, leading to missing information.

Example: If you send **100 packets** of data but only **90 arrive**, there is a **10% packet loss**.

Real-life Example:

- In **WhatsApp voice calls**, when packet loss occurs, the voice cuts off for a few seconds.
- In **online meetings**, if you see a frozen video or hear robotic audio, it is due to packet loss.

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❖ How to Improve Network Performance?

✓ **Increase Bandwidth** → Upgrade to a faster internet connection.

✓ **Reduce Latency** → Use a wired connection (Ethernet) instead of Wi-Fi.

✓ **Improve Throughput** → Avoid using too many devices on the same network.

✓ **Lower Jitter** → Use high-quality routers and avoid using multiple applications at once.

✓ **Fix Packet Loss** → Check for loose cables or switch to a stable network provider.

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❖ Transmission Impairment :

When data travels through a network (using cables or wireless signals), sometimes it **gets weak, distorted, or lost** before reaching its destination. This problem is called **transmission impairment**.

Types of Transmission Impairment:

1. Attenuation (Weakening of Signal)

- As the signal travels a long distance, it **loses strength** and becomes weak.
- Example: A phone call sounds **low** when the signal is weak.
- Solution: Use **signal boosters** or repeaters to strengthen the signal.

2. Distortion (Change in Shape of Signal)

- The signal **changes its form** while traveling due to different speeds of data waves.
- Example: A video call may have **delayed audio and mismatched video**.
- Solution: Use **better transmission mediums** like fiber optics.

3. Noise (Unwanted Signals Mixing with Data)

- Extra electrical signals mix with the data, causing **errors** or unwanted changes.
- Example: A radio station picks up **static noise** when signals interfere.
- Solution: Use **shielded cables** and filters to reduce noise.

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❖ Switching & Switching Methods in Computer Networks :

Switching is the method used to send data from one device to another in a network. It decides **how data travels** from the sender to the receiver. There are **three main types** of switching methods:

1. Circuit Switching: (Phone Call)

A dedicated communication path is established between sender and receiver before data transfer starts.

Example: Traditional **telephone calls** use circuit switching. Once a call is connected, a dedicated path is created, and the whole conversation happens through that path.

✓ **Advantage:** Reliable, as the full path is reserved.

✗ **Disadvantage:** Wastes resources if the connection is **idle**.

Sender ----> Switch 1 ----> Switch 2 ----> Receiver
(A Fixed Path is Established Before Data Transfer)

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❌ **Disadvantages:**

- Wastes resources because the connection remains **even when no data is being sent.**
- Not flexible if a network has **many users.**

2. Packet Switching(Like Sending Emails)

👉 **Data is divided into small packets and sent through the best available route.**

📌 **Example:**

- Imagine sending a **WhatsApp message**. Your message is broken into small parts (packets), sent separately, and then reassembled at the receiver's end.
- If one route is busy, the packets take different paths but still reach the destination.

✅ **Advantages:**

- **Efficient use of network resources** because no fixed path is needed.
- **Faster transmission** and easy to handle network failures.

❌ Disadvantages:

- Data packets can get **delayed or lost** if the network is busy.
- Sometimes, packets arrive **out of order**, so extra processing is needed to arrange them.

```
Sender ----> Packet 1 ----> Switch 1 ----> Receiver
       ----> Packet 2 ----> Switch 2 ----> Receiver
       ----> Packet 3 ----> Switch 3 ----> Receiver
(Packets take different routes but reach the same destination)
```

3. Message Switching(Like Post office)

👉 **Entire messages are sent from one switch to another (store-and-forward method).**

📌 Example:

- Think of **email**. When you send an email, it is **stored** in a mail server before being forwarded to the recipient when they check their inbox.

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✓ Advantages:

- **No dedicated connection** is required.
- Works well for large messages that don't require instant delivery.

✗ Disadvantages:

- **Slower** than packet switching because each message is stored before being sent.
- Needs **more storage space** at intermediate nodes.

Sender ----> Switch 1 (Stores Message) ----> Switch 2 (Stores Message) ----> Receiver
(Message is stored and then forwarded to the next switch)

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Comparison Table

Switching Type	How it Works?	Example	Pros	Cons
Circuit Switching	Fixed path created before communication	Telephone Call	Reliable, no data loss	Wastes resources if idle
Packet Switching	Data is broken into packets and sent separately	WhatsApp, Internet	Efficient, fast, flexible	Packets may arrive late or out of order
Message Switching	Entire message is stored before forwarding	Email	No need for dedicated path	Slower, requires storage

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❖ What is Multiplexing?

Multiplexing is a method used in networking and communication to **send multiple signals (data) over a single communication channel** at the same time. This helps in **saving bandwidth** and **improving efficiency**.

📌 Example:

Think of a **highway** where multiple cars travel on the same road but in different lanes. Similarly, multiplexing allows multiple data streams to travel through a single medium without interference.

Why Do We Use Multiplexing?

i. **Efficient Use of Resources** – Instead of using separate channels for each signal, multiple signals share one channel.
ii. **Reduces Cost** – Less hardware is needed because multiple users can share a single communication medium.
iii. **Increases Data Transfer Speed** – More data can be transmitted in less time.
iv. **Better Bandwidth Utilization** – It prevents wastage of network capacity.

Thank You...