# What is Computer Network?

A computer network is a set of devices connected through links. A node can be computer, printer, or any other device capable of sending or receiving the data. The links connecting the nodes are known as communication channels.

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

Components Of Computer Network:
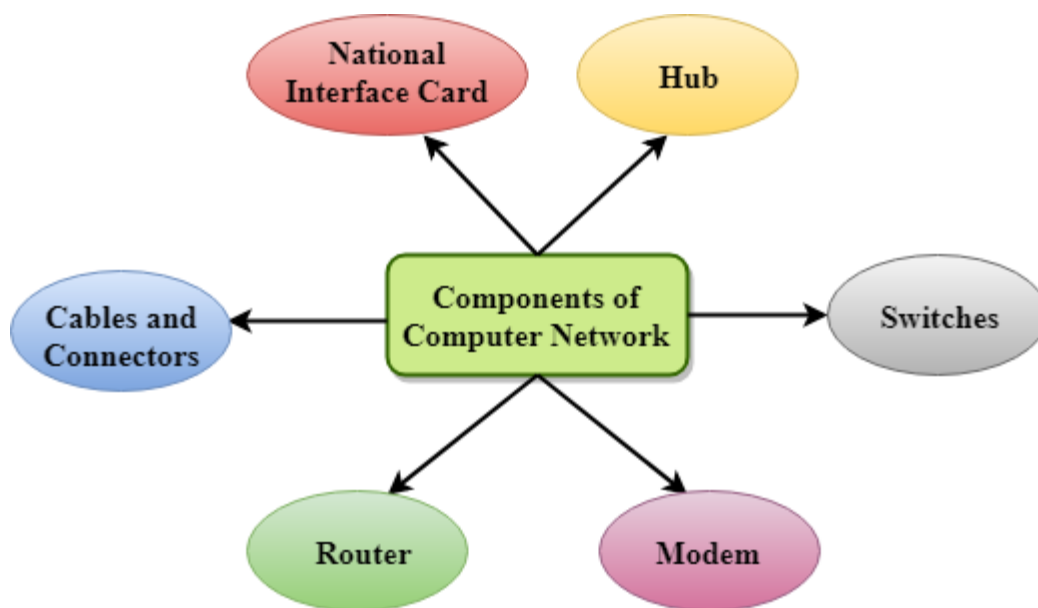
NIC(National interface card)

NIC is a device that helps the computer to communicate with another device. The network interface card contains the hardware addresses, the data-link layer protocol use this address to identify the system on the network so that it transfers the data to the correct destination.

There are two types of NIC: wireless NIC and wired NIC.

- o **Wireless NIC:** All the modern laptops use the wireless NIC. In Wireless NIC, a connection is made using the antenna that employs the **radio wave technology**.
- o **Wired NIC:** Cables use the **wired NIC** to transfer the data over the medium.

Hub

Hub is a central device that splits the network connection into multiple devices. When computer requests for information from a computer, it sends the request to the Hub. Hub distributes this request to all the interconnected computers.

Switches

Switch is a networking device that groups all the devices over the network to transfer the data to another device. A switch is better than Hub as it does not broadcast the message over the network, i.e., it sends the message to the device for which it belongs to. Therefore, we can say that switch sends the message directly from source to the destination.

Cables and connectors

Cable is a transmission media that transmits the communication signals. **There are three types of cables:**

- o **Twisted pair cable:** It is a high-speed cable that transmits the data over **1Gbps** or more.
- o **Coaxial cable:** Coaxial cable resembles like a TV installation cable. Coaxial cable is more expensive than twisted pair cable, but it provides the high data transmission speed.
- o **Fibre optic cable:** Fibre optic cable is a high-speed cable that transmits the data using light beams. It provides high data transmission speed as compared to other cables. It is more expensive as compared to other cables, so it is installed at the government level.

Router

Router is a device that connects the LAN to the internet. The router is mainly used to connect the distinct networks or connect the internet to multiple computers.


Modem

Modem connects the computer to the internet over the existing telephone line. A modem is not integrated with the computer motherboard. A modem is a separate part on the PC slot found on the motherboard.

Uses Of Computer Network

- o **Resource sharing:** Resource sharing is the sharing of resources such as programs, printers, and data among the users on the network without the requirement of the physical location of the resource and user.
- o **Server-Client model:** Computer networking is used in the **server-client model**. A server is a central computer used to store the information and maintained by the system administrator. Clients are the machines used to access the information stored in the server remotely.
- o **Communication medium:** Computer network behaves as a communication medium among the users. For example, a company contains more than one computer has an email system which the employees use for daily communication.
- o **E-commerce:** Computer network is also important in businesses. We can do the business over the internet. For example, amazon.com is doing their business over the internet, i.e., they are doing their business over the internet.

Features Of Computer network
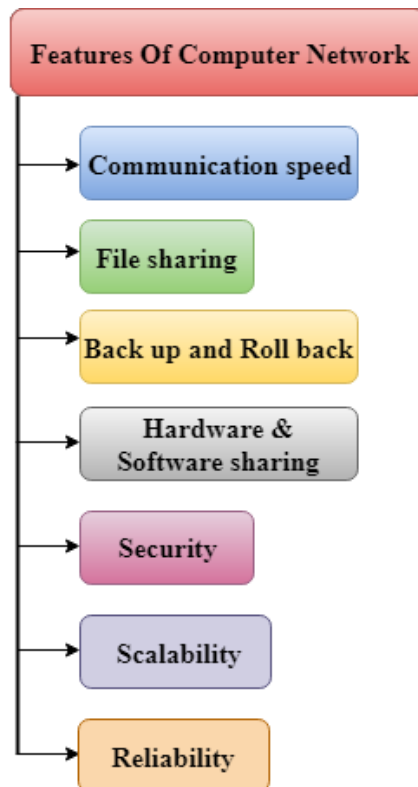
Communication speed

Network provides us to communicate over the network in a fast and efficient manner. For example, we can do video conferencing, email messaging, etc. over the internet. Therefore, the computer network is a great way to share our knowledge and ideas.

File sharing

File sharing is one of the major advantage of the computer network. Computer network provides us to share the files with each other.

Back up and Roll back is easy

Since the files are stored in the main server which is centrally located. Therefore, it is easy to take the back up from the main server.

Software and Hardware sharing

We can install the applications on the main server, therefore, the user can access the applications centrally. So, we do not need to install the software on every machine. Similarly, hardware can also be shared.

Security

Network allows the security by ensuring that the user has the right to access the certain files and applications.

Scalability

Scalability means that we can add the new components on the network. Network must be scalable so that we can extend the network by adding new devices. But, it decreases the speed of the connection and data of the transmission speed also decreases, this increases the chances of error occurring. This problem can be overcome by using the routing or switching devices.

Reliability

Computer network can use the alternative source for the data communication in case of any hardware failure.

Computer Network Architecture

Computer Network Architecture is defined as the physical and logical design of the software, hardware, protocols, and media of the transmission of data. Simply we can say that how computers are organized and how tasks are allocated to the computer.

The two types of network architectures are used:
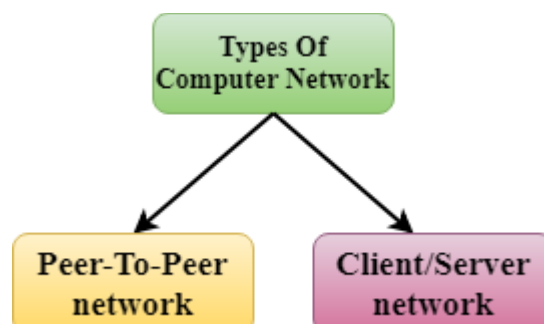
- Peer-To-Peer network
- Client/Server network

Peer-To-Peer network

- Peer-To-Peer network is a network in which all the computers are linked together with equal privilege and responsibilities for processing the data.
- Peer-To-Peer network is useful for small environments, usually up to 10 computers.
- Peer-To-Peer network has no dedicated server.
- Special permissions are assigned to each computer for sharing the resources, but this can lead to a problem if the computer with the resource is down.
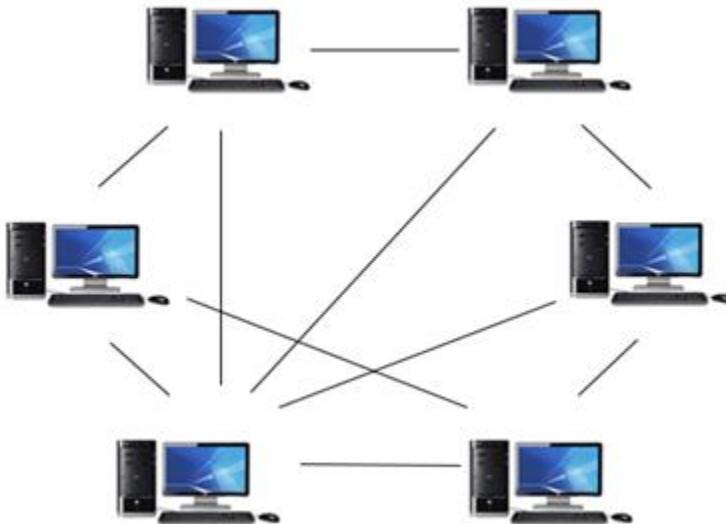

Advantages Of Peer-To-Peer Network:

- It is less costly as it does not contain any dedicated server.
- If one computer stops working but, other computers will not stop working.
- It is easy to set up and maintain as each computer manages itself.

Disadvantages Of Peer-To-Peer Network:

- In the case of Peer-To-Peer network, it does not contain the centralized system . Therefore, it cannot back up the data as the data is different in different locations.
- It has a security issue as the device is managed itself.

Client/Server Network

- Client/Server network is a network model designed for the end users called clients, to access the resources such as songs, video, etc. from a central computer known as Server.
- The central controller is known as a **server** while all other computers in the network are called **clients**.
- A server performs all the major operations such as security and network management.
- A server is responsible for managing all the resources such as files, directories, printer, etc.
- All the clients communicate with each other through a server. For example, if client1 wants to send some data to client 2, then it first sends the request to the server for the permission. The server sends the response to the client 1 to initiate its communication with the client 2.
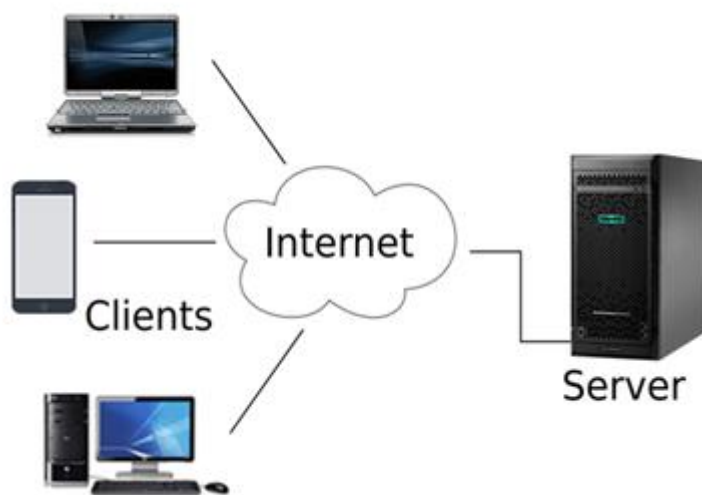
Advantages Of Client/Server network:

- A Client/Server network contains the centralized system. Therefore we can back up the data easily.
- A Client/Server network has a dedicated server that improves the overall performance of the whole system.
- Security is better in Client/Server network as a single server administers the shared resources.
- It also increases the speed of the sharing resources.

Disadvantages Of Client/Server network:

o   Client/Server network is expensive as it requires the server with large memory.

o   A server has a Network Operating System(NOS) to provide the resources to the clients, but the cost of NOS is very high.

o   It requires a dedicated network administrator to manage all the resources.

Router

o   A router is a hardware device which is used to connect a LAN with an internet connection. It is used to receive, analyse and forward the incoming packets to another network.

o   A router works in a **Layer 3 (Network layer)** of the OSI Reference model.

o   A router forwards the packet based on the information available in the routing table.

o   It determines the best path from the available paths for the transmission of the packet.

Advantages Of Router:

o   **Security:** The information which is transmitted to the network will traverse the entire cable, but the only specified device which has been addressed can read the data.

o   **Reliability:** If the server has stopped functioning, the network goes down, but no other networks are affected that are served by the router.

o   **Performance:** Router enhances the overall performance of the network. Suppose there are 24 workstations in a network generates a same amount of traffic. This increases the traffic load on the network. Router splits the single network into two networks of 12 workstations each, reduces the traffic load by half.

o   **Network range**

Computer Network Types

A computer network is a group of computers linked to each other that enables the computer to communicate with another computer and share their resources, data, and applications.
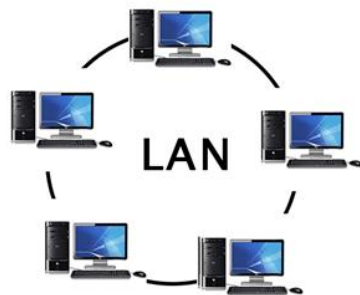
A computer network can be categorized by their size. A **computer network** is mainly of **four types**:
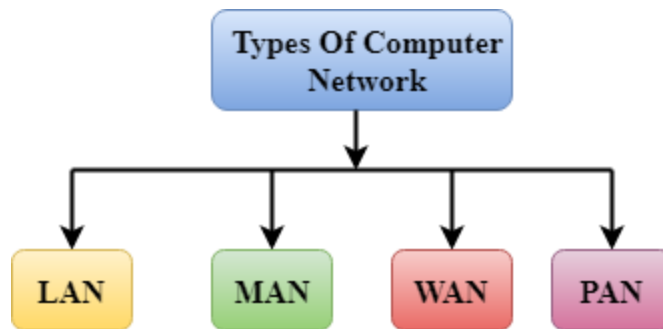
- o LAN(Local Area Network)
- o PAN(Personal Area Network)
- o MAN(Metropolitan Area Network)
- o WAN(Wide Area Network)

LAN(Local Area Network)

- o Local Area Network is a group of computers connected to each other in a small area such as building, office.
- o LAN is used for connecting two or more personal computers through a communication medium such as twisted pair, coaxial cable, etc.
- o It is less costly as it is built with inexpensive hardware such as hubs, network adapters, and ethernet cables.
- o The data is transferred at an extremely faster rate in Local Area Network.
- o Local Area Network provides higher security.


PAN(Personal Area Network)

- o Personal Area Network is a network arranged within an individual person, typically within a range of 10 meters.

- Personal Area Network is used for connecting the computer devices of personal use is known as Personal Area Network.
- **Thomas Zimmerman** was the first research scientist to bring the idea of the Personal Area Network.
- Personal Area Network covers an area of **30 feet**.
- Personal computer devices that are used to develop the personal area network are the laptop, mobile phones, media player and play stations.

MAN(Metropolitan Area Network)

- A metropolitan area network is a network that covers a larger geographic area by interconnecting a different LAN to form a larger network.
- Government agencies use MAN to connect to the citizens and private industries.
- In MAN, various LANs are connected to each other through a telephone exchange line.
- The most widely used protocols in MAN are RS-232, Frame Relay, ATM, ISDN, OC-3, ADSL, etc.
- It has a higher range than Local Area Network(LAN).
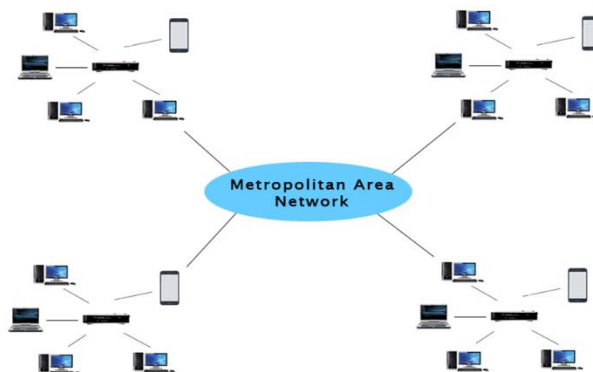
Uses Of Metropolitan Area Network:

- MAN is used in communication between the banks in a city.
- It can be used in an Airline Reservation.
- It can be used in a college within a city.
- It can also be used for communication in the military.

WAN(Wide Area Network)

- A Wide Area Network is a network that extends over a large geographical area such as states or countries.
- A Wide Area Network is quite bigger network than the LAN.
- A Wide Area Network is not limited to a single location, but it spans over a large geographical area through a telephone line, fibre optic cable or satellite links.
- The internet is one of the biggest WAN in the world.
- A Wide Area Network is widely used in the field of Business, government, and education.
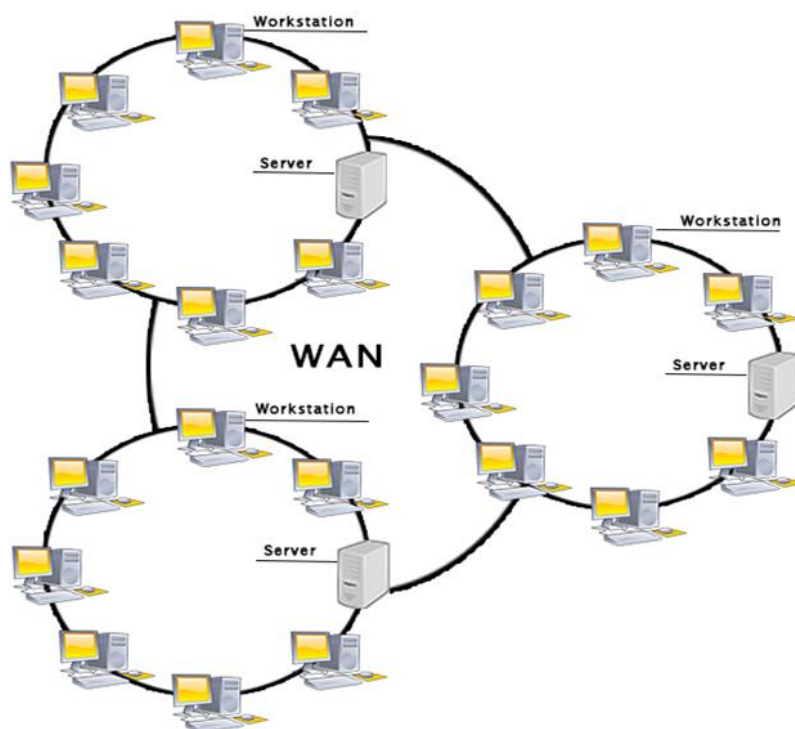
Advantages Of Wide Area Network:

- Geographical area
- Centralized data
- Get updated files
- Exchange messages
- Sharing of software and resources
- High bandwidth

## Disadvantages of Wide Area Network:

- Security issue
- Needs Firewall & antivirus software
- High Setup cost
- Troubleshooting problems

Internetwork

- An internetwork is defined as two or more computer network LANs or WAN or computer network segments are connected using devices, and they are configured by a local addressing scheme. This process is known as **internetworking**.

- An interconnection between public, private, commercial, industrial, or government computer networks can also be defined as **internetworking**.

- An internetworking uses the **internet protocol**.

- The reference model used for internetworking is **Open System Interconnection(OSI)**.

What is Topology?

Topology defines the structure of the network of how all the components are interconnected to each other.
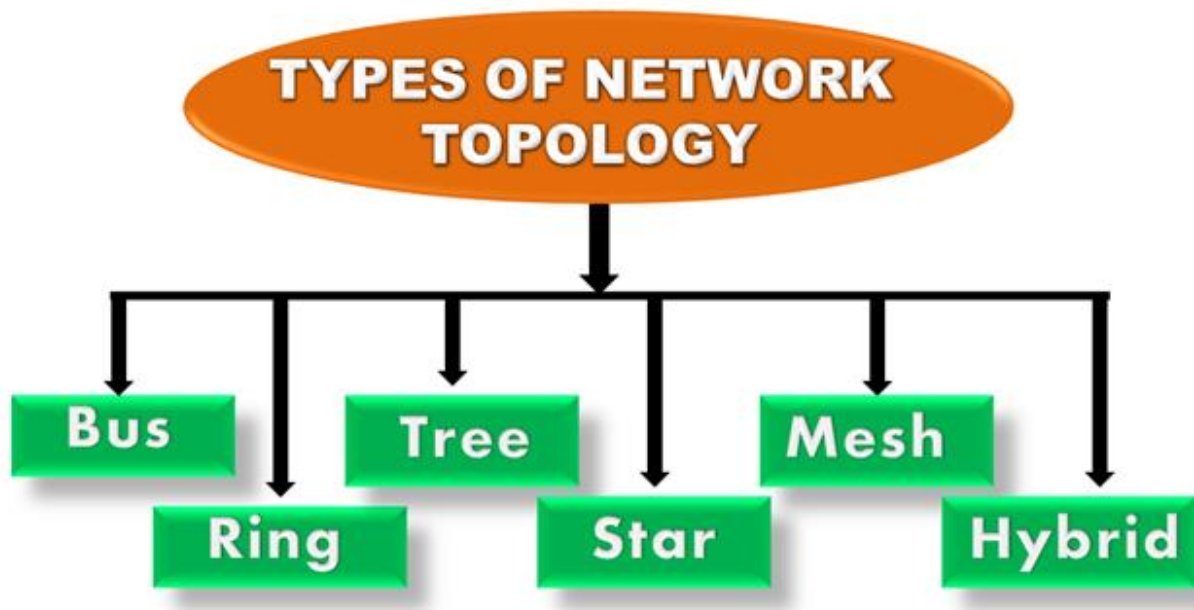
Bus Topology

- 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 bus topology is mainly used in 802.3 (ethernet) and 802.4 standard networks.

- o The configuration of a bus topology is quite simpler as compared to other topologies.
- o The backbone cable is considered as a **"single lane"** through which the message is broadcast to all the stations.
- o The most common access method of the bus topologies is **CSMA** (Carrier Sense Multiple Access).

Advantages of Bus topology:

- o **Low-cost cable**
- o **Moderate data speeds**
- o **Familiar technology**
- o **Limited failure:** A failure in one node will not have any effect on other nodes.

Disadvantages of Bus topology:

- o **Extensive cabling:** A bus topology is quite simpler, but still it requires a lot of cabling.
- o **Difficult troubleshooting:** It requires specialized test equipment to determine the cable faults.
- o **Signal interference:** If two nodes send the messages simultaneously, then the signals of both the nodes collide with each other.
- o **Reconfiguration difficult:** Adding new devices to the network would slow down the network.
- o **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.

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:

- o **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.

- o **Failure:** The breakdown in one station leads to the failure of the overall network.

- o **Reconfiguration difficult:** Adding new devices to the network would slow down the network.

- o **Delay:** Communication delay is directly proportional to the number of nodes. Adding new devices increases the communication delay.

Star Topology
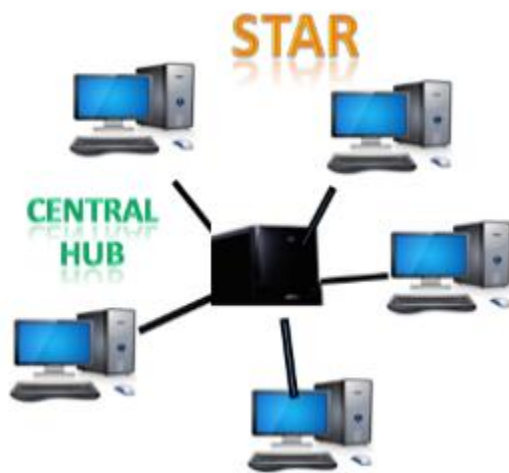
- o Star topology is an arrangement of the network in which every node is connected to the central hub, switch or a central computer.

- o The central computer is known as a **server**, and the peripheral devices attached to the server are known as **clients**.

- o Coaxial cable or RJ-45 cables are used to connect the computers.

- o Hubs or Switches are mainly used as connection devices in a **physical star topology**.

- o Star topology is the most popular topology in network implementation.

Advantages of Star topology

- o **Efficient troubleshooting:** Troubleshooting is quite efficient in a star topology as compared to bus topology.

- o **Network control:** Complex network control features can be easily implemented in the star topology.
- o **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.
- o **Familiar technology:** Star topology is a familiar technology as its tools are cost-effective.
- o **Easily expandable:** It is easily expandable as new stations can be added to the open ports on the hub.
- o **Cost effective:** Star topology networks are cost-effective as it uses inexpensive coaxial cable.
- o **High data speeds**

Disadvantages of Star topology

- o **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.
- o **Cable:** Sometimes cable routing becomes difficult when a significant amount of routing is required.

Tree topology
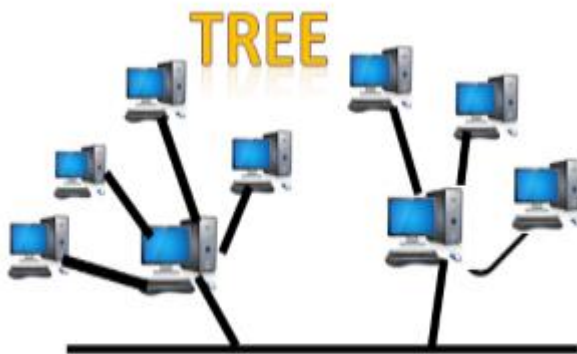
- o Tree topology combines the characteristics of bus topology and star topology.
- o A tree topology is a type of structure in which all the computers are connected with each other in hierarchical fashion.
- o The top-most node in tree topology is known as a root node, and all other nodes are the descendants of the root node.
- o 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**

- **Easily expandable:** We can add the new device to the existing network.

- **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.

Mesh topology
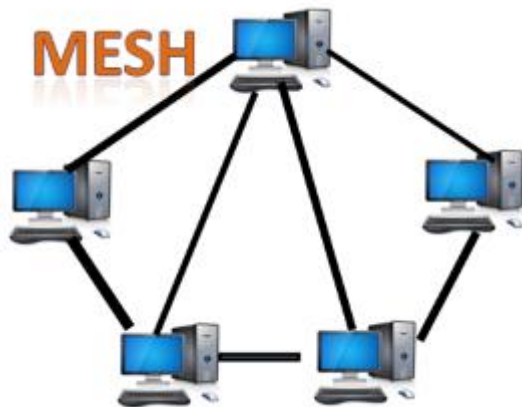
- Mesh technology is an arrangement of the network in which computers are interconnected with each other through various redundant connections.

- 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 can be formed by using the formula: **Number of cables = (n*(n-1))/2;**

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.
- **Efficiency:** In this topology, redundant connections are high that reduces the efficiency of the network.

Hybrid Topology
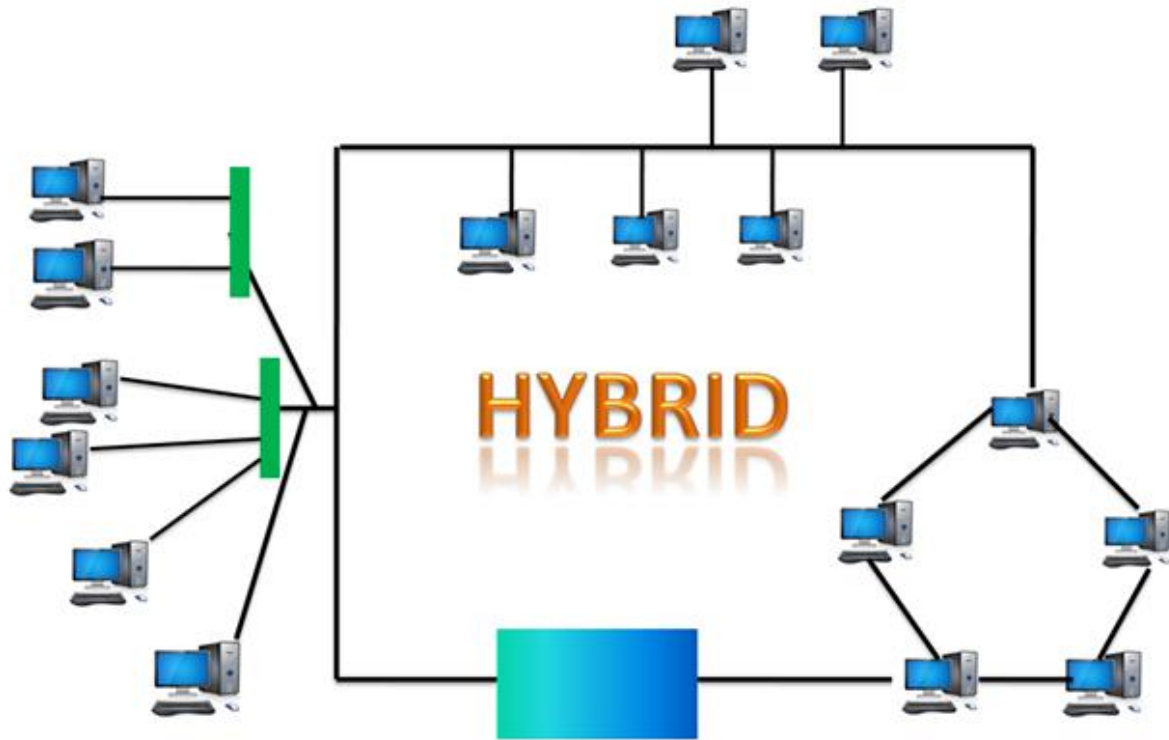
- ○ The combination of various different topologies is known as **Hybrid topology**.
- ○ A Hybrid topology is a connection between different links and nodes to transfer the data.
- ○ When two or more different topologies are combined together is termed as Hybrid topology and if similar topologies are connected with each other will not result in Hybrid topology.

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.
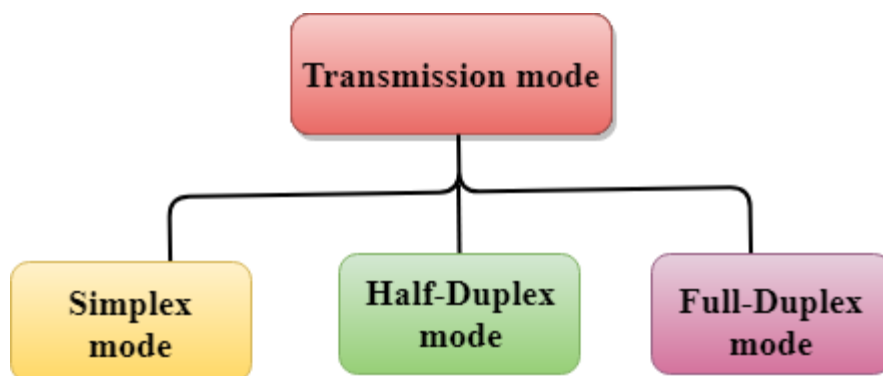
Disadvantages of Hybrid topology

- o **Complex design**
- o **Costly Hub**
- o **Costly infrastructure**

Transmission modes

- o The way in which data is transmitted from one device to another device is known as **transmission mode**.

- o The transmission mode is also known as the communication mode.

- o Each communication channel has a direction associated with it, and transmission media provide the direction. Therefore, the transmission mode is also known as a directional mode.

- o The transmission mode is defined in the physical layer.

The Transmission mode is divided into three categories:

Simplex mode
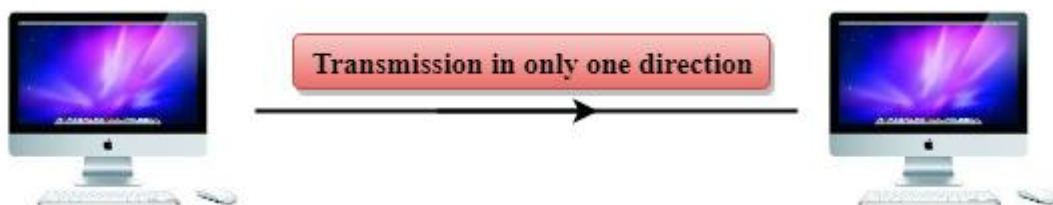
- o In Simplex mode, the communication is unidirectional, i.e., the data flow in one direction.

- o A device can only send the data but cannot receive it or it can receive the data but cannot send the data.

- This transmission mode is not very popular as mainly communications require the two-way exchange of data. The simplex mode is used in the business field as in sales that do not require any corresponding reply.

- The radio station is a simplex channel as it transmits the signal to the listeners but never allows them to transmit back.

- Keyboard and Monitor are the examples of the simplex mode as a keyboard can only accept the data from the user and monitor can only be used to display the data on the screen.

- The main advantage of the simplex mode is that the full capacity of the communication channel can be utilized during transmission.
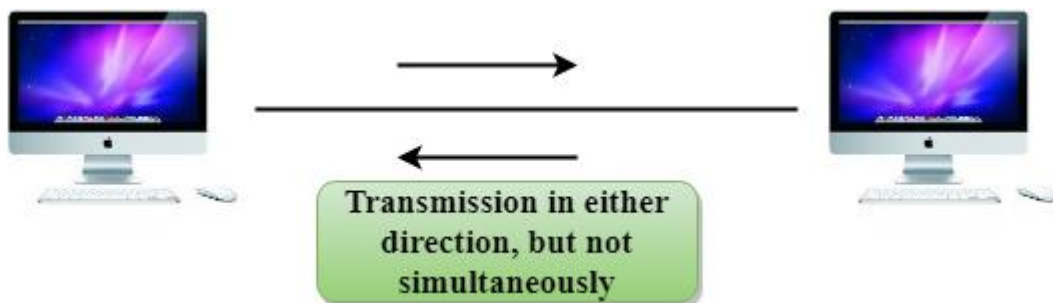
Advantage of Simplex mode:

- In simplex mode, the station can utilize the entire bandwidth of the communication channel, so that more data can be transmitted at a time.

Disadvantage of Simplex mode:

- Communication is unidirectional, so it has no inter-communication between devices.

Half-Duplex mode

- In a Half-duplex channel, direction can be reversed, i.e., the station can transmit and receive the data as well.

- Messages flow in both the directions, but not at the same time.

- The entire bandwidth of the communication channel is utilized in one direction at a time.

- In half-duplex mode, it is possible to perform the error detection, and if any error occurs, then the receiver requests the sender to retransmit the data.

- A **Walkie-talkie** is an example of the Half-duplex mode. In Walkie-talkie, one party speaks, and another party listens. After a pause, the other speaks and first party listens. Speaking simultaneously will create the distorted sound which cannot be understood.

Advantage of Half-duplex mode:

o In half-duplex mode, both the devices can send and receive the data and also can utilize the entire bandwidth of the communication channel during the transmission of data.

Disadvantage of Half-Duplex mode:

o In half-duplex mode, when one device is sending the data, then another has to wait, this causes the delay in sending the data at the right time.

Full-duplex mode

Transmission in both the directions simultaneously.
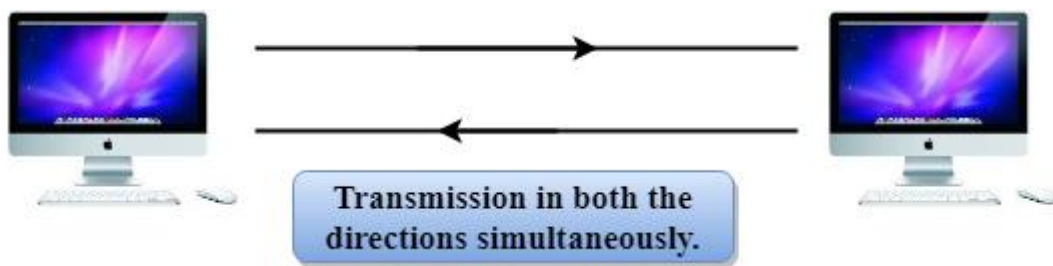
o In Full duplex mode, the communication is bi-directional, i.e., the data flow in both the directions.

o Both the stations can send and receive the message simultaneously.

o Full-duplex mode has two simplex channels. One channel has traffic moving in one direction, and another channel has traffic flowing in the opposite direction.

o The Full-duplex mode is the fastest mode of communication between devices.

o The most common example of the full-duplex mode is a telephone network. When two people are communicating with each other by a telephone line, both can talk and listen at the same time.

Advantage of Full-duplex mode:

o Both the stations can send and receive the data at the same time.

Disadvantage of Full-duplex mode:

o If there is no dedicated path exists between the devices, then the capacity of the communication channel is divided into two parts.

# Differences b/w Simplex, Half-duplex and Full-duplex mode

Basis for comparison	Simplex mode	Half-duplex mode	Full-duplex mode
Direction of communication	In simplex mode, the communication is unidirectional.	In half-duplex mode, the communication is bidirectional, but one at a time.	In full-duplex mode, the communication is bidirectional.
Send/Receive	A device can only send the data but cannot receive it or it can only receive the data but cannot send it.	Both the devices can send and receive the data, but one at a time.	Both the devices can send and receive the data simultaneously.
Performance	The performance of half-duplex mode is better than the simplex mode.	The performance of full-duplex mode is better than the half-duplex mode.	The Full-duplex mode has better performance among simplex and half-duplex mode as it doubles the utilization of the capacity of the communication channel.
Example	Examples of Simplex mode are radio, keyboard, and monitor.	Example of half-duplex is Walkie-Talkies.	Example of the Full-duplex mode is a telephone network.

OSI Model

- o OSI stands for **Open System Interconnection** is a reference model that describes how information from a software application in one computer moves through a physical medium to the software application in another computer.
- o OSI consists of seven layers, and each layer performs a particular network function.
- o OSI model was developed by the International Organization for Standardization (ISO) in 1984, and it is now considered as an architectural model for the inter-computer communications.
- o OSI model divides the whole task into seven smaller and manageable tasks. Each layer is assigned a particular task.

o   Each layer is self-contained, so that task assigned to each layer can be performed independently.
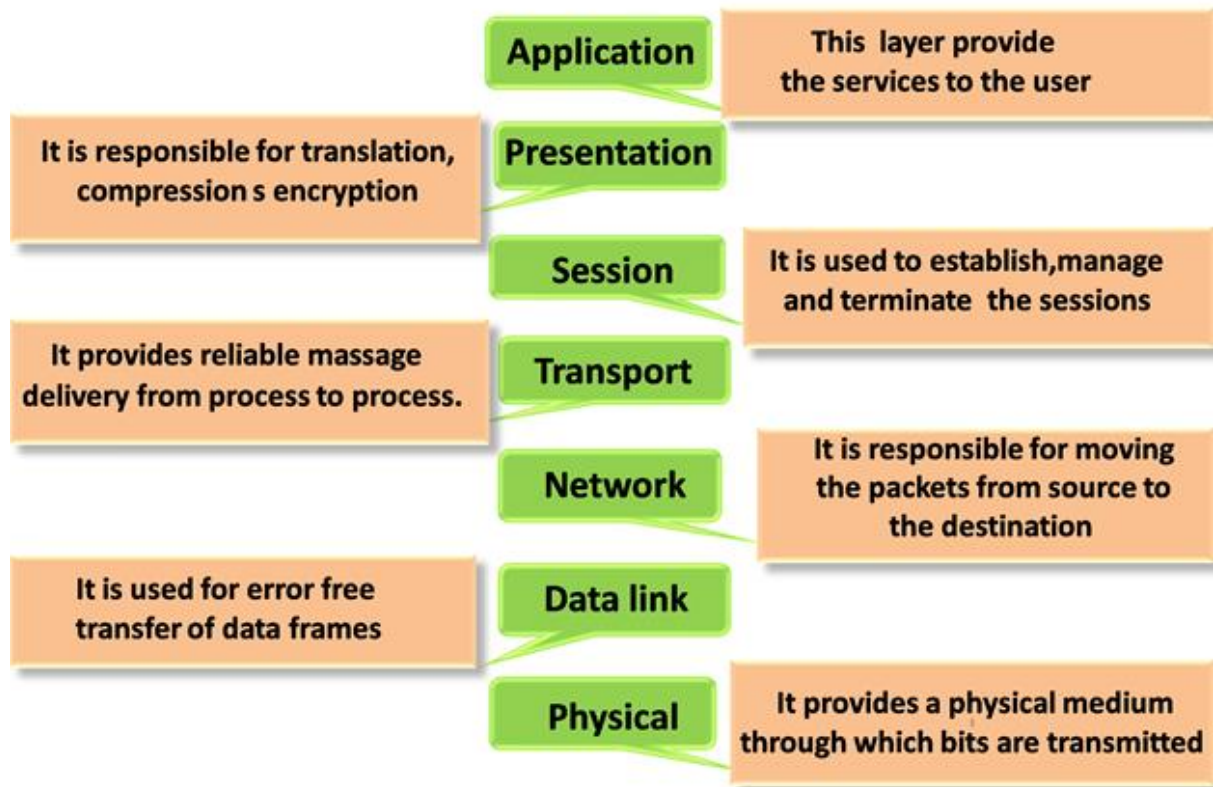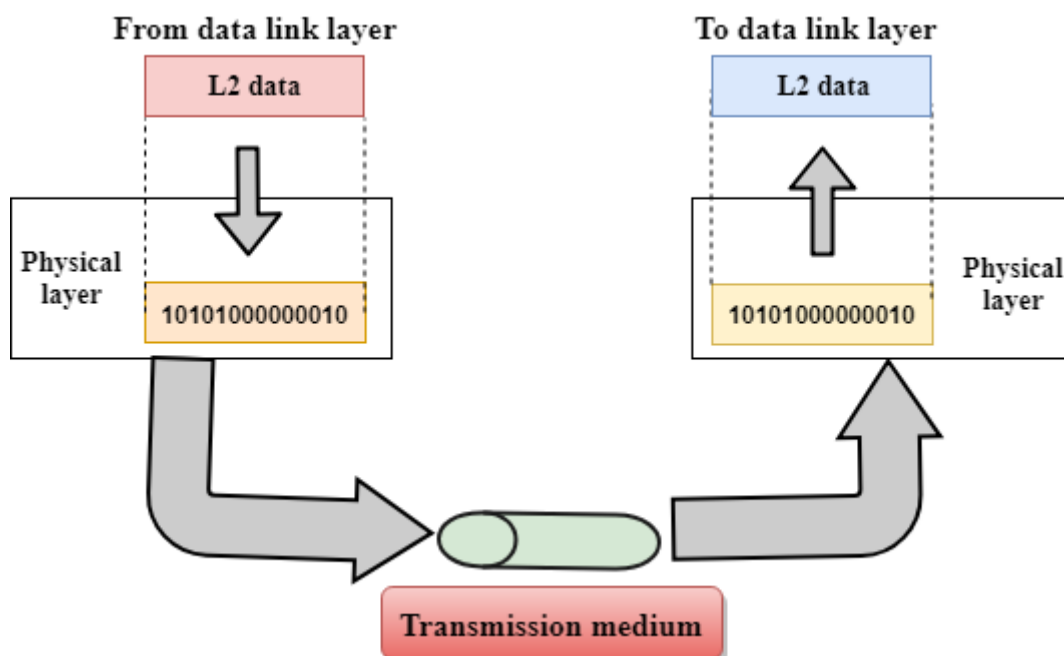
Characteristics of OSI Model:
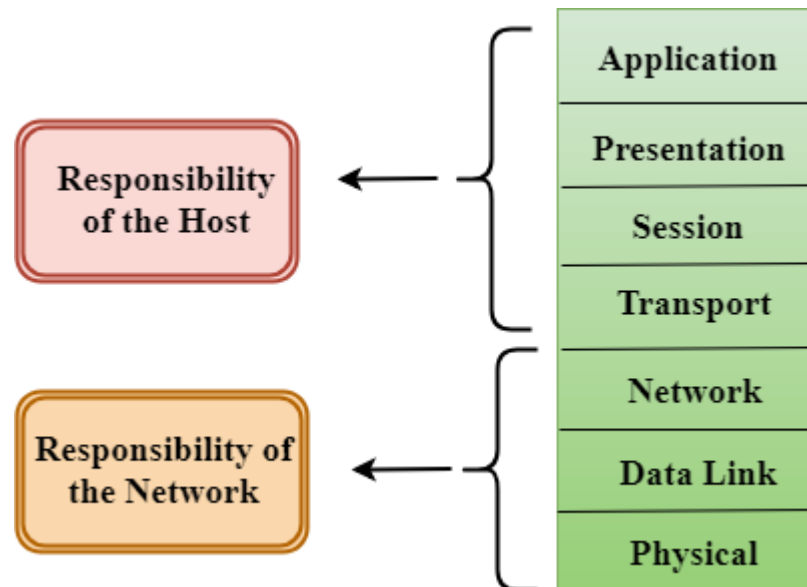
7 Layers of OSI Model

There are the seven OSI layers. Each layer has different functions. A list of seven layers are given below:

1. Physical Layer
2. Data-Link Layer
3. Network Layer
4. Transport Layer
5. Session Layer
6. Presentation Layer
7. Application Layer

	Application	This layer provide the services to the user
It is responsible for translation, compression s encryption	Presentation	
	Session	It is used to establish,manage and terminate the sessions
It provides reliable massage delivery from process to process.	Transport	
	Network	It is responsible for moving the packets from source to the destination
It is used for error free transfer of data frames	Data link	
	Physical	It provides a physical medium through which bits are transmitted

1) Physical layer

From data link layer

L2 data

Physical layer

10101000000010

To data link layer

L2 data

Physical layer

10101000000010

Transmission medium

- o The main functionality of the physical layer is to transmit the individual bits from one node to another node.
- o It is the lowest layer of the OSI model.

- o It establishes, maintains and deactivates the physical connection.
- o It specifies the mechanical, electrical and procedural network interface specifications.

Functions of a Physical layer:

- o **Line Configuration:** It defines the way how two or more devices can be connected physically.
- o **Data Transmission:** It defines the transmission mode whether it is simplex, half-duplex or full-duplex mode between the two devices on the network.
- o **Topology:** It defines the way how network devices are arranged.
- o **Signals:** It determines the type of the signal used for transmitting the information.

2) Data-Link Layer
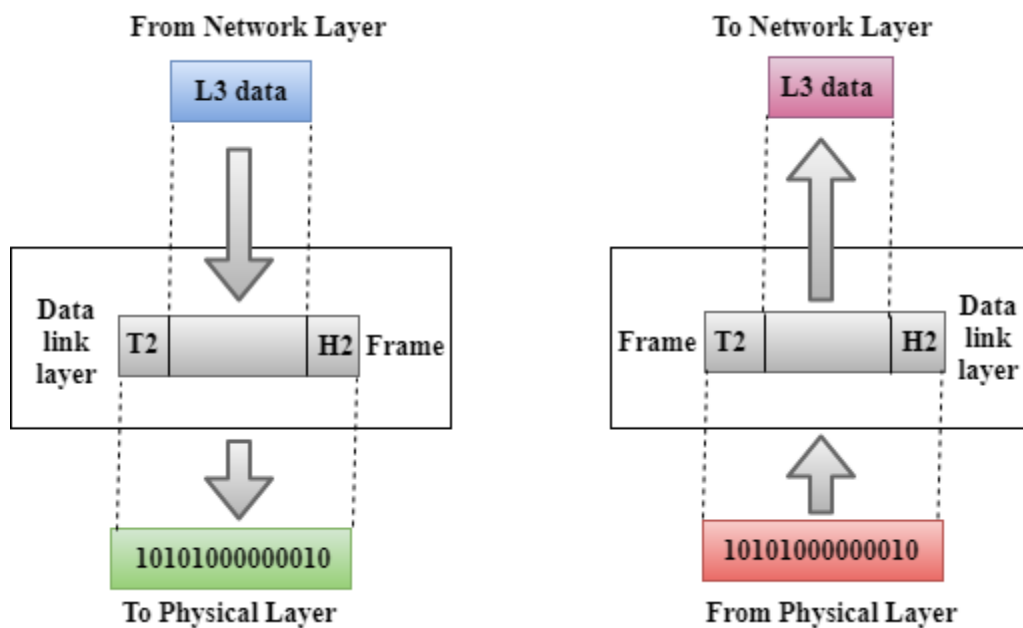
- o This layer is responsible for the error-free transfer of data frames.
- o It defines the format of the data on the network.
- o It provides a reliable and efficient communication between two or more devices.
- o It is mainly responsible for the unique identification of each device that resides on a local network.
- o It contains two sub-layers:
    - o **Logical Link Control Layer**

- o It is responsible for transferring the packets to the Network layer of the receiver that is receiving.
- o It identifies the address of the network layer protocol from the header.
- o It also provides flow control.
- o **Media Access Control Layer**
  - o A Media access control layer is a link between the Logical Link Control layer and the network's physical layer.
  - o It is used for transferring the packets over the network.

Functions of the Data-link layer

- o **Framing:** The data link layer translates the physical's raw bit stream into packets known as Frames. The Data link layer adds the header and trailer to the frame. The header which is added to the frame contains the hardware destination and source address.

Header	Packet	Trailer

- o **Physical Addressing:** The Data link layer adds a header to the frame that contains a destination address. The frame is transmitted to the destination address mentioned in the header.
- o **Flow Control:** Flow control is the main functionality of the Data-link layer. It is the technique through which the constant data rate is maintained on both the sides so that no data get corrupted. It ensures that the transmitting station such as a server with higher processing speed does not exceed the receiving station, with lower processing speed.
- o **Error Control:** Error control is achieved by adding a calculated value CRC (Cyclic Redundancy Check) that is placed to the Data link layer's trailer which is added to the message frame before it is sent to the physical layer. If any error seems to occurr, then the receiver sends the acknowledgment for the retransmission of the corrupted frames.
- o **Access Control:** When two or more devices are connected to the same communication channel, then the data link layer protocols are used to determine which device has control over the link at a given time.

3) Network Layer
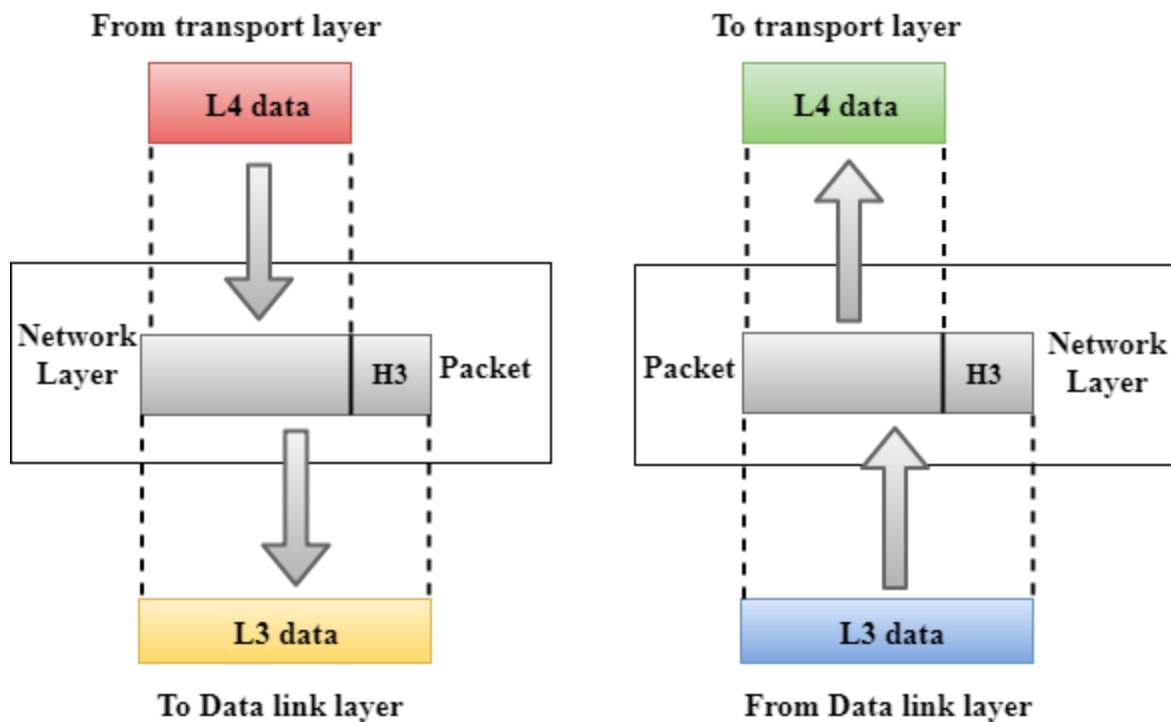
- It is a layer 3 that manages device addressing, tracks the location of devices on the network.
- It determines the best path to move data from source to the destination based on the network conditions, the priority of service, and other factors.
- The Data link layer is responsible for routing and forwarding the packets.
- Routers are the layer 3 devices, they are specified in this layer and used to provide the routing services within an internetwork.
- The protocols used to route the network traffic are known as Network layer protocols. Examples of protocols are IP and Ipv6.

Functions of Network Layer:

- **Internetworking:** An internetworking is the main responsibility of the network layer. It provides a logical connection between different devices.
- **Addressing:** A Network layer adds the source and destination address to the header of the frame. Addressing is used to identify the device on the internet.
- **Routing:** Routing is the major component of the network layer, and it determines the best optimal path out of the multiple paths from source to the destination.
- **Packetizing:** A Network Layer receives the packets from the upper layer and converts them into packets. This process is known as Packetizing. It is achieved by internet protocol (IP).

4) Transport Layer
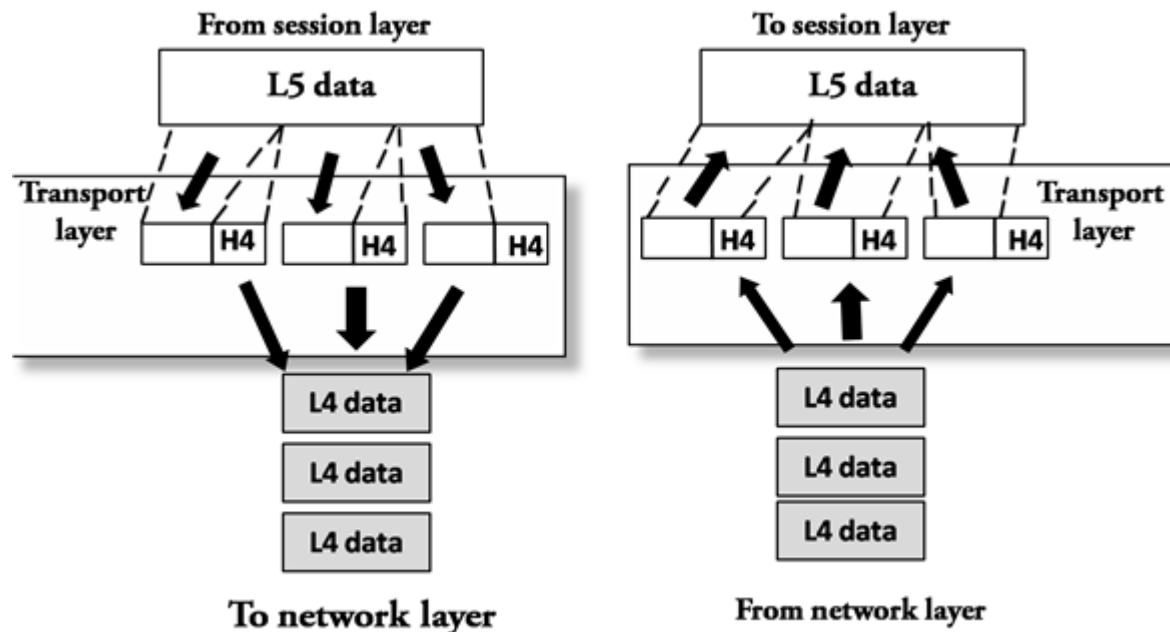
- o The Transport layer is a Layer 4 ensures that messages are transmitted in the order in which they are sent and there is no duplication of data.
- o The main responsibility of the transport layer is to transfer the data completely.
- o It receives the data from the upper layer and converts them into smaller units known as segments.
- o This layer can be termed as an end-to-end layer as it provides a point-to-point connection between source and destination to deliver the data reliably.
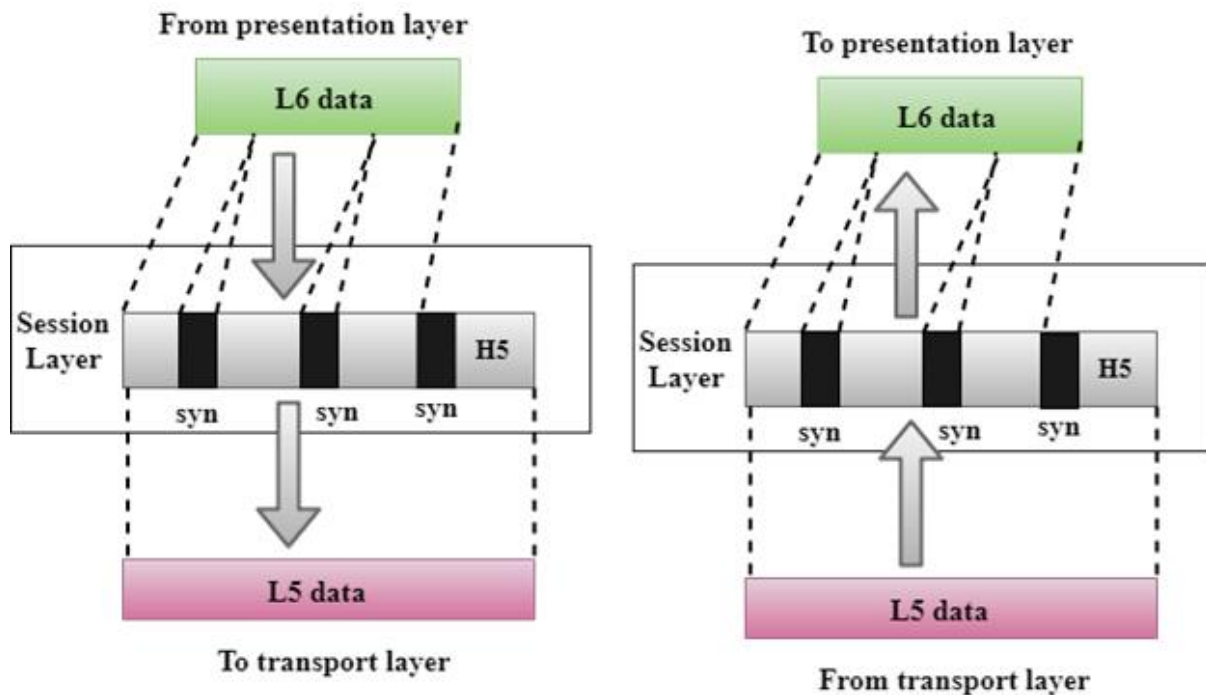
The two protocols used in this layer are:

- o **Transmission Control Protocol**
  - o It is a standard protocol that allows the systems to communicate over the internet.
  - o It establishes and maintains a connection between hosts.
  - o When data is sent over the TCP connection, then the TCP protocol divides the data into smaller units known as segments. Each segment travels over the internet using multiple routes, and they arrive in different orders at the destination. The transmission control protocol reorders the packets in the correct order at the receiving end.
- o **User Datagram Protocol**

- o User Datagram Protocol is a transport layer protocol.
- o It is an unreliable transport protocol as in this case receiver does not send any acknowledgment when the packet is received, the sender does not wait for any acknowledgment. Therefore, this makes a protocol unreliable.

Functions of Transport Layer:

- o **Service-point addressing:** Computers run several programs simultaneously due to this reason, the transmission of data from source to the destination not only from one computer to another computer but also from one process to another process. The transport layer adds the header that contains the address known as a service-point address or port address. The responsibility of the network layer is to transmit the data from one computer to another computer and the responsibility of the transport layer is to transmit the message to the correct process.

- o **Segmentation and reassembly:** When the transport layer receives the message from the upper layer, it divides the message into multiple segments, and each segment is assigned with a sequence number that uniquely identifies each segment. When the message has arrived at the destination, then the transport layer reassembles the message based on their sequence numbers.

- o **Connection control:** Transport layer provides two services Connection-oriented service and connectionless service. A connectionless service treats each segment as an individual packet, and they all travel in different routes to reach the destination. A connection-oriented service makes a connection with the transport layer at the destination machine before delivering the packets. In connection-oriented service, all the packets travel in the single route.

- o **Flow control:** The transport layer also responsible for flow control but it is performed end-to-end rather than across a single link.

- o **Error control:** The transport layer is also responsible for Error control. Error control is performed end-to-end rather than across the single link. The sender transport layer ensures that message reach at the destination without any error.

5) Session Layer

From presentation layer

L6 data

Session Layer

syn   syn   syn   H5

L5 data

To transport layer

To presentation layer

L6 data

Session Layer

syn   syn   syn   H5

L5 data

From transport layer

- o It is a layer 3 in the OSI model.
- o The Session layer is used to establish, maintain and synchronizes the interaction between communicating devices.

Functions of Session layer:

- o **Dialog control:** Session layer acts as a dialog controller that creates a dialog between two processes or we can say that it allows the communication between two processes which can be either half-duplex or full-duplex.
- o **Synchronization:** Session layer adds some checkpoints when transmitting the data in a sequence. If some error occurs in the middle of the transmission of data, then the transmission will take place again from the checkpoint. This process is known as Synchronization and recovery.

6) Presentation Layer

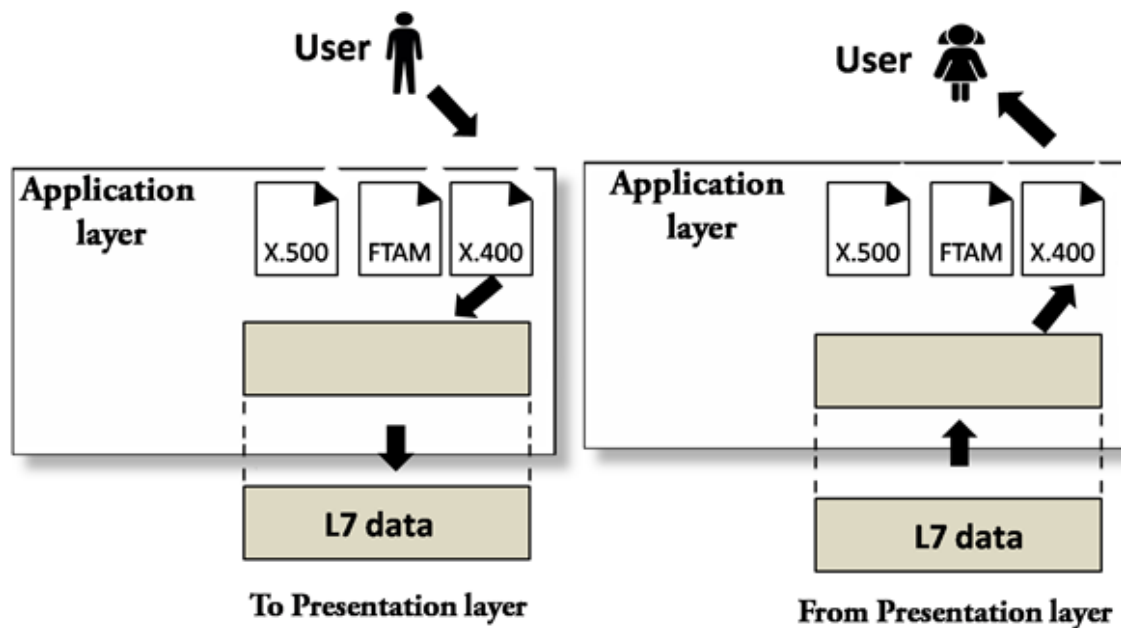From application layer   To application layer
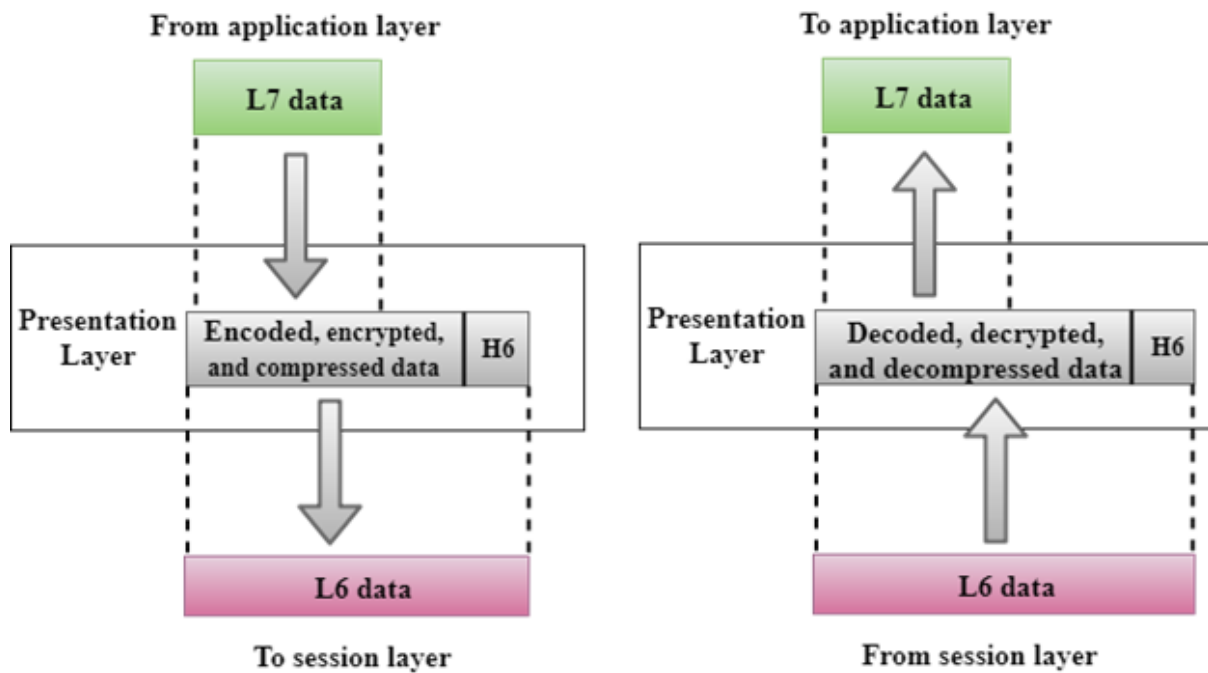
- o A Presentation layer is mainly concerned with the syntax and semantics of the information exchanged between the two systems.
- o It acts as a data translator for a network.
- o This layer is a part of the operating system that converts the data from one presentation format to another format.
- o The Presentation layer is also known as the syntax layer.

Functions of Presentation layer:

- o **Translation:** The processes in two systems exchange the information in the form of character strings, numbers and so on. Different computers use different encoding methods, the presentation layer handles the interoperability between the different encoding methods. It converts the data from sender-dependent format into a common format and changes the common format into receiver-dependent format at the receiving end.
- o **Encryption:** Encryption is needed to maintain privacy. Encryption is a process of converting the sender-transmitted information into another form and sends the resulting message over the network.
- o **Compression:** Data compression is a process of compressing the data, i.e., it reduces the number of bits to be transmitted. Data compression is very important in multimedia such as text, audio, video.

7) Application Layer

To Presentation layer   From Presentation layer

- o   An application layer serves as a window for users and application processes to access network service.
- o   It handles issues such as network transparency, resource allocation, etc.
- o   An application layer is not an application, but it performs the application layer functions.
- o   This layer provides the network services to the end-users.

Functions of Application layer:

- o   **File transfer, access, and management (FTAM):** An application layer allows a user to access the files in a remote computer, to retrieve the files from a computer and to manage the files in a remote computer.
- o   **Mail services:** An application layer provides the facility for email forwarding and storage.
- o   Directory services: An application provides the distributed database sources and is used to provide that global information about various objects.

TCP/IP model

- o   The TCP/IP model was developed prior to the OSI model.
- o   The TCP/IP model is not exactly similar to the OSI model.
- o   The TCP/IP model consists of five layers: the application layer, transport layer, network layer, data link layer and physical layer.

- TCP/IP is a hierarchical protocol made up of interactive modules, and each of them provides specific functionality.
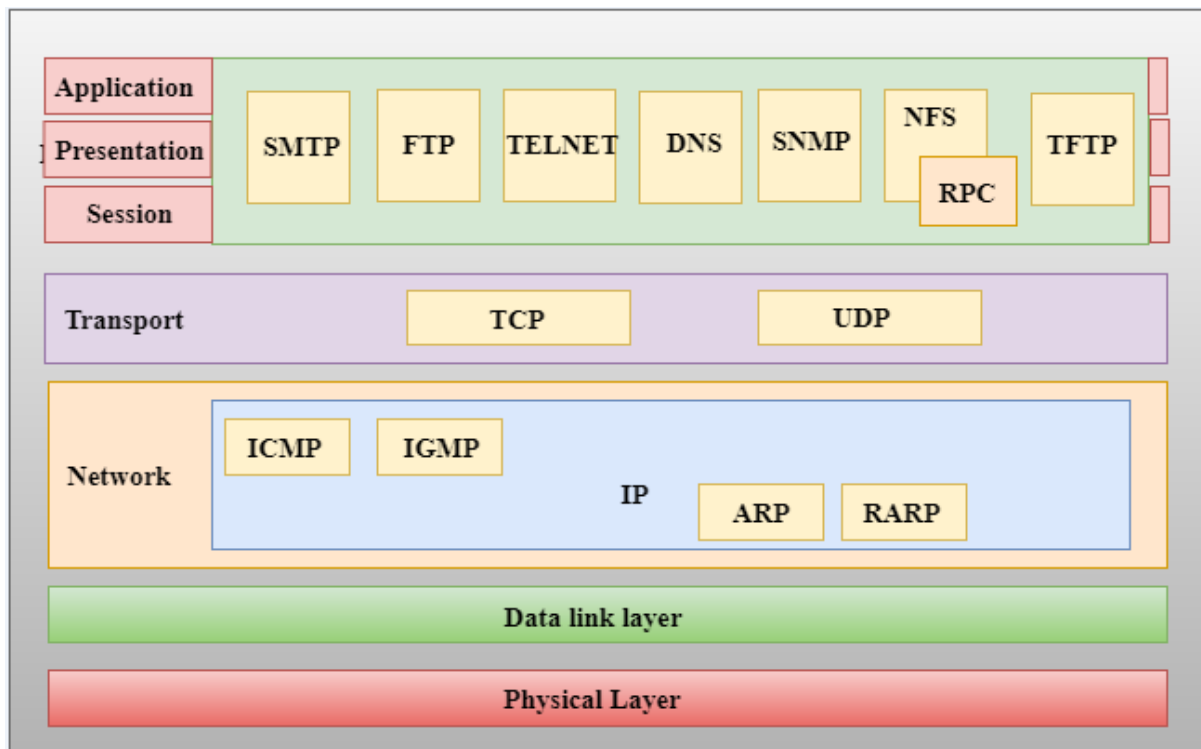
The TCP/IP model is a concise version of the OSI model. It contains four layers, unlike seven layers in the OSI model. The layers are:

1. Process/Application Layer
2. Host-to-Host/Transport Layer
3. Internet Layer
4. Network Access/Link Layer

1. Network Access Layer –

This layer corresponds to the combination of Data Link Layer and Physical Layer of the OSI model. It looks out for hardware addressing and the protocols present in this layer allows for the physical transmission of data.

2. Internet Layer –

This layer parallels the functions of OSI's Network layer. It defines the protocols which are responsible for logical transmission of data over the entire network. The main protocols residing at this layer are :

1. IP – stands for Internet Protocol and it is responsible for delivering packets from the source host to the destination host by looking at the IP addresses in the packet headers.
2. ICMP – stands for Internet Control Message Protocol. It is encapsulated within IP datagrams and is responsible for providing hosts with information about network problems.
3. ARP – stands for Address Resolution Protocol. Its job is to find the hardware address of a host from a known IP address.

3. Host-to-Host Layer –

This layer is analogous to the transport layer of the OSI model. It is responsible for end-to-end communication and error-free delivery of data. It shields the upper-layer applications from the complexities of data. The two main protocols present in this layer are :

1. Transmission Control Protocol (TCP) – It is known to provide reliable and error-free communication between end systems. It performs sequencing and segmentation of data.
2. User Datagram Protocol (UDP) – On the other hand does not provide any such features. It is the go-to protocol if your application does not require reliable transport as it is very cost-effective. Unlike TCP, which is connection-oriented protocol, UDP is connectionless.

4. Application Layer –

This layer performs the functions of top three layers of the OSI model: Application, Presentation and Session Layer. It is responsible for node-to-node communication and controls user-interface specifications. Some of the protocols present in this layer are: HTTP, HTTPS, FTP, TFTP, Telnet, SSH, SMTP, SNMP, NTP, DNS, DHCP, NFS, X Window, LPD.

Types of Transmission Media

In data communication terminology, a transmission medium is a physical path between the transmitter and the receiver i.e. it is the channel through which data is sent from one place to another. Transmission Media is broadly classified into the following types:
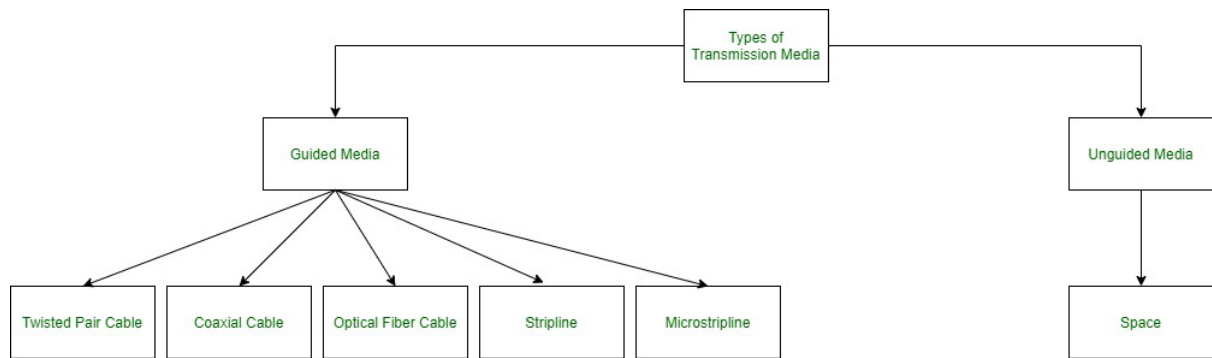
1. Guided Media: It is also referred to as Wired or Bounded transmission media. Signals being transmitted are directed and confined in a narrow pathway by using physical-links.

Features:

- High Speed
- Secure
- Used for comparatively shorter distances

There are 3 major types of Guided Media:

Twisted pair:

Twisted pair is a physical media made up of a pair of cables twisted with each other. A twisted pair cable is cheap as compared to other transmission media. Installation of the twisted pair cable is easy, and it is a lightweight cable. The frequency range for twisted pair cable is from 0 to 3.5KHz.

A twisted pair consists of two insulated copper wires arranged in a regular spiral pattern.

The degree of reduction in noise interference is determined by the number of turns per foot. Increasing the number of turns per foot decreases noise interference.

Types of Twisted pair:
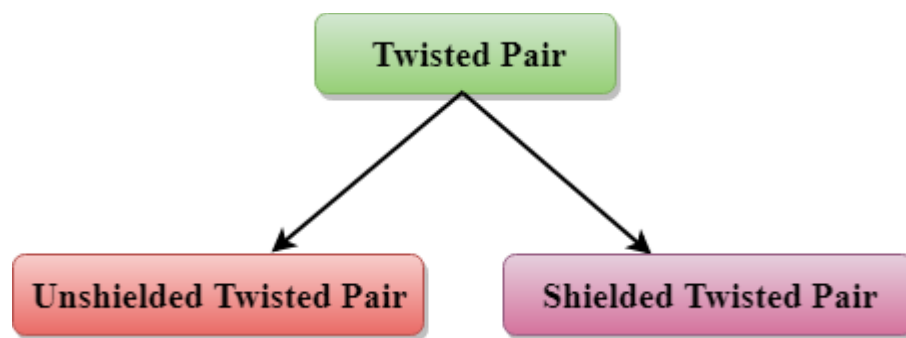
Coaxial Cable

- o Coaxial cable is very commonly used transmission media, for example, TV wire is usually a coaxial cable.
- o The name of the cable is coaxial as it contains two conductors parallel to each other.
- o It has a higher frequency as compared to Twisted pair cable.
- o The inner conductor of the coaxial cable is made up of copper, and the outer conductor is made up of copper mesh. The middle core is made up of non-conductive cover that separates the inner conductor from the outer conductor.
- o The middle core is responsible for the data transferring whereas the copper mesh prevents from the **EMI**(Electromagnetic interference).
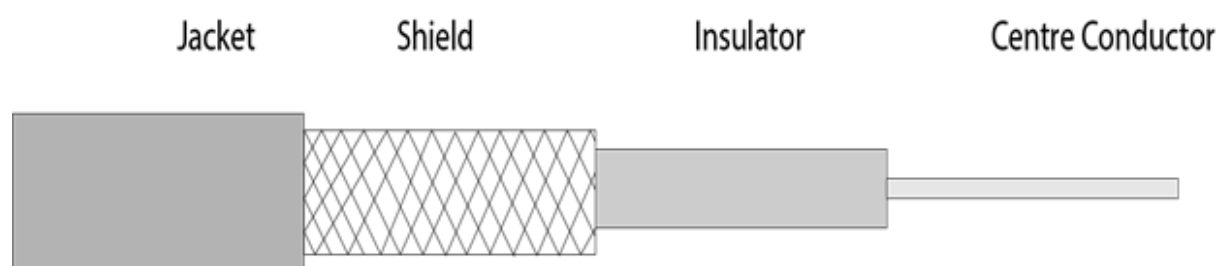
Fibre Optic

- o Fibre optic cable is a cable that uses electrical signals for communication.
- o Fibre optic is a cable that holds the optical fibres coated in plastic that are used to send the data by pulses of light.

- o The plastic coating protects the optical fibres from heat, cold, electromagnetic interference from other types of wiring.
- o Fibre optics provide faster data transmission than copper wires.

**Diagrammatic representation of fibre optic cable:**

UnGuided Transmission

- o An unguided transmission transmits the electromagnetic waves without using any physical medium. Therefore it is also known as **wireless transmission**.
- o In unguided media, air is the media through which the electromagnetic energy can flow easily.

Unguided transmission is broadly classified into three categories:

Radio waves

- o Radio waves are the electromagnetic waves that are transmitted in all the directions of free space.
- o Radio waves are omnidirectional, i.e., the signals are propagated in all the directions.
- o In the case of radio waves, the sending and receiving antenna are not aligned, i.e., the wave sent by the sending antenna can be received by any receiving antenna.
- o An example of the radio wave is **FM radio**.
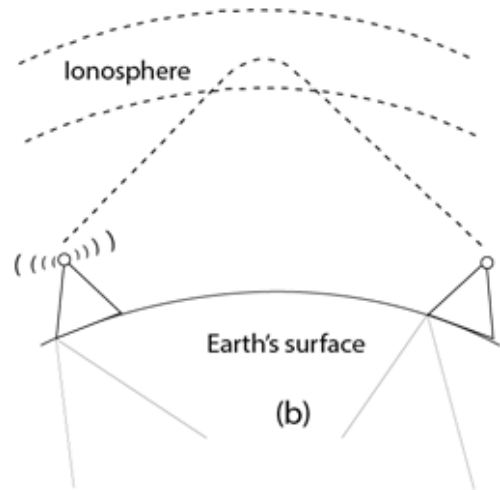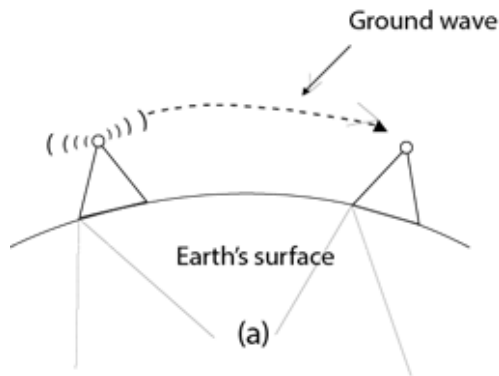
Microwaves

- o Terrestrial microwave
- o Satellite microwave communication.

Terrestrial Microwave Transmission

- o Terrestrial Microwave transmission is a technology that transmits the focused beam of a radio signal from one ground-based microwave transmission antenna to another.

Satellite Microwave Communication

- o A satellite is a physical object that revolves around the earth at a known height.
- o Satellite communication is more reliable nowadays as it offers more flexibility than cable and fibre optic systems.

Infrared

- o An infrared transmission is a wireless technology used for communication over short ranges.
- o The frequency of the infrared in the range from 300 GHz to 400 THz.
- o It is used for short-range communication such as data transfer between two cell phones, TV remote operation, data transfer between a computer and cell phone resides in the same closed area.

Manchester

- o It changes the signal at the middle of the bit interval but does not return to zero for synchronization.

- In Manchester encoding, a negative-to-positive transition represents binary 1, and positive-to-negative transition represents 0.
- Manchester has the same level of synchronization as RZ scheme except that it has two levels of amplitude.

Differential Manchester

- It changes the signal at the middle of the bit interval for synchronization, but the presence or absence of the transition at the beginning of the interval determines the bit. A transition means binary 0 and no transition means binary 1.
- In Manchester Encoding scheme, two signal changes represent 0 and one signal change represent 1.
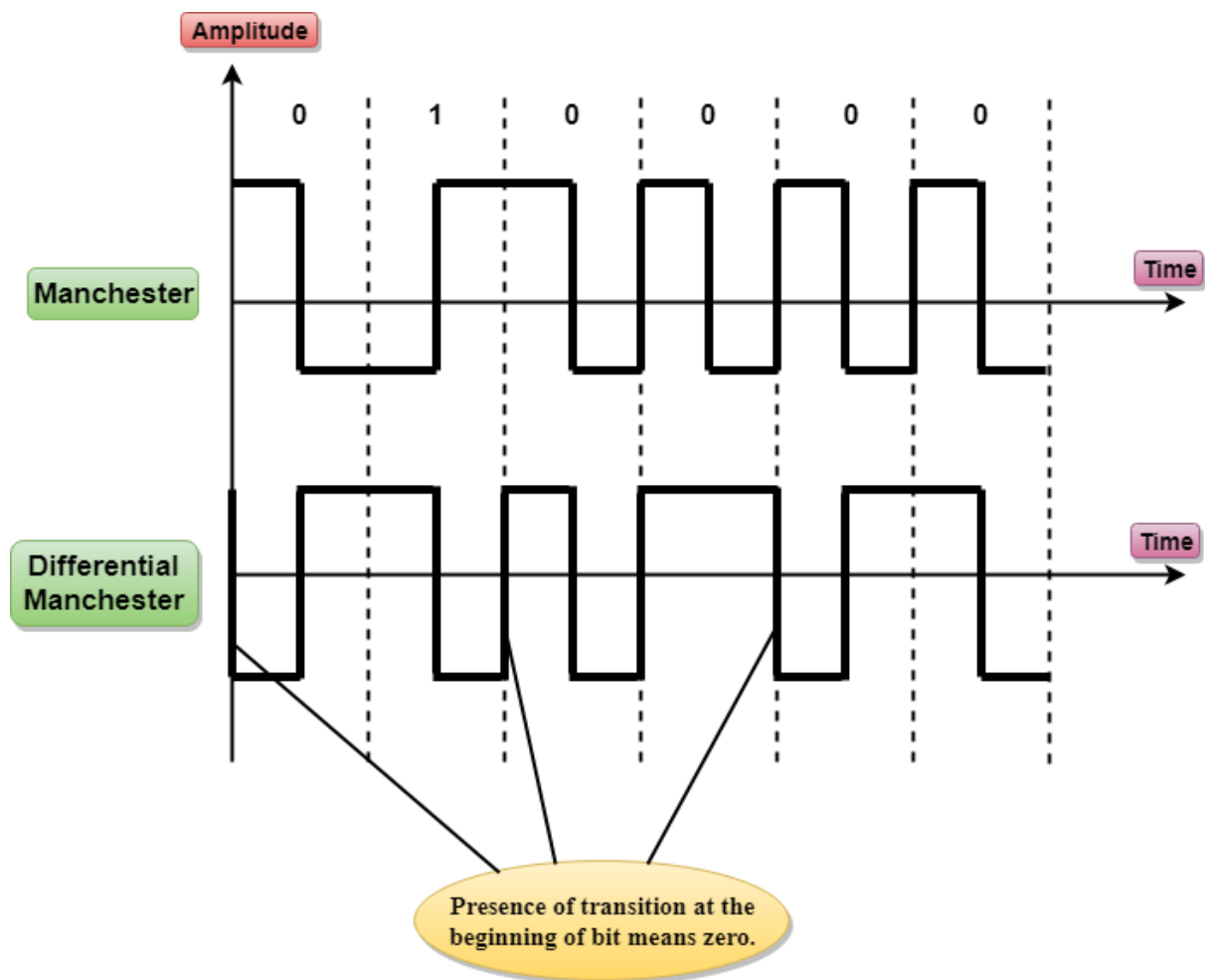
What Does Asynchronous Communication Mean?

Asynchronous communication is a transmission technique commonly used by personal computers (PCs) to connect to modems, printers, fax

machines, modems, etc. With asynchronous communication, a series of bytes or ASCII characters can be sent via a single wire.

The data is transmitted as a series of bits.

Integrated Services Digital Network (ISDN)

These are a set of communication standards for simultaneous digital transmission of voice, video, data, and other network services over the traditional circuits of the public switched telephone network. Before *Integrated Services Digital Network (ISDN)*, the telephone system was seen as a way to transmit voice, with some special services available for data. The main feature of ISDN is that it can integrate speech and data on the same lines, which were not available in the classic telephone system.

ISDN is a circuit-switched telephone network system, but it also provides access to packet-switched networks that allows digital transmission of voice and data. This results in potentially better voice or data quality than an analog phone can provide. It provides a packet-switched connection for data in increments of 64 kilobit/s. It provided a maximum of 128 kbit/s bandwidth in both upstream and downstream directions. A greater data rate was achieved through channel bonding.

Broadband-ISDN(B-ISDN)–
Narrowband ISDN has been designed to operate over the current communications infrastructure, which is heavily dependent on the copper cable however B-ISDN relies mainly on the evolution of fibre optics. According to CCITT B-ISDN is best described as a service requiring transmission channels capable of supporting rates greater than the primary rate.

Advantages of ISDN:

- ISDN channels have a reliable connection.
- ISDN is used to facilitate the user with multiple digital channels.
- It has faster data transfer rate.

Disadvantages of ISDN:

- ISDN lines costlier than the other telephone system.
- It requires specialized digital devices.
- It is less flexible.

Asynchronous Transfer Mode (ATM):

It is an International Telecommunication Union- Telecommunications Standards Section (ITU-T) efficient for call relay and it transmits all information including multiple service types such as data, video, or voice which is conveyed in small fixed-size packets called cells. Cells are transmitted asynchronously and the network is connection-oriented.

ATM is a technology that has some event in the development of broadband ISDN in the 1970s and 1980s, which can be considered an evolution of packet switching. *Each cell is 53 bytes long* – 5 bytes header and 48 bytes payload. Making an ATM call requires first sending a message to set up a connection.

Subsequently, all cells follow the same path to the destination. It can handle both constant rate traffic and variable rate traffic. Thus it can carry multiple types of traffic with **end-to-end** quality of service. ATM is independent of a transmission medium, they may be sent on a wire or fiber by themselves or they may also be packaged inside the payload of other carrier systems. ATM networks use "Packet" or "cell" Switching with virtual circuits. Its design helps in the implementation of high-performance multimedia networking.