Networking Concepts

chapter 04

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Objectives of the Session

1. Understand the basics of computer networks.
2. Explore different types of networks: LAN, WAN, and the Internet.
3. Learn about the role of the Internet in ICT and AI applications.
4. Lab: Network setup and basic troubleshooting.

What is a Computer Network?

Definition: A computer network is a collection of interconnected devices (computers, servers, routers, etc.) that share resources and exchange data.

Characteristics of a Computer Network

1. Share resources from one computer to another.
2. Create files and store them in one computer, access those files from the other computer(s) connected over the network.
3. Connect a printer, scanner, or a fax machine to one computer within the network and let other computers of the network use the machines available over the network.

Following is the **list of hardware's** required to set up a computer network.

1. Network Cables
2. Distributors
3. Routers
4. Internal Network Cards
5. External Network Cards

list of hardware's

Network Cables

1. Network cables are used to connect computers. The most commonly used cable is Category 5 cable RJ-45.

list of hardware's

Distributors

A computer can be connected to another one via a serial port but if we need to connect many computers to produce a network, this serial connection will not work.

The solution is to use a central body to which other computers, printers, scanners, etc. can be connected and then this body will manage or distribute network traffic.

list of hardware's

- Router:

- Acts as the central point for connecting computers and other devices in a network.
- Has ports to connect devices using network cables.
- Modern routers are often wireless, allowing devices to connect without physical cables.
- Helps direct data traffic between devices and connects the network to the Internet.

list of hardware's

Network Card

- Network card is a necessary component of a computer without which a computer cannot be connected over a network. It is also known as the network adapter or Network Interface Card (NIC). Most branded computers have network card pre-installed.
- Network cards are of two types: Internal and External Network Cards.

list of hardware's

Internal Network Cards

•Motherboard has a slot for internal network card where it is to be inserted. Internal network cards are of two types in which the first type uses Peripheral Component Interconnect (PCI) connection, while the second type uses Industry Standard Architecture (ISA). Network cables are required to provide network access.

list of hardware's

External Network Cards

External network cards are of two types: Wireless and USB based. Wireless network card needs to be inserted into the motherboard, however no network cable is required to connect to the network.

list of hardware's

Universal Serial Bus (USB):

USB card is easy to use and connects via USB port. Computers automatically detect USB card and can install the drivers required to support the USB network card automatically.

Dear Students,

Please complete an assignment where you list five additional hardware components required to set up a computer network. For each component, provide the following:

1. A brief description of its functionality and uses.
2. A simple, labeled diagram illustrating the device.

Ensure that your explanations are clear and concise. Submit your work by the designated deadline.

Nodes

- **Definition**: Nodes are the devices that participate in the network. These devices can be computers, printers, servers, smartphones, and other hardware that send, receive, and process data.
- **Types of Nodes**:
  - **End Devices**: Devices like PCs, mobile phones, and printers that either generate or consume data.
  - **Network Devices**: Routers, switches, hubs, and access points that manage and direct network traffic.
- **Function**: Nodes interact with each other to perform various tasks, like sharing files, printing documents, or accessing web resources.

Benefits of Computer Networks

1. **Resource Sharing:** Share files, printers, and other resources.
2. **Communication:** Facilitates data sharing through email, messaging, etc.
3. **Data Security**: Centralized control for data backups and security.
4. **Scalability:** Easy to expand by adding new devices.
5. **Cost Efficiency:** Reduces the need for standalone devices and resources.

Network Components

1. **Server:** Manages resources and provides services to clients.
2. **Client:** Devices that use network resources (computers, smartphones).
3. **Router:** Directs data traffic between networks.
4. **Switch:** Connects devices within a network.
5. **Hub:** Basic device to connect multiple devices, less common no

Types of Networks

- Networks can be categorized depending on size, complexity, level of security, or geographical range. We will discuss some of the most popular topologies based on geographical spread.

PAN (Personal Area Network):

- PAN is the acronym for Personal Area Network. PAN is the interconnection between devices within the range of a person's private space, typically within a range of 10 metres.
- If you have transferred images or songs from your laptop to mobile or from mobile to your friend's mobile using Bluetooth, you have set up and used a personal area network.

PAN (Personal Area Network):

- A person can connect her laptop, smart phone, personal digital assistant and portable printer in a network at home. This network could be fully Wi-Fi or a combination of wired and wireless.

LAN (Local Area Network):

Definition: LAN is a wired network spread over a single site such as an office, building, school or manufacturing unit.

Purpose: Set up when team members need to share resources (software and hardware) within a specific location but not with the outside world.

Software Resources:

1. Official documents
2. User manuals
3. Employee handbooks

LAN (Local Area Network):

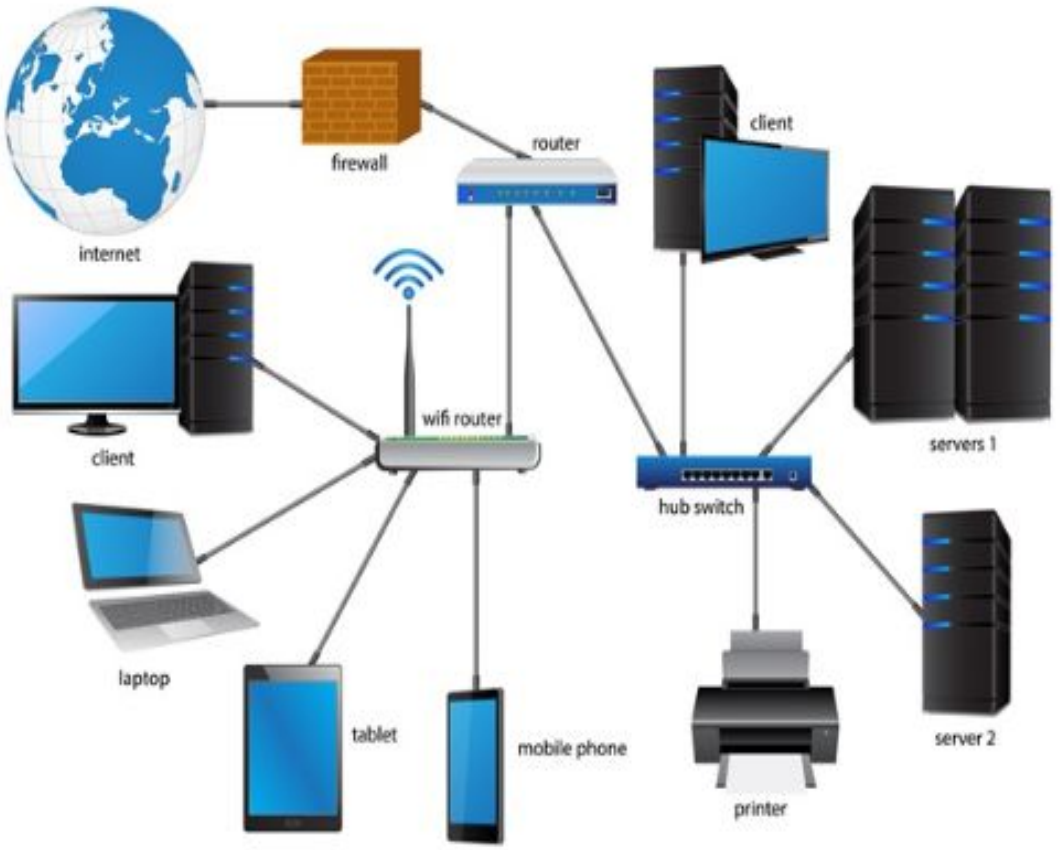
Hardware Resources:

1. Printers
2. Fax machines
3. Modems
4. Shared memory/storage space

Cost Efficiency: Sharing hardware over the network decreases infrastructure costs for the organization.

LAN (Local Area Network):

A LAN may be set up using wired or wireless connections. A LAN that is completely wireless is called Wireless LAN or WLAN.



LAN (Local Area Network):

- **Features**:
  - Limited to a single location (e.g., home, office).
  - High data transfer rate (100 Mbps to 1 Gbps).
  - Uses Ethernet cables or Wi-Fi.
- **Common Uses**:
  - Connecting computers in a single office or building.
  - Sharing resources like printers or files.
- **Example**: A company's internal network in one building.

MAN (Metropolitan Area Network):

1. MAN is the acronym for Metropolitan Area Network.
2. It is a network spread over a city, college campus or a small region.
3. MAN is larger than a LAN and typically spread over several kilometres.
4. Objective of MAN is to share hardware and software resources, thereby decreasing infrastructure costs.
5. MAN can be built by connecting several LANs.

MAN (Metropolitan Area Network):

1. The most common example of MAN is cable TV network.

- **MAN (Metropolitan Area Network)**:
- Covers a city or a large campus.
- Larger than LAN but smaller than WAN.

WAN (Wide Area Network):

1. WAN or Wide Area Network is spread over a country or many countries.
2. WAN is typically a network of many LANs, MANs and WANs.
3. Network is set up using wired or wireless connections, depending on availability and reliability.

WAN (Wide Area Network):

- Connects devices over a large geographic area (e.g., cities, countries).
- The Internet is the largest example of a WAN.
- Slower than LANs due to longer distances.

WAN (Wide Area Network):

Features:

- Spans across multiple locations (cities, countries).
- Lower data transfer rates compared to LAN.
- Uses leased telecommunication lines or satellite links.

- **Common Uses**:
  - Connecting remote offices of a corporation.
  - The Internet is the most widely known WAN.
- **Example**: Connecting company offices across different countries.

The Internet

Definition:
A global network of networks, connecting millions of private, public, academic, and business networks.

Key Features:

1. Based on TCP/IP protocols. I will add more slides about TCP/IP protocols in last)
2. Accessible worldwide.
3. Enables data exchange, communication, and web services.

Role of the Internet in ICT

1. **Information Access:** The Internet provides a vast resource of information, tools, and services that drive ICT.
2. **Communication:** Tools like email, instant messaging, and video conferencing have revolutionized communication.
3. **Business Applications:** Cloud services, e-commerce platforms, and online collaboration tools operate over the Internet.
4. **Data Processing:** AI tools often use Internet-based platforms (e.g., cloud computing, distributed systems) for processing large datasets.

Role of the Internet in AI Applications

1. **Data Collection:** AI models require vast amounts of data; the Internet is a key source for data collection (social media, IoT, etc.).
2. **Cloud Computing:** AI tools like machine learning models are often hosted on cloud platforms like AWS, Google Cloud, or Microsoft Azure.
3. **Collaboration:** AI research is driven by global collaboration, enabled through the Internet (online repositories, forums).
4. **Real-Time Systems:** AI in areas like autonomous vehicles and smart cities depends on real-time Internet data processing.

Dear Students,

Please complete an assignment on the following topic:

"What is the difference between Intranet and Internet, Internet vs. internet?"

Types of Network Topology:

Network topology refers to the arrangement of nodes, links, or devices in a computer network.
It defines how different components are connected and interact with each other.
Understanding various topologies is essential for designing efficient and reliable networks.

Types of Network Topology:

Common types of network topologies include:

1. Point to Point Topology
2. Mesh Topology
3. Star Topology
4. Bus Topology
5. Ring Topology
6. Tree Topology
7. Hybrid Topology

Each topology has its own advantages and disadvantages based on factors like cost, reliability, and performance.

Point-to-Point Topology

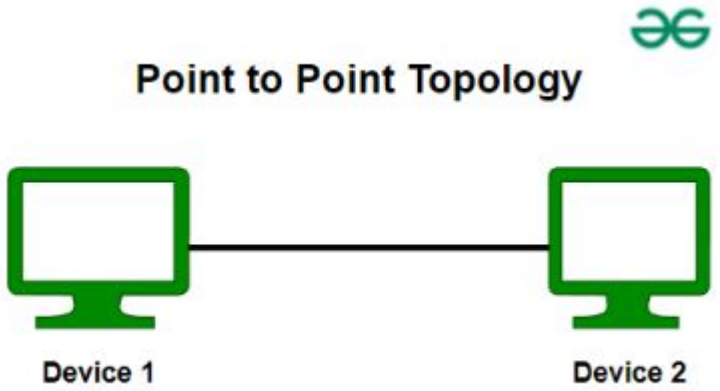
Point-to-point topology involves direct communication between two nodes.

Functionality: One node acts as the sender, and the other acts as the receiver.

It is the simplest form of communication in a network.

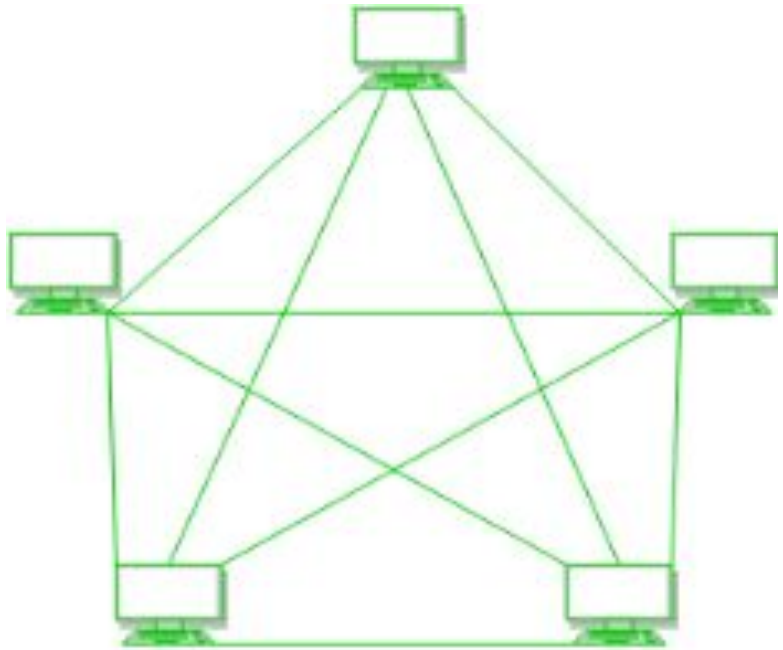
Provides high bandwidth between the two connected devices.

Commonly used in dedicated connections, such as wired links or wireless communication.



Mesh Topology:

1. Mesh topology connects every device in the network to all other devices.
2. Devices can communicate directly without needing a central hub or switch.
3. Offers multiple paths for data, making the network highly reliable.
4. If one connection fails, data can still be sent through other routes.
5. Commonly used in large networks where reliability and fault tolerance are important.



Mesh Topology:

Advantages of Mesh Topology:

1. Communication is very fast between the nodes.
2. Mesh Topology is robust.
3. The fault is diagnosed easily. Data is reliable because data is transferred among the devices through dedicated channels or links.
4. Provides security and privacy.
5. A mesh doesn’t have a centralized authority.

Mesh Topology:

Disadvantages of Mesh Topology

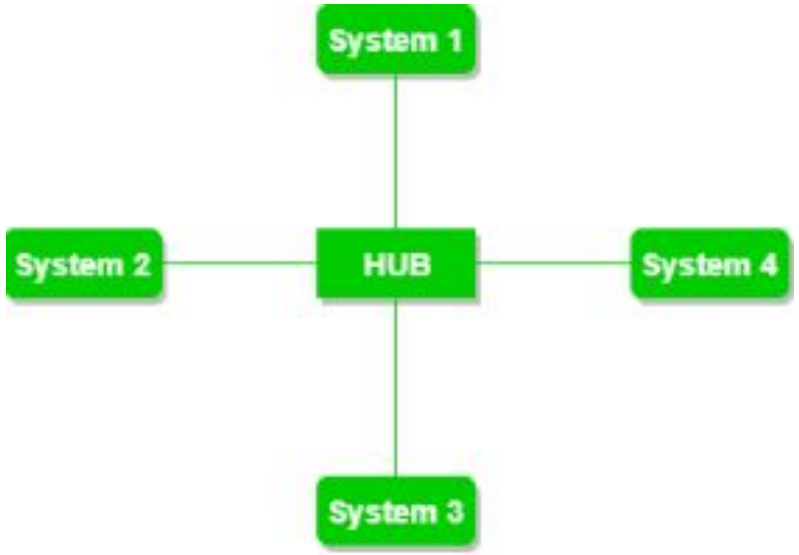
1. Installation and configuration are difficult.
2. The cost of cables is high as bulk wiring is required, hence suitable for less number of devices.
3. The cost of maintenance is high.

A common example of mesh topology is the internet backbone, where various internet service providers are connected to each other via dedicated channels. This topology is also used in military communication systems and aircraft navigation systems.

Star Topology:

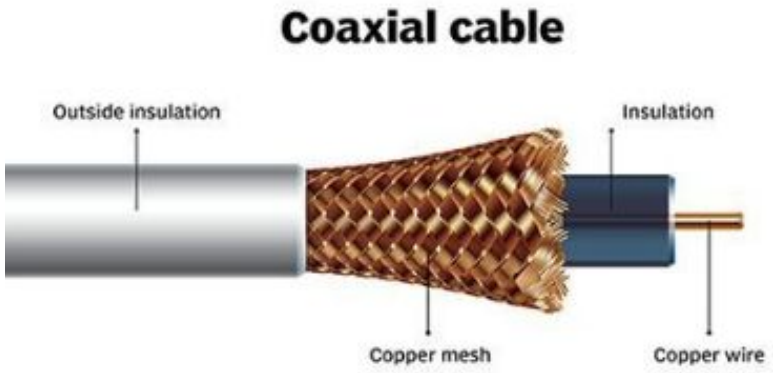
In Star Topology, all devices are connected to a central hub using cables.
The hub acts as the central node, and all other devices (nodes) communicate through it.
The hub can be:

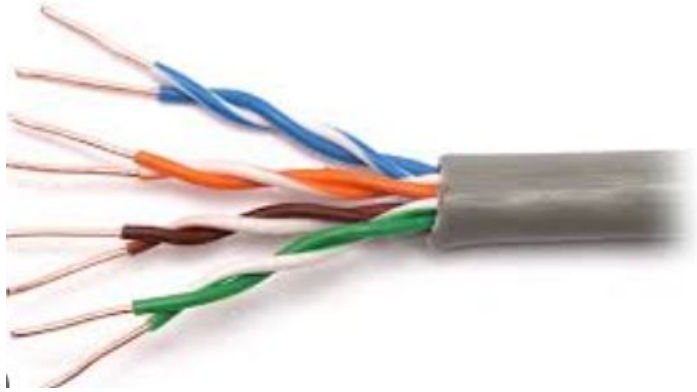
1. **Passive:** Simply broadcasts data without processing it.
2. **Active:** An intelligent hub with repeaters that amplify the signal.



Star Topology:

1. Coaxial cables or RJ-45 cables are commonly used for connections.
2. Easy to manage and expand, but if the hub fails, the entire network goes down.





Twisted pair cables

Star Topology:

Advantages of Star Topology:

1. If N devices are connected to each other in a star topology, then the number of cables required to connect them is N. So, it is easy to set up.
2. Each device requires only 1 port i.e. to connect to the hub, therefore the total number of ports required is N.
3. It is Robust. If one link fails only that link will affect and not other than that.
4. Easy to fault identification and fault isolation.
5. Star topology is cost-effective as it uses inexpensive coaxial cable.

Star Topology:

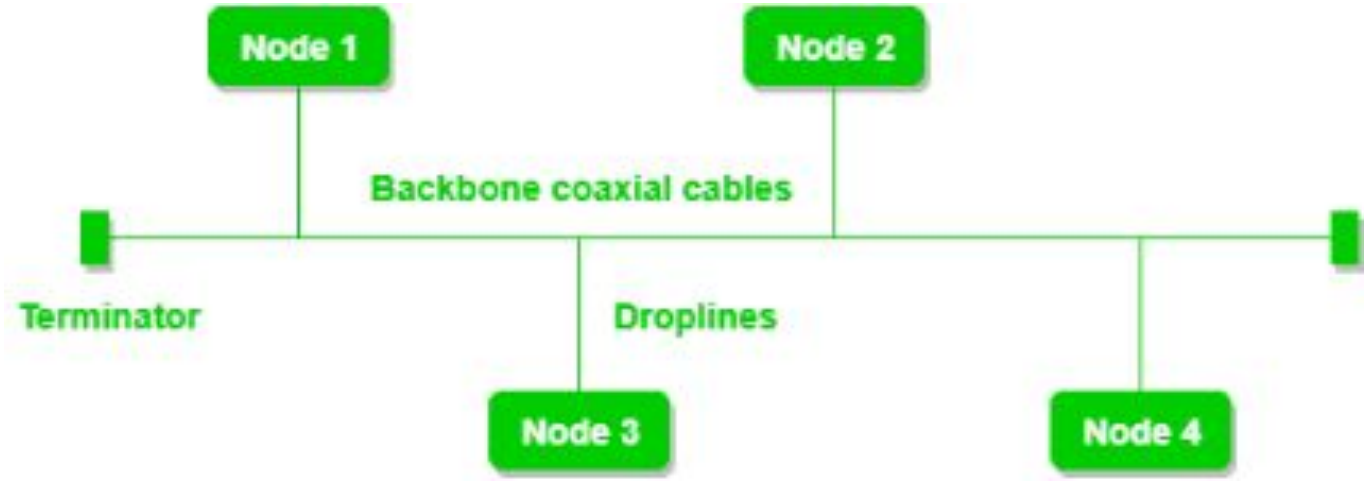
Disadvantages of Star Topology:

1. If the concentrator (hub) on which the whole topology relies fails, the whole system will crash down.
2. The cost of installation is high.
3. Performance is based on the single concentrator i.e. hub.

A common example of star topology is a **local area network (LAN) in** an office where all computers are connected to a central hub. This topology is also used in wireless networks where all devices are connected to a wireless access point.

Bus Topology:

In Bus Topology, all devices are connected to a single central cable (the bus).
Data is sent in both directions along the bus, and each device checks if the data is meant for it.



Bus Topology:

- **Advantages of Bus Topology**

1. If N devices are connected to each other in a bus topology, then the number of cables required to connect them is 1, known as backbone cable, and N drop lines are required.
2. Coaxial or twisted pair cables are mainly used in bus-based networks that support up to 10 Mbps.
3. The cost of the cable is less compared to other topologies, but it is used to build small networks.
4. Bus topology is familiar technology as installation and troubleshooting techniques are well known.

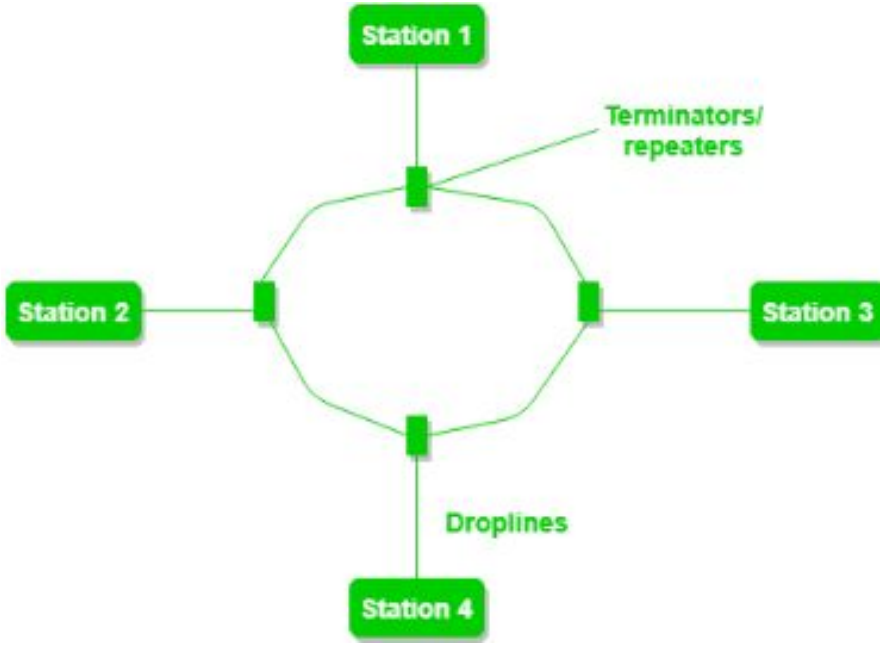
Bus Topology:

Disadvantages of Bus Topology

1. A bus topology is quite simpler, but still, it requires a lot of cabling.
2. If the common cable fails, then the whole system will crash down.
3. If the network traffic is heavy, it increases collisions in the network. To avoid this, various protocols are used in the MAC layer known as Pure Aloha, Slotted Aloha, CSMA/CD, etc.
4. Adding new devices to the network would slow down networks.
5. Security is very low.

Ring Topology:

In Ring Topology, each device is connected to two other devices, forming a circular path for data to travel.
Data moves in one direction (unidirectional) or both directions (bidirectional) around the ring.



Ring Topology:

- A number of repeaters are used for Ring topology with a large number of nodes, because if someone wants to send some data to the last node in the ring topology with 100 nodes, then the data will have to pass through 99 nodes to reach the 100th node. Hence to prevent data loss repeaters are used in the network.

Ring Topology :

Advantages of Ring Topology

1. The data transmission is high-speed.
2. The possibility of collision is minimum in this type of topology.
3. Cheap to install and expand.
4. It is less costly than a star topology.

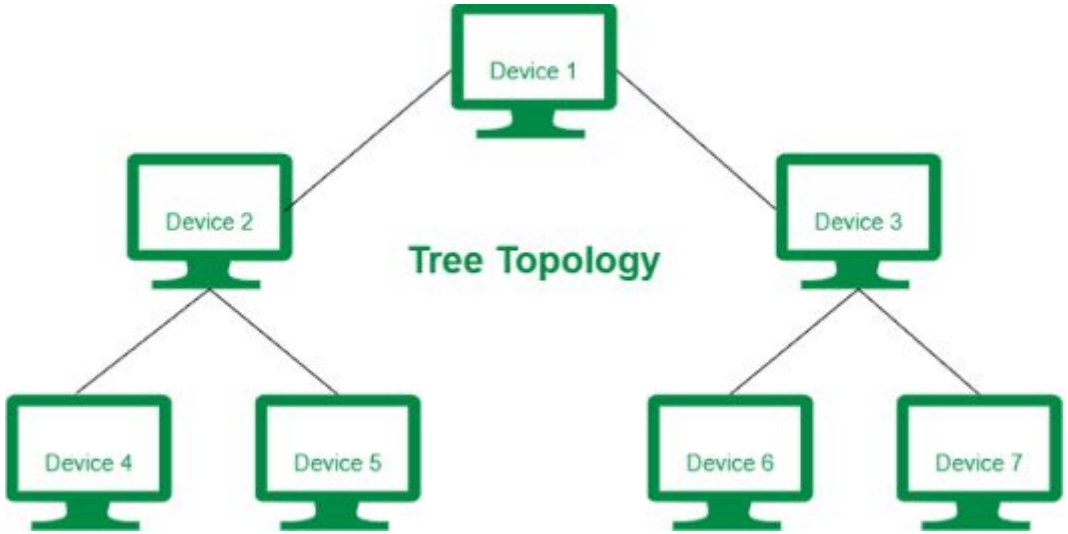
Ring Topology :

Disadvantages of Ring Topology

1. The failure of a single node in the network can cause the entire network to fail.
2. Troubleshooting is difficult in this topology.
3. The addition of stations in between or the removal of stations can disturb the whole topology.
4. Less secure.

Tree Topology:

1. Tree Topology is a combination of Star and Bus topologies, creating a hierarchical structure.
2. Devices are connected in a parent-child relationship, with a central backbone (bus) and branches of star-configured networks.



Tree Topology:

Advantages of Tree Topology

1. It allows more devices to be attached to a single central hub thus it decreases the distance that is traveled by the signal to come to the devices.
2. It allows the network to get isolated and also prioritize from different computers.
3. We can add **new devices to the existing network.**
4. **Error detection** and **error correction** are very easy in a tree topology.

Tree Topology:

Disadvantages of Tree Topology

1. If the central hub gets fails the entire system fails.
2. The cost is high because of the cabling.
3. If new devices are added, it becomes difficult to reconfigure.

Tree Topology:

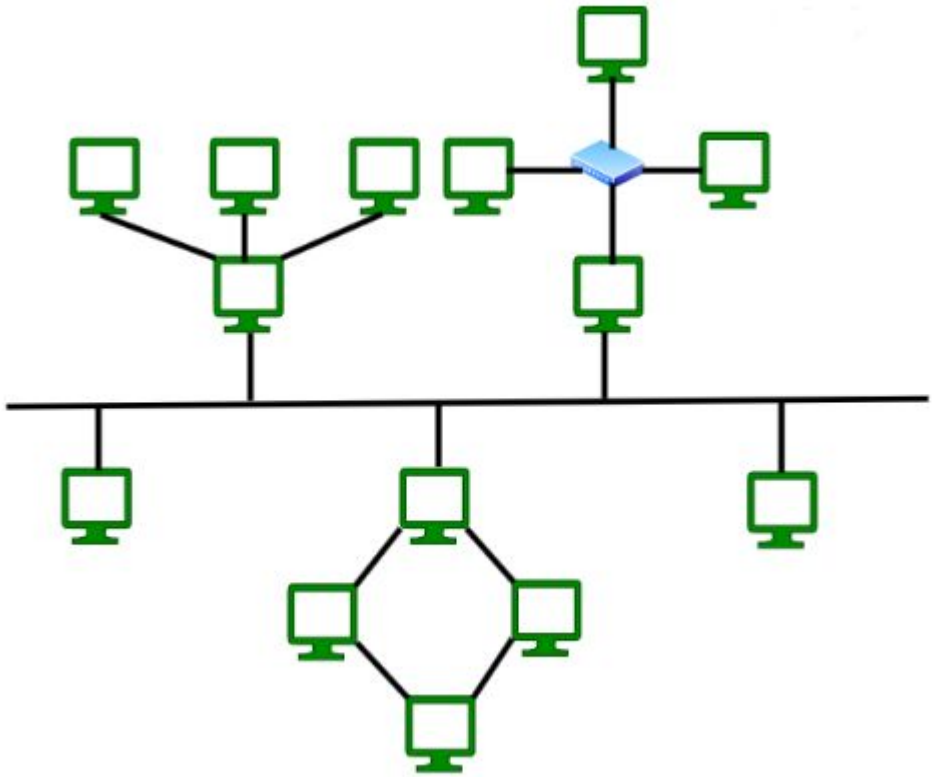
A common example of a tree topology is the hierarchy in a large organization. At the top of the tree is the CEO, who is connected to the different departments or divisions (child nodes) of the company. Each department has its own hierarchy, with managers overseeing different teams (grandchild nodes). The team members (leaf nodes) are at the bottom of the hierarchy, connected to their respective managers and departments.

Assignment: Create a Hierarchy of Aror University

1. **Begin with the Vice Chancellor (VC) at the top, and identify the various faculties, departments, and administrative units as child nodes.**
2. **For each department, include the Heads of Departments (HoDs), faculty members, and support staff as part of the hierarchy.**
3. **Ensure that your diagram clearly shows the relationships and connections between the different levels of the university's organization.**

Hybrid Topology:

Hybrid Topology is a combination of two or more different types of network topologies (e.g., star, bus, ring).
It is designed to meet the specific needs of a network by leveraging the strengths of various topologies.



Hybrid Topology:

Advantages of Hybrid Topology

1. This topology is **very flexible** .
2. The size of the network can be easily expanded by **adding new devices.**

Disadvantages of Hybrid Topology

1. It is challenging **to design the architecture** of the Hybrid Network.
2. **Hubs** used in this topology are **very expensive.**
3. The infrastructure cost is very high as a hybrid network **requires a lot of cabling and network devices** .

Hybrid Topology Example:

A common example of a hybrid topology is a university campus network. The network may have a backbone of a star topology, with each building connected to the backbone through a switch or router. Within each building, there may be a bus or ring topology connecting the different rooms and offices. The wireless access points also create a mesh topology for wireless devices. This hybrid topology allows for efficient communication between different buildings while providing flexibility and redundancy within each building.

Networking Terms:

1. **Reliability**: The ability of a network to consistently perform its intended functions without failure, ensuring data is transmitted accurately and without loss.
2. **Redundancy**: The inclusion of extra components or pathways in a network to provide backup in case of failure, enhancing reliability and availability.

Networking Terms:

1. **Scalability:** The capacity of a network to grow and accommodate increased loads or additional devices without compromising performance.
2. **Bandwidth:** The maximum rate of data transfer across a network path, often expressed in bits per second (bps).
3. **Fault Tolerance:** The ability of a network to continue operating smoothly in the event of a failure in one or more of its components.
4. **Performance**: A measure of how effectively a network operates, including factors like speed, efficiency, and responsiveness.

Conclusion:

1. In conclusion, network topologies play a crucial role in determining the efficiency and reliability of a computer network.
2. Each topology, whether it’s bus, star, ring, mesh, or tree, offers unique benefits and potential drawbacks.
3. By understanding these different arrangements, network designers can choose the most appropriate topology to meet the specific needs of their systems, ensuring optimal performance and connectivity.