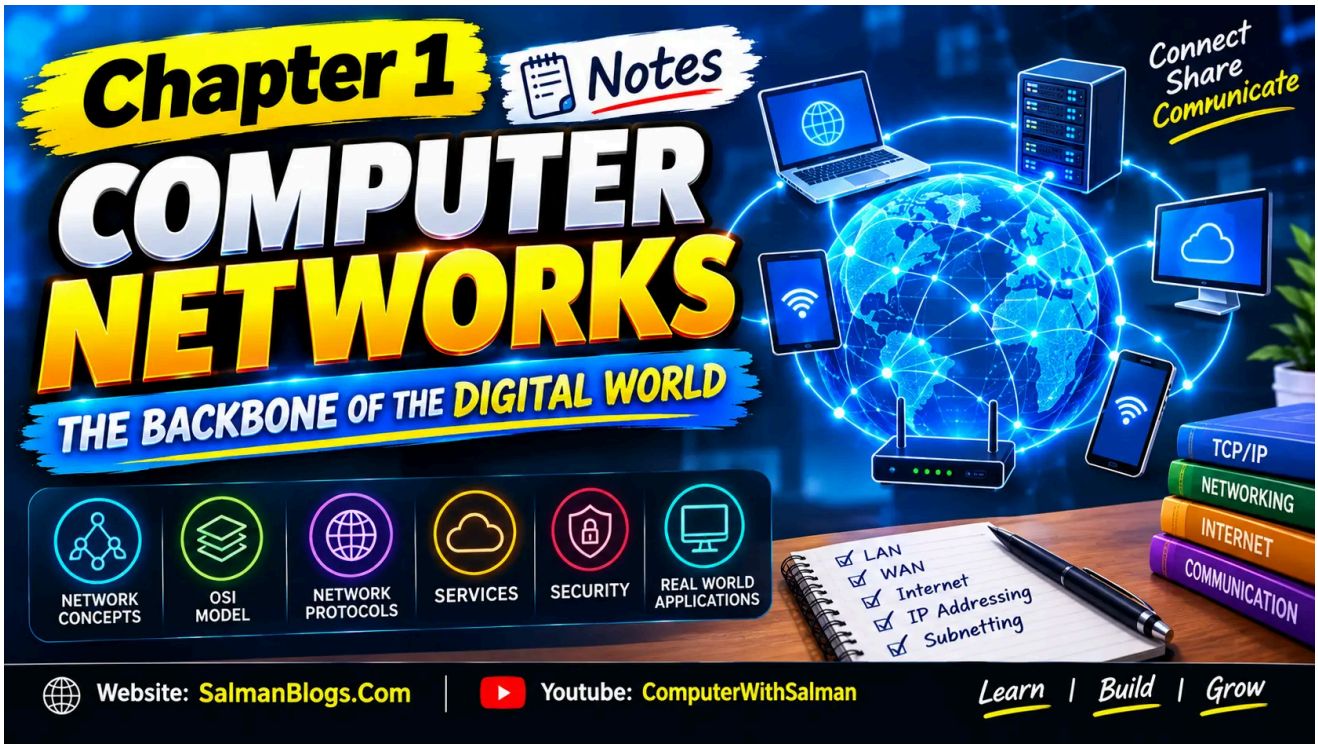
Computer Networks

Posted in **12 Computer Science**



These lecture notes are prepared by **Salman Ahmad**, who is both a **teacher** and a **web developer**. The purpose of this material is to make the topic clear and useful for students of Class 10 Computer Science.

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Computer Network

A **computer network** is a group of **computers and other devices connected to each other** so they can **communicate and share resources**.
Shared resources mean: Data, files, printers, storage, and internet connections.

Examples of Computer Networks

- **School Computer Lab:** Computers are connected to share files, printers, and other resources.
- **Office Network:** Employees' computers are connected to share data, printers, and other resources.

- **Home Network:** A laptop, smartphone, smart TV, and printer can be connected through a Wi-Fi router.
- **Bank Network:** Computers and ATMs are connected to exchange banking information and provide banking services.
- **University Network:** Computers in different departments are connected to share resources and access university services.
- **Hospital Network:** Computers are connected to share patient, medical, and administrative information.
- **Internet:** Millions of computers, smartphones, servers, and other devices are connected to communicate and exchange data.

> **Note:** In the test, you can write **any 1 or 2 examples** of computer networks. The extra examples are provided only for **better learning and understanding**.

Uses of Computer Network

- **Internet Browsing:** Networks allow users to access websites and online information.
- **Mobile Phones:** Networks are used for calls, messages, and mobile applications.
- **Education:** Schools use networks for online classes and learning systems.
- **Banking:** Banks use networks for online transactions and ATM services.
- **Social Media:** Social media platforms use networks to connect users and share content.
- **Smart Homes:** Networks allow users to connect and control smart devices such as lights, cameras, and appliances.

Network Architecture

Network architecture is the **design and structure of a computer network**. It includes the **hardware, software, and communication rules (protocols)** that allow devices to connect and communicate with each other.

Basic Components

- **Hardware:** Computers, servers, routers, switches, cables, and other physical network devices.
- **Software:** Network operating systems, applications, and network services that help manage and use the network.
- **Communication Rules:** Protocols that define how devices communicate and exchange data with each other.

Example

A **school network** uses computers and switches as **hardware**, network software and services as **software**, and protocols such as **TCP/IP** as **communication rules**.

Types of Computer Network

Computer networks can be classified according to their **coverage area and use**.

1. LAN (Local Area Network)

A **LAN** connects computers and devices within a **small geographical area**, such as a home, school, office, or computer lab.
Example: Computers connected within a school computer lab.

2. WAN (Wide Area Network)

A **WAN** connects networks over a **large geographical area**, such as different cities, countries, or continents.
A WAN used by a specific organization is also called a **Private WAN**.
Example: A company's network connecting its offices in Lahore, Karachi, and Islamabad is a **Private WAN**.

3. Public WAN

A **Public WAN** is a wide-area network that is **available to the general public** and is usually provided by telecommunication or internet service providers.
Example: The **Internet** is the largest example of a Public WAN.

Easy to Remember

- **LAN → Small area**
- **WAN / Private WAN → Large area + Specific organization**
- **Public WAN → Large area + Public access**

Networking Devices (90% Important – Long Question)

Networking devices are hardware devices used to **connect computers and other devices** and help them **communicate and share data over a network**.
The following are important networking devices:

1. NIC (Network Interface Card)

A **NIC** is a hardware component that allows a computer or other device to **connect to a network**.
It provides the device with a way to **send and receive data** over a network. A NIC can provide a **wired connection** through Ethernet or a **wireless connection** through Wi-Fi.
Example:
A desktop computer uses an Ethernet NIC to connect to a network using a network cable.
Main function:
Connects a device to a network.

2. Switch

A **switch** is a networking device that connects **multiple devices within the same network**.
It receives data from one device and forwards it to the **correct destination device**.
Example:
In a school computer lab, several computers can be connected to a switch so they can communicate and share network resources.
Main function:
Connects devices within a LAN and forwards data to the correct device.

3. Router

A **router** connects **different networks** and forwards data between them.
It determines where data should go and sends it toward the **appropriate network**.
Example:
A home router connects the devices in your home network to the **Internet**.
Main function:
Connects different networks and directs data between them.

4. Modem

A **modem** is a device that provides a connection between a local network and an **Internet Service Provider (ISP)** by converting signals used for communication over the service provider's connection.
Example:
A home internet connection may use a modem to connect the home network to the ISP's network.
Main function:
Provides communication between the user's network and the ISP.

5. Wireless Access Point (WAP)

A **Wireless Access Point (WAP)** allows wireless devices to **connect to a network using Wi-Fi**.

It provides a wireless connection between devices such as laptops, smartphones, and tablets and the network.

Example:

A school can install a wireless access point so students can connect their laptops and phones to the school network through Wi-Fi.

Main function:

Provides wireless network access to devices.

Network Topology **(70% Important – Long Question) Most of the time any one topology or maximum 2 topologies can be asked to explain.**

Network topology refers to the way computers, devices, and other components are **arranged and connected** in a computer network.

It shows how different devices are connected to each other and how data can travel between them.

Types of Network Topology

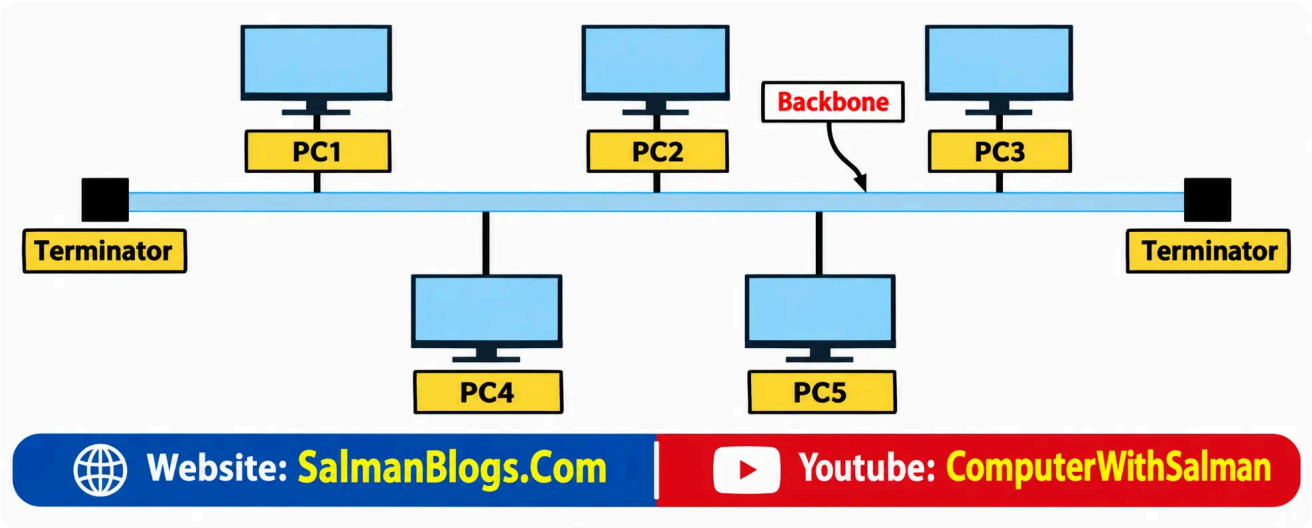
Common types of network topology include:

1. **Bus Topology**
2. **Star Topology**
3. **Ring Topology**
4. **Mesh Topology**
5. **Tree Topology**

Bus Topology

Bus topology is a network topology in which all computers and other devices are connected to a **single main cable**, called the **backbone cable**. **Backbone Cable also called** Netowrk cable.

Diagram



How Bus Topology Works

1. A computer sends data through the **main cable**.
2. The data travels along the backbone cable.
3. All connected computers can receive the signal.
4. The computer whose address matches the destination **accepts the data**.
5. **Terminators** are placed at both ends of the cable to prevent the signal from reflecting back.

> **Note:** In bus topology, all devices share one main cable called the **backbone cable**. Terminators are placed at both ends of the cable to prevent signals from reflecting back.

Advantages of Bus Topology

1. **Easy to Install** – It is easy to install because only one main cable is required.
2. **Requires Less Cable** – Compared with some other topologies, bus topology uses less cable because all devices share one main cable.
3. **Low Cost** – It is relatively inexpensive because less cable and fewer networking components are required.

Disadvantages of Bus Topology

1. **Main Cable Failure** – If the main cable fails, the **entire network can stop working**.
2. **Performance Decreases** – When many devices are connected, network performance can decrease because all devices share the same main cable.
3. **Difficult to Find Faults** – Finding a fault can be difficult because all devices share the same cable, making it harder to identify the exact location of the problem.

Example of Bus Topology

In a small computer lab, several computers can be connected to one main cable. When one computer sends data, the signal travels through the cable and reaches all connected computers, but only the intended computer accepts the data.

> **Remember: Bus Topology = One Main Cable + All Devices Connected to It**

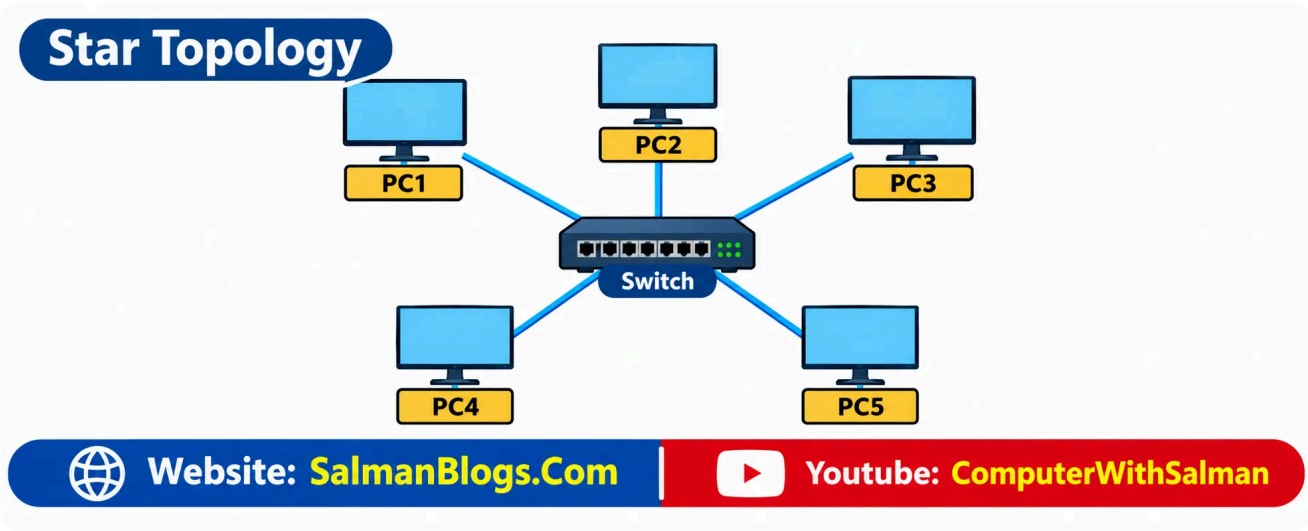
Star Topology

Star topology is a type of network topology in which **all computers and devices are connected to a central networking device**, such as a **switch or hub**.
The central device manages communication between the connected devices.

Example of Star Topology

Imagine a classroom where every student communicates through a **teacher**. If one student wants to send a message to another student, the message goes through the teacher.
Similarly, in star topology, devices communicate through the **central device**.

Diagram



How Star Topology Works

1. A computer sends data to the **central switch or hub**.
2. The central device receives the data.
3. It forwards the data to the **intended computer**.
4. Other computers do not normally receive the data meant for another device.

> **Note:** In star topology, each device has a **separate connection** to the central device. Therefore, if one connection fails, usually only that particular device is affected.

Advantages of Star Topology

- **Easy to Install and Manage** – Each device has a separate connection to the central device, making the network easier to install and manage.
- **Easy to Identify Faults** – If one device or cable fails, it is usually easy to find the problem.
- **Failure of One Cable Does Not Affect the Whole Network** – If the connection of one device fails, other devices can continue communicating.

Disadvantages of Star Topology

- **More Cable is Required** – Every device needs a separate connection to the central device.
- **More Expensive** – A switch or hub is required to connect all the devices.
- **Failure of the Central Device** – If the central switch or hub fails, it can affect the **entire network** because all devices depend on it.

> **Remember:** In **Star Topology**, all devices are connected to a **central switch or hub**.

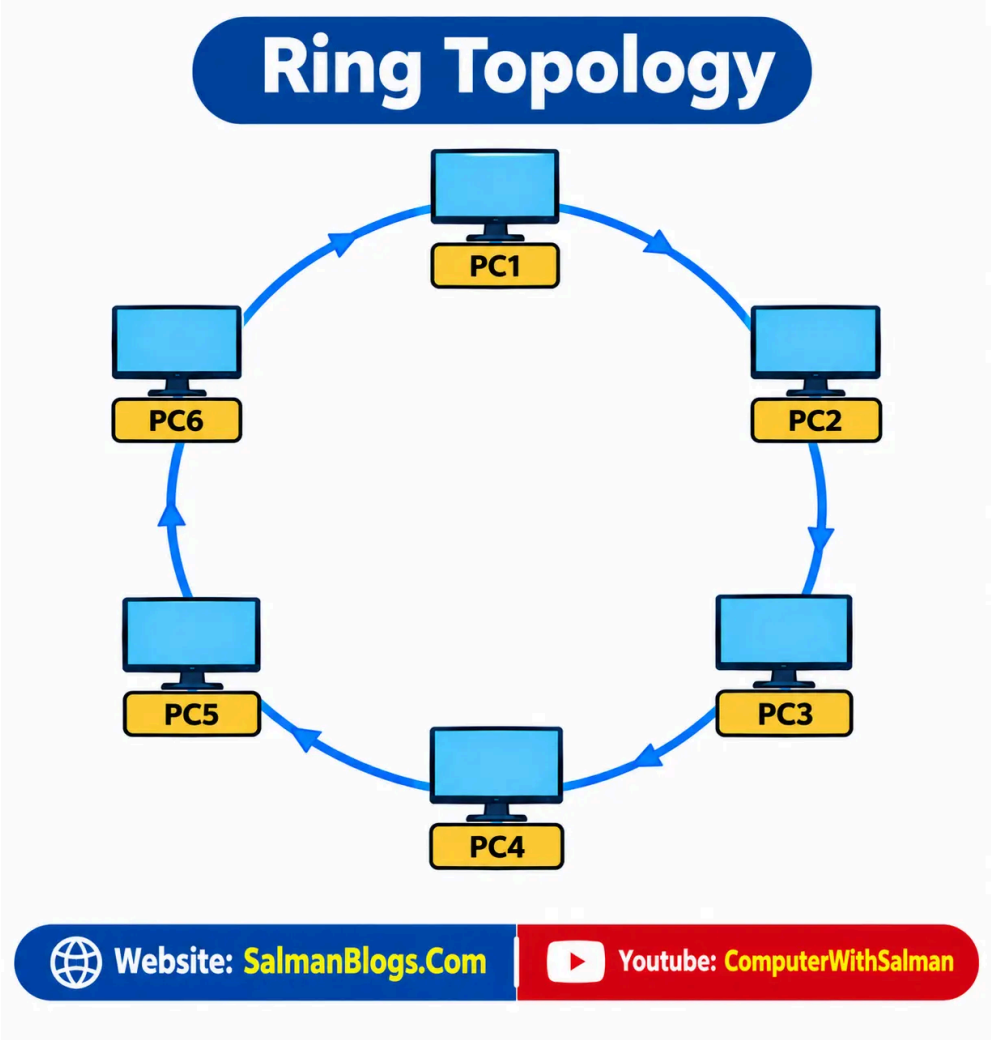
Ring Topology

Ring topology is a type of network topology in which **all computers and devices are connected in a circular arrangement**, forming a **ring**.
Each device is connected to **two other devices**, one on each side. Data travels from one device to the next until it reaches the intended destination.

Example

Imagine people sitting in a **circle** and passing a message from one person to the next. Similarly, in ring topology, data moves from one computer to the next around the ring.

Diagram



How Ring Topology Works

1. A computer sends data to the **next computer** in the ring.
2. The data continues from one computer to the next.
3. This process continues until the data reaches the **destination computer**.
4. The data follows the **ring structure** of the network.

> **Note:** In a ring topology, if one cable or device fails, it can **interrupt communication around the entire ring**.

Advantages of Ring Topology

- **Less Chance of Data Collision** – Data travels in an organized manner, reducing the chance of data collisions.
- **Equal Access to the Network** – Each computer gets a chance to transmit data.
- **Predictable Data Transmission** – Data follows a fixed path around the ring, making data transmission predictable.

Disadvantages of Ring Topology

- **Failure of One Device or Cable** – A failure of one device or cable can affect the **entire network**.
- **Difficult to Add or Remove Devices** – Adding or removing a device can be difficult because the ring connection may need to be interrupted.
- **Difficult to Find Faults** – Finding a fault can be difficult because a problem at one point can affect communication around the ring.

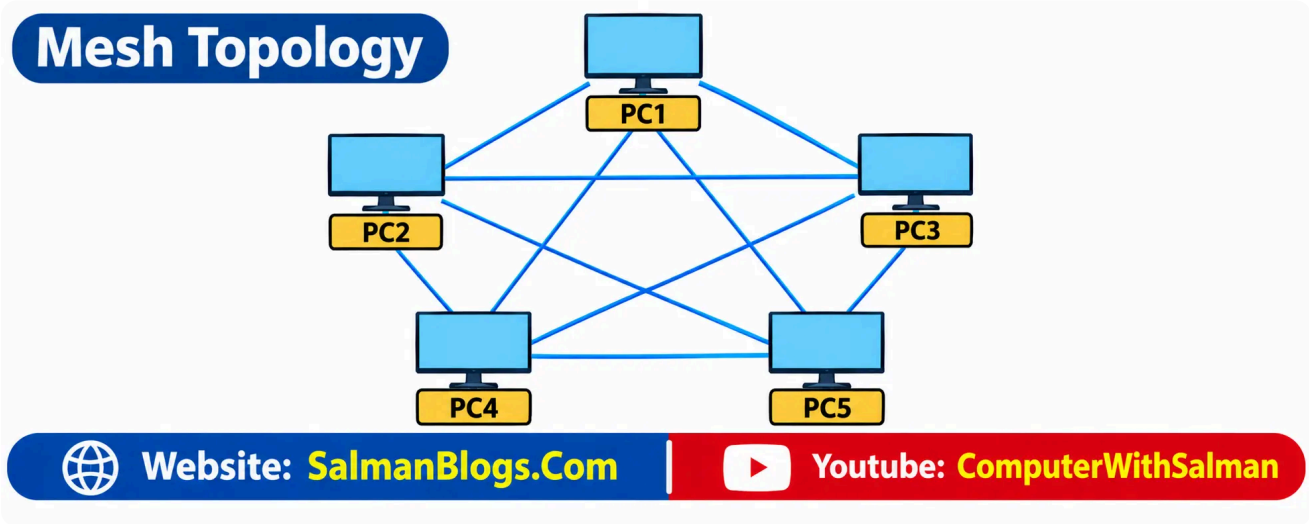
> **Remember:** In **Ring Topology**, devices are connected in a **circular arrangement**, and each device is connected to **two other devices**.

Mesh Topology

Mesh topology is a type of network topology in which **devices are connected to multiple other devices**. In a **full mesh**, every device has a direct connection with every other device.

Example

Suppose **Bank A, Bank B, Bank C, and Bank D** are connected with multiple links. If Bank A needs to send data to Bank D and the direct connection is unavailable, the data can travel through **Bank B or Bank C**.



How Mesh Topology Works

1. A device sends data through a **direct connection** to another device.
2. If one connection fails, data can often use **another available path**.
3. In a full mesh, **multiple paths** are available between devices.

Note: Mesh topology provides **high reliability** because devices have multiple connections. However, it requires **more cables and connections**, making it expensive and difficult to install.

Advantages of Mesh Topology

- **Highly Reliable** – Failure of one connection does not usually stop the entire network.
- **Multiple Paths are Available** – Data can use another available path if one connection fails.
- **Easy to Identify Faults** – Individual connections can be checked separately to find problems.

Disadvantages of Mesh Topology

- **Expensive** – A large number of cables and network connections are required.
- **Difficult to Install** – Many connections have to be made between devices.
- **Difficult to Manage** – Managing the network becomes difficult when there are many devices and connections.
- **Requires More Cables** – Mesh topology requires more cables as compared with other topologies.

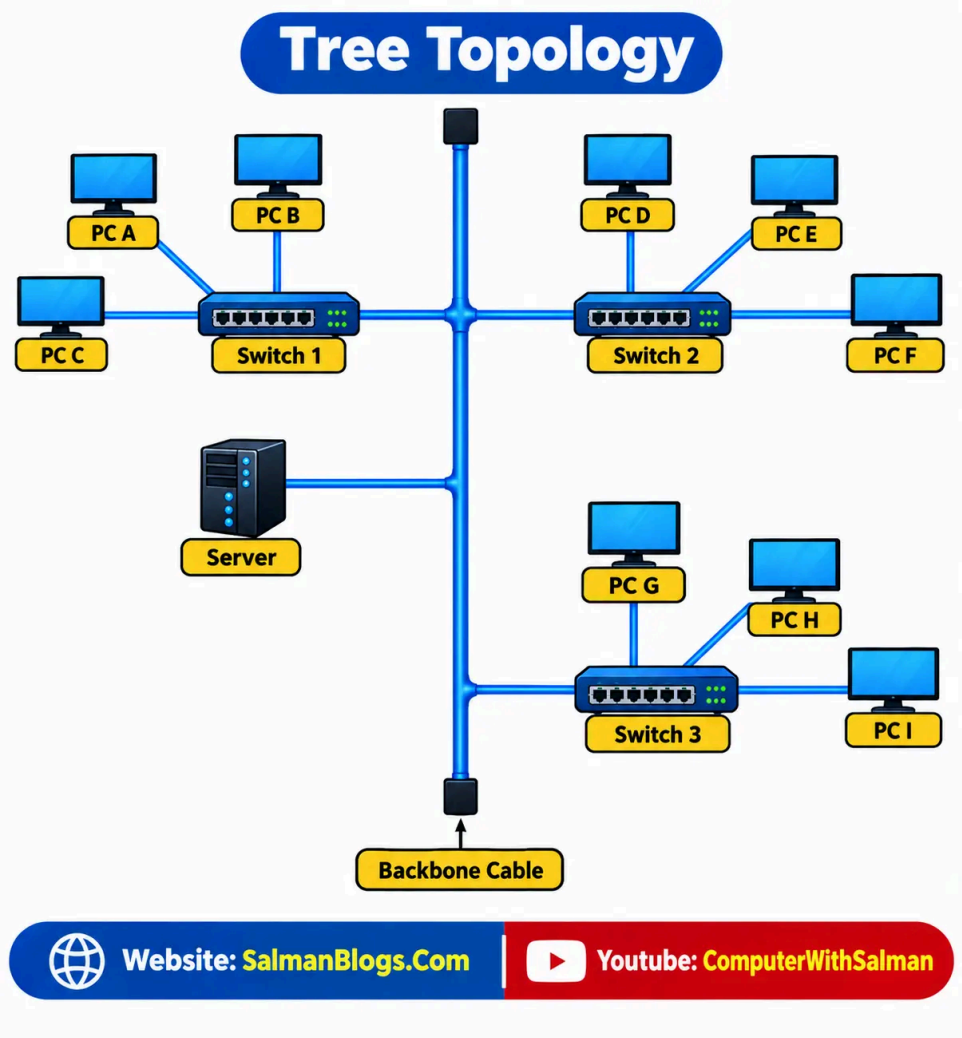
Remember: In **Mesh Topology**, devices have **multiple connections and multiple possible paths** for data transmission. This makes the network highly reliable.

Tree Topology

Tree topology is a type of network topology in which devices are arranged in a **hierarchical structure**. It combines the features of **star topology and bus topology**. In a tree topology, multiple smaller networks are connected to a **main backbone cable**.

Example

In the example below, the **backbone cable** acts as the main connection. Several **switches** are connected to the backbone, and each switch connects multiple computers. For example, **Switch 1** connects PC A, PC B, and PC C, while **Switch 2** connects PC D, PC E, and PC F. Similarly, **Switch 3** connects PC G, PC H, and PC I. A **server** is also connected to the network.



How Tree Topology Works

1. The **backbone cable** provides the main connection between different sections of the network.
2. **Switches** are connected to the backbone and act as connection points for groups of devices.
3. Each switch connects multiple **computers and other network devices**.
4. Data can travel from one device through its switch and the **backbone** to another part of the network.

> **Note:** Tree topology is useful for **large networks** because devices can be organized into different branches. However, if the **main backbone connection fails**, communication between different branches may be affected.

Advantages of Tree Topology

- **Easy to Expand** – New devices or branches can be added to the network without changing the entire structure.

- **Suitable for Large Networks** – Devices can be divided into different groups or branches, making large networks easier to organize.
- **Easy to Manage** – Each branch can be managed separately through its switch.
- **Easy to Identify Faults** – Problems can often be located within a particular branch of the network.

Disadvantages of Tree Topology

- **Backbone Failure** – If the main backbone cable fails, communication between different branches may be affected.
- **Expensive** – More cables, switches, and other networking equipment are required.
- **Difficult to Install** – Setting up the hierarchical structure requires careful planning and configuration.
- **Requires More Cables** – Tree topology uses more cables because several branches and devices need to be connected.

> **Remember:** In **Tree Topology**, devices are arranged in a **hierarchical structure**. A main **backbone** connects different branches, while **switches** connect groups of computers within each branch. This makes tree topology suitable for organizing **large networks**.

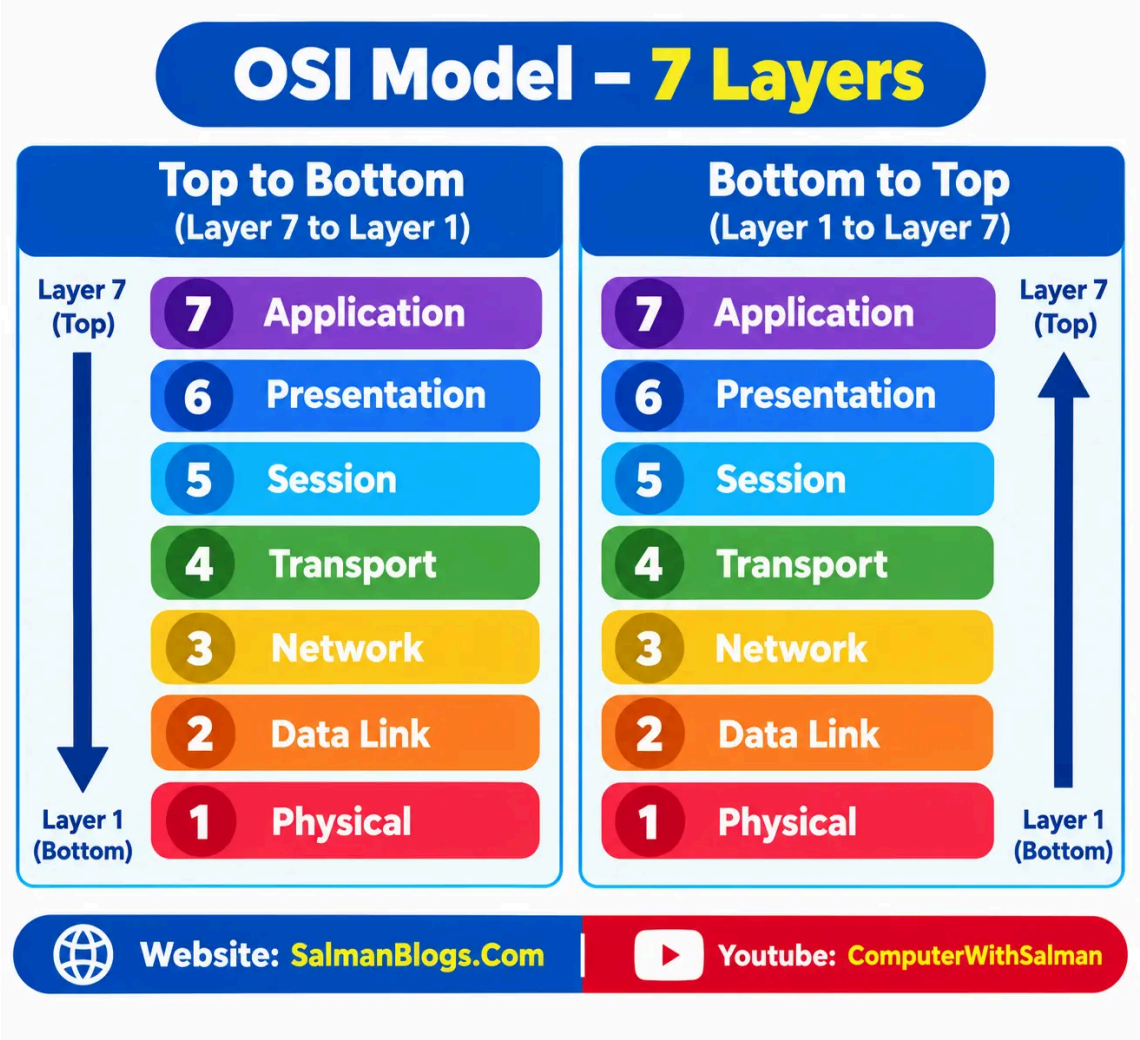
Network Models and Layers

A **network model** is a framework that explains **how data moves from one device to another over a network**. It divides network communication into different **layers**, where each layer performs a specific job.
The two common network models are **OSI** and **TCP/IP**.

OSI Layers Model (80% Important – Long Question)

[Also called OSI Model, Layers Model, OSI Model]
The **OSI (Open Systems Interconnection) Model** divides network communication into **7 layers**. Each layer performs a specific function and works together with the other layers to transfer data between devices.

Diagram



Layer	Name	Explanation
7	**Application**	Provides network services directly to applications used by users, such as **web browsers, email, and file-transfer applications**.
6	**Presentation**	Prepares data so that different systems can understand it. It also handles **data formatting, encryption, decryption, and compression**.
5	**Session**	Establishes, manages, and terminates communication sessions between applications. It keeps communication organized while data is being exchanged.
4	**Transport**	Controls the delivery of data between devices. It divides data into smaller parts and helps ensure that

Layer	Name	Explanation
		the data reaches the destination **correctly and in the proper order**.
3	**Network**	Handles **logical addressing, such as IP addresses**, and determines the best path for data to travel between different networks.
2	**Data Link**	Transfers data between devices on the same network. It uses **MAC addresses** and helps detect errors that occur during local data transmission.
1	**Physical**	Deals with the actual transmission of data as **electrical signals, radio waves, or light signals** through cables or wireless connections.

> **Note:** The OSI Model has **7 layers**. When writing the layers in an exam, **do not change or mix their order**. You can write the layers either from **top to bottom (Layer 7 to Layer 1)** or from **bottom to top (Layer 1 to Layer 7)**. However, the correct order must be maintained. If the order of the layers is changed or mixed, the answer will be considered **wrong**.

Network Protocols and Services (85% Important – Long Question)

Network protocols are rules that define **how devices communicate and exchange data over a network**. Different protocols are used for different network services.

1. TCP/IP

TCP/IP (Transmission Control Protocol/Internet Protocol) is a set of protocols used for communication between devices on a network.

- **TCP (Transmission Control Protocol)** controls the **transmission of data** and helps ensure that it reaches the destination correctly and in the proper order.
- **IP (Internet Protocol)** provides **addresses for devices** and helps deliver data to the correct destination.

Example: When two devices communicate over the Internet, **TCP manages the transmission of data**, while **IP uses device addresses to deliver the data to the**

correct destination.

2. HTTP

HTTP (HyperText Transfer Protocol) is used to **transfer web pages and other web content** between a web browser and a web server.
Example: Opening a website using an HTTP connection.

3. File Transfer Protocol (FTP)

FTP (File Transfer Protocol) is used to **transfer files between computers over a network**. It allows users to **upload and download files**.
FTP is commonly used by **web developers** to transfer website files between their computers and web servers. It can also be used to transfer large files.
Example: A web developer uses FTP to **upload website files from their computer to a web server**.

4. DNS

DNS (Domain Name System) converts **domain names into IP addresses** so computers can locate servers on a network.
Example: When you enter `google.com`, DNS helps find the IP address of the Google server.

IP Addressing

IP addressing is the method of giving an **IP address to each device on a network** so that devices can identify and communicate with each other.
Example: `192.168.1.10`

Types of IP Addresses

1. IPv4

IPv4 uses a **32-bit address** written in four numbers separated by dots.
Example: `192.168.1.10`

Total Possible Addresses

Since IPv4 uses **32 bits**, the total number of possible addresses is:
2^{32} = 4,294,967,296 addresses
Therefore, IPv4 can theoretically provide about **4.29 billion unique IP addresses**.

Network Part

The **network part** identifies **which network the device is connected to**, such as the network of a school, office, or home.

Host Part

The **host part** identifies the **specific device connected to that network**.

Example

IP Address: `192.168.1.10`

- **Network Part:** `192.168.1` → identifies the local network.
- **Host Part:** `10` → identifies the specific computer or device on that network.

> **Remember:**
> **Network Part → Which network?**
> **Host Part → Which device?**

2. IPv6

IPv6 uses a **128-bit address** written in hexadecimal numbers separated by colons.

Example: `2001:0db8:85a3:0000:0000:8a2e:0370:7334`

Total Possible Addresses

Since IPv6 uses **128 bits**, the total number of possible addresses is:

2^{128} = 340,282,366,920,938,463,463,374,607,431,768,211,456 addresses

This is approximately **3.4×10^{38} addresses**.

IPv6 Address

Example: `2001:db8:1234:5678:abcd:1234:5678:0001`

1. Global Routing Prefix → Which Main Network?

The **Global Routing Prefix** identifies the **main network assigned to an organization**. For example, a university gets a large IPv6 network from its Internet Service Provider (ISP).

`2001:db8:1234`

This part tells us that the address belongs to **this organization's network**.

2. Subnet ID → Which Smaller Network?

An organization can divide its large network into smaller networks called **subnets**.

For example, a university may have:

- **Computer Lab** → Subnet 1
- **Administration** → Subnet 2
- **Teachers** → Subnet 3

```
5678
```

This part identifies **which subnet** the device belongs to.

3. Interface ID → Which Device?

Finally, the **Interface ID** identifies the **specific device** inside that subnet.

```
abcd:1234:5678:0001
```

For example, this could identify **one particular computer** in the Computer Lab subnet.

Complete Idea

Global Routing Prefix → Organization's main network

↓

Subnet ID → Specific subnet

↓

Interface ID → Specific device

> **Note:**
> **Global Routing Prefix + Subnet ID = Network Part**
> **Interface ID = Host/Device Part**

Example

Imagine a school network:

School → Computer Lab → Computer 5

- **Global Routing Prefix** = School's main network
- **Subnet ID** = Computer Lab
- **Interface ID** = Computer 5

> **Remember:** The basic idea of IP addressing is to identify **which network** a device belongs to and **which specific device** it is within that network.

Subnetting

Subnetting is the process of **dividing one large network into smaller networks called subnets**.
Example: A school can divide its network into separate subnets for the **Computer Lab**, **Teachers**, and **Administration**.

> **Remember: Subnetting = Dividing one large network into smaller networks (subnets).**

NAT (Network Address Translation)

NAT (Network Address Translation) is a technique used by a router to **translate private IP addresses into a public IP address** when devices communicate over the Internet.
Devices in a **home, school, or office** use **private IP addresses**. When they access the Internet, the **router uses NAT to replace the private IP address with its public IP address**.

> **Remember: NAT = Private IP Address → Public IP Address** when a device communicates over the Internet.

Home Network Setup and Configuration

A **home network** is a network that connects devices in a home so they can **communicate and share resources**, such as an Internet connection, files, and printers.

Components of a Home Network

1. **Router:** Connects the home network to the Internet and directs data between devices.
2. **Network Devices:** Computers, laptops, smartphones, smart TVs, printers, and other devices connected to the network.
3. **Ethernet Cables:** Used to connect devices through a **wired connection**.
4. **Wireless Access Point (Wi-Fi):** Allows devices to connect to the network **wirelessly**.

Wired Network Connection

A **wired network connection** connects a device to the network using an **Ethernet cable**.
Example: A desktop computer is connected to a router using an Ethernet cable to access the Internet.

Wireless Network Connection

A **wireless network connection** allows devices to connect to the network using **Wi-Fi**, without an Ethernet cable.
Example: A smartphone connects to the home router through Wi-Fi to access the Internet.

> **Remember: Wired connection → Ethernet cable**
> **Wireless connection → Wi-Fi**

Wi-Fi Security and Router Configuration

Wi-Fi security means protecting a wireless network from **unauthorized access**. A router can be configured to control how devices connect to the network and protect the network using a **password and encryption**.

Router Web Interface

A **router web interface** is a webpage provided by the router that allows the user to **configure and manage router settings**.
Example: A user can open the router's web interface to change the **Wi-Fi name, password, security settings**, and other network settings.

1. Router Configuration

Router configuration means setting up and changing the router's settings according to the **network requirements**.
Common router settings include:

- **Wi-Fi Name (SSID):** The name of the wireless network.
- **Wi-Fi Password:** The password required to connect to the network.
- **Security Settings:** Settings used to protect the wireless network.
- **IP Address Settings:** Settings related to IP addresses used by the router and network devices.

Example: A user changes the Wi-Fi name from `Home_WiFi` to `Salman_Home`.

2. Wi-Fi Encryption

Wi-Fi encryption protects the data transmitted over a wireless network and helps prevent unauthorized users from accessing the network.
Common Wi-Fi security standards include **WPA2** and **WPA3**.
Example: When a Wi-Fi network uses WPA2 or WPA3 with a strong password, unauthorized users cannot easily connect to the network.

3. Default Gateway

The **default gateway** is the device, usually the **router**, that provides a path from the local network to other networks, such as the **Internet**.
Example: When a computer on a home network wants to access a website on the Internet, it sends the data to the router, which acts as the **default gateway**.

Guest Network

A **guest network** is a separate Wi-Fi network created for **visitors**.
It allows guests to access the **Internet** without giving them direct access to devices on the **main home network**.

> **Remember:**
> **Router Web Interface** → Manage router settings
> **Router Configuration** → Set and change router settings
> **Wi-Fi Encryption** → Protect wireless communication
> **Default Gateway** → Provides a path to other networks
> **Guest Network** → Separate Wi-Fi access for visitors

Network Diagnostic Tools and Commands

Network diagnostic tools and commands are used to **check, test, and troubleshoot network connections**. They help identify problems with devices, IP addresses, and network communication.

1. Ping Command

The **ping** command is used to check whether a device or server is **reachable over a network**. It sends a small test message to the destination and checks whether a response is received.
Example:

```
ping google.com
```

If a response is received, it generally means that the destination is **reachable**.
Main use: Check network connectivity.

2. ipconfig and ifconfig Commands

The **ipconfig** and **ifconfig** commands are used to view network configuration information such as the **IP address, subnet mask, and default gateway**.

ipconfig

ipconfig is commonly used in **Windows** to display network configuration information.

```
ipconfig
```

ifconfig

ifconfig is traditionally used in **Linux and Unix-based systems** to display and configure network interfaces.

```
ifconfig
```

Example: You can use these commands to find your computer's **IP address** and **default gateway**.

3. Telnet

Telnet is a network protocol and command-line tool used to **establish a connection to a remote device** over a network.
Example: A network administrator can use Telnet to connect to a remote network device and manage it through the command line.

> **Note:** Telnet does **not encrypt** the communication. For secure remote access, **SSH** is generally preferred.

4. PuTTY

PuTTY is a software application used to connect to **remote computers and network devices**.
It supports protocols such as **SSH** and **Telnet**.
Example: A network administrator can use PuTTY to connect to a router using **SSH** and configure it remotely.

5. Secure Shell (SSH)

SSH (Secure Shell) is a secure protocol used to **access and manage remote computers or network devices** over a network.
SSH **encrypts the communication** between the local and remote devices, helping protect the data from unauthorized access.
Example: A network administrator can use SSH to securely connect to a remote router and configure its settings.

Network Performance

Network performance refers to how efficiently and quickly data is transferred between devices over a network. It is mainly affected by factors such as **bandwidth, latency, and network delays**.

1. Network Bandwidth

Network bandwidth is the maximum amount of data that can be transmitted over a network connection in a **given amount of time**.
It is usually measured in **bits per second (bps)**, such as **Mbps** (Megabits per second) or **Gbps** (Gigabits per second).

2. Network Latency

Network latency is the **time taken for data to travel from one device to another** over a network.
It is usually measured in **milliseconds (ms)**.
Example: If a game has **20 ms latency**, data travels between your device and the game server with very little delay. If the latency is **200 ms**, there will be a noticeable delay.

> **Easy Idea: Lower latency = Faster response**

Causes of Network Delay

Network delay happens when data takes longer than expected to travel through a network. It can occur due to several reasons:

- **Too Many Users:** Heavy network usage can slow down communication because many users are sharing the available network resources.
- **Poor-Quality Cables:** Damaged or low-quality cables can cause errors and may result in retransmission of data, causing delays.
- **Long Distance:** Data may take more time to travel when the source and destination are far apart.
- **Network Congestion:** Too much data traffic on a network can slow down data transmission.
- **Hardware Problems:** Faulty or overloaded network devices, such as routers and switches, can cause delays.

> **Remember:**
> **Bandwidth →** Amount of data that can be transmitted per second
> **Latency →** Time taken for data to travel
> **Lower latency →** Faster response
> **Network delay →** Data takes longer to reach its destination

Network Load Balancing

Network load balancing is a technique used to **distribute network traffic or requests among multiple servers or network links**. It prevents one server or link from becoming overloaded and helps the network provide better **speed, performance, and reliability**.
Example: If thousands of users access a website at the same time, load balancing can distribute their requests among several servers instead of sending all requests to one server.

Benefits of Load Balancing

- Improves **network speed and response time**.
- Prevents **overloading** of a server or network link.
- Reduces the risk of **server failure**.
- Provides a better **user experience**.
- Handles **high traffic** more efficiently.
- Improves **network reliability and availability**.

Basic Load Balancing Methods

There are different methods for distributing network traffic among multiple servers.

1. Round Robin

Round Robin sends requests to servers **one by one in a fixed order**.

Example:

```
Server 1 → Server 2 → Server 3 → Server 1 → Server 2 → Server 3
```

This method distributes requests in a simple repeating sequence.

2. Least Connection

The **Least Connection** method sends a new request to the server that currently has the **fewest active connections**.

Example: Suppose there are three servers:

- Server 1 → 10 active connections
- **Server 2 → 3 active connections**
- Server 3 → 7 active connections

A new user request will be sent to **Server 2** because it has the **fewest active connections**.

> **Easy Idea: Least Connection → Send traffic to the least busy server.**

3. IP Hash

The **IP Hash** method uses the **user's IP address** to determine which server will handle the request.

The load balancer calculates a hash based on the user's IP address and uses the result to select a server.

Example:

- User A → IP `192.168.1.10` → Server 1
- User B → IP `192.168.1.20` → Server 2
- User C → IP `192.168.1.30` → Server 3

> **Remember:**
> **Round Robin →** Servers are selected one by one in order.
> **Least Connection →** Sends the request to the server with the fewest active

connections.
IP Hash → Uses the client's IP address to select a server.

Network Security

Network security means protecting a network, its devices, and data from **unauthorized access, attacks, and other security threats**.

1. Firewall

A **firewall** is a security system that **monitors and controls incoming and outgoing network traffic** based on security rules.
Example: A firewall can block an unauthorized connection from accessing a computer or network.

2. Encryption

Encryption converts readable data into an **unreadable form** so that unauthorized people cannot understand it.
Example: When data is sent over a secure connection such as **HTTPS**, encryption helps protect the data from being read by attackers.

3. Access Control

Access control determines **who can access a network, device, or resource and what they are allowed to do**.
Example: In a school network, students may be allowed to access learning resources, while an administrator may have permission to change network settings.

Common Network Security Threats

- **Malware:** Malicious software that can damage systems or steal information.
- **Phishing:** Fake messages or websites used to trick users into revealing sensitive information.
- **Unauthorized Access:** Accessing a network or system without permission.
- **Denial-of-Service (DoS) Attack:** Overloading a system or network with traffic to make it unavailable.
- **Man-in-the-Middle (MITM) Attack:** An attacker secretly intercepts communication between two parties.

- **Password Attacks:** Attempts to guess or steal passwords to gain unauthorized access.

Data Backup and Recovery

Data backup means making a **copy of important data** so it can be restored if the original data is lost or damaged. Data may be lost because of **viruses, accidental deletion, hardware failure**, or other problems.
Data recovery is the process of **restoring lost or damaged data**. Regular backups make recovery easier and help reduce data loss.

Types of Data Backup

There are three common types of backup:

1. Full Backup

A **full backup** saves **all selected data** in the backup.
Example: Backing up all files on a computer at once.

2. Incremental Backup

An **incremental backup** saves only the data that has **changed since the last backup**.
Example: After a full backup, only newly added or changed files are backed up.

3. Differential Backup

A **differential backup** saves all data that has **changed since the last full backup**.
Example: If a full backup was made on Monday, Tuesday's differential backup saves Tuesday's changes. Wednesday's differential backup saves both **Tuesday + Wednesday changes**.

Backup Storage

Backups can be stored on different types of storage, including:

- **Hard Drives**
- **External Storage Devices**
- **Cloud Storage**

Example: A user can save a backup of important documents on an external hard drive or in cloud storage.

Data Recovery Methods

- **Backup Files:** Used to restore lost or damaged data from a previously created backup.
- **Recovery Software:** Software that can help recover accidentally deleted or lost files.
- **System Restore:** Restores system settings and files to an earlier state.
- **Professional Data Recovery:** Specialists can attempt to recover data from severely damaged storage devices.

Usability and Security Tradeoffs

Usability

Usability means how **easy a system is to use**. A usable system is simple, clear, and easy to learn. Users can perform tasks without confusion.

Good Usability

- **Saves time and effort**
- **Makes tasks easier**
- **Reduces confusion**
- **Improves user satisfaction**

Example: A website with a simple menu and clear buttons is easier for users to use.

Security

Security means protecting **systems and data from unauthorized access, attacks, and damage**. It helps keep information private and safe.

Good Security

- **Prevents unauthorized access**
- **Protects against viruses and hackers**
- **Keeps data safe and private**
- **Reduces risks and damage**

Example: A website using strong passwords and **two-factor authentication** provides better security.

Tradeoff Between Usability and Security

Sometimes, **increasing security can make a system harder or slower to use**. This is called a **usability and security tradeoff**.
For example:

- **Strong passwords** provide better security but can be more difficult to remember.
- **Extra login steps** improve security but can take more time for users.
- **Simple login systems** are easier to use but may provide less security.

Therefore, a system should maintain a **balance between usability and security** so it is both **easy to use and properly protected**.

Multiple Choice Questions (MCQs) on Computer Networks

1. What is a computer network?

a. A single computer without any connection
b. A group of computers and devices connected to communicate and share resources
c. A type of storage device
d. A computer programming language

> **Answer: b. A group of computers and devices connected to communicate and share resources**

2. Which of the following is a common use of a computer network?

a. Internet browsing
b. Increasing monitor size
c. Changing keyboard color
d. Increasing processor temperature

> **Answer: a. Internet browsing**

3. What does network architecture describe?

a. The physical size of a computer
b. The speed of a processor
c. The design and structure of a computer network
d. The storage capacity of a hard drive

> **Answer: c. The design and structure of a computer network**