EII-UNIT 4: Computer Networking

Introduction to computer networks Types of networks : LAN, MAN, WAN, Wireless networks, Switching, Internet, Network topology : point to point, Star, Ring, Bus, Mesh, Tree, Daisy Chain, Hybrid Network devices : Repeater, Switch, Networking cables, Router, Bridge, Hub, Brouter, Gateway. Wired LANs:- Ethernet: Ethernet protocol, standard Ethernet, 100 MBPS Ethernet, Gigabit Ethernet, 10 Gigabit Ethernet, Computer network model: OSI and TCP/IP.

NETWORKS

A network is a set of devices (often referred to as nodes) connected by communication links. A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network. "Computer network'' to mean a collection of autonomous computers interconnected by a single technology. Two computers are said to be interconnected if they are able to exchange information.

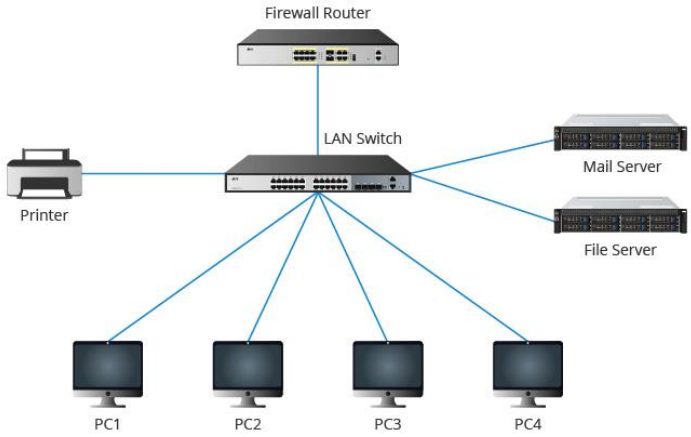
A Computer Network can be defined as a group of computers and other devices connected in some ways to exchange data. Each device on the network is treated as a node and each node has a unique address.

Types of Computer Network

1. Local Area Network (LAN)

1. Local area network is a group of computers connected with each other in a small places such as school, hospital, apartment etc. with a link (wires, Ethernet, cables, fiberoptics,Wi-Fi)
2. LAN is secure because there is no outside connection with the local area network thus the data which is shared is safe on the local area network and can't be accessed outside.
3. LAN due to their small size are considerably faster, their speed can range anywhere from 100 to 100Mbps.

4. LANs are not limited to wire connection, there is a new evolution to the LANs that allows local area network to work on a wireless connection.



Advantages of LAN

Here are pros/benefits of using LAN:

- Computer resources like hard-disks, DVD-ROM, and printers can share local area networks. This significantly reduces the cost of hardware purchases.
- You can use the same software over the network instead of purchasing the licensed software for each client in the network.
- Data of all network users can be stored on a single hard disk of the server computer.
- You can easily transfer data and messages over networked computers.
- It will be easy to manage data at only one place, which makes data more secure.
- Local Area Network offers the facility to share a single internet connection among all the LAN users.

Disadvantages of LAN

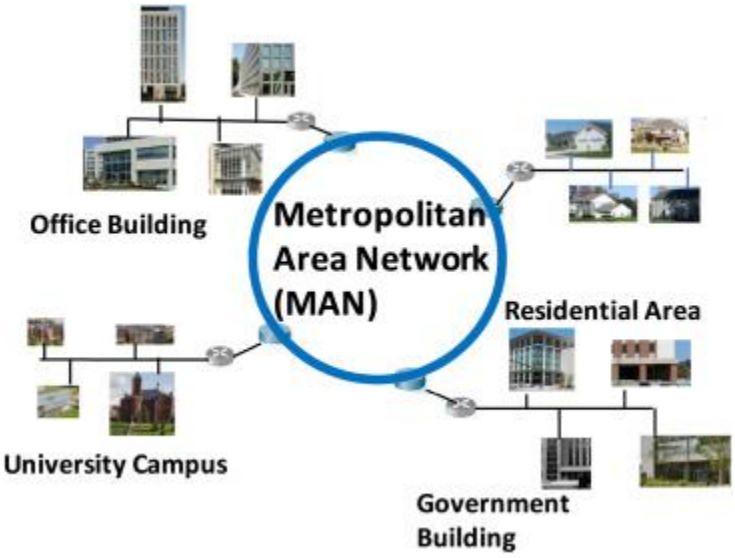
Here are the important cons/ drawbacks of LAN:

- LAN will indeed save cost because of shared computer resources, but the initial cost of installing Local Area Networks is quite high.
- The LAN admin can check personal data files of every LAN user, so it does not offer good privacy.

- Unauthorized users can access critical data of an organization in case LAN admin is not able to secure centralized data repository.
- Local Area Network requires a constant LAN administration as there are issues related to software setup and hardware failures

Metropolitan Area Network (MAN)

MAN network covers larger area by connections LANs to a larger network of computers. In Metropolitan area network various Local area networks are connected with each other through telephone lines. The size of the Metropolitan area network is larger than LANs and smaller than WANs(wide area networks), a MANs covers the larger area of a city or town.



Advantages of MAN

Here are pros/benefits of using MAN system:

- It offers fast communication using high-speed carriers, like fiber optic cables.
- It provides excellent support for an extensive size network and greater access to WANs.
- The dual bus in MAN network provides support to transmit data in both directions concurrently.
- A MAN network mostly includes some areas of a city or an entire city.

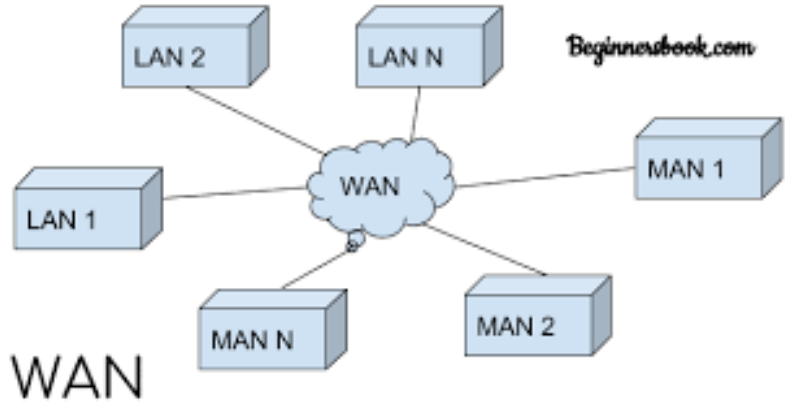
Disadvantages of MAN

Here are drawbacks/ cons of using the MAN network:

- You need more cable to establish MAN connection from one place to another.
- In MAN network it is tough to make the system secure from hackers

Wide area network (WAN)

Wide area network provides long distance transmission of data. The size of the WAN is larger than LAN and MAN. A WAN can cover country, continent or even a whole world. Internet connection is an example of WAN. Other examples of WAN are mobile broadband connections such as 3G, 4G etc.



Advantages of WAN

Here are the benefits/ pros of using WAN:

- WAN helps you to cover a larger geographical area. Therefore business offices situated at longer distances can easily communicate.
- Contains devices like mobile phones, laptop, tablet, computers, gaming consoles, etc.
- WLAN connections work using radio transmitters and receivers built into client devices.

Disadvantage of WAN

Here are drawbacks/cons of using WAN:

- The initial setup cost of investment is very high.
- It is difficult to maintain the WAN network. You need skilled technicians and network administrators.
- There are more errors and issues because of the wide coverage and the use of different technologies.
- It requires more time to resolve issues because of the involvement of multiple wired and wireless technologies.
- Offers lower security compared to other types of networks.

Wireless Networks 

1. Wireless networks are computer networks that are not connected by cables of any kind.
2. A wireless network provides a network without the use of wires because by using it you can connect your computer to the network using radio waves and can move your computer anywhere.
3. The basis of wireless systems are radio waves, an implementation that takes place at the physical level of network structure.
4. Wireless Networks uses spread-spectrum technology
5. Wireless networks are classified into different type such as wireless LAN, WAN, MAN, PAN or
6. Examples of wireless networks include cell phone networks, wireless local area networks (WLANs), wireless sensor networks, satellite communication networks, and terrestrial microwave networks.

Advantages of Wireless Network

1. Wireless networks are a powerful tool for increasing productivity and encouraging information sharing.
2. Wireless networks are a powerful tool for increasing productivity and encouraging information sharing.
3. Without connecting wires you can have access to emails, documents, applications, and other network resources, employees can move where you need to and have constant access to do your job.
4. Compared to a wired network, wireless networks are cost effective as it reduces the amount of buying cables and other connecting accessories. It also requires less maintenance since there is no wiring involved.

5. Mobility is the great advantage of the wireless network as it enables you to access the server from anywhere in the room. Sometimes you can connect it remotely if you are away from home or office.
6. The security of wireless is very good as it involves the latest encryption technology. So the data and sensitive information cannot be hacked.

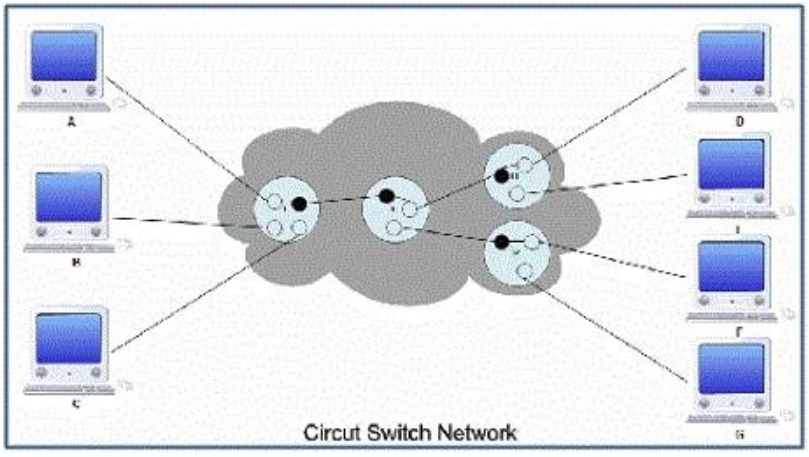
Switching techniques

1. In large networks, there can be multiple paths from sender to receiver. The switching technique will decide the best route for data transmission.
2. Switching technique is used to connect the systems for making one-to-one communication.
3. In the simplest terms, a switch is a mechanism that allows us to interconnect links to form a larger network. A switch is a multi-input, multi-output device that transfers packets from an input to one or more outputs.

4. Hardware devices that can be used for switching or transfering data from one location to another that can use multiple layers of the Open Systems Interconnection (OSI) model. Hardware devices that can used for switching data in single location like collage lab is Hardware switch or hub but if you want to transfer data between to different location or remote location then we can use router or gateways.

Types of Switching Techniques

Circuit Switching



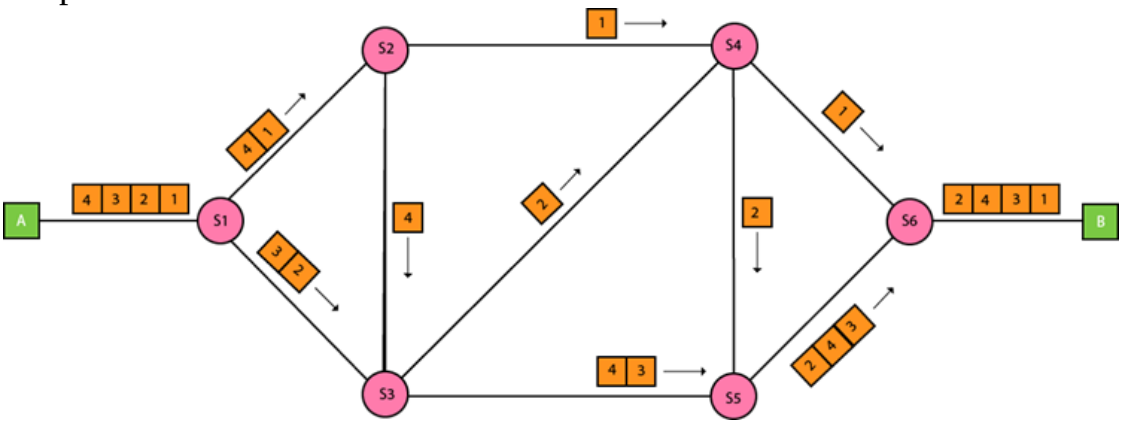
Circuit-switching is the real-time connection-oriented system. In Circuit Switching a dedicated channel (or circuit) is set up for a single connection between the sender and recipient during the communication session.

1. Circuit switching is a switching technique that establishes a dedicated path between sender and receiver.
2. In the Circuit Switching Technique, once the connection is established then the dedicated path will remain to exist until the connection is terminated.
3. Circuit switching in a network operates in a similar way as the telephone works.
4. A complete end-to-end path must exist before the communication takes place.
5. In case of circuit switching technique, when any user wants to send the data, voice, video, a request signal is sent to the receiver then the receiver sends back the acknowledgment to ensure the availability of the dedicated path. After receiving the acknowledgment, dedicated path transfers the data.
6. Circuit switching is used in public telephone network. It is used for voice transmission.
7. Fixed data can be transferred at a time in circuit switching technology.

Packet Switching

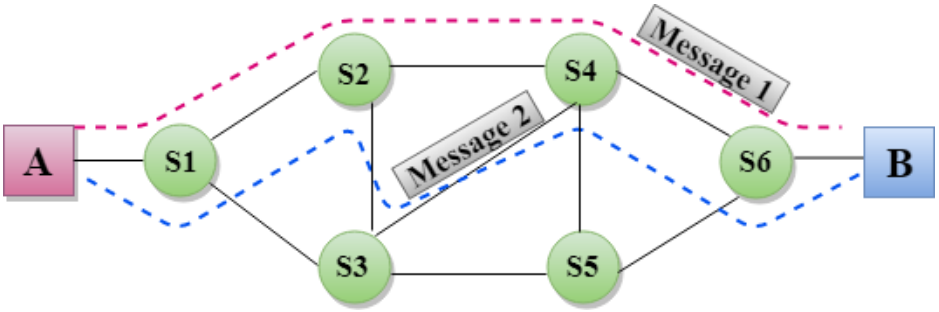
The basic example of Packet Switching is the Internet.In Packet Switching, data can be fragmented into suitably-sized pieces in variable length or blocks that are called packets that can be routed independently by network devices based on the destination address contained certain “formatted” header within each packet. The packet switched networks allow sender and recipient without reserving the circuit. Multiple paths are exist between sender and recipient in a packet switching network.They does not require a call setup to transfer packets between sender and

recipient.



Message Switching

Message switching does not set up a dedicated channel (or circuit) between the sender and recipient during the communication session. In Message Switching each message is treated as an independent block.



Internet

The **Internet** is the global system of interconnected computer networks that uses the Internet protocol suite (TCP/IP) to communicate between networks and devices.

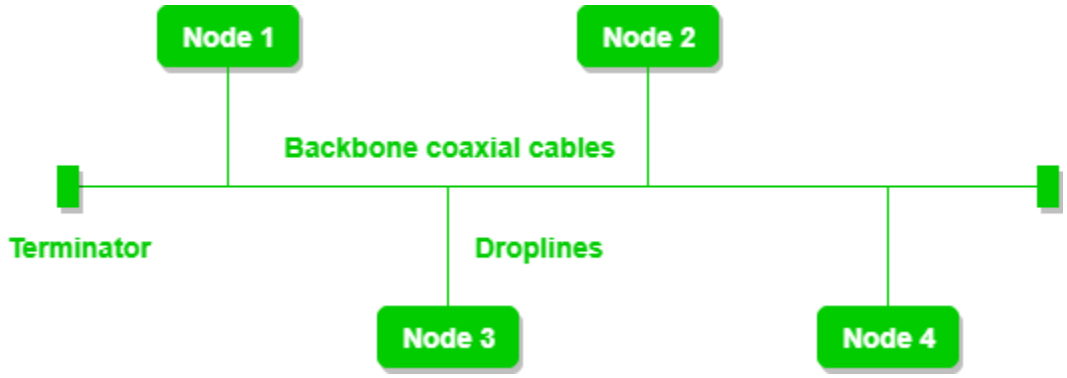
The Internet works through a series of networks that connect devices around the world through telephone lines. Users are provided access to the Internet by Internet service providers. The widespread use of mobile broadband and Wi-Fi in the 21st century has allowed this connection to be wireless.

Network Topologies

The term Network **Topology** defines the **geographic Physical or logical arrangement of** computer **networking devices** . The term **Topology** refers to the way in which the various nodes or computers of a network are linked together. It describes the actual layout of the computer network hardware. Two or more devices connect to a link; two or more links form a topology. Topology determines the data paths that may be used between any pair of devices of the network.

BUS Topology

Bus topology is a network type in which every computer and network device is connected to single cable. When it has exactly two endpoints, then it is called **Linear Bus topology**.



Problems with this topology :

- If the common cable fails, then the whole system will crash down.
- If the network traffic is heavy, it increases collisions in the network. To avoid this, various protocols are used in MAC layer known as Pure Aloha, Slotted Aloha, CSMA/CD etc

Features of Bus Topology

1. It transmits data only in one direction.
2. Every device is connected to a single cable

Advantages of Bus Topology

1. It is cost effective.
2. Cable required is least compared to other network topology.
3. Used in small networks.
4. It is easy to understand.
5. Easy to expand joining two cables together.

Disadvantages of Bus Topology

1. Cables fails then whole network fails.
2. If network traffic is heavy or nodes are more the performance of the network decreases.
3. Cable has a limited length.
4. It is slower than the ring topology

Mesh Topology:

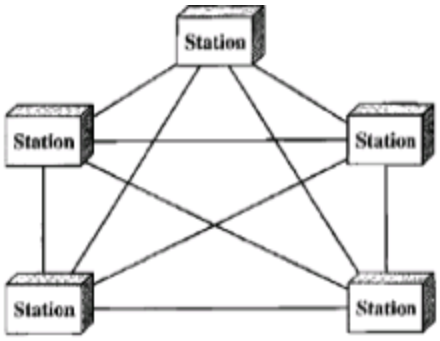
In this topology, every device has a dedicated point to point link to every other device.

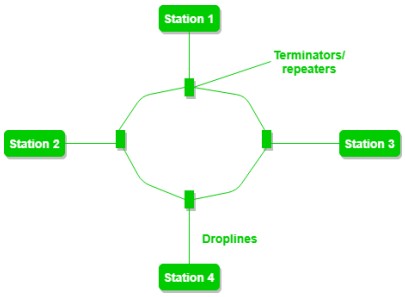
Advantages:

- It eliminates traffic problems that occurs when links must be shared by multiple devices
- It is robust and makes fault identification and fault isolation easy.

Disadvantages:

- Installation and reconnection are difficult.
- The share bulk of wiring can be greater than the available space can accommodate
- The hardware required to connect each links (I/O ports and cable) can be prohibitively expensive.





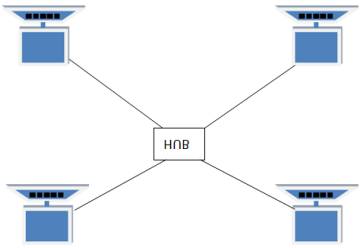
The following operations takes place in ring topology are :

1. One station is known as **monitor** station which takes all the responsibility to perform the operations.
2. To transmit the data, station has to hold the token. After the transmission is done, the token is to be released for other stations to use.
3. When no station is transmitting the data, then the token will circulate in the ring.
4. There are two types of token release techniques : **Early token release** releases the token just after the transmitting the data and **Delay token release** releases the token after the acknowledgement is received from the receiver

Star Topology:

In this topology, each device has a dedicated point-to-point link only to a central controller usually called a hub. Unlike a mesh topology a star topology does not allow direct traffic between devices, Controller acts as on Exchange.

In star topology, all the devices are connected to a single hub through a cable. This hub is the central node and all others nodes are connected to the central node. The hub can be passive in nature i.e. not intelligent hub such as broadcasting devices, at the same time the hub can be intelligent known as active hubs. Active hubs have repeaters in them.



Features of Star Topology

1. Every node has its own dedicated connection to the hub.
2. Hub acts as a repeater for data flow.
3. Can be used with twisted pair, Optical Fibre or coaxial cable.

Advantages of Star Topology

1. Fast performance with few nodes and low network traffic.
2. Hub can be upgraded easily.
3. Easy to troubleshoot.
4. Easy to setup and modify.
5. Only that node is affected which has failed, rest of the nodes can work smoothly.

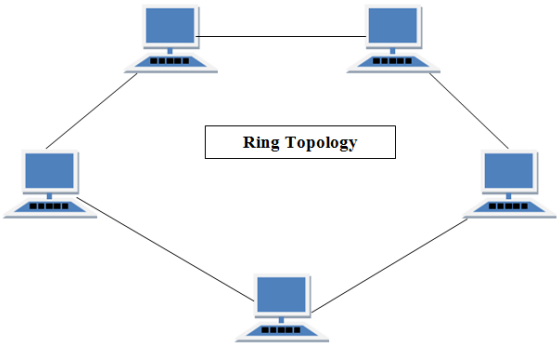
Disadvantages of Star Topology

1. Cost of installation is high.
2. Expensive to use.
3. If the hub fails then the whole network is stopped because all the nodes depend on the hub.
4. Performance is based on the hub that is it depends on its capacity
5. More cabling required as compared to bus or ring topology
6. One of the biggest disadvantages of a star topology is the dependency of the whole topology on one single point, the hub, if the hub goes down, the whole system is dead.

Ring Topology:

The physical ring **Topology** is a **circular loop of point-to-point links**. Each device connects directly to the **ring or indirectly through and interface device** or drop cable. Message travel around the ring from node to node in a very organized manner. Each workstation checks the message for a matching destination address. If the address doesn't match the node simply regenerates the message and sends it on its way. If the address matches, the node accepts the message and sends a reply to the originating sender.

- • In ring topology, the various nodes are connected in form of a ring or circle (physical ring), in which data flows in a circle, from one station to another station.



Features of Ring Topology

1. A number of repeaters are used for Ring topology with large number of nodes, because if someone wants to send some data to the last node in the ring topology with 100 nodes, then the data will have to pass through 99 nodes to reach the 100th node. Hence to prevent data loss repeaters are used in the network.
2. The transmission is unidirectional, but it can be made bidirectional by having 2 connections between each Network Node, it is called **Dual Ring Topology**.
3. In Dual Ring Topology, two ring networks are formed, and data flow is in opposite direction in them. Also, if one ring fails, the second ring can act as a backup, to keep the network up.

4. Data is transferred in a sequential manner that is bit by bit. Data transmitted, has to pass through each node of the network, till the destination node.

Advantages of Ring Topology

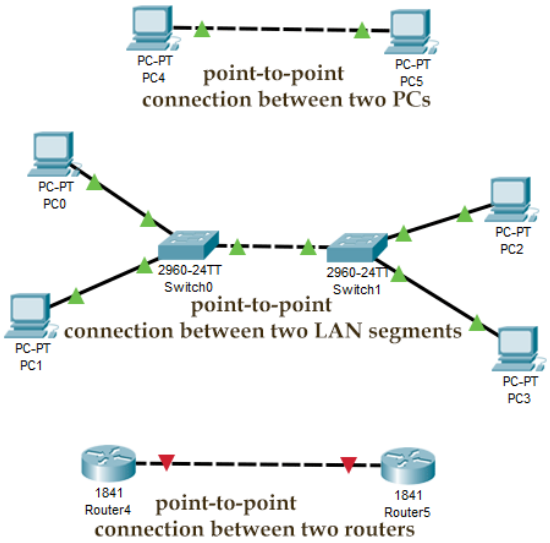
1. Transmitting network is not affected by high traffic or by adding more nodes, as only the nodes having tokens can transmit data.
2. Cheap to install and expand

Disadvantages of Ring Topology

1. Troubleshooting is difficult in ring topology.
2. Adding or deleting the computers disturbs the network activity.
3. Failure of one computer disturbs the whole network.

Point-to-point topology

This is the simplest form of network topology. In this topology, two end devices directly connect with each other. The following image shows a few examples of this topology.



Tree Topology

Tree topology has a group of star networks connected to a linear bus backbone cable. It incorporates features of both star and bus topologies. Tree topology is also called hierarchical topology.

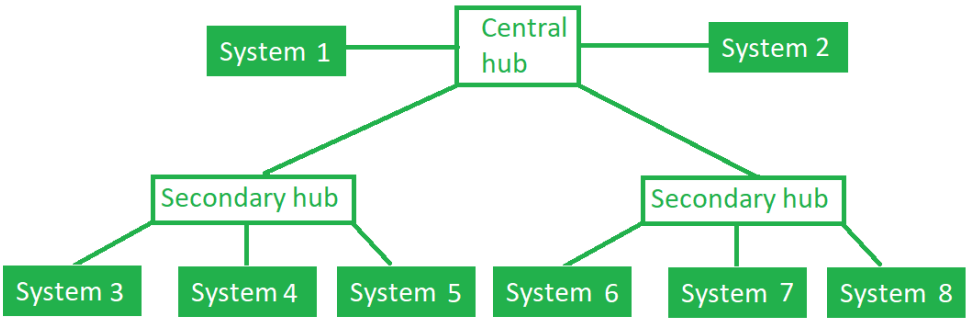
In this topology, each device has a dedicated point-to-point link only to a central controller usually called a hub. Unlike a mesh topology a star topology does not allow direct traffic between devices, Controller acts as on Exchange.

Advantages:

- Less expensive than mesh topology as it requires less cabling
- Easy to install and reconfigure

Disadvantages:

- More cabling required as compared to bus or ring topology
- One of the biggest disadvantages of a star topology is the dependency of the whole topology on one single point, the hub, if the hub goes down, the whole system is dead.



Features of Tree Topology

1. Ideal if workstations are located in groups.
2. Used in Wide Area Network.

Advantages of Tree Topology

1. Extension of bus and star topologies.

2. Expansion of nodes is possible and easy.
3. Easily managed and maintained.
4. Error detection is easily done.

Disadvantages of Tree Topology

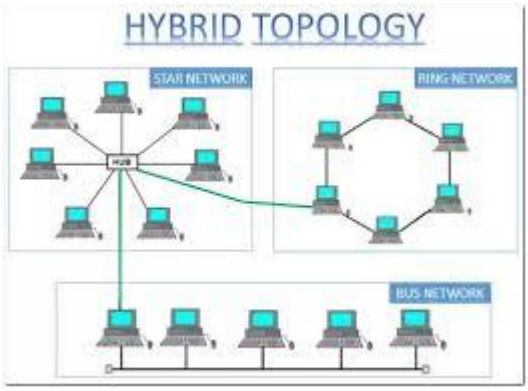
1. Heavily cabled.
2. Costly.
3. If more nodes are added maintenance is difficult.
4. Central hub fails, network fails.

Hybrid Topology

This topology is a mix of two or more topologies. For example, there are two networks; one is built from the star topology and another is built from the bus topology. If we connect both networks to build a single large network, the topology of the new network will be known as the hybrid topology.

You are not restricted to the bus and star topologies. You can combine any topology with another topology. In modern network implementations, the hybrid topology is mostly used to mix the wired network with the wireless network.

The following image shows an example of the hybrid network topology



Features of Hybrid Topology

1. It is a combination of two or topologies

2. Inherits the advantages and disadvantages of the topologies included

Advantages of Hybrid Topology

1. Reliable as Error detecting and trouble shooting is easy.
2. Effective.
3. Scalable as size can be increased easily.
4. Flexible.

Disadvantages of Hybrid Topology

1. Complex in design.
2. Costly

Daisy chain

The Daisy chain in the computer network topology is the interconnection of computers, peripherals or network nodes in sequence (one by one). If a message is intended for a computer that is in the middle line, each system bounces them in the chain until it reaches its destination. The main benefit of the daisy chain system is the simplicity of connecting computers and nodes.

Daisy-chaining is a common method used by system administrators to add more or new machines to the network. But it depends on what kind of network topology we use. For Instance, if we are using a point-to-point network, we must add the new device at the end of the chain (sometimes in the middle). However, in the ring network, there is no endpoint. so, the extra node becomes part of the topology.

Daisy Chain Network Advantages

- No Use of extra cables
- Data transmission is relatable fast and easier
- Cheap in terms of construction

Daisy Chain Network Disadvantages

- If a number of nodes increases in the network, it can slow down the whole network

Network devices:

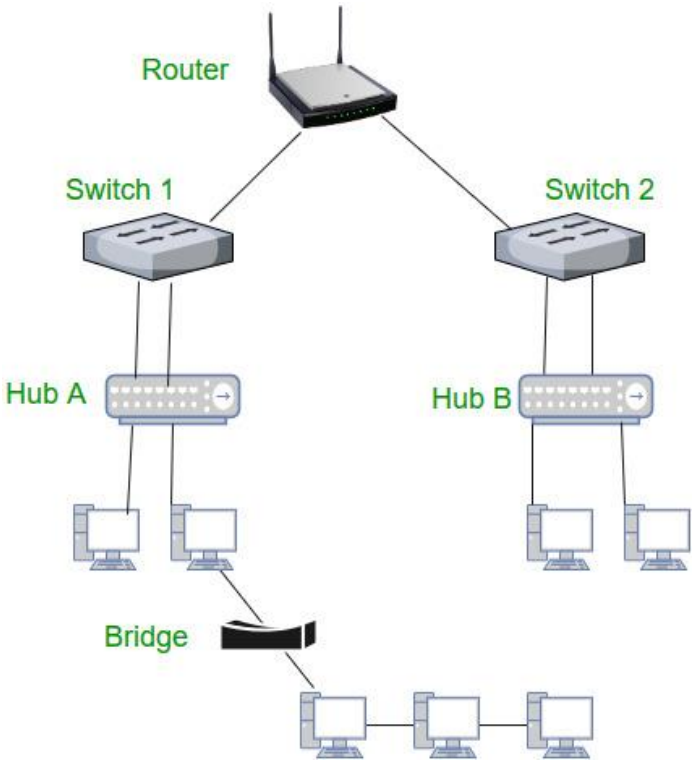
1. **Repeater** – A repeater operates at the physical layer. Its job is to regenerate the signal over the same network before the signal becomes too weak or corrupted so as to extend the length to which the signal can be transmitted over the same network. An important point to be noted about repeaters is that they do not amplify the signal. When the signal becomes weak, they copy the signal bit by bit and regenerate it at the original strength. It is a 2-port device.

2. **Hub** – A hub is basically a multiport repeater. A hub connects multiple wires coming from different branches, for example, the connector in star topology which connects different stations. Hubs cannot filter data, so data packets are sent to all connected devices. Also, they do not have the intelligence to find out best path for data packets which leads to inefficiencies and wastage.

3. **Bridge** – A bridge operates at data link layer. A bridge is a repeater, with add on the functionality of filtering content by reading the MAC addresses of source and destination. It is also used for interconnecting two LANs working on the same protocol. It has a single input and single output port, thus making it a 2 port device.

4. **Switch** – A switch is a multiport bridge with a buffer and a design that can boost its efficiency(a large number of ports imply less traffic) and performance. A switch is a data link layer device. The switch can perform error checking before forwarding data, that makes it very efficient as it does not forward packets that have errors and forward good packets selectively to correct port only.

5. **Routers** – A router is a device like a switch that routes data packets based on their IP addresses. Router is mainly a Network Layer device. Routers normally connect LANs and WANs together and have a dynamically updating routing table based on which they make decisions on routing the data packets. Router divide broadcast domains of hosts connected through it.



6. **Gateway** – A gateway, as the name suggests, is a passage to connect two networks together that may work upon different networking models. They basically work as the messenger agents that take data from one system, interpret it, and transfer it to another system. Gateways are also called protocol converters and can operate at any network layer. Gateways are generally more complex than switch or router.

7. Brouter – It is also known as bridging router is a device which combines features of both bridge and router. It can work either at data link layer or at network layer. Working as router, it is capable of routing packets across networks and working as bridge, it is capable of filtering local area network traffic.

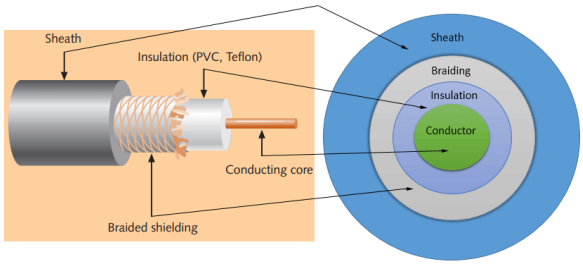
Network cables

To connect two or more computers or networking devices in a network, network cables are used. There are three types of network cables; coaxial, twisted-pair, and fiber-optic.

Coaxial cable

This cable contains a conductor, insulator, braiding, and sheath. The sheath covers the braiding, braiding covers the insulation, and the insulation covers the conductor.

The following image shows these components.



Sheath

This is the outer layer of the coaxial cable. It protects the cable from physical damage.

Braided shield

This shield protects signals from external interference and noise. This shield is built from the same metal that is used to build the core.

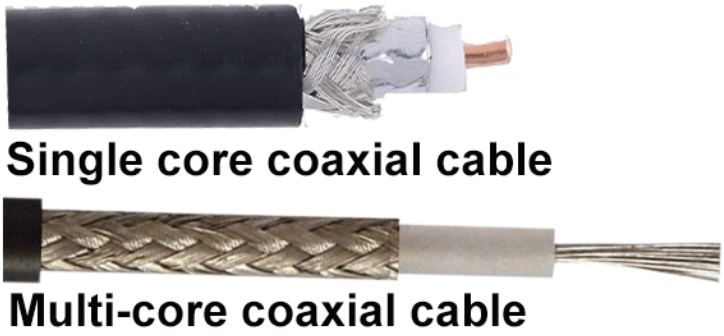
Insulation

Insulation protects the core. It also keeps the core separate from the braided-shield. Since both the core and the braided-shield use the same metal, without this layer, they will touch each other and create a short-circuit in the wire.

Conductor

The conductor carries electromagnetic signals. Based on conductor a coaxial cable can be categorized into two types; single-core coaxial cable and multi-core coaxial cable.

A **single-core** coaxial cable uses a single central metal (usually copper) conductor, while a **multi-core** coaxial cable uses multiple thin strands of metal wires. The following image shows both types of cable.



Twisted-pair cables

The twisted-pair cable was primarily developed for computer networks. This cable is also known as **Ethernet cable**. Almost all modern LAN computer networks use this cable.

This cable consists of color-coded pairs of insulated copper wires. Every two wires are twisted around each other to form pair. Usually, there are four pairs. Each pair has one solid color and one stripped color wire. Solid colors are blue, brown, green and orange. In stripped color, the solid color is mixed with the white color.

Based on how pairs are stripped in the plastic sheath, there are two types of twisted-pair cable; UTP and STP.

In the **UTP (*Unshielded twisted-pair*) cable**, all pairs are wrapped in a single plastic sheath.

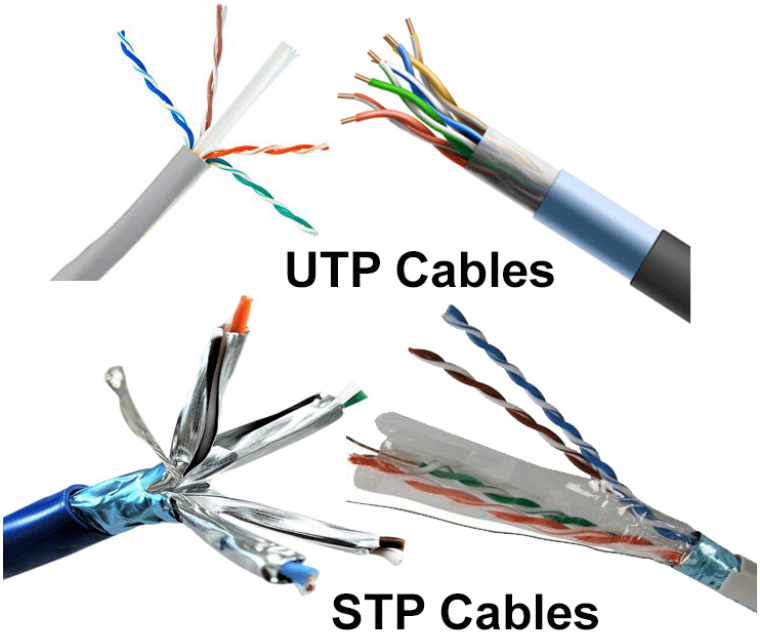
In the **STP (*Shielded twisted-pair*) cable**, each pair is wrapped with an additional metal shield, then all pairs are wrapped in a single outer plastic sheath.

Similarities and differences between STP and UTP cables

- Both STP and UTP can transmit data at 10Mbps, 100Mbps, 1Gbps, and 10Gbps.

- Since the STP cable contains more materials, it is more expensive than the UTP cable.
- Both cables use the same RJ-45 (registered jack) modular connectors.
- The STP provides more noise and EMI resistant than the UTP cable.
- The maximum segment length for both cables is 100 meters or 328 feet.
- Both cables can accommodate a maximum of 1024 nodes in each segment.

The following image shows both types of twisted-pair cable.



- Cat 5e, 6, 6a are the commonly used twisted-pair cables.

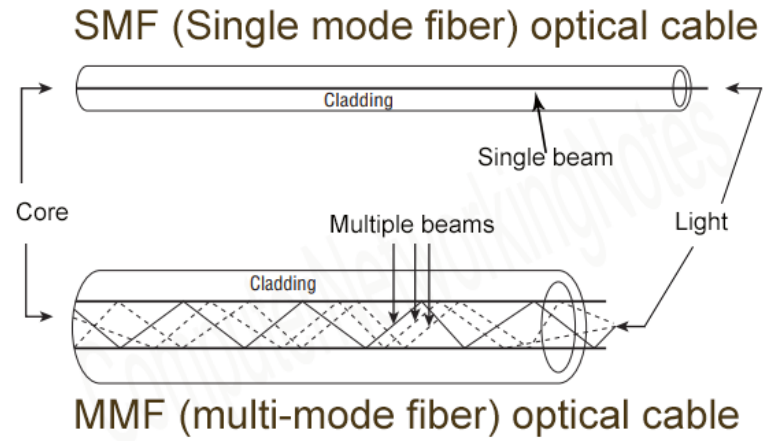
Fiber optic cable

This cable consists of core, cladding, buffer, and jacket. The core is made from the thin strands of glass or plastic that can carry data over the long distance. The core is wrapped in the cladding; the cladding is wrapped in the buffer, and the buffer is wrapped in the jacket.

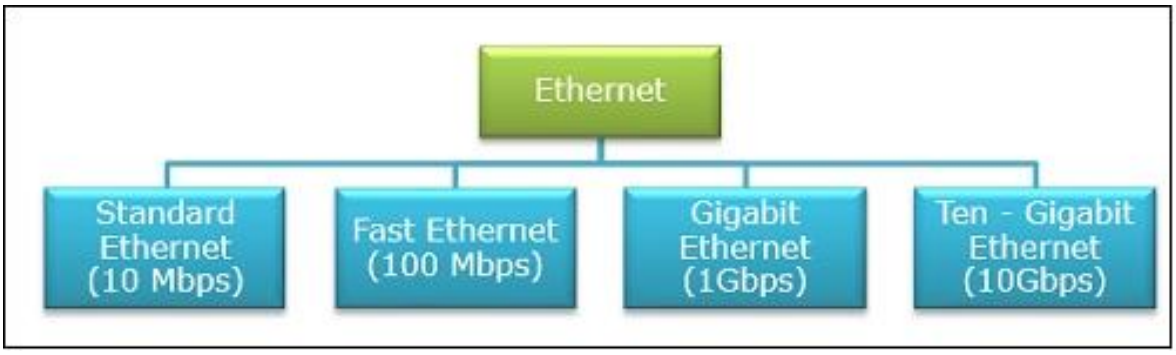
- Core carries the data signals in the form of the light.
- Cladding reflects light back to the core.
- Buffer protects the light from leaking.
- The jacket protects the cable from physical damage.

Fiber optic cable is completely immune to EMI and RFI. This cable can transmit data over a long distance at the highest speed. It can transmit data up to 40 kilometers at the speed of 100Gbps.

Fiber optic uses light to send data. It reflects light from one endpoint to another. Based on how many beams of light are transmitted at a given time, there are two types of fiber optical cable; SMF and MMF.



ETHERNET



Types of wired LAN Technology

Ethernet is the traditional technology for connecting devices in a wired local area network (LAN) or wide area network (WAN), enabling them to communicate with each other via a protocol -- a set of rules or common network language. Ethernet describes how network devices can format and transmit data so other devices on the same local or campus area network segment can recognize, receive and process the information. An Ethernet cable is the physical, encased wiring over which the data travels

How Ethernet works

IEEE specifies in the family of standards called IEEE 802.3 that the Ethernet protocol touches both Layer 1 (physical layer) and Layer 2 (data link layer) on the Open Systems Interconnection (OSI) network protocol model.

Ethernet defines two units of transmission: packet and frame. The frame includes not just the payload of data being transmitted, but also the following:

- the physical media access control (MAC) addresses of both the sender and receiver;
- virtual LAN (VLAN) tagging and quality of service (QoS) information; and

- error correction information to detect transmission problems.

Each frame is wrapped in a packet that contains several bytes of information to establish the connection and mark where the frame starts.

The Ethernet is a local area network (LAN) set of protocols which serves the physical and data link layers. Ethernet utilizes a linear bus or star topology. Ethernet served as the basis for the IEEE 802.3 standard.

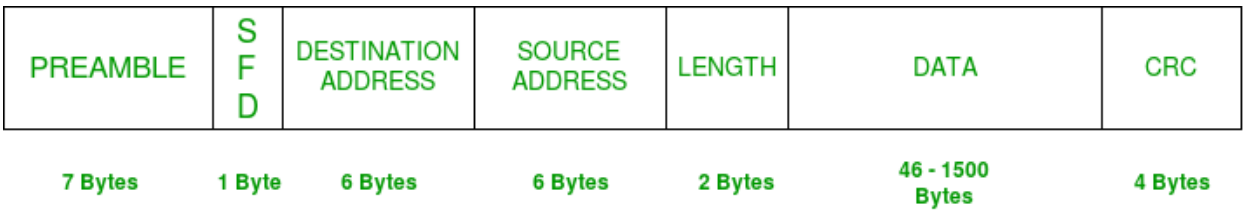
The Ethernet deals with the low level - Physical and Data Link Layers.

The Data Link Layer is divided into two sublayers:

- Logical Link Control (LLC). This sublayer establishes the transmission paths between computers or devices on a network.
- Media Access Control (MAC). On a network, the network interface card (NIC) has an unique hardware address which identifies a computer or peripheral device. The hardware address is used for the MAC sublayer addressing. Ethernet uses the MAC hardware addresses for the source and destination for each packet transmitted.

Ethernet uses CSMA/CD when transmitting packets. The Carrier Sense Multiple Access with Collision Detection (CSMA/CD) is an algorithm, for transmitting and receiving packets over a common network hardware medium, by aiding in avoiding transmission collisions. The network is checked for other transmissions; when the way is clear, the computer transmissions can begin. If a collision is detected the packet is retransmitted later.

Basic frame format which is required for all MAC implementation is defined in **IEEE 802.3 standard**. Though several optional formats are being used to extend the protocol's basic capability.
Ethernet frame starts with Preamble and SFD, both works at the physical layer. Ethernet header contains both Source and Destination MAC address, after which the payload of the frame is present. The last field is CRC which is used to detect the error.



IEEE 802.3 ETHERNET Frame Format

- **PREAMBLE –** Ethernet frame starts with 7-Bytes Preamble. This is a pattern of alternative 0's and 1's which indicates starting of the frame and allow sender and receiver to establish bit synchronization. Initially, PRE (Preamble) was introduced to allow for the loss of a few bits due to signal delays. But today's high-speed Ethernet don't need Preamble to protect the frame bits.
  PRE (Preamble) indicates the receiver that frame is coming and allow the receiver to lock onto the data stream before the actual frame begins.
- **Start of frame delimiter (SFD) –** This is a 1-Byte field which is always set to 10101011. SFD indicates that upcoming bits are starting of the frame, which is the destination address. Sometimes SFD is considered the part of PRE, this is the reason Preamble is described as 8 Bytes in many places. The SFD warns station or stations that this is the last chance for synchronization.
- **Destination Address –** This is 6-Byte field which contains the MAC address of machine for which data is destined.
- **Source Address –** This is a 6-Byte field which contains the MAC address of source machine. As Source Address is always an individual address (Unicast), the least significant bit of first byte is always 0.

- **Length –** Length is a 2-Byte field, which indicates the length of entire Ethernet frame. This 16-bit field can hold the length value between 0 to 65534, but length cannot be larger than 1500 because of some own limitations of Ethernet.
- **Data –** This is the place where actual data is inserted, also known as **Payload**. Both IP header and data will be inserted here if Internet Protocol is used over Ethernet. The maximum data present may be as long as 1500 Bytes. In case data length is less than minimum length i.e. 46 bytes, then padding 0's is added to meet the minimum possible length.
- **Cyclic Redundancy Check (CRC) –** CRC is 4 Byte field. This field contains a 32-bits hash code of data, which is generated over the Destination Address,

Source Address, Length, and Data field. If the checksum computed by destination is not the same as sent checksum value, data received is corrupted.

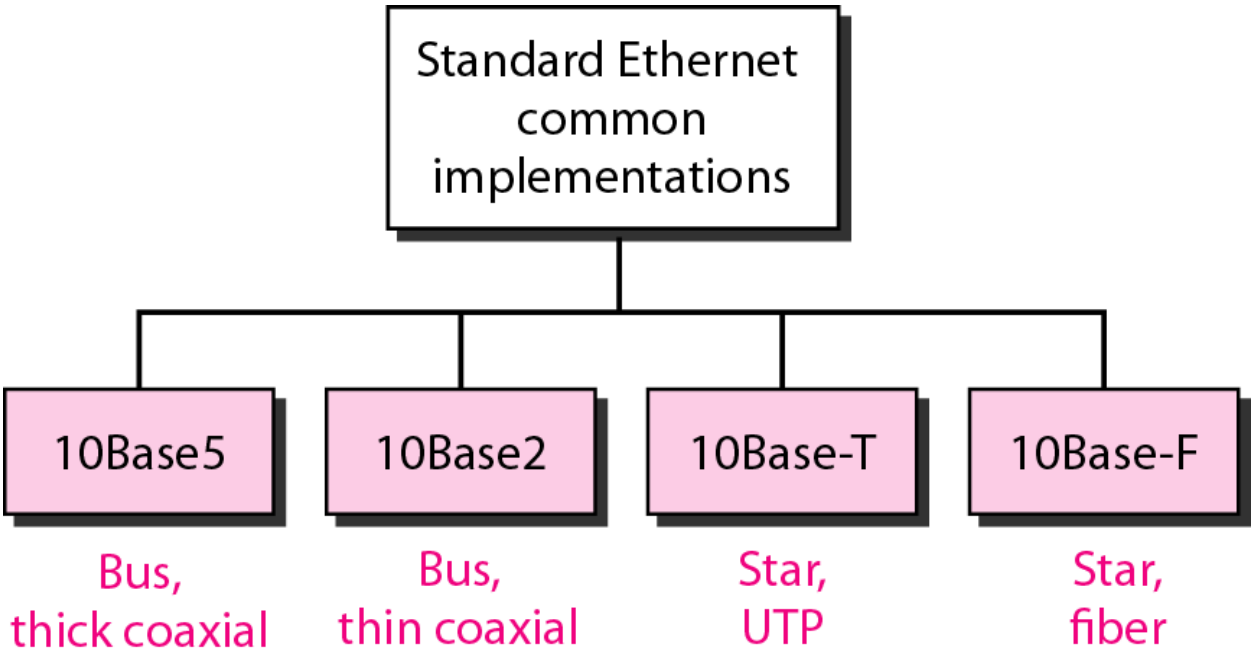
Note – Size of frame of Ethernet IEEE 802.3 varies 64 bytes to 1518 bytes including data length (46 to 1500 bytes).

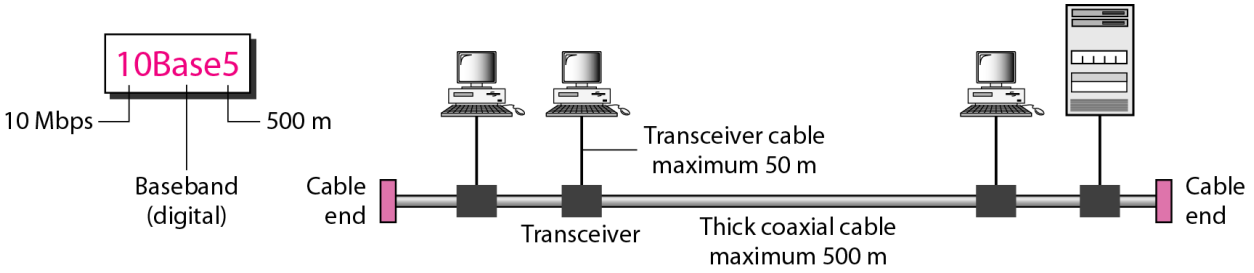
Ethernet

Ethernet is the most popular physical layer LAN technology in use today. It defines the number of conductors that are required for a connection, the performance thresholds that can be expected, and provides the framework for data transmission. A standard Ethernet network can transmit data at a rate up to 10 Megabits per second (10 Mbps). Other LAN types include Token Ring, Fast Ethernet, Gigabit Ethernet, 10 Gigabit Ethernet, Fiber Distributed Data Interface (FDDI), Asynchronous Transfer Mode (ATM) and LocalTalk.

Ethernet is popular because it strikes a good balance between speed, cost and ease of installation. These benefits, combined with wide acceptance in the computer marketplace and the ability to support virtually all popular network protocols, make Ethernet an ideal networking technology for most computer users today.

The Institute for Electrical and Electronic Engineers developed an Ethernet standard known as IEEE Standard 802.3. This standard defines rules for configuring an Ethernet network and also specifies how the elements in an Ethernet network interact with one another. By adhering to the IEEE standard, network equipment and network protocols can communicate efficiently.





Fast Ethernet

The Fast Ethernet standard (IEEE 802.3u) has been established for Ethernet networks that need higher transmission speeds. This standard raises the Ethernet speed limit from 10 Mbps to 100 Mbps with only minimal changes to the existing cable structure. Fast Ethernet provides faster throughput for video, multimedia, graphics, Internet surfing and stronger error detection and correction.

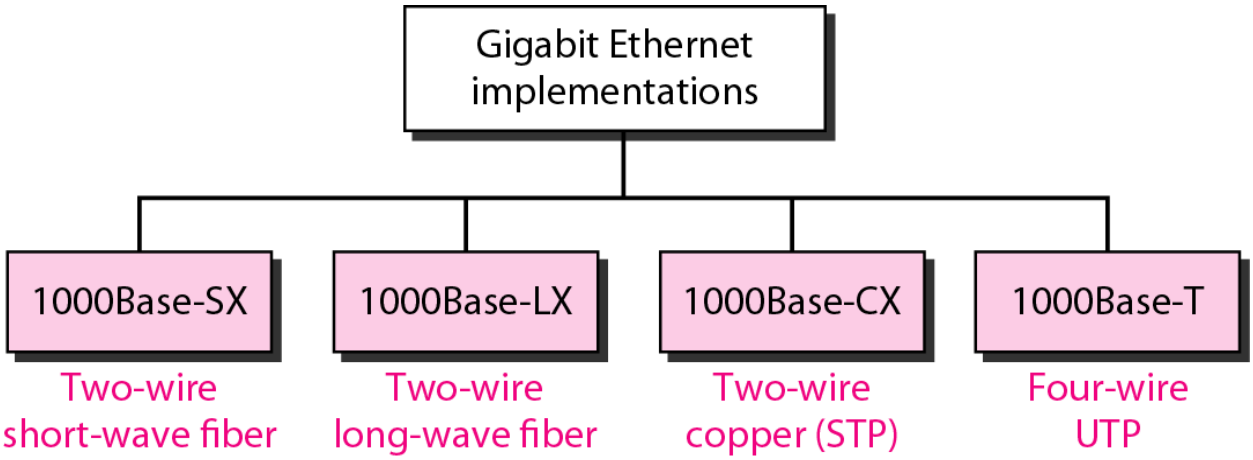
There are three types of Fast Ethernet: 100BASE-TX for use with level 5 UTP cable; 100BASE-FX for use with fiber-optic cable; and 100BASE-T4 which utilizes an extra two wires for use with level 3 UTP cable. The 100BASE-TX standard has become the most popular due to its close compatibility with the 10BASE-T Ethernet standard.

Network managers who want to incorporate Fast Ethernet into an existing configuration are required to make many decisions. The number of users in each site on the network that need the higher throughput must be determined; which segments of the backbone need to be reconfigured specifically for 100BASE-T; plus what hardware is necessary in order to connect the 100BASE-T segments with existing 10BASE-T segments. Gigabit Ethernet is a future technology that promises a migration path beyond Fast Ethernet so the next generation of networks will support even higher data transfer speeds.

Gigabit Ethernet

Gigabit Ethernet was developed to meet the need for faster communication networks with applications such as multimedia and Voice over IP (VoIP). Also known as "gigabit-Ethernet-over-copper" or 1000Base-T, GigE is a version of Ethernet that runs at speeds 10 times faster than 100Base-T. It is defined in the IEEE 802.3 standard and is currently used as an enterprise backbone. Existing Ethernet LANs with 10 and 100 Mbps cards can feed into a Gigabit Ethernet backbone to interconnect high performance switches, routers and servers.

From the data link layer of the OSI model upward, the look and implementation of Gigabit Ethernet is identical to that of Ethernet. The most important differences between Gigabit Ethernet and Fast Ethernet include the additional support of full duplex operation in the MAC layer and the data rates.



10 Gigabit Ethernet

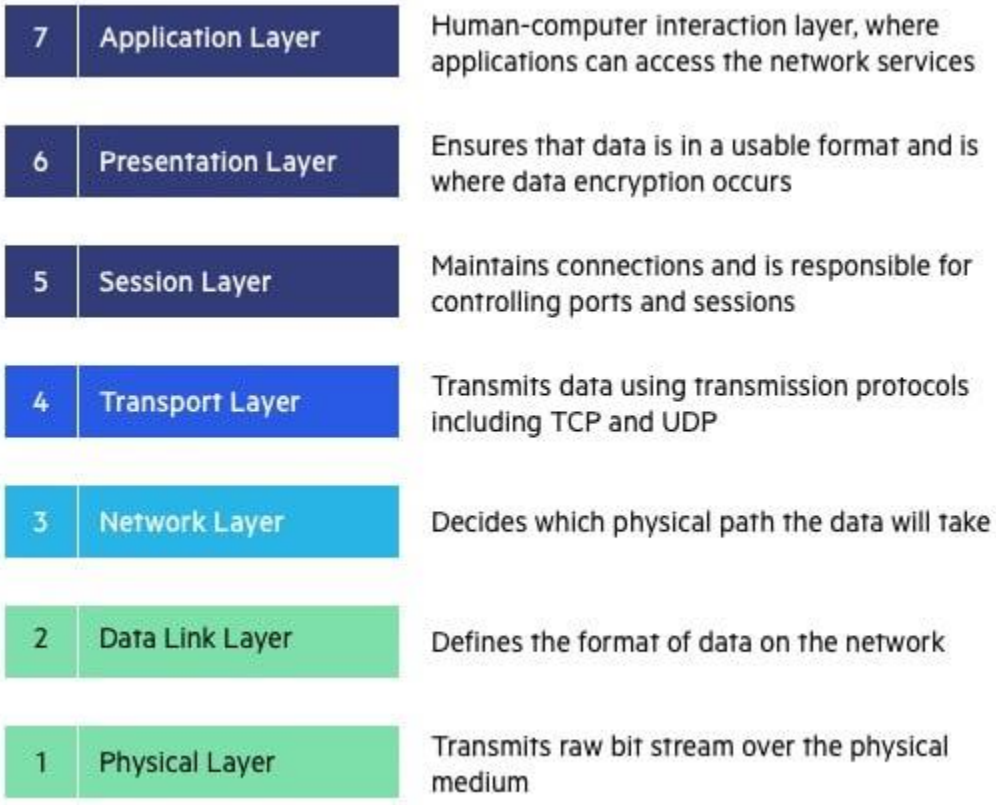
10 Gigabit Ethernet is the fastest and most recent of the Ethernet standards. IEEE 802.3ae defines a version of Ethernet with a nominal rate of 10Gbits/s that makes it 10 times faster than Gigabit Ethernet.

Unlike other Ethernet systems, 10 Gigabit Ethernet is based entirely on the use of optical fiber connections. This developing standard is moving away from a LAN design that broadcasts to all nodes, toward a system which includes some elements of wide area routing. As it is still very new, which of the standards will gain commercial acceptance has yet to be determined.

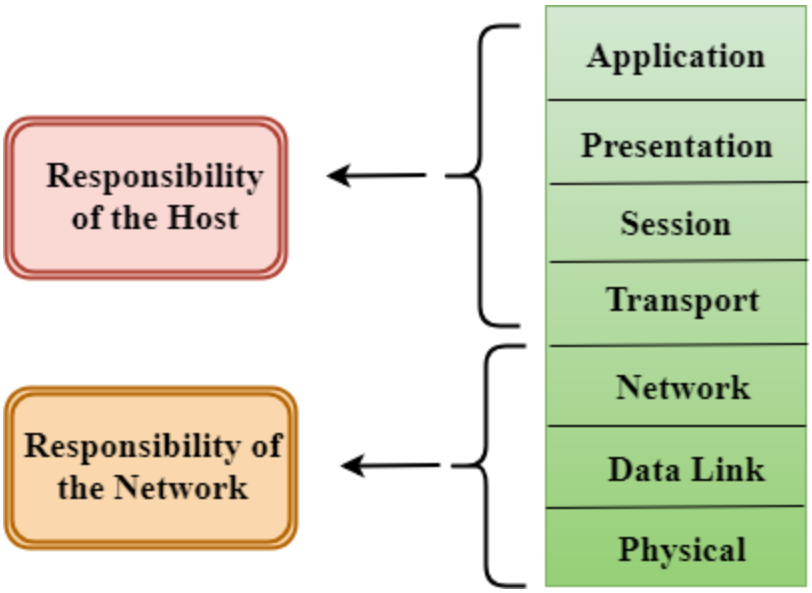
Name	IEEE Standard	Data Rate	Media Type	Maximum Distance
Ethernet	802.3	10 Mbps	10Base-T	100 meters
Fast Ethernet/ 100Base-T	802.3u	100 Mbps	100Base-TX 100Base-FX	100 meters 2000 meters
Gigabit Ethernet/ GigE	802.3z	1000 Mbps	1000Base-T 1000Base-SX 1000Base-LX	100 meters 275/550 meters 550/5000 meters
10 Gigabit Ethernet	IEEE 802.3ae	10 Gbps	10GBase-SR 10GBase-LX4 10GBase-LR/ER 10GBase-SW/LW/EW	300 meters 300m MMF/ 10km SMF 10km/40km 300m/10km/40km

OSI Model Explained: The OSI 7 Layers

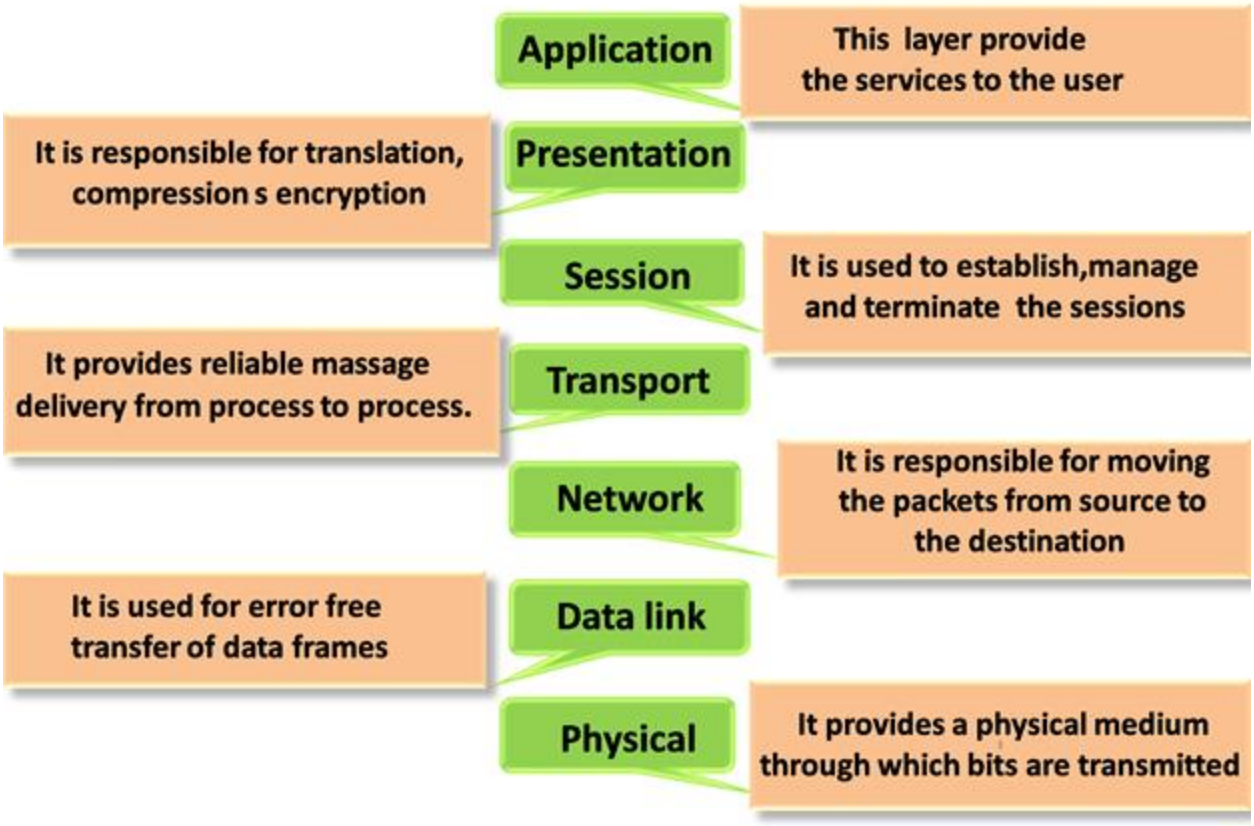
Open System Interconnection



A Penguin Said That Nobody Drinks Pepsi



- The OSI model is divided into two layers: upper layers and lower layers.
- The upper layer of the OSI model mainly deals with the application related issues, and they are implemented only in the software. The application layer is closest to the end user. Both the end user and the application layer interact with the software applications. An upper layer refers to the layer just above another layer.
- The lower layer of the OSI model deals with the data transport issues. The data link layer and the physical layer are implemented in hardware and software. The physical layer is the lowest layer of the OSI model and is closest to the physical medium. The physical layer is mainly responsible for placing the information on the physical medium.



7. Application Layer

The application layer is used by end-user software such as web browsers and email clients. It provides protocols that allow software to send and receive information and present meaningful data to users. A few examples of application layer protocols are the Hypertext Transfer Protocol (HTTP), File Transfer Protocol (FTP), Post Office Protocol (POP), Simple Mail Transfer Protocol (SMTP), and Domain Name System (DNS).

6. Presentation Layer

The presentation layer prepares data for the application layer. It defines how two devices should encode, encrypt, and compress data so it is received correctly on the other end. The presentation layer takes any data transmitted by the application layer and prepares it for transmission over the session layer.

5. Session Layer

The session layer creates communication channels, called sessions, between devices. It is responsible for opening sessions, ensuring they remain open and functional while data is being transferred, and closing them when communication ends. The session layer can also set checkpoints during a data transfer—if the session is interrupted, devices can resume data transfer from the last checkpoint.

4. Transport Layer

The transport layer takes data transferred in the session layer and breaks it into "segments" on the transmitting end. It is responsible for reassembling the segments on the receiving end, turning it back into data that can be used by the session layer. The transport layer carries out flow control, sending data at a rate that matches the connection speed of the receiving device, and error control, checking if data was received incorrectly and if not, requesting it again.

3. Network Layer

The network layer has two main functions. One is breaking up segments into network packets, and reassembling the packets on the receiving end. The other is routing packets by discovering the best path across a physical network. The network layer uses network addresses (typically Internet Protocol addresses) to route packets to a destination node.

2. Data Link Layer

The data link layer establishes and terminates a connection between two physically-connected nodes on a network. It breaks up packets into frames and sends them from source to destination. This layer is composed of two parts—Logical Link Control (LLC), which identifies network protocols, performs error checking and synchronizes frames, and Media Access Control (MAC) which uses MAC addresses to connect devices and define permissions to transmit and receive data.

1. Physical Layer

The physical layer is responsible for the physical cable or wireless connection between network nodes. It defines the connector, the electrical cable or wireless technology connecting the devices, and is responsible for transmission of the raw data, which is simply a series of 0s and 1s, while taking care of bit rate control.

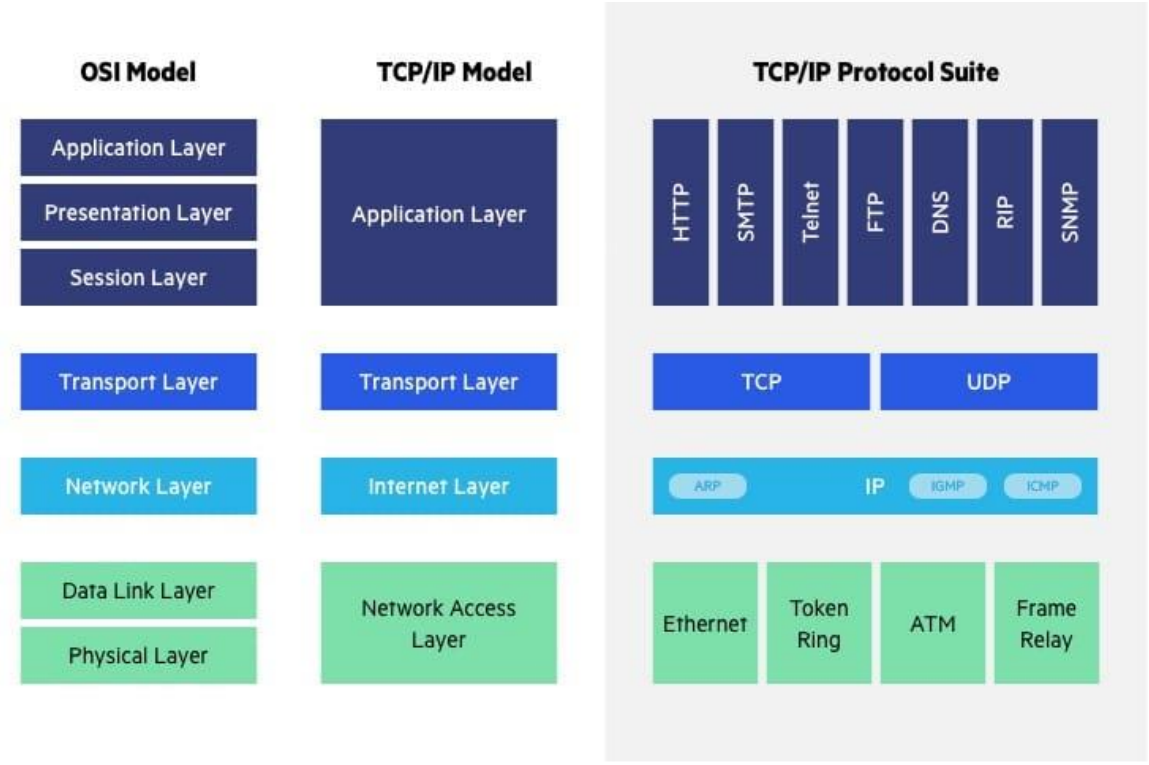
Advantages of OSI Model

The OSI model helps users and operators of computer networks:

- Determine the required hardware and software to build their network.
- Understand and communicate the process followed by components communicating across a network.
- Perform troubleshooting, by identifying which network layer is causing an issue and focusing efforts on that layer.

The OSI model helps network device manufacturers and networking software vendors:

- Create devices and software that can communicate with products from any other vendor, allowing open interoperability
- Define which parts of the network their products should work with.
- Communicate to users at which network layers their product operates – for example, only at the application layer, or across the stack.



The Transfer Control Protocol/Internet Protocol (TCP/IP) is older than the OSI model and was created by the US Department of Defense (DoD). A key difference between the models is that TCP/IP is simpler, collapsing several OSI layers into one:

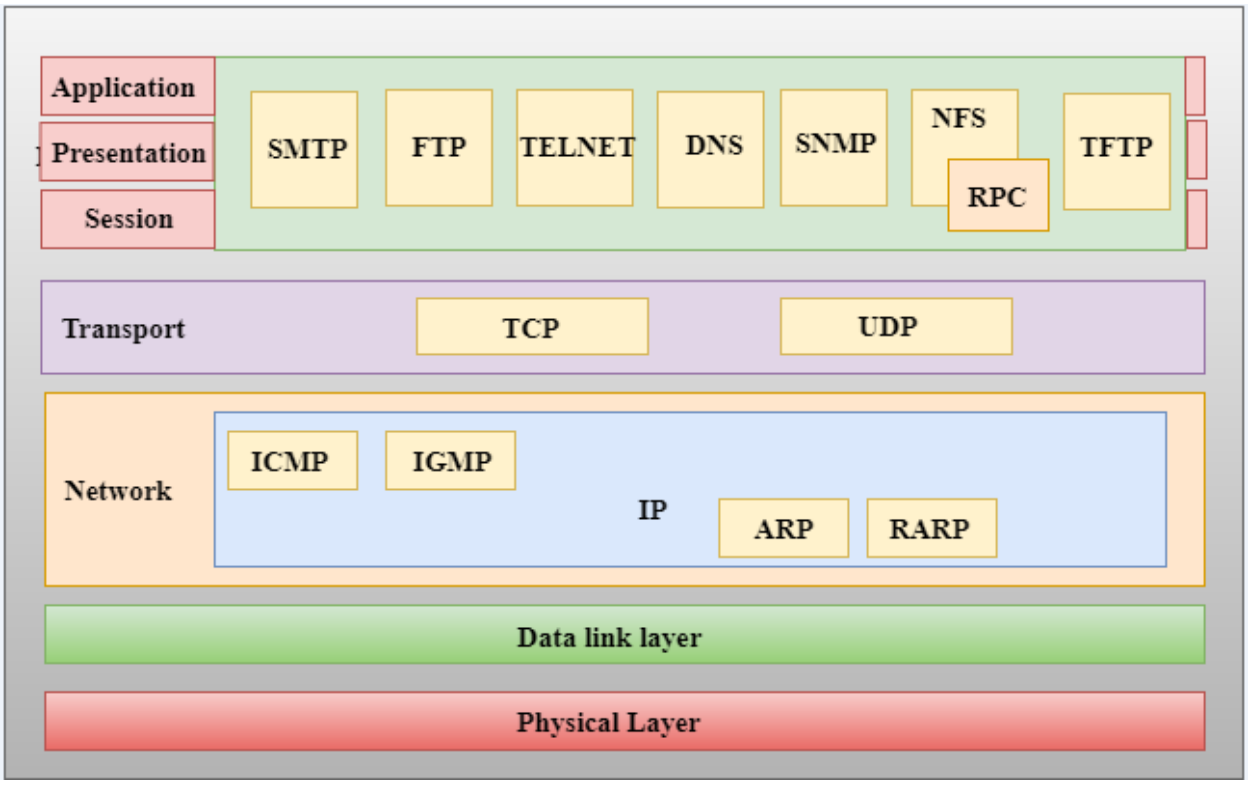
- OSI layers 5, 6, 7 are combined into one Application Layer in TCP/IP
- OSI layers 1, 2 are combined into one Network Access Layer in TCP/IP – however TCP/IP does not take responsibility for sequencing and acknowledgement functions, leaving these to the underlying transport layer.

Other important differences:

- TCP/IP is a functional model designed to solve specific communication problems, and which is based on specific, standard protocols. OSI is a generic, protocol-independent model intended to describe all forms of network communication.
- In TCP/IP, most applications use all the layers, while in OSI simple applications do not use all seven layers. Only layers 1, 2 and 3 are mandatory to enable any data communication.

It stands for Transmission Control Protocol/Internet Protocol. 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



Internet Layer

- An internet layer is the second layer of the TCP/IP model.
- An internet layer is also known as the network layer.
- The main responsibility of the internet layer is to send the packets from any network, and they arrive at the destination irrespective of the route they take.

Following are the protocols used in this layer are:

IP Protocol: IP protocol is used in this layer, and it is the most significant part of the entire TCP/IP suite.

Following are the responsibilities of this protocol:

- **IP Addressing:** This protocol implements logical host addresses known as IP addresses. The IP addresses are used by the internet and higher layers to identify the device and to provide internetwork routing.

- **Host-to-host communication:** It determines the path through which the data is to be transmitted.
- **Data Encapsulation and Formatting:** An IP protocol accepts the data from the transport layer protocol. An IP protocol ensures that the data is sent and received securely, it encapsulates the data into message known as IP datagram.
- **Fragmentation and Reassembly:** The limit imposed on the size of the IP datagram by data link layer protocol is known as Maximum Transmission unit (MTU). If the size of IP datagram is greater than the MTU unit, then the IP protocol splits the datagram into smaller units so that they can travel over the local network. Fragmentation can be done by the sender or intermediate router. At the receiver side, all the fragments are reassembled to form an original message.
- **Routing:** When IP datagram is sent over the same local network such as LAN, MAN, WAN, it is known as direct delivery. When source and destination are on the distant network, then the IP datagram is sent indirectly. This can be accomplished by routing the IP datagram through various devices such as routers.

ARP Protocol

- ARP stands for **Address Resolution Protocol**.
- ARP is a network layer protocol which is used to find the physical address from the IP address.
- **The two terms are mainly associated with the ARP Protocol:**
    - **ARP request:** When a sender wants to know the physical address of the device, it broadcasts the ARP request to the network.
    - **ARP reply:** Every device attached to the network will accept the ARP request and process the request, but only recipient recognize the IP address and sends back its physical address in the form of ARP reply. The recipient adds the physical address both to its cache memory and to the datagram header

ICMP Protocol

- **ICMP** stands for Internet Control Message Protocol.
- It is a mechanism used by the hosts or routers to send notifications regarding datagram problems back to the sender.

- A datagram travels from router-to-router until it reaches its destination. If a router is unable to route the data because of some unusual conditions such as disabled links, a device is on fire or network congestion, then the ICMP protocol is used to inform the sender that the datagram is undeliverable.
- An ICMP protocol mainly uses two terms:
  - **ICMP Test:** ICMP Test is used to test whether the destination is reachable or not.
  - **ICMP Reply:** ICMP Reply is used to check whether the destination device is responding or not.
- The core responsibility of the ICMP protocol is to report the problems, not correct them. The responsibility of the correction lies with the sender.
- ICMP can send the messages only to the source, but not to the intermediate routers because the IP datagram carries the addresses of the source and destination but not of the router that it is passed to.

Transport Layer

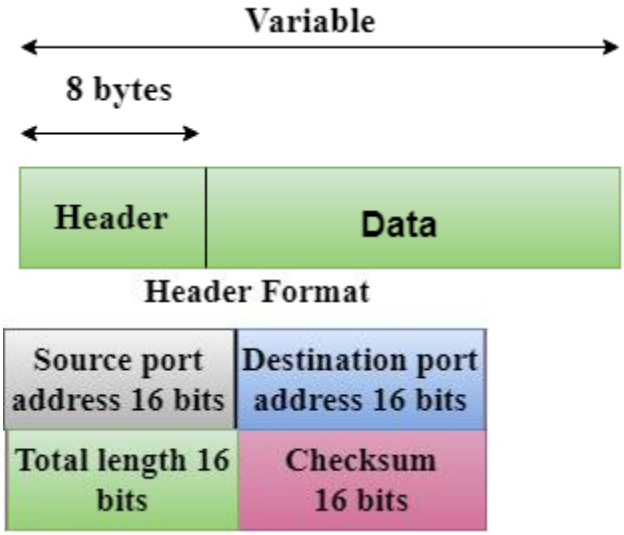
The transport layer is responsible for the reliability, flow control, and correction of data which is being sent over the network.

The two protocols used in the transport layer are **User Datagram protocol and Transmission control protocol**.

- **User Datagram Protocol (UDP)**
  - It provides connectionless service and end-to-end delivery of transmission.
  - It is an unreliable protocol as it discovers the errors but not specify the error.
  - User Datagram Protocol discovers the error, and ICMP protocol reports the error to the sender that user datagram has been damaged.
  - **UDP consists of the following fields:**
    Source port address: The source port address is the address of the application program that has created the message.
    Destination port address: The destination port address is the address of the application program that receives the message.
    Total length: It defines the total number of bytes of the user datagram

in bytes.
Checksum: The checksum is a 16-bit field used in error detection.

- UDP does not specify which packet is lost. UDP contains only checksum; it does not contain any ID of a data segment.



- **Transmission Control Protocol (TCP)**
  - It provides a full transport layer services to applications.
  - It creates a virtual circuit between the sender and receiver, and it is active for the duration of the transmission.
  - TCP is a reliable protocol as it detects the error and retransmits the damaged frames. Therefore, it ensures all the segments must be received and acknowledged before the transmission is considered to be completed and a virtual circuit is discarded.
  - At the sending end, TCP divides the whole message into smaller units known as segment, and each segment contains a sequence number which is required for reordering the frames to form an original message.
  - At the receiving end, TCP collects all the segments and reorders them based on sequence numbers.

Application Layer

- An application layer is the topmost layer in the TCP/IP model.
- It is responsible for handling high-level protocols, issues of representation.

- This layer allows the user to interact with the application.
- When one application layer protocol wants to communicate with another application layer, it forwards its data to the transport layer.
- There is an ambiguity occurs in the application layer. Every application cannot be placed inside the application layer except those who interact with the communication system. For example: text editor cannot be considered in application layer while web browser using **HTTP** protocol to interact with the network where **HTTP** protocol is an application layer protocol.

Following are the main protocols used in the application layer:

- **HTTP:** HTTP stands for Hypertext transfer protocol. This protocol allows us to access the data over the world wide web. It transfers the data in the form of plain text, audio, video. It is known as a Hypertext transfer protocol as it has the efficiency to use in a hypertext environment where there are rapid jumps from one document to another.
- **SNMP:** SNMP stands for Simple Network Management Protocol. It is a framework used for managing the devices on the internet by using the TCP/IP protocol suite.
- **SMTP:** SMTP stands for Simple mail transfer protocol. The TCP/IP protocol that supports the e-mail is known as a Simple mail transfer protocol. This protocol is used to send the data to another e-mail address.
- **DNS:** DNS stands for Domain Name System. An IP address is used to identify the connection of a host to the internet uniquely. But, people prefer to use the names instead of addresses. Therefore, the system that maps the name to the address is known as Domain Name System.
- **TELNET:** It is an abbreviation for Terminal Network. It establishes the connection between the local computer and remote computer in such a way that the local terminal appears to be a terminal at the remote system.
- **FTP:** FTP stands for File Transfer Protocol. FTP is a standard internet protocol used for transmitting the files from one computer to another computer.