

Data Communication

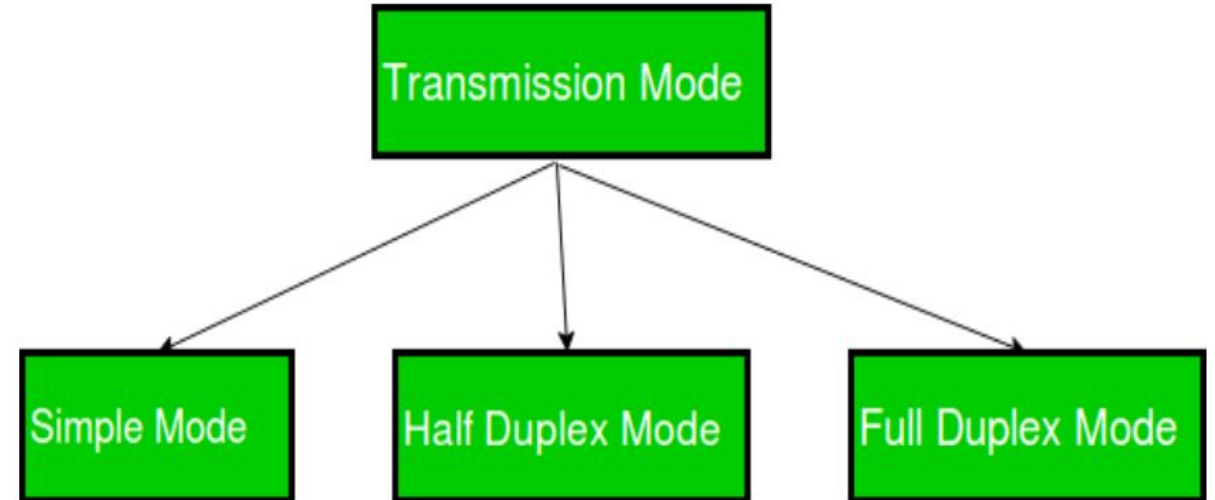
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Intro

- Communication refers to the exchange of information using a specific medium, such as vacuum, space, wireless medium, wired medium, etc. Good communication always transmits information with reduced attenuation and noise. The received signal is the same as the transmitted signal with clear information. Communication is a two-way process of sharing information. In digital terms, communication refers to the exchange of digital information from the transmitter to the receiver.
- The components of a communication system are the transmitter, communication channel, and receiver. The transmitter transmits the data to the communication channel, which further sends it to the receiver. Various devices are used in cascade or parallel with the transmitters and receivers for different purposes, such as modulation, demodulation, noise removal, sampling, etc. The devices include modulators, filters, amplifiers, encoders, and decoders.

Modes of Communication

- Modes of data communication in computer networks refer to the methods used to communicate data between devices in a network. There are three modes of data communication in computer networks:



Simplex Mode

- Communication in Simplex mode is unidirectional, similar to a one-way street. On a channel, only one of the two devices can send and the other can only receive. The simplex mode can utilize the entire channel capacity to transfer data in only one direction.
- As an example, consider the keyboard and standard monitors. The keyboard can only provide input, whereas the monitor can only provide output.



- **Advantages of Simplex Mode:**

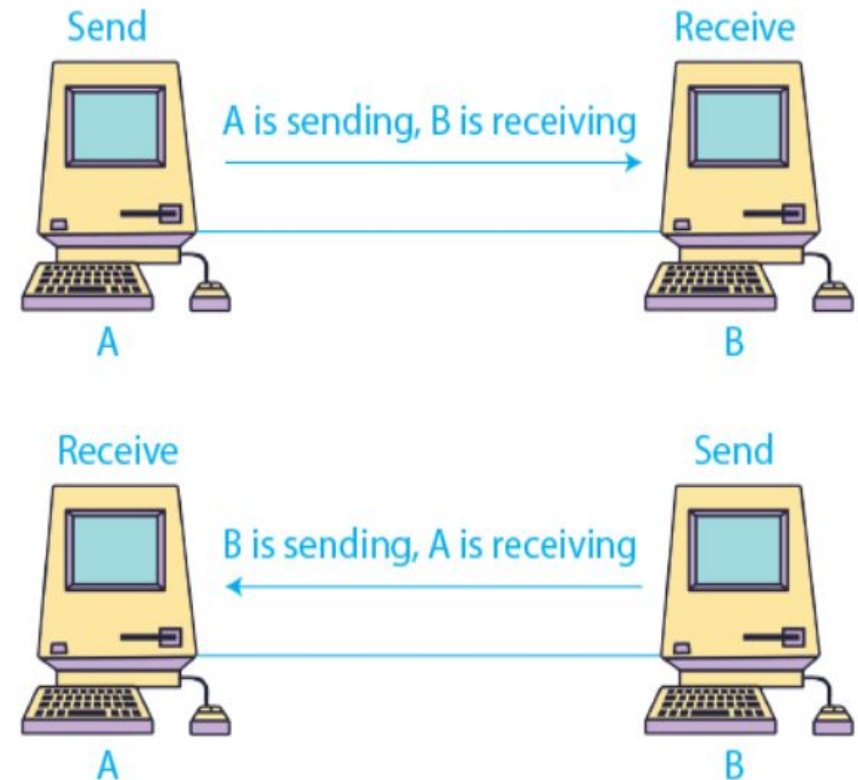
1. Simplex mode is straightforward and easy to implement.
2. It requires less complex hardware than other modes of data communication.
3. Simplex mode is ideal for applications that require one-way communication, such as broadcasting or monitoring systems, where the receiver does not need to send any data back to the sender.
4. It is less susceptible to errors and signal interference compared to other modes of data communication.

- **Disadvantages of Simplex Mode:**

1. It is not suitable for applications that require bi-directional communication.
2. It is less efficient than other modes of data communication, as only one device can send data at a time, leading to lower data transfer rates.
3. It is limited in range and speed.

Half Duplex Mode

- In half-duplex mode, each station can send and receive, but not at the same time. When one device is sending the signal, the other can only receive it, and vice versa. The half-duplex mode is used when communication is not required in both directions at the same time. For either direction, the channel's complete capacity can be used.
- Example: A walkie-talkie, in which messages are sent one at a time in both directions.



- **Advantages of Half Duplex Mode:**

1. Half duplex mode offers bidirectional communication, allowing devices to send and receive data to and from each other.
2. It requires less bandwidth than full-duplex mode since only one device can transmit at a time, making it more efficient in situations where the number of devices is limited.
3. It is less expensive than full-duplex mode since it requires less complex hardware.

- **Disadvantages of Half Duplex Mode:**

1. It is slower than full-duplex mode since devices need to take turns to send and receive data.
2. It is susceptible to collisions when multiple devices try to transmit data simultaneously, which can lead to data loss and increased latency.
3. It is not suitable for real-time applications that require high-speed data transfer.

Full Duplex Mode

- Full duplex mode is a type of data communication mode that allows data to be transmitted in both directions simultaneously. In full duplex mode, devices can send and receive data at the same time.
- Full-duplex mode comes in handy when communication in both directions is required all the time. But because of two-way communication, the capacity of the channel must be divided equally between the two directions.
- Example: A telephone network connects two people via a phone line, allowing both to talk and listen at the same time.



- **Advantages of Full Duplex Mode:**

1. Full duplex mode offers bidirectional communication, allowing devices to send and receive data simultaneously.
2. It provides faster data transfer compared to half-duplex mode.
3. It is less susceptible to collisions since devices can transmit and receive data simultaneously, reducing data loss and latency.

- **Disadvantages of Full Duplex Mode:**

1. It requires more bandwidth than half duplex mode.
2. It requires more complex hardware than half duplex mode, making it more expensive.
3. It may be more susceptible to signal interference since it requires complex signal processing and error correction mechanisms.

Computer Network

- **Computer Network** is a group of computers connected with each other through wires/wireless, optical fibers or optical links so that various devices can interact with each other through a network.
- The aim of the computer network is the sharing of resources among various devices.
- In the case of computer network technology, there are several types of networks that vary from simple to complex level.

Uses of Computer Network

Here are some common application of computer networks

- Helps you to share resource such as printers
- Allows you to share expensive software's and database among network participants
- Provides fast and effective communication from one computer to another computer
- Helps you to exchange data and information among users via a network.

Advantages of Computer Networking

- Here are the fundamental benefits/pros of using Computer Networking:
- Helps you to connect with multiple computers together to send and receive information when accessing the network.
- Helps you to share printers, scanners, and email.
- Helps you to share information at very fast speed
- Electronic communication is more efficient and less expensive than without the network.

Disadvantages of Computer Networking

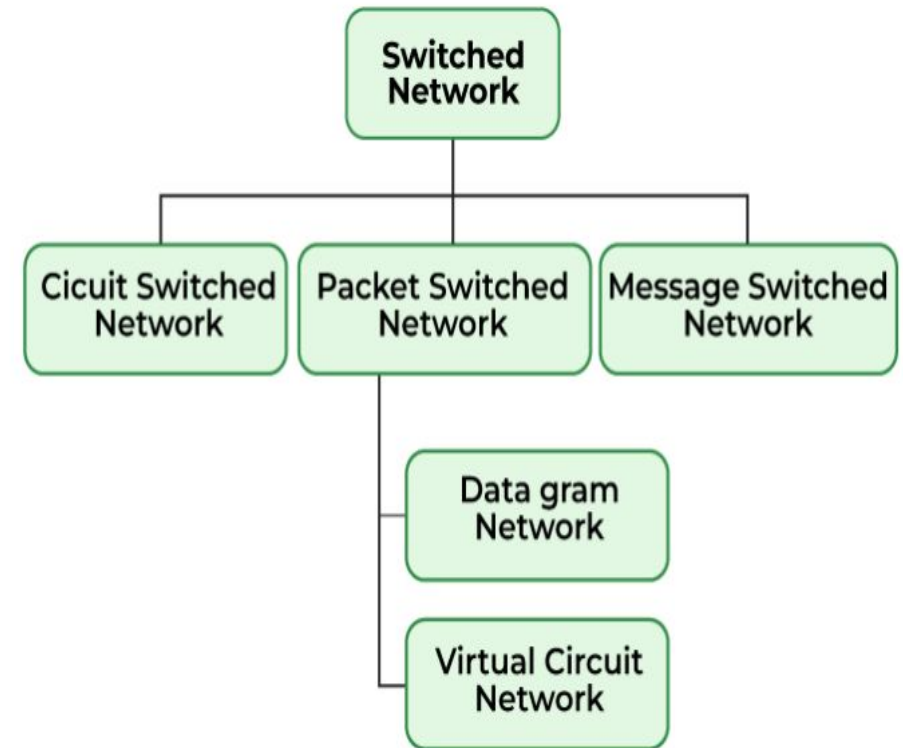
- Here are drawbacks/ cons of using computer networks:
- Investment for hardware and software can be costly for initial set-up
- If you don't take proper security precautions like file encryption, firewalls then your data will be at risk.
- Some components of the network design may not last for many years, and it will become useless or malfunction and need to be replaced.
- Requires time for constant administration
- Frequent server failure and issues of regular cable faults

Benefits

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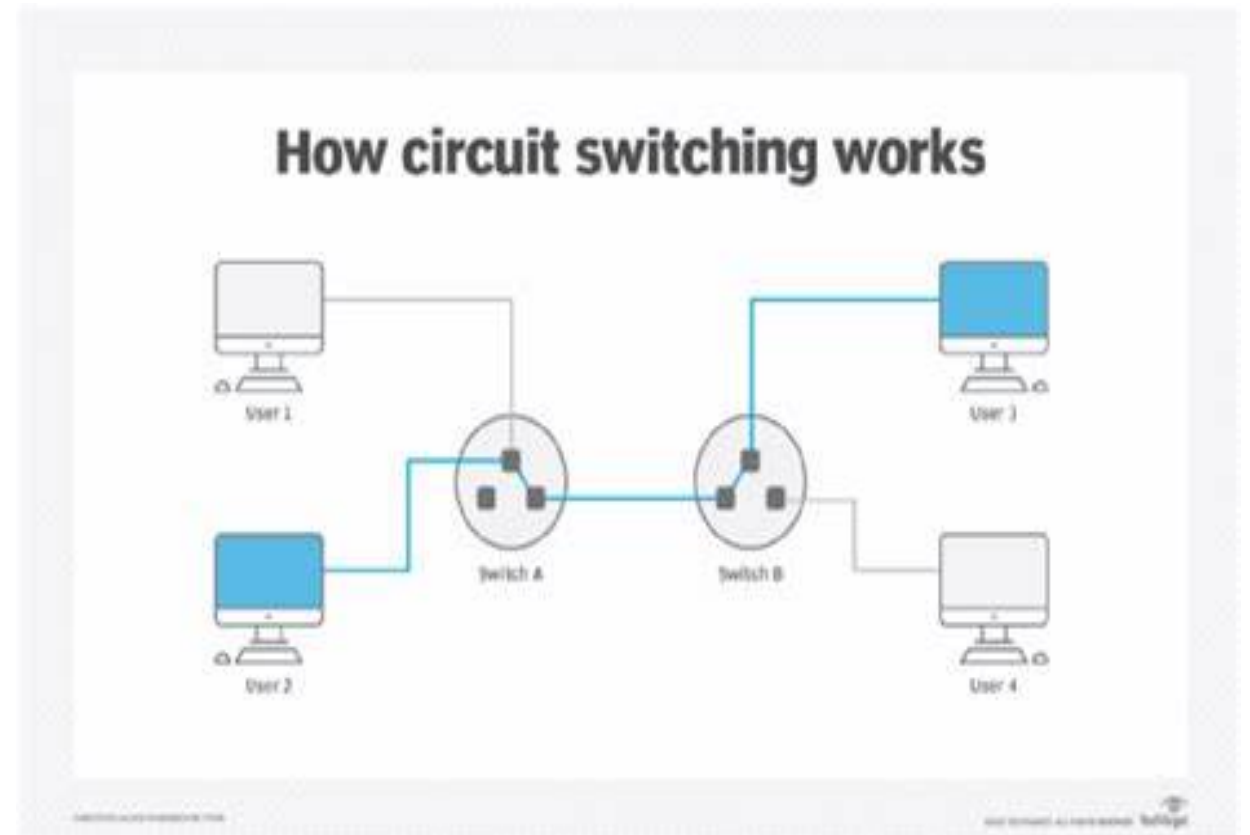
Switching Methods

- In computer networking, Switching is the process of transferring data packets from one device to another in a network, or from one network to another, using specific devices called switches. A computer user experiences switching all the time for example, accessing the Internet from your computer device, whenever a user requests a webpage to open, the request is processed through switching of data packets only.



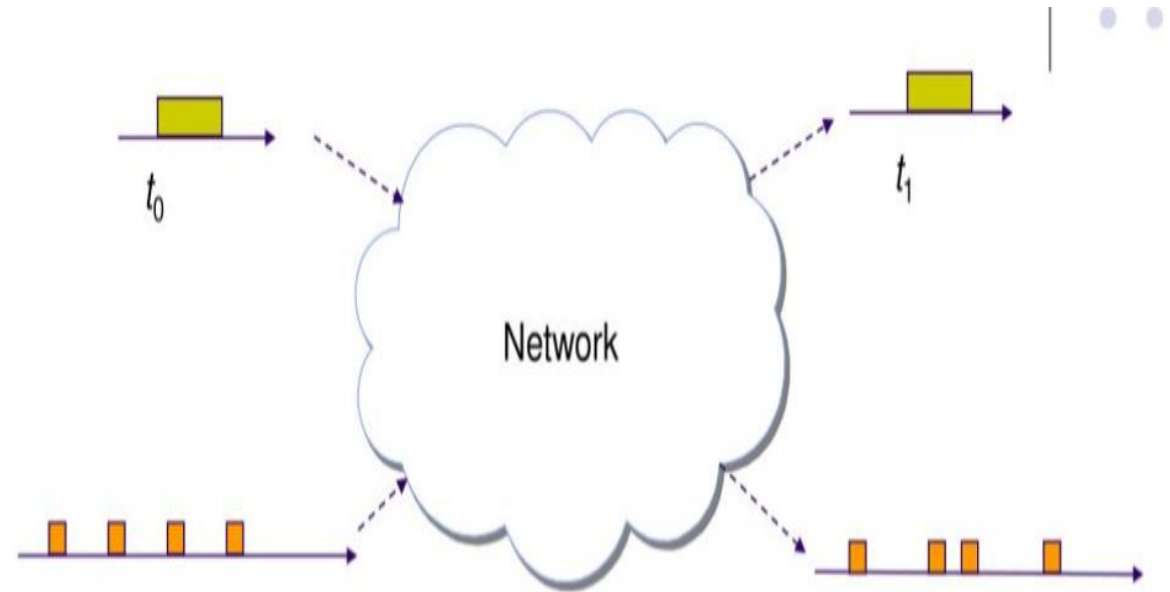
Circuit Switching

- In this type of switching, a connection is established between the source and destination beforehand. This connection receives the complete bandwidth of the network until the data is transferred completely. This approach is better than message switching as it does not involve sending data to the entire network, instead of its destination only.



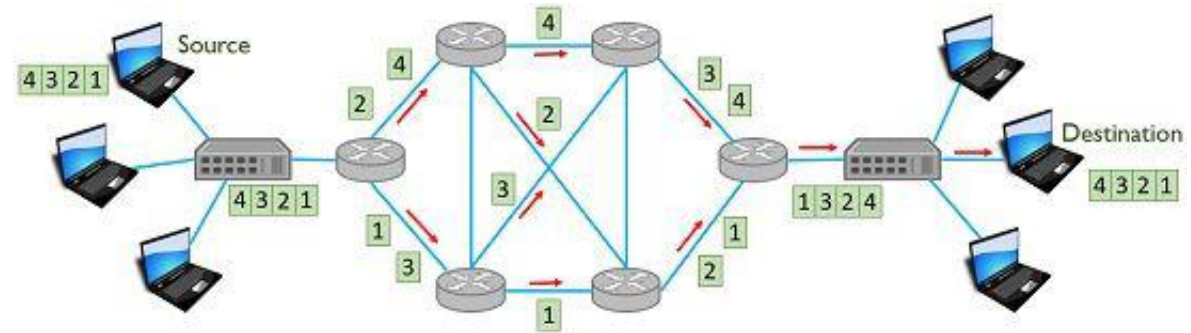
Packet Switching

- This technique requires the data to be broken down into smaller components, data frames, or packets. These data frames are then transferred to their destinations according to the available resources in the network at a particular time. This switching type is used in modern computers and even the Internet. Here, each data frame contains additional information about the destination and other information required for proper transfer through network components.



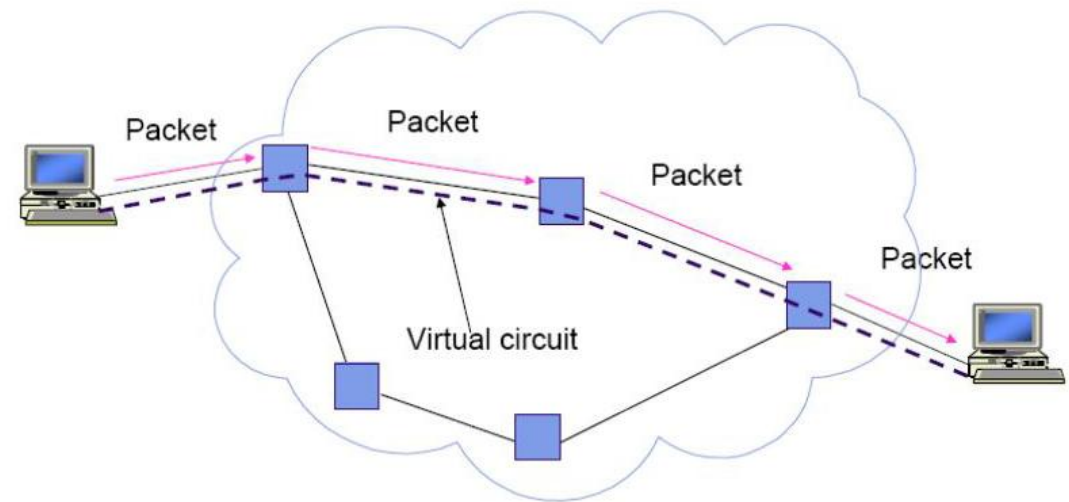
Datagram Packet Switching

- In Datagram Packet switching, each data frame is taken as an individual entity and thus, they are processed separately. Here, no connection is established before data transmission occurs. Although this approach provides flexibility in data transfer, it may cause a loss of data frames or late delivery of the data frames.



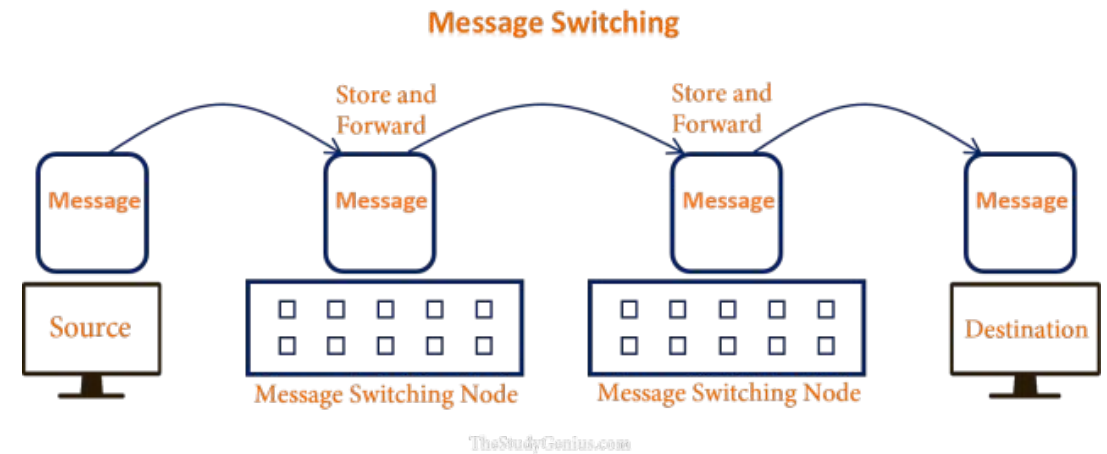
Virtual Circuit Packet Switching

- In Virtual-Circuit Packet switching, a logical connection between the source and destination is made before transmitting any data. These logical connections are called virtual circuits. Each data frame follows these logical paths and provides a reliable way of transmitting data with less chance of data loss.



Message Switching

- This is an older switching technique that has become obsolete. In message switching technique, the entire data block/message is forwarded across the entire network thus, making it highly inefficient.



Types of Network

There are mainly five types of Computer Networks

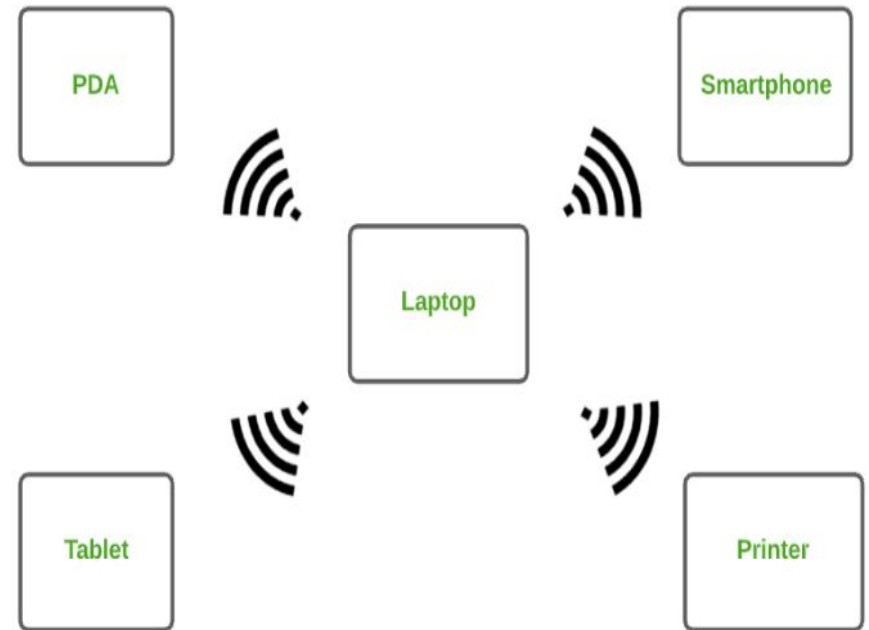
1. Personal Area Network (PAN)
2. Local Area Network (LAN)
3. Campus Area Network (CAN)
4. Metropolitan Area Network (MAN)
5. Wide Area Network (WAN)

Other types of Network

1. Wireless Local Area Network (WLAN)
2. Storage Area Network (SAN)
3. System-Area Network (SAN)
4. Passive Optical Local Area Network (POLAN)
5. Enterprise Private Network (EPN)
6. Virtual Private Network (VPN)
7. Home Area Network (HAN)

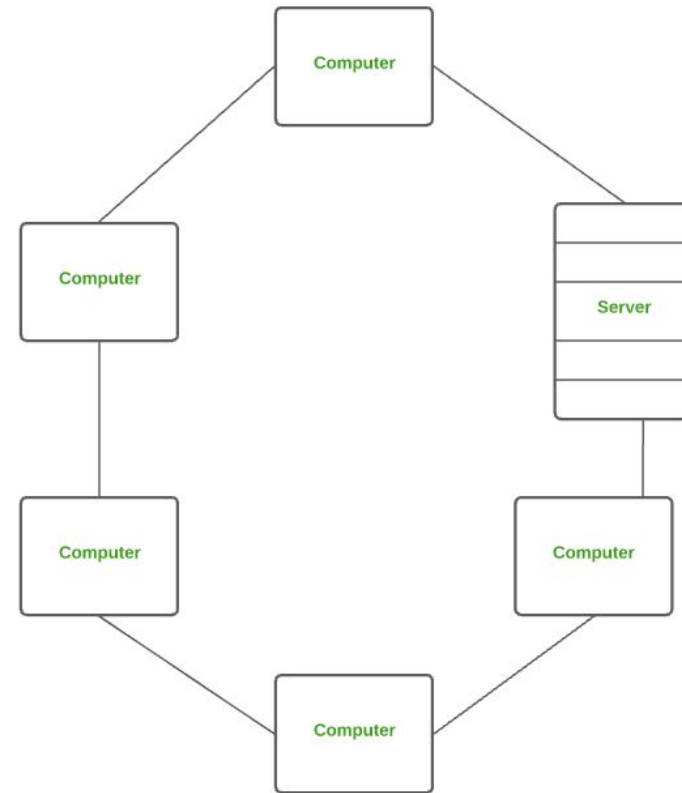
Personal Area Network

- PAN is the most basic type of computer network. This network is restrained to a single person, that is, communication between the computer devices is centered only on an individual's workspace. PAN offers a network range of 1 to 100 meters from person to device providing communication. Its transmission speed is very high with very easy maintenance and very low cost.
- This uses Bluetooth, IrDA, and Zigbee as technology.
- Examples of PAN are USB, computer, phone, tablet, printer, PDA, etc.



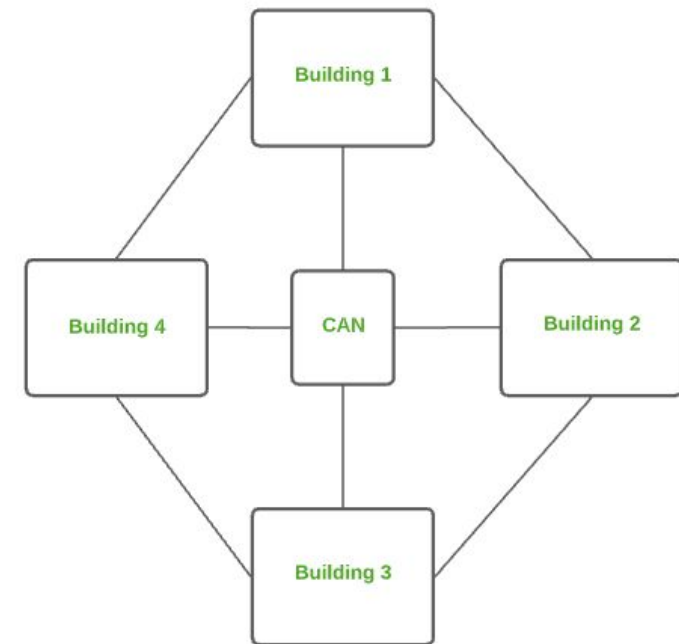
Local Area Network

- LAN is the most frequently used network. A LAN is a computer network that connects computers through a common communication path, contained within a limited area, that is, locally. A LAN encompasses two or more computers connected over a server. The two important technologies involved in this network are Ethernet and Wi-fi. It ranges up to 2km & transmission speed is very high with easy maintenance and low cost.
- Examples of LAN are networking in a home, school, library, laboratory, college, office, etc.



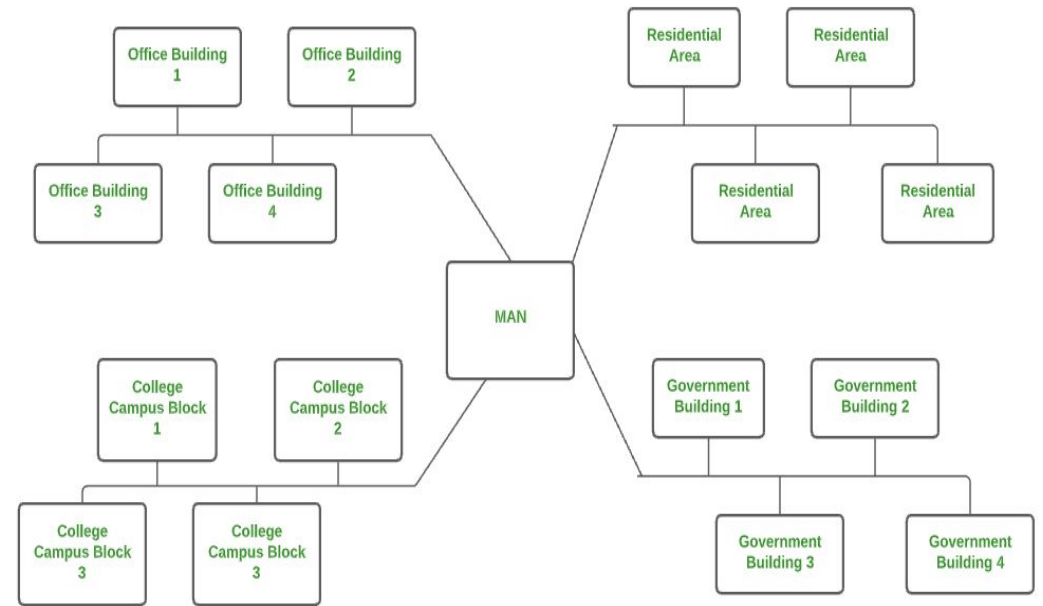
Campus Area Network

- CAN is bigger than a LAN but smaller than a MAN. This is a type of computer network that is usually used in places like a school or colleges. This network covers a limited geographical area that is, it spreads across several buildings within the campus. CAN mainly use Ethernet technology with a range from 1km to 5km.
- Its transmission speed is very high with a moderate maintenance cost and moderate cost.
- Examples of CAN are networks that cover schools, colleges, buildings, etc.



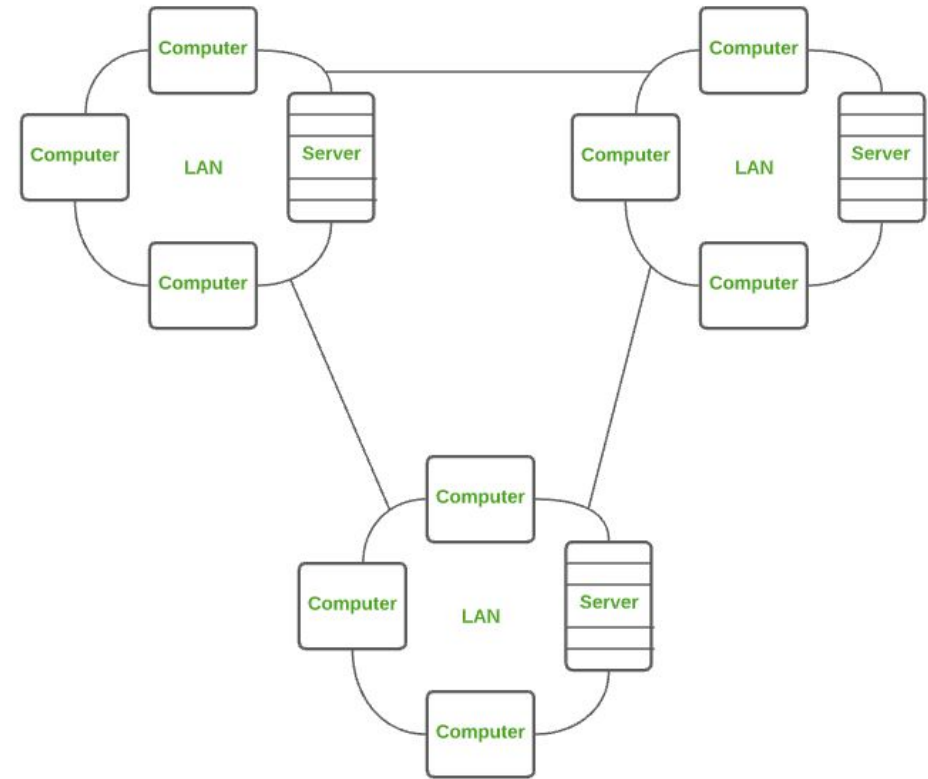
Metropolitan Area Network

- A MAN is larger than a LAN but smaller than a WAN. This is the type of computer network that connects computers over a geographical distance through a shared communication path over a city, town, or metropolitan area. This network mainly uses FDDI, CDDI, and ATM as the technology with a range from 5km to 50km. Its transmission speed is average. It is difficult to maintain, and it comes with a high cost.
- Examples of MAN are networking in towns, cities, a single large city, a large area within multiple buildings, etc.



Wide Area Network

- WAN is a type of computer network that connects computers over a large geographical distance through a shared communication path. It is not restrained to a single location but extends over many locations. WAN can also be defined as a group of local area networks that communicate with each other with a range above 50km.
- Here we use Leased-Line & Dial-up technology. Its transmission speed is very low and it comes with very high maintenance and very high cost.
- The most common example of WAN is the Internet.

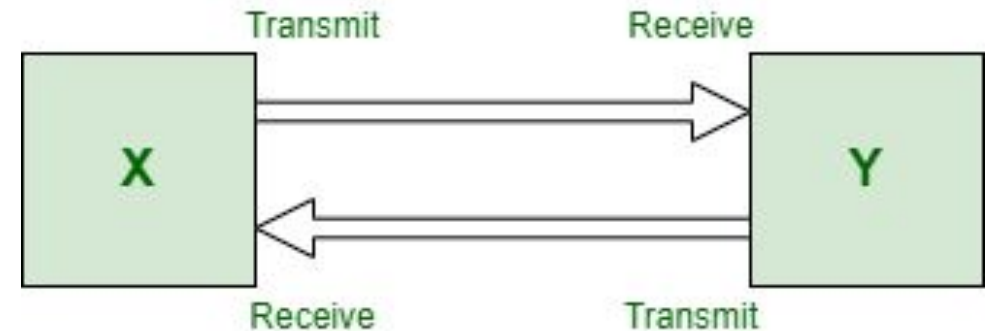


Topology

- In Computer Network ,there are various ways through which different components are connected to one another. **Network Topology** is the way that defines the structure, and how these components are connected to each other.
- The arrangement of a network that comprises nodes and connecting lines via sender and receiver is referred to as **Network Topology**. The various network topologies are:
 - Point to Point Topology
 - Mesh Topology
 - Star Topology
 - Bus Topology
 - Ring Topology
 - Tree Topology
 - Hybrid Topology

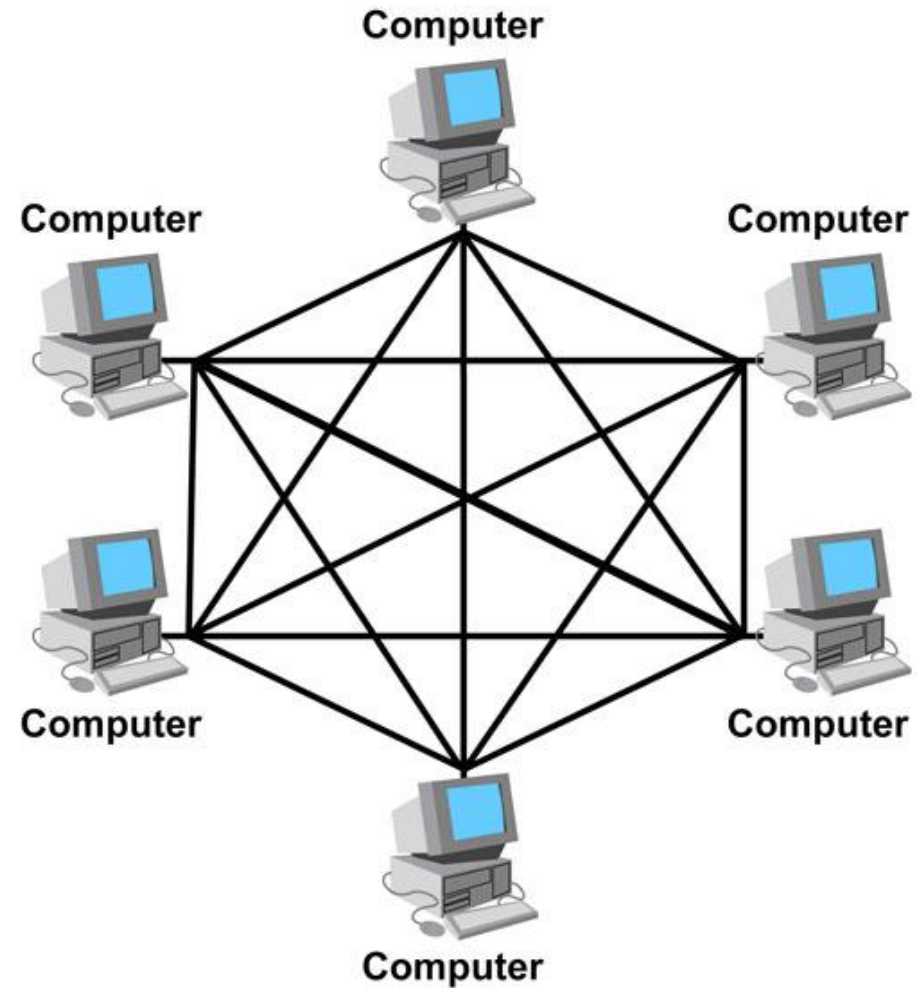
Point-to-Point Topology

- Point-to-Point Topology is a type of topology that works on the functionality of the sender and receiver. It is the simplest communication between two nodes, in which one is the sender and the other one is the receiver. Point-to-Point provides high bandwidth.



Mesh Topology

- Mesh technology is an arrangement of the network in which computers are interconnected with each other through various redundant connections.
- There are multiple paths from one computer to another computer.
- It does not contain the switch, hub or any central computer which acts as a central point of communication.
- The Internet is an example of the mesh topology.
- Mesh topology is mainly used for WAN implementations where communication failures are a critical concern.
- Mesh topology is mainly used for wireless networks.



- **Mesh topology is divided into two categories:**
- Fully connected mesh topology
 - In a full mesh topology, each computer is connected to all the computers available in the network.
- Partially connected mesh topology
 - In a partial mesh topology, not all but certain computers are connected to those computers with which they communicate frequently.

Advantages of Mesh topology:

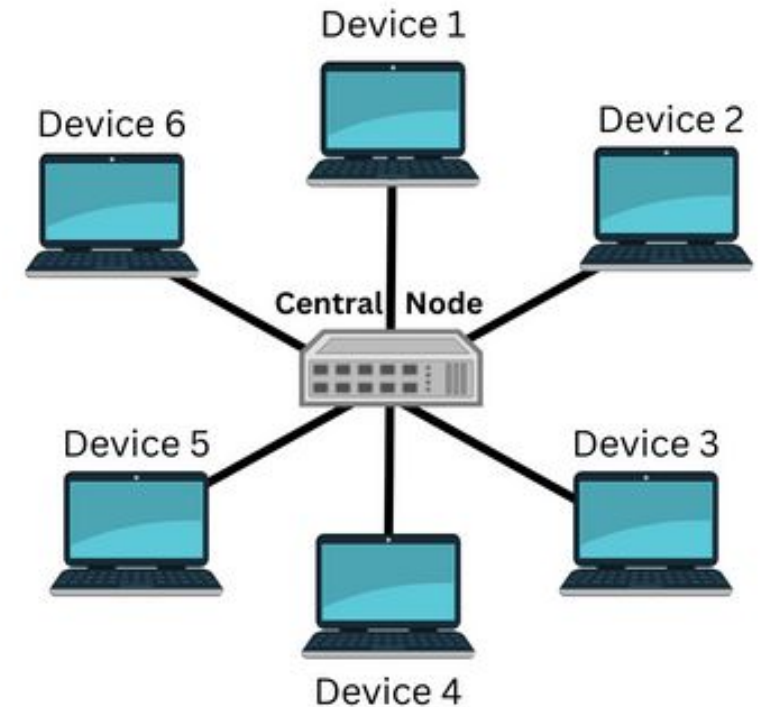
- **Reliable:** The mesh topology networks are very reliable as if any link breakdown will not affect the communication between connected computers.
- **Fast Communication:** Communication is very fast between the nodes.
- **Easier Reconfiguration:** Adding new devices would not disrupt the communication between other devices.

Disadvantages of Mesh topology

- **Cost:** A mesh topology contains a large number of connected devices such as a router and more transmission media than other topologies.
- **Management:** Mesh topology networks are very large and very difficult to maintain and manage. If the network is not monitored carefully, then the communication link failure goes undetected.
- **Efficiency:** In this topology, redundant connections are high that reduces the efficiency of the network.

Star Topology

- Star topology is an arrangement of the network in which every node is connected to the central hub, switch or a central computer.
- The central computer is known as a server, and the peripheral devices attached to the server are known as clients.
- Coaxial cable or UTP cables are used to connect the computers.
- Hubs or Switches are mainly used as connection devices in a physical star topology.
- Star topology is the most popular topology in network implementation.



Advantages of Star topology

- **Efficient troubleshooting:** Troubleshooting is quite efficient in a star topology as compared to bus topology. In a bus topology, the manager has to inspect the kilometers of cable. In a star topology, all the stations are connected to the centralized network. Therefore, the network administrator has to go to the single station to troubleshoot the problem.
- **Network control:** Complex network control features can be easily implemented in the star topology. Any changes made in the star topology are automatically accommodated.
- **Limited failure:** As each station is connected to the central hub with its own cable, therefore failure in one cable will not affect the entire network.
- **Familiar technology:** Star topology is a familiar technology as its tools are cost-effective.
- **Easily expandable:** It is easily expandable as new stations can be added to the open ports on the hub.
- **Cost effective:** Star topology networks are cost-effective as it uses inexpensive coaxial cable.
- **High data speeds:** It supports a bandwidth of approx. 100Mbps. Ethernet 100BaseT is one of the most popular Star topology networks.

Disadvantages of Star topology

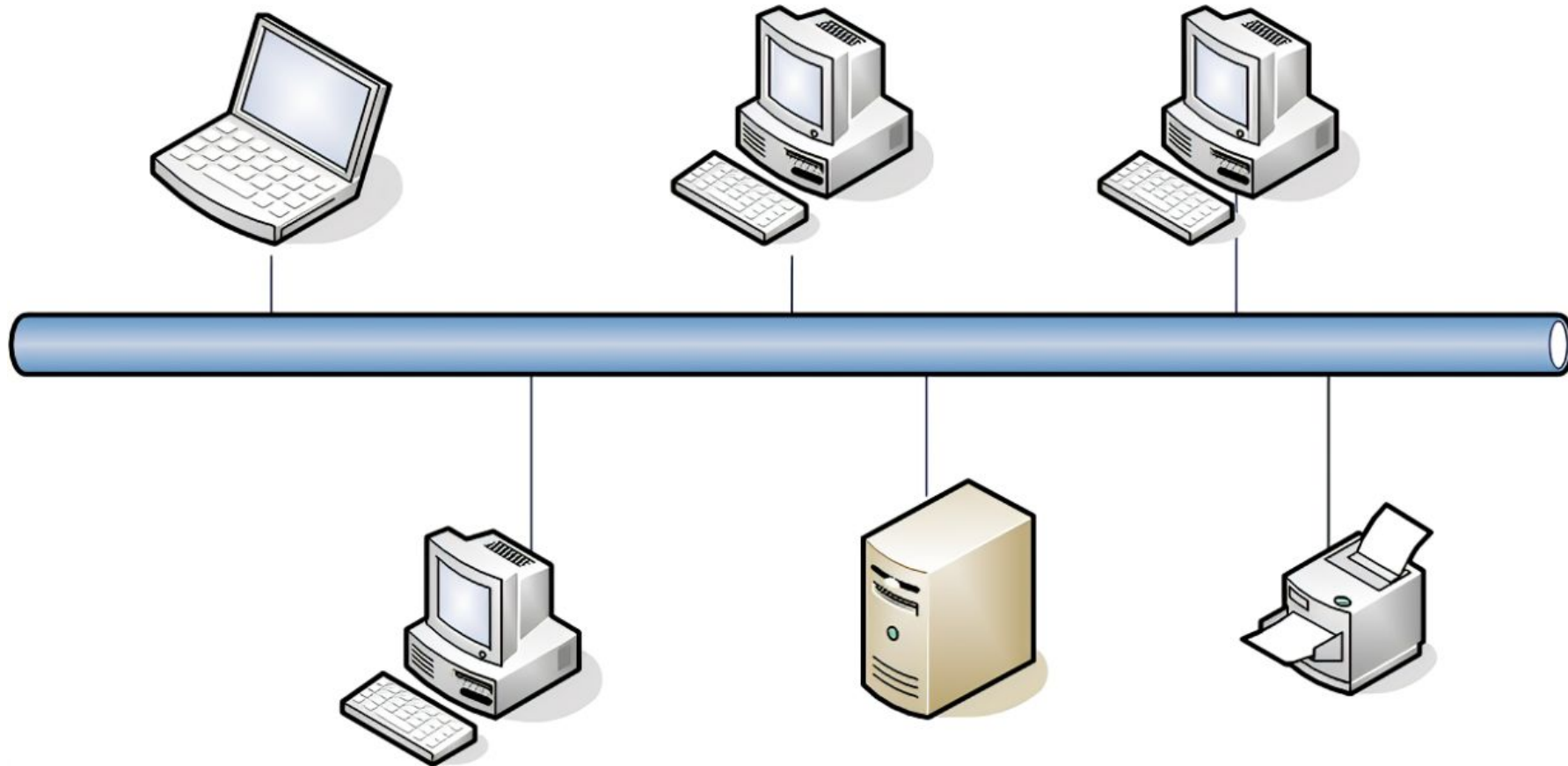
- **A Central point of failure:** If the central hub or switch goes down, then all the connected nodes will not be able to communicate with each other.
- **Cable:** Sometimes cable routing becomes difficult when a significant amount of routing is required.

Bus Topology

- The bus topology is designed in such a way that all the stations are connected through a single cable known as a backbone cable.
- Each node is either connected to the backbone cable by drop cable or directly connected to the backbone cable.
- When a node wants to send a message over the network, it puts a message over the network. All the stations available in the network will receive the message whether it has been addressed or not.
- The configuration of a bus topology is quite simpler as compared to other topologies.
- The backbone cable is considered as a "**single lane**" through which the message is broadcast to all the stations.
- The most common access method of the bus topologies is **CSMA** (Carrier Sense Multiple Access).

- **CSMA:** It is a media access control used to control the data flow so that data integrity is maintained, i.e., the packets do not get lost. There are two alternative ways of handling the problems that occur when two nodes send the messages simultaneously.
- **CSMA CD:** CSMA CD (**Collision detection**) is an access method used to detect the collision. Once the collision is detected, the sender will stop transmitting the data. Therefore, it works on "**recovery after the collision**".
- **CSMA CA:** CSMA CA (**Collision Avoidance**) is an access method used to avoid the collision by checking whether the transmission media is busy or not. If busy, then the sender waits until the media becomes idle. This technique effectively reduces the possibility of the collision. It does not work on "recovery after the collision".

BUS Topology



Advantages of Bus topology:

- **Low-cost cable:** In bus topology, nodes are directly connected to the cable without passing through a hub. Therefore, the initial cost of installation is low.
- **Moderate data speeds:** Coaxial or twisted pair cables are mainly used in bus-based networks that support upto 10 Mbps.
- **Familiar technology:** Bus topology is a familiar technology as the installation and troubleshooting techniques are well known, and hardware components are easily available.
- **Limited failure:** A failure in one node will not have any effect on other nodes.

Disadvantages of Bus topology:

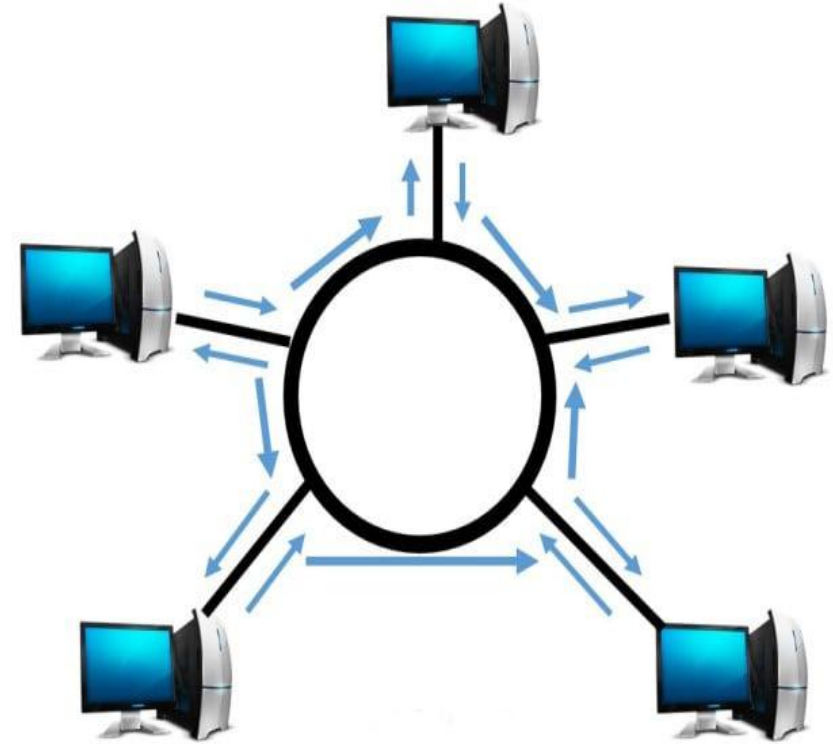
- **Extensive cabling:** A bus topology is quite simpler, but still it requires a lot of cabling.
- **Difficult troubleshooting:** It requires specialized test equipment to determine the cable faults. If any fault occurs in the cable, then it would disrupt the communication for all the nodes.
- **Signal interference:** If two nodes send the messages simultaneously, then the signals of both the nodes collide with each other.
- **Reconfiguration difficult:** Adding new devices to the network would slow down the network.
- **Attenuation:** Attenuation is a loss of signal leads to communication issues. Repeaters are used to regenerate the signal.

Ring Topology

- Ring topology is like a bus topology, but with connected ends.
- The node that receives the message from the previous computer will retransmit to the next node.
- The data flows in one direction, i.e., it is unidirectional.
- The data flows in a single loop continuously known as an endless loop.
- It has no terminated ends, i.e., each node is connected to other node and having no termination point.
- The data in a ring topology flow in a clockwise direction.
- The most common access method of the ring topology is **token passing**.
 - **Token passing:** It is a network access method in which token is passed from one node to another node.
 - **Token:** It is a frame that circulates around the network.

Working of Token passing

- A token moves around the network, and it is passed from computer to computer until it reaches the destination.
- The sender modifies the token by putting the address along with the data.
- The data is passed from one device to another device until the destination address matches. Once the token received by the destination device, then it sends the acknowledgment to the sender.
- In a ring topology, a token is used as a carrier.



Advantages of Ring topology:

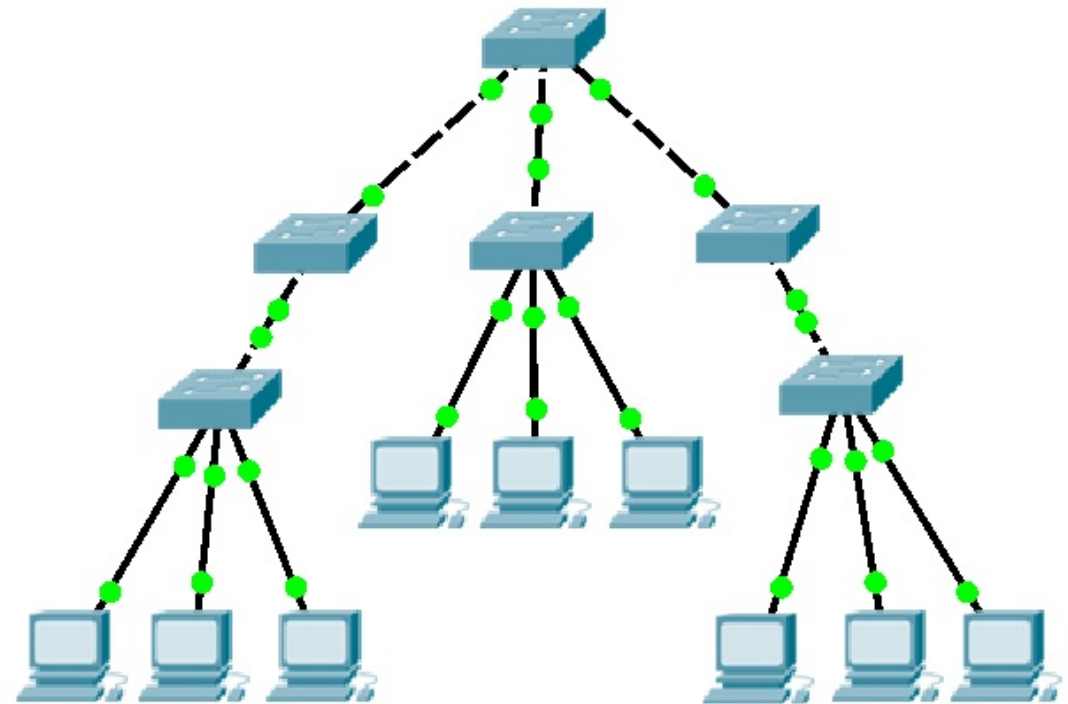
- **Network Management:** Faulty devices can be removed from the network without bringing the network down.
- **Product availability:** Many hardware and software tools for network operation and monitoring are available.
- **Cost:** Twisted pair cabling is inexpensive and easily available. Therefore, the installation cost is very low.
- **Reliable:** It is a more reliable network because the communication system is not dependent on the single host computer.

Disadvantages of Ring topology:

- **Difficult troubleshooting:** It requires specialized test equipment to determine the cable faults. If any fault occurs in the cable, then it would disrupt the communication for all the nodes.
- **Failure:** The breakdown in one station leads to the failure of the overall network.
- **Reconfiguration difficult:** Adding new devices to the network would slow down the network.
- **Delay:** Communication delay is directly proportional to the number of nodes. Adding new devices increases the communication delay.

Tree Topology

- Tree topology combines the characteristics of bus topology and star topology.
- A tree topology is a type of structure in which all the computers are connected with each other in hierarchical fashion.
- The top-most node in tree topology is known as a root node, and all other nodes are the descendants of the root node.
- There is only one path exists between two nodes for the data transmission. Thus, it forms a parent-child hierarchy.



Advantages of Tree topology

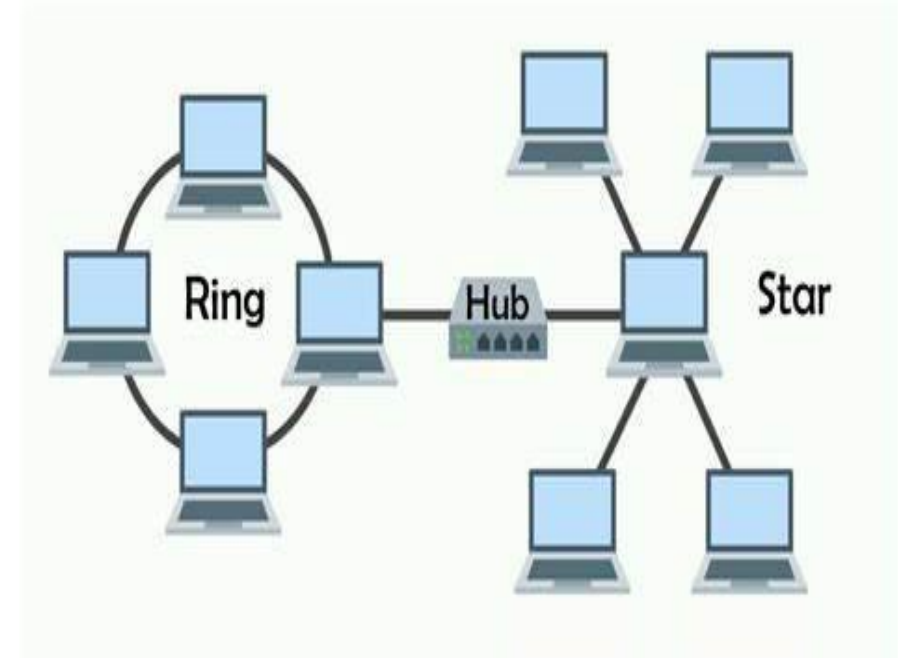
- **Support for broadband transmission:** Tree topology is mainly used to provide broadband transmission, i.e., signals are sent over long distances without being attenuated.
- **Easily expandable:** We can add the new device to the existing network. Therefore, we can say that tree topology is easily expandable.
- **Easily manageable:** In tree topology, the whole network is divided into segments known as star networks which can be easily managed and maintained.
- **Error detection:** Error detection and error correction are very easy in a tree topology.
- **Limited failure:** The breakdown in one station does not affect the entire network.
- **Point-to-point wiring:** It has point-to-point wiring for individual segments.

Disadvantages of Tree topology

- **Difficult troubleshooting:** If any fault occurs in the node, then it becomes difficult to troubleshoot the problem.
- **High cost:** Devices required for broadband transmission are very costly.
- **Failure:** A tree topology mainly relies on main bus cable and failure in main bus cable will damage the overall network.
- **Reconfiguration difficult:** If new devices are added, then it becomes difficult to reconfigure.

Hybrid Topology

- The combination of various different topologies is known as **Hybrid topology**.
- A Hybrid topology is a connection between different links and nodes to transfer the data.
- When two or more different topologies are combined together is termed as Hybrid topology and if similar topologies are connected with each other will not result in Hybrid topology. For example, if there exist a ring topology in one branch of XYZ bank and bus topology in another branch of XYZ bank, connecting these two topologies will result in Hybrid topology.



Advantages of Hybrid Topology

- **Reliable:** If a fault occurs in any part of the network will not affect the functioning of the rest of the network.
- **Scalable:** Size of the network can be easily expanded by adding new devices without affecting the functionality of the existing network.
- **Flexible:** This topology is very flexible as it can be designed according to the requirements of the organization.
- **Effective:** Hybrid topology is very effective as it can be designed in such a way that the strength of the network is maximized and weakness of the network is minimized.

Disadvantages of Hybrid topology

- **Complex design:** The major drawback of the Hybrid topology is the design of the Hybrid network. It is very difficult to design the architecture of the Hybrid network.
- **Costly Hub:** The Hubs used in the Hybrid topology are very expensive as these hubs are different from usual Hubs used in other topologies.
- **Costly infrastructure:** The infrastructure cost is very high as a hybrid network requires a lot of cabling, network devices, etc.

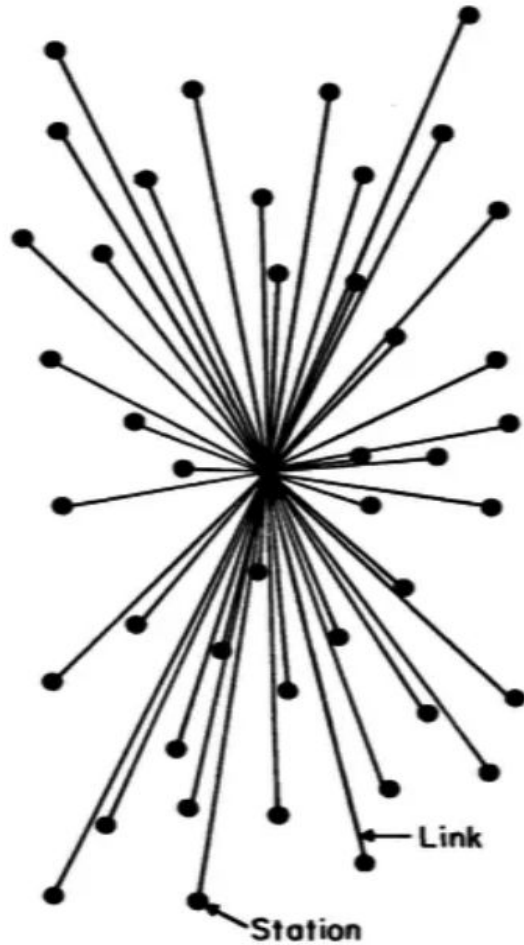
Communication Protocols

- A protocol is a complete set of rules and standards that allow different devices to communicate or understand each other.
- In other words, to ensure that computers in a network can communicate, they must share a common language called protocol.
- Therefore, protocol is a set of rules or standards that enable communication between computers in a network.
- It represents an agreement between the communication devices.
- Protocols are software and must be installed on network components that need them.
- Computers can only communicate with each other if they use the same protocol.

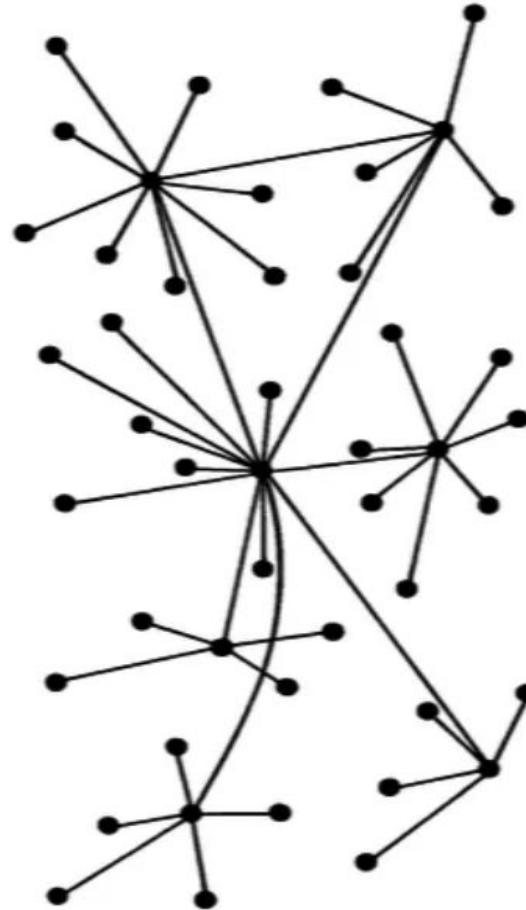
The protocols define:

- Types of error checking to be used.
- Data compression method, if any.
- How a sending device will indicate that it has finished sending a message.
- How a receiving device will indicate that it has received a message.
- Some of the popular protocols are TCP/IP, HTTP, FTP, SMTP, POP, Token-Ring, Ethernet, etc.

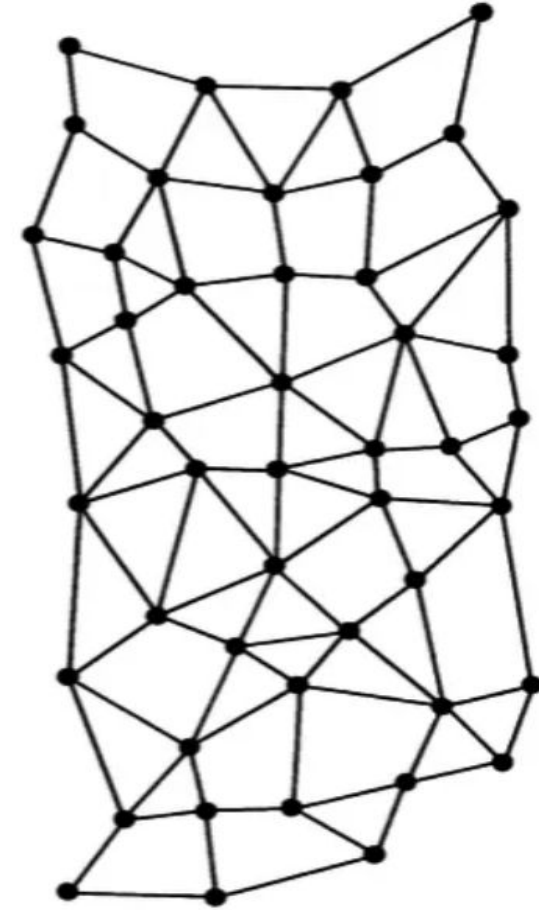
Centralized, Decentralized & Distributed System



CENTRALIZED
(A)



DECENTRALIZED
(B)

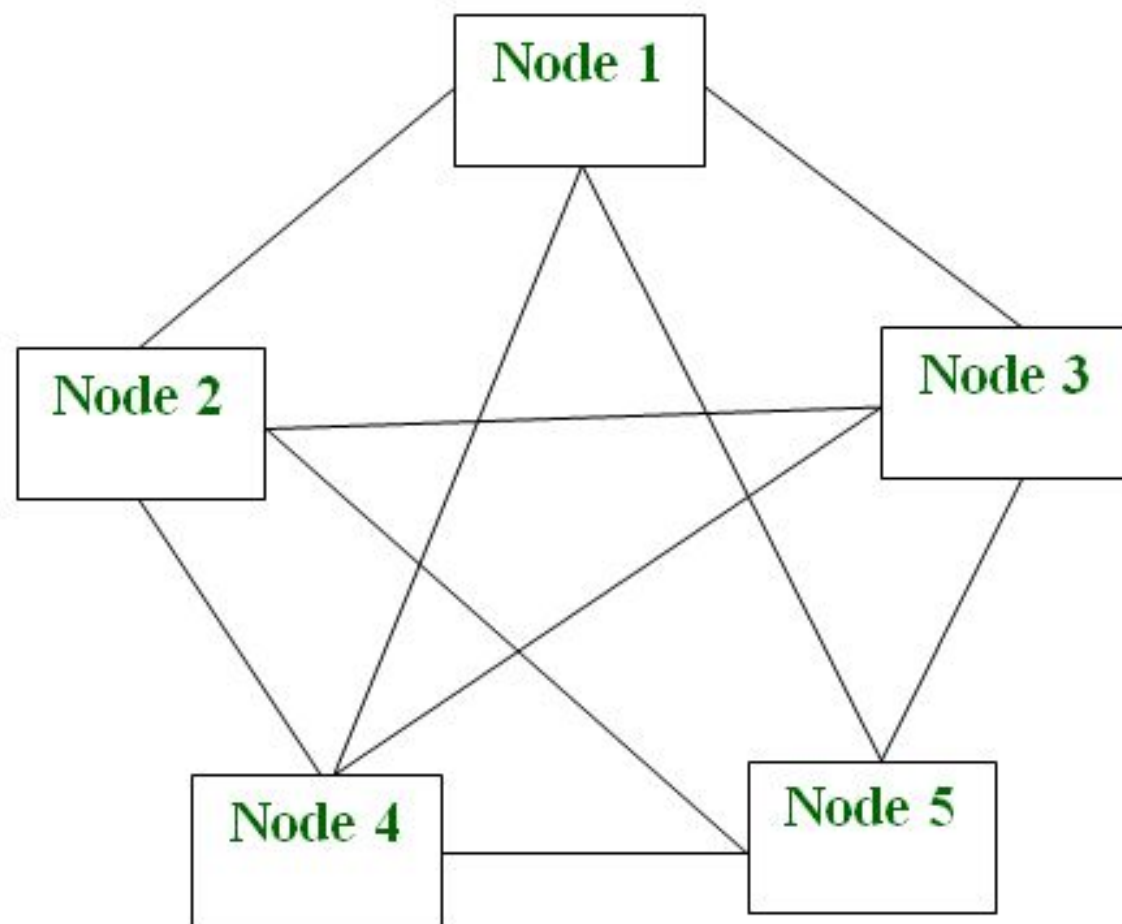


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Network Types

Peer to Peer Network Architecture

- Each computer in the network has the same set of responsibilities and capabilities.
- Each device in the network serves as both a client and server.
- The architecture is useful in residential areas, small offices, or small companies where each computer act as an independent workstation and stores the data on its hard drive.
- Each computer in the network has the ability to share data with other computers in the network.



P2P Architecture

Uses of P2P Network

- **File sharing:** P2P network is the most convenient, cost-efficient method for file sharing for businesses. Using this type of network there is no need for intermediate servers to transfer the file.
- **Blockchain:** The P2P architecture is based on the concept of decentralization. When a peer-to-peer network is enabled on the blockchain it helps in the maintenance of a complete replica of the records ensuring the accuracy of the data at the same time. At the same time, peer-to-peer networks ensure security also.
- **Direct messaging:** P2P network provides a secure, quick, and efficient way to communicate. This is possible due to the use of encryption at both the peers and access to easy messaging tools.

- **Collaboration:** The easy file sharing also helps to build collaboration among other peers in the network.
- **File sharing networks:** Many P2P file sharing networks like G2, and eDonkey have popularized peer-to-peer technologies.
- **Content distribution:** In a P2P network, unlike the client-server system so the clients can both provide and use resources. Thus, the content serving capacity of the P2P networks can actually increase as more users begin to access the content.

Advantages of P2P Network

- **Easy to maintain:** The network is easy to maintain because each node is independent of the other.
- **Less costly:** Since each node acts as a server, therefore the cost of the central server is saved. Thus, there is no need to buy an expensive server.
- **No network manager:** In a P2P network since each node manages his or her own computer, thus there is no need for a network manager.
- **Adding nodes is easy:** Adding, deleting, and repairing nodes in this network is easy.
- **Less network traffic:** In a P2P network, there is less network traffic than in a client/ server network.

Disadvantages of P2P Network

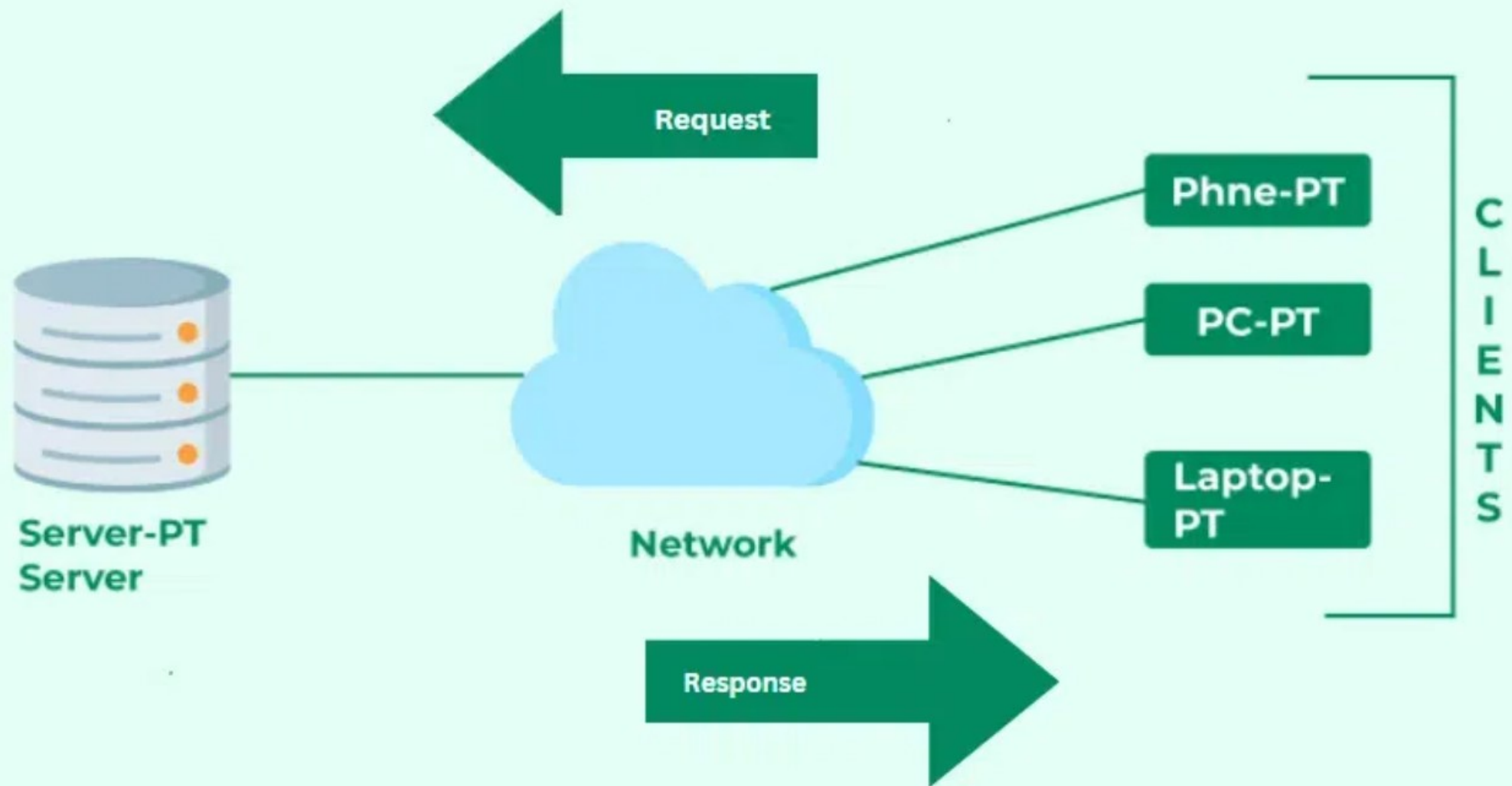
- **Data is vulnerable:** Because of no central server, data is always vulnerable to getting lost because of no backup.
- **Less secure:** It becomes difficult to secure the complete network because each node is independent.
- **Slow performance:** In a P2P network, each computer is accessed by other computers in the network which slows down the performance of the user.
- **Files hard to locate:** In a P2P network, the files are not centrally stored, rather they are stored on individual computers which makes it difficult to locate the files.

Multipoint Network

- Multi-point communication is the communication that occurs when a communication channel is shared not just between two devices or nodes but also between numerous devices or nodes participating in the conversation.
- A multipoint connection is one that connects more than two devices together. Multidrop line configuration is another name for the multipoint connection. Numerous devices share a single link in a multipoint connection. As a result, it is possible to say that all devices connected to the link temporarily share the channel capacity. The devices use a turn-by-turn link, which is called a time-shared line configuration.
- In a broadcast network, the packet transmitted by the sender is received and processed by each device on the link. However, the receiver evaluates whether the packet belongs to it or not based on the address field in the packet; if it does not, the packet is discarded. If the packet belongs to the recipient, store it and respond appropriately to the sender.

Client Server Network

- In client-server network relationships, certain computers act as servers and others act as clients.
- A server is simply a computer that provides the network resources and provides service to other computers when they request it. A client is the computer running a program that requests the service from a server. Local area network (LAN) is based on client server network relationship.
- A client-server network is one on which all available network resources such as files, directories, applications and shared devices, are centrally managed and hosted and then are accessed by the client.
- Client server networks are defined by the presence of servers on a network that provide security and administration of the network.



Advantages of C/S Network

- Centralized system with all data in a single place.
- Cost efficient requires less maintenance cost and Data recovery is possible.
- The capacity of the Client and Servers can be changed separately.

Disadvantages of C/S Network

- Clients are prone to viruses, Trojans, and worms if present in the Server or uploaded into the Server.
- Servers are prone to Denial of Service (DOS) attacks.
- Data packets may be spoofed or modified during transmission.
- Phishing or capturing login credentials or other useful information of the user are common and MITM(Man in the Middle) attacks are common.

Network Protocols

- A network protocol is a set of rules that govern data communication between different devices in the network. It determines what is being communicated, how it is being communicated, and when it is being communicated. It permits connected devices to communicate with each other, irrespective of internal and structural differences.
- The protocols can be broadly classified into three major categories: (Assignment)
 - Network Communication (HTTP, TCP,UDP etc)
 - Network Management (ICMP, SNMP etc)
 - Network Security (SSL, TLS etc)

- **Syntax:** Syntax refers to the structure or the format of the data that gets exchanged between the devices. Syntax of the message includes the type of data, composition of the message, and sequencing of the message. The starting 8 bits of data are considered as the address of the sender. The next 8 bits are considered to be the address of the receiver. The remaining bits are considered as the message itself..
- **Semantics:** Semantics defines data transmitted between devices. It provides rules and norms for understanding message or data element values and actions.
- **Timing:** Timing refers to the synchronization and coordination between devices while transferring the data. Timing ensures at what time data should be sent and how fast data can be sent. For example, If a sender sends 100 Mbps but the receiver can only handle 1 Mbps, the receiver will overflow and lose data. Timing ensures preventing of data loss, collisions, and other timing-related issues.

Standards

- Standards are the set of rules for data communication that are needed for the exchange of information among devices. It is important to follow Standards which are created by various Standard Organizations like IEEE, ISO, ANSI, etc.

Types of Standards

- De Facto Standard: The meaning of the work "*De Facto*" is "By Fact" or "By Convention". These are the standards that have not been approved by any Organization but have been adopted as Standards because of their widespread use. Also, sometimes these standards are often established by Manufacturers. For example: Apple and Google are two companies that established their own rules for their products which are different. Also, they use some same standard rules for manufacturing their products.
- De Jure Standard: The meaning of the word "*De Jure*" is "By Law" or "By Regulations". Thus, these are the standards that have been approved by officially recognized bodies like ANSI, ISO, IEEE, etc. These are the standards that are important to follow if it is required or needed. For example: All the data communication standard protocols like SMTP, TCP, IP, UDP etc. are important to follow the same when we need them.

Standard Organization

- ISO (International Standard Organization)
- IEEE (Institute of Electrical & Electronic Engineering)
- EIA (Electronic Industries Association)
- TIA (Telecommunication Industries Association)
- ITU (International Telecommunication Union)
- ANSI (American National Standard Institute)