UNIT 1

Introduction: Network Topologies, Types of Networks: WAN, LAN, MAN. Reference models: The OSI Reference Model, the TCP/IP Reference Model, A Comparison of the OSI and TCP/IP Reference Models.
Physical Layer: Guided Transmission media- Twisted-pair cable, Coaxial cable and Fiber optic cable.

Introduction:

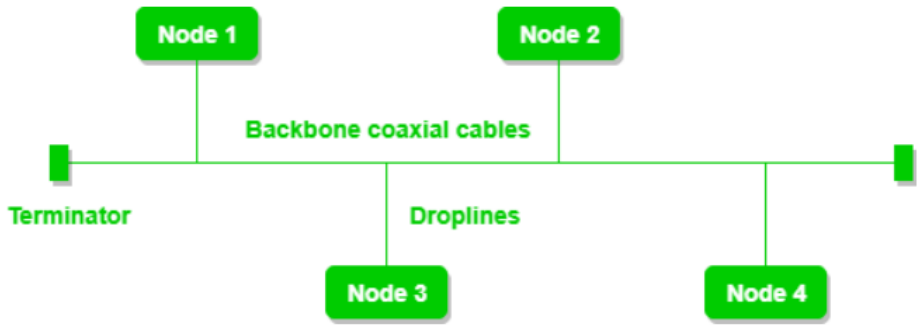
Computer Network is **"**an interconnected collection of autonomous computers**"**. Two computers are said to be interconnected if they are able to communicate and exchange information. If one computer can forcibly start, stop or control another one, the computers are not autonomous. Computer Networks are mainly used where there is a need for resource sharing and communication.

Network Topologies

Network Topology is the schematic description of a network arrangement, connecting various nodes(sender and receiver) through lines of connection. The arrangement of a network that comprises nodes and connecting lines via sender and receiver is referred to as network topology.

1. BUS Topology

Bus topology is a network type in which every computer and network device is connected to a single cable. It is bi-directional. It is a multi-point connection and a non-robust topology because if the backbone fails the topology crashes. In Bus Topology, various MAC (Media Access Control) protocols are followed by LAN ethernet connections like TDMA, Pure Aloha, CDMA, Slotted Aloha, 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

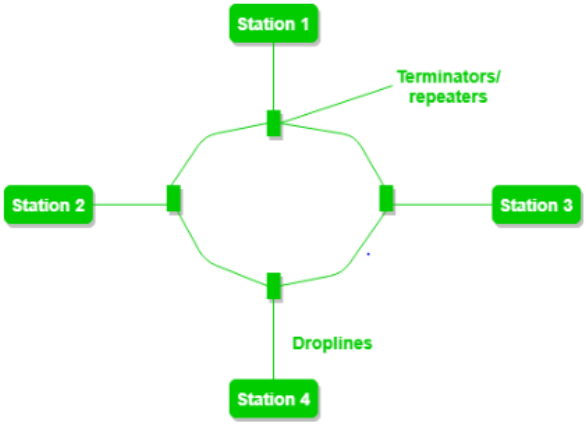
1. It is cost effective.
2. Cable required is least compared to other network topology.
3. Used in small networks.
4. It is easy to understand.
5. Easy to expand joining two cables together.

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

2. Ring Topology

It is called ring topology because it forms a ring as each computer is connected to another computer, with the last one connected to the first. Exactly two neighbours for each device.



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

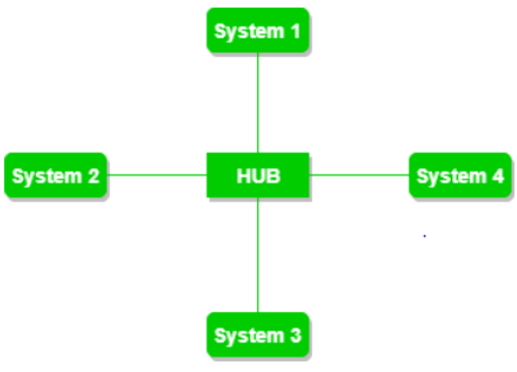
1. Transmitting network is not affected by high traffic or by adding more nodes, as only the nodes having tokens can transmit data.
2. Cheap to install and expand

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.

3. Star Topology

In this type of topology all the computers 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.



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

Mesh Topology

It is a point-to-point connection to other nodes or devices. All the network nodes are connected to each other. Mesh has n(n-1)/2 physical channels to link n devices.

There are two techniques to transmit data over the Mesh topology, they are :

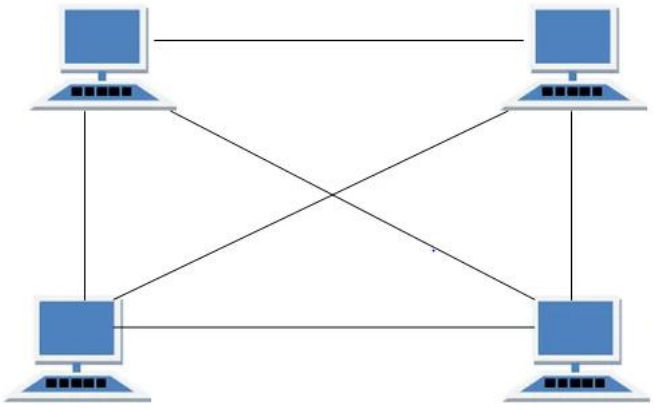
1. Routing
2. Flooding

MESH Topology: Routing

In routing, the nodes have a routing logic, as per the network requirements. Like routing logic to direct the data to reach the destination using the shortest distance. Or, routing logic which has information about the broken links, and it avoids those node etc. We can even have routing logic, to re-configure the failed nodes.

MESH Topology: Flooding

In flooding, the same data is transmitted to all the network nodes, hence no routing logic is required. The network is robust, and the its very unlikely to lose the data. But it leads to unwanted load over the network.



Types of Mesh Topology

1. **Partial Mesh Topology :** In this topology some of the systems are connected in the same fashion as mesh topology but some devices are only connected to two or three devices.
2. **Full Mesh Topology :** Each and every nodes or devices are connected to each other.

Features of Mesh Topology

1. Fully connected.

2. Robust.
3. Not flexible.

Advantages of Mesh Topology

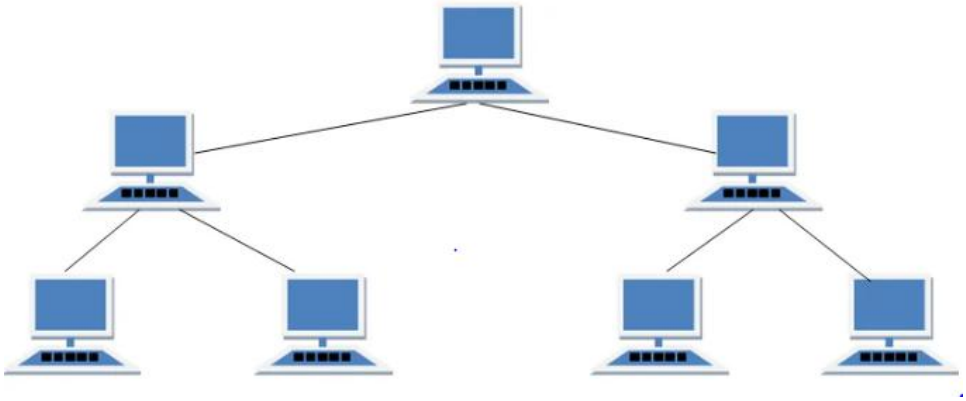
1. Each connection can carry its own data load.
2. It is robust.
3. Fault is diagnosed easily.
4. Provides security and privacy.

Disadvantages of Mesh Topology

1. Installation and configuration is difficult.
2. Cabling cost is more.
3. Bulk wiring is required

Tree Topology

It has a root node and all other nodes are connected to it forming a hierarchy. It is also called hierarchical topology. It should at least have three levels to the hierarchy.



Features of Tree Topology

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

Advantages of Tree Topology

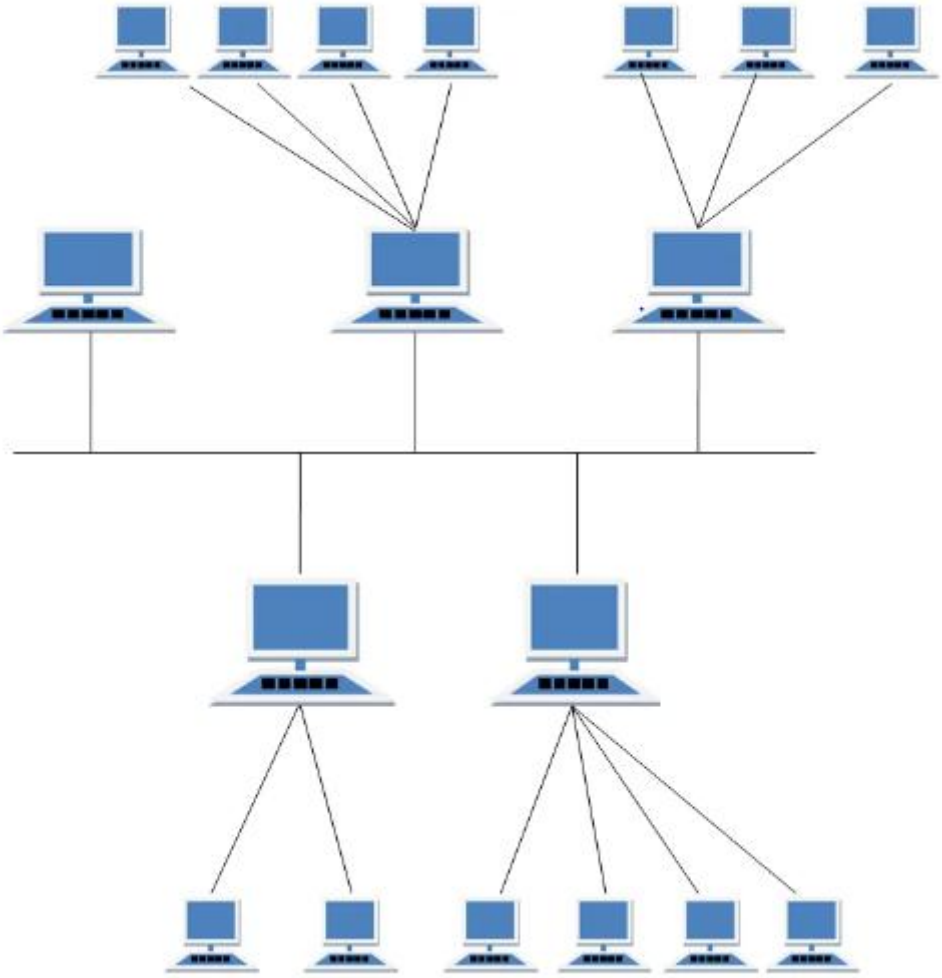
1. Extension of bus and star topologies.
2. Expansion of nodes is possible and easy.
3. Easily managed and maintained.
4. Error detection is easily done.

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

It is two different types of topologies which is a mixture of two or more topologies. For example if in an office in one department ring topology is used and in another star topology is used, connecting these topologies will result in Hybrid Topology (ring topology and star 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

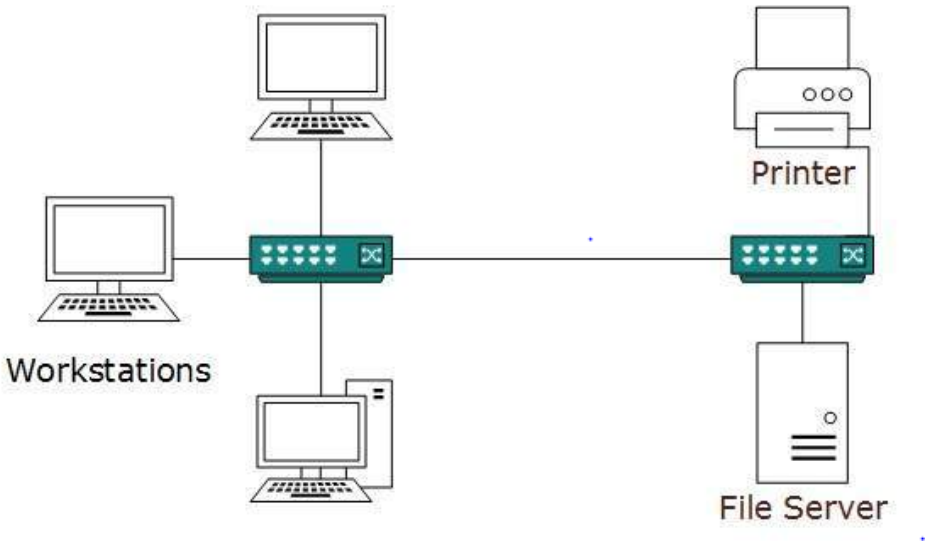
1. Complex in design.
2. Costly.

Types of Networks

Local Area Network (LAN)

A computer network spanned inside a building and operated under single administrative system is generally termed as Local Area Network (LAN). Usually,LAN covers an organization' offices, schools, colleges or universities. Number of systems connected in LAN may vary from as least as two to as much as 16 million.

LAN provides a useful way of sharing the resources between end users.The resources such as printers, file servers, scanners, and internet are easily sharable among computers.



LANs are composed of inexpensive networking and routing equipment. It may contains local servers serving file storage and other locally shared applications. It mostly operates on private IP addresses and does not involve heavy routing. LAN works under its own local domain and controlled centrally.

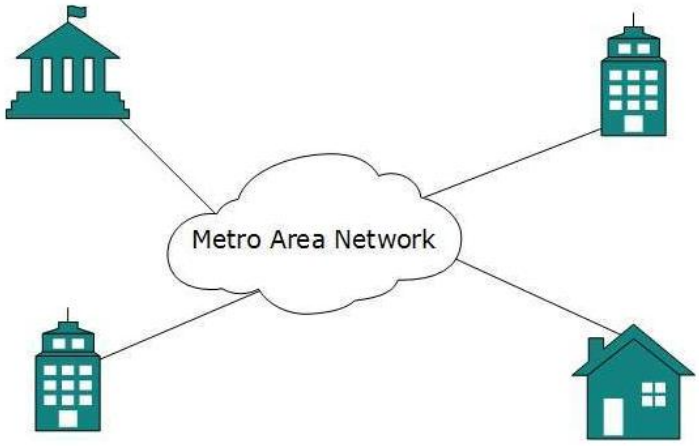
LAN uses either Ethernet or Token-ring technology. Ethernet is most widely employed LAN technology and uses Star topology, while Token-ring is rarely seen.

LAN can be wired,wireless, or in both forms at once.

Metropolitan Area Network (MAN)

The Metropolitan Area Network (MAN) generally expands throughout a city such as cable TV network. It can be in the form of Ethernet,Token-ring, ATM, or Fiber Distributed Data Interface (FDDI).

Metro Ethernet is a service which is provided by ISPs. This service enables its users to expand their Local Area Networks. For example, MAN can help an organization to connect all of its offices in a city.

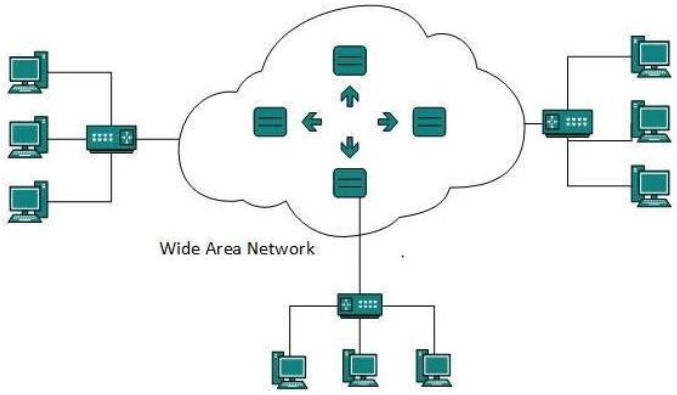


Backbone of MAN is high-capacity and high-speed fiber optics. MAN works in between Local Area Network and Wide Area Network. MAN provides uplink for LANs to WANs or internet.

Wide Area Network (WAN)

As the name suggests,the Wide Area Network (WAN) covers a wide area which may span across provinces and even a whole country. Generally, telecommunication networks are Wide Area Network.

These networks provide connectivity to MANs and LANs. Since they are equipped with very high speed backbone, WANs use very expensive network equipment.

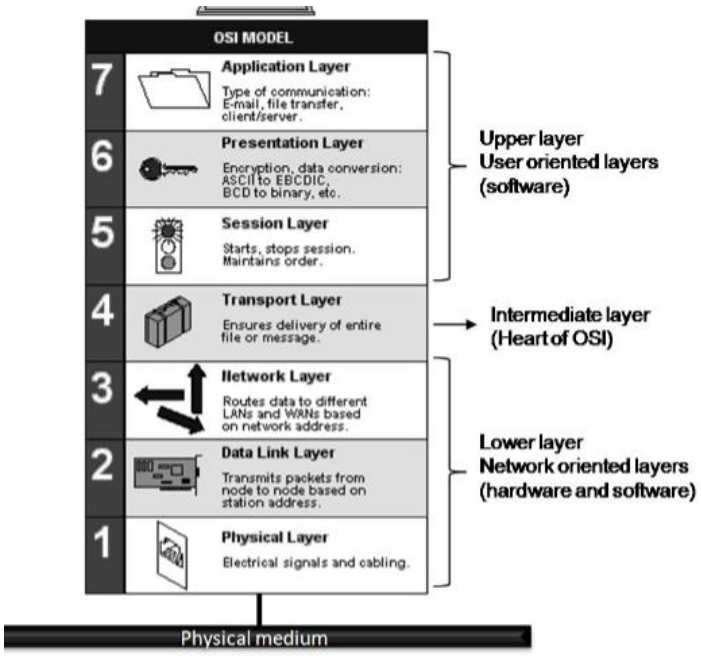


Reference models

The Open System Interconnection (OSI) reference model describes how information from a software application in one computer moves through a network medium to a software application in another computer. The OSI reference model is a conceptual model composed of seven layers, each specifying particular network functions. The model was developed by the International Organization for Standardization (ISO) in 1984, and it is now considered the primary architectural model for inter-computer communications.

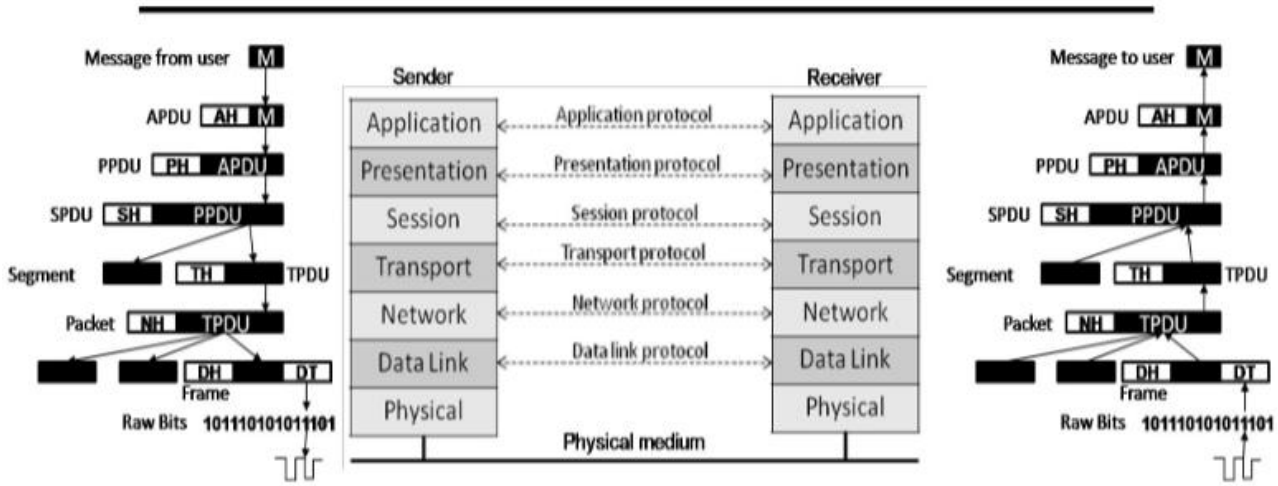
The OSI model divides the tasks involved with moving information between networked Computers into seven smaller, more manageable task groups. A task or group of tasks is then assigned to each of the seven OSI layers. Each layer is reasonably self-contained so that the tasks assigned to each layer can be implemented independently. This enables the solutions offered by one layer to be updated without adversely affecting the other layers. The upper layers of the OSI model deal with application issues and generally are implemented only in software. The highest layer, the application layer, is closest to the end user. The lower layers of the OSI model handle data transport issues. The physical layer and the data link layer are implemented in hardware and software. The lowest layer, the physical layer, is closest to the physical network medium (the network cabling) and is responsible for actually placing information on the medium.

The OSI Reference Model includes seven layers:



Information Flow in OSI

Information being transferred from a software application in one computer system to a software application in another must pass through the OSI layers. For example, if a software application in System A has information to transmit to a software application in System B, the application program in System A will pass its information to the application layer of System A. The application layer then passes the information to the presentation layer, which relays the data to the session layer, and so on down to the physical layer. At the physical layer, the information is placed on the physical network medium and is sent across the medium to System B. The physical layer of System B removes the information from the physical medium, and then its physical layer passes the information up to the data link layer, which passes it to the network layer, and so on, until it reaches the application layer of System B. Finally, the application layer of System B passes the information to the recipient application program to complete the communication process. But protocols are defined such a way that the communication is being done between peers, so a virtual communication path is indicated in the diagram with dashed lines.



The actual communication process among OSI layers is explained below:

1. At the sender machine, Application layer accepts message from user and adds an application header (AH) to it, to form an application protocol data unit (APDU) and forwards it to Presentation layer.
2. Presentation layer adds a presentation header (PH) to APDU, to form a presentation protocol data unit (PPDU) and forwards it to Session layer.
3. Session layer adds a session header (SH) to TPDU, to form a session protocol data unit (SPDU) and forwards it to Transport layer.
4. If necessary Transport layer divides SPDU into number of segments and adds a transport header (TH) to each segment, to form a transport protocol data unit (TPDU) and forwards it to Network layer.
5. For each TPDU, Network layer adds a network header (NH), to form a Packet and forwards the packets to Data link layer.
6. Data link layer divides the packets into smaller parts (if necessary) and adds a data link header (DH) and a data link trailer (DT) to each part, to form a Frame. The frames are then forwarded to Physical layer in the form of raw bits.
7. Physical layer encodes these bits into a digital signal and transmits that signal to the destination machine via the physical medium.
8. Physical layer on the destination machine receives this digital signal, decodes it back into raw bits, and forwards it to Data link layer.
9. Data link layer removes the DHs and DTs from each frame, combines them into packets and forwards them to Network layer
10. Network layer removes NH from each frame and forwards TPDUs to Transport layer.

11. Transport layer removes TH from each TPDU, combines the segments back into SPDUs and forwards them to Session layer.
12. Session layer removes SHs from SPDUs and forwards PPDUs to Presentation layer.
13. Presentation layer removes PHs from PPDUs and forwards APDUs to Application layer.
14. Finally, Application layer removes AH and presents the message to user thus completes the communication.

Functionalities of OSI Layer

- **Physical layer**

Focuses on transmission of raw bits over network medium Deals with physical, mechanical and electrical characteristics of physical medium, like:

- ✓ No. of pins in the connector and their purpose
- ✓ Voltages to represent 1 and 0
- ✓ Duration of each bit
- ✓ Signal levels and data rate
- ✓ Whether simultaneous transmission in both directions

Data link layer

Focus is on error free transmission of data to the next immediate network node. The main purpose of data link layer is to transmit frames to the next network node and to receive acknowledgements from it. But these acknowledgements may induce network/link overhead. To reduce this up to some extent acknowledgements are combined with the reverse data (if any) and transmitted back to the source host. This technique of combining acknowledgements with data is known as Piggy backing.

Data link layer deals with:

- ✓ Framing

Framing includes dividing data from upper layers into frames, transmitting them, sequencing and combining them at the receiver side. The receiver also must be able to detect the boundaries of frame.

- ✓ Error control (bit level)

Error control is concerned with insuring that all frames are eventually delivered (possibly in order) to a destination. This includes both error detection and correction.

- ✓ Flow control

Flow control deals with throttling the speed of the sender to match that of the receiver. Usually, this is a dynamic process, as the receiving speed depends on such changing factors as the load, and availability of buffer space.

- ✓ Access control

Data link layer also handles the problem of medium access control, when more than one hosts sharing a common transmission line.

Network layer

Network layer deals with:

- ✓ Routing

The network layer is responsible for routing packets from the source to destination. The routing algorithm is the piece of software that decides where a packet goes next. There are two types of algorithms:

Adaptive algorithms use such dynamic information as current topology, load, delay, etc. to select routes.

In **non-adaptive algorithms**, routes never change once initial routes have been selected. Also called static routing.

- ✓ Congestion control

In any network when there is too much the data traffic at a node, the network slows down or starts loosing data, it is known as network congestion. It degrades quality of service and also can lead to delays, lost data. Network layer incorporates some methods to avoid these kind of situations.

- ✓ Addressing

Network layer also handles addressing schemes that are used to identify the node uniquely in a network. Most widely used addressing scheme is IP addressing.

Transport layer

This layer ensures a reliable transmission to the receiver by maintaining a pure end- to-end connectivity.

Transport layer deals with:

- ✓ Segmentation and Reassembling

If the data coming from upper layers is too long for transmission, the transport layer divides them into number of pieces, called segments. At the receiver side these segments are to be sequenced in the correct order and reassembled.

- ✓ Flow control

The data link layer solution of reallocating buffers is inappropriate because a machine may have hundreds of connections sharing a single physical link. In addition, appropriate settings for the flow control parameters depend on the communicating end points (e.g., Cray supercomputers vs. PCs), not on the protocol used. Don't send data unless there is room. In the data link case, the line is not being used for anything else; thus retransmissions are inexpensive. At the transport level, end-to-end retransmissions are needed, which wastes resources by sending the same packet over the same links multiple times. If the receiver has no buffer space, the sender should be prevented from sending data.

Session layer

Session layer deals with:

- ✓ Session management

The Session Layer provides the mechanism for opening, closing and managing a session between end-user application processes. Communication sessions consist of requests and responses that occur between applications.

- ✓ Token management

For some protocols, it is required that both sides don't attempt same operation at the same time. To manage these activities, the session layer provides tokens that can be exchanged. Only one side that is holding token can perform the critical operation.

- ✓ Synchronization

Consider the problem that might occur when trying to transfer a 4-hour file transfer with a 2-hour mean time between crashes. After each transfer was aborted, the whole transfer has to start again and again would probably fail. To eliminate this problem, Session layer provides a way to insert checkpoints into data streams, so that after a crash, only the data transferred after the last checkpoint have to be repeated.

Presentation layer

This layer is concerned with Syntax and Semantics of the information transmitted, i.e. the format of the data.

The services that Presentation layer provides are:

Encoding: Encoding data in a standard agreed upon way.

Compression: Compression is useful because it helps reduce the consumption of expensive resources, such as transmission bandwidth

Encryption: Encryption is the process of transforming information using an algorithm to make it unreadable to anyone except those possessing special knowledge, usually referred to as a key. Encryption is used to protect data in transit.

Application layer

The Application Layer focuses more on network services, APIs, utilities, UID, and operating system environments. Most of the protocols reside in this layer only. Some of them are mentioned below:

Protocol	Name	Purpose
HTTP	Hyper Text Transfer Protocol	Accessing web pages
FTP	File Transfer Protocol	Accessing remote files
telnet	Terminal Emulation Protocol	Remote login
SMTP	Simple Mail Transfer Protocol	Mailing applications
NNTP	Network News Transfer Protocol	News applications

TCP/IP Reference Model

TCP/IP Reference Model is a four-layered suite of communication protocols. It was developed by the DoD (Department of Defence) in the 1960s. It is named after the two main protocols that are used in the model, namely, TCP and IP. TCP stands for Transmission Control Protocol and IP stands for Internet Protocol.

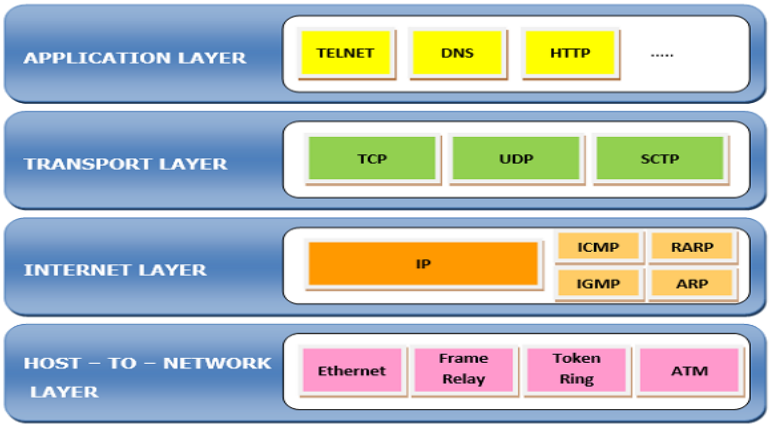
TCP/IP is a four layered architecture as shown below:

<table>
<tr><th>Layers in TCP/IP</th><th>OSI Model</th></tr>
<tr><td>Application</td><td>Application</td></tr>
<tr><td rowspan="3">Transport</td><td>Presentation</td></tr>
<tr><td>Session</td></tr>
<tr><td>Transport</td></tr>
<tr><td>Network/Internet</td><td>Network</td></tr>
<tr><td>Data-link</td><td>Data-link</td></tr>
<tr><td>Physical</td><td>Physical</td></tr>
</table>

The four layers in the TCP/IP protocol suite are −

- **Host-to- Network Layer** −It is the lowest layer that is concerned with the physical transmission of data. TCP/IP does not specifically define any protocol here but supports all the standard protocols.
- **Internet Layer** −It defines the protocols for logical transmission of data over the network. The main protocol in this layer is Internet Protocol (IP) and it is supported by the protocols ICMP, IGMP, RARP, and ARP.
- **Transport Layer** − It is responsible for error-free end-to-end delivery of data. The protocols defined here are Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).
- **Application Layer** − This is the topmost layer and defines the interface of host programs with the transport layer services. This layer includes all high-level protocols like Telnet, DNS, HTTP, FTP, SMTP, etc.

The following diagram shows the layers and the protocols in each of the layers −



A Comparison of the OSI and TCP/IP Reference Models.

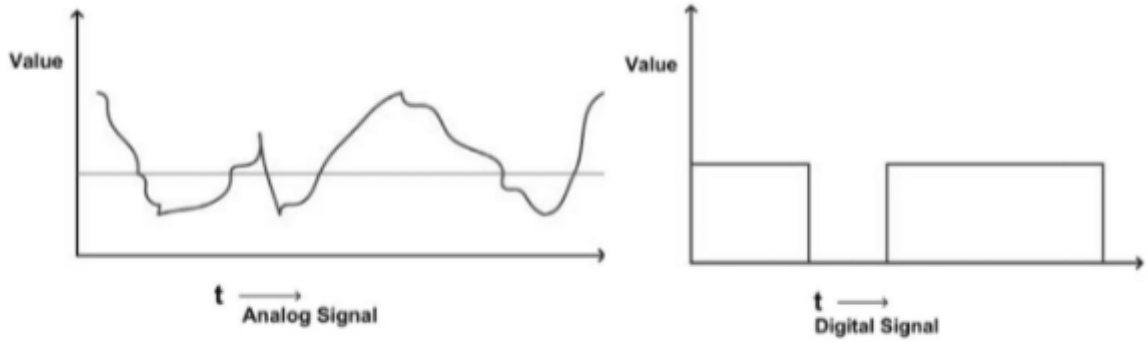
OSI	TCP/IP
OSI represents **Open System Interconnection**.	TCP/IP model represents the Transmission Control Protocol / Internet Protocol.
OSI is a generic, protocol independent standard. It is acting as an interaction gateway between the network and the final-user.	TCP/IP model depends on standard protocols about which the computer network has created. It is a connection protocol that assigns the network of hosts over the internet.
The OSI model was developed first, and then protocols were created to fit the network architecture's needs.	The protocols were created first and then built the TCP/IP model.
It provides quality services.	It does not provide quality services.
The OSI model represents defines administration, interfaces and conventions. It describes clearly which layer provides services.	It does not mention the services, interfaces, and protocols.
The protocols of the OSI model are better unseen and can be returned with another appropriate protocol quickly.	The TCP/IP model protocols are not hidden, and we cannot fit a new protocol stack in it.
It is difficult as distinguished to TCP/IP.	It is simpler than OSI.
It provides both connection and connectionless oriented transmission in the network layer; however, only connection-oriented transmission in the transport layer.	It provides connectionless transmission in the network layer and supports connecting and connectionless-oriented transmission in the transport layer.
It uses a horizontal approach.	It uses a vertical approach.
The smallest size of the OSI header is 5 bytes.	The smallest size of the TCP/IP header is 20 bytes.
Protocols are unknown in the OSI model and are returned while the technology modifies.	In TCP/IP, returning protocol is not difficult

Physical Layer: Guided Transmission media- Twisted-pair cable, Coaxial cable and Fiber optic cable.

Physical Layer controls the transmission of the actual data onto the network cable. It defines the electrical signals, line states and encoding of the data and the connector types used.

Data refers to information that conveys some meaning based on some mutually agreed up rules or conventions between a sender and a receiver and today it comes in a variety of forms such as text, graphics, audio, video and animation.

Signal is electrical, electronic or optical representation of data, which can be sent over a communication medium. Stated in mathematical terms, a signal is merely a function of the data. Analog signals are continuous-valued; digital signals are discrete-valued.



A signal can be represented as a function of time, i.e. it varies with time. However, it can be also expressed as a function of frequency, i.e. a signal can be considered as a composition of different frequency components.

Amplitude: It is the value of the signal at different instants of time. It is measured in volts. Frequency: It is inverse of the time period, i.e. f = 1/T. The unit of frequency is Hertz (Hz) or cycles per second.

Depending on some type of typical signal formats or modulation schemes, a few terminologies evolved to classify different types of signals. So, we can have either a base band or broadband signaling. Base-band is defined as one that uses digital signaling, which is inserted in the transmission channel as voltage pulses. On the other hand, Broadband systems are those, which use analog signaling to transmit information using a carrier of high frequency.

Transmission Media

Transmission media can be defined as physical path between transmitter and receiver in a data transmission system. And it may be classified into two types:

1. Guided

Guided Transmission Media uses a cabling system that guides the data signals along a specific path. The data signals are bound by the cabling system. Guided Media is also known as Bound Media.

2. Unguided

Unguided Transmission Media consists of a means for the data signals to travel but nothing to guide them along a specific path. The data signals are not bound to a cabling media and as such are often called Unbound Media.

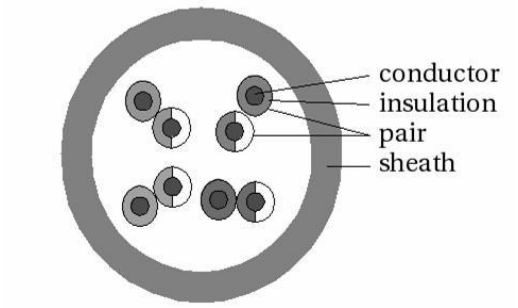
Twisted pair

Twisted pair cabling is a type of wiring in which two conductors (the forward and return conductors of a single circuit) are twisted together.

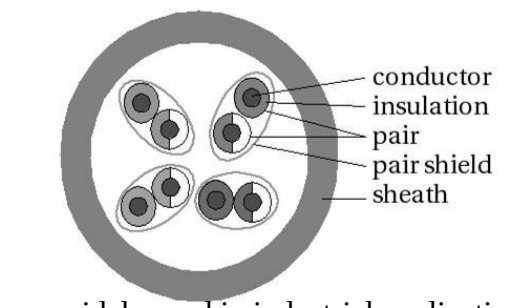
The pairs are twisted to provide protection against crosstalk, the noise generated by adjacent pairs. When electrical current flows through a wire, it creates a small, circular Magnetic field around the wire. When two wires in an electrical circuit are placed close together, their magnetic fields are the exact opposite of each other. Thus, the two magnetic fields cancel each other out. They also cancel out any outside magnetic fields. Twisting the wires can enhance this cancellation effect.

Typically, a number of pairs are bundled together into a cable by wrapping them in a tough protective sheath. And can carry both analog and digital signals. Data rate is determined by wire thickness and length. Shielding is added to eliminate interference from other wires impacts signal-to-noise ratio, and ultimately, the data rate. Twisted pairs offer good, low-cost communication.
There are 4 types of twisted pairs:

1. UTP (Unshielded Twisted Pair)

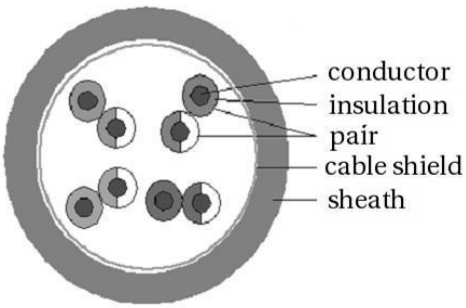


2. STP (Shielded Twisted Pair)



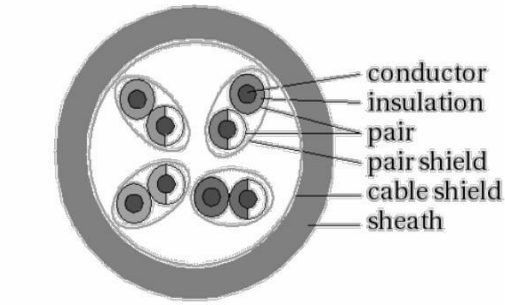
Shielded cables are widely used in industrial applications in order to suppress unwanted crosstalk effects between neighboring wires.

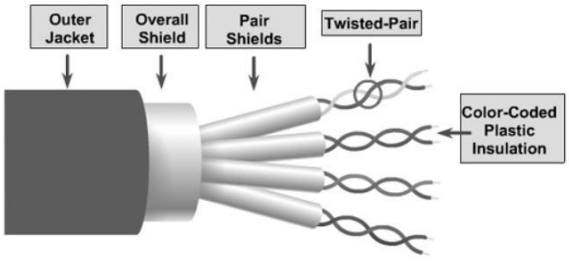
3. S/UTP (Screened Unshielded Twisted Pair)



Screened twisted pairs uses a single foil or braided screen surrounding all four pairs in order to minimize EMI radiation and susceptibility to outside noise.

4. S/STP (Screened Shielded Twisted Pair)





Unshielded and shielded twisted pair cabling standards (by TIA/EIS[2] and ISO/IEC[3])

Standard	Operating Frequency	Data rate
Category 1 / Cat 1	< 100 kHz	Used for telephone communications. Not suitable for transmitting data.
Cat 2	1 MHz	4 Mbps
Cat 3	16 MHz	10 Mbps
Cat 4	20 MHz	16 Mbps
Cat 5	100 MHz	100 Mbps
Cat 5e	100 MHz	1000 Mbps
Cat 6	250 MHz	1000 Mbps
Cat 6a	500 MHz	10000 Mbps
Cat 7	600 MHz	10 Gbps
Cat 7a	1000 MHz	40 Gbps

Advantages of Twisted pair cable

1. It can be used to carry both analog and digital data.
2. It is relatively easy to implement and terminate.
3. It is the least expensive media of transmission for short distances.
4. If portion of a twisted pair cable is damaged it does not effect the entire network.

Disadvantages of Twisted pair cable

1. It offers poor noise immunity as a result signal distortion is more?
2. Attenuation is very high.
3. It supports lower bandwidth as compared to other Medias. It supports 10 mbps upto a distance of 100 meters on a 10BASE-T.
4. It offers very poor security and is relatively easy to tap.
5. Being thin in size, they are likely to break easily.

Applications of Twisted Pair Cables:

Some of the applications of twisted pair cables are as follows:

(1) In telephone lines to carry voice and data channels.

(2) In the local loop.

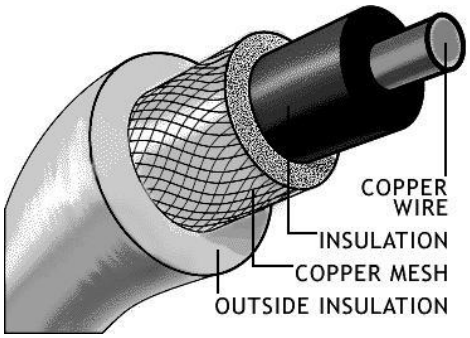
(3) In the DSL line (ADSL)

(4) Local area networks such as 10 Base-T and 100 Base-T. Use the twisted pair cables.

(5) In the ISDN (Integrated Services Digital Network).

Coaxial Cable

Coaxial cable, or coax, is an electrical cable with an inner conductor surrounded by a tubular insulating layer typically of a flexible material with a high dielectric constant, all of which are surrounded by a conductive layer called the *shield* (typically of a woven copper braid or thin metallic foil), and finally covered with a thin insulating layer on the outside.



This second layer, or shield, acts both as the second wire in the circuit and as a shield for the inner conductor, and can help reduce the amount of outside interference.

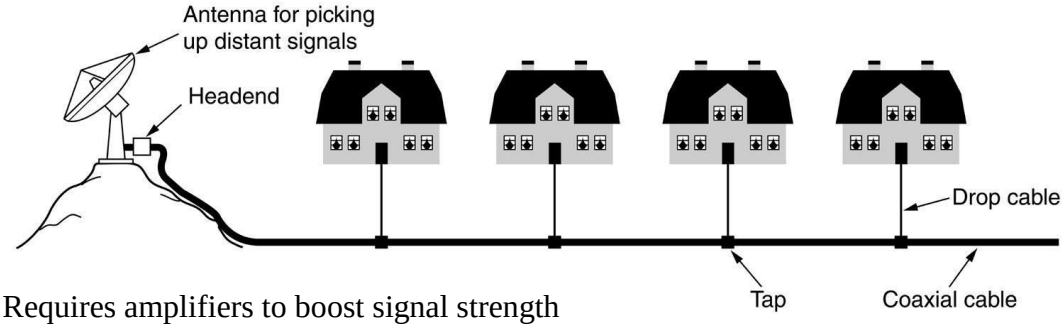
Coax cables are a bit expensive when compared with UTPs, but they can run for longer distances without a repeater/switch. For example if an Ethernet can run up to 100m with UTP, the same Ethernet can run up to 500m with coax.

There are 2 types of coax cables available:

1. Baseband coax (50Ω cable used for digital signaling)
2. Broadband coax (75Ω cable used for analog signaling)

Broadband Coaxial cable

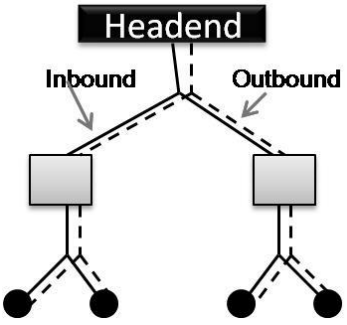
- Typically bandwidth of 300 MHz, total data rate of about 150 Mbps
- Operates at distances up to 100 km
- Uses analog signaling
- Technology used in cable television.



- Requires amplifiers to boost signal strength

Because amplifiers are one way, data flows in only one direction two types of systems have emerged:

1. *Dual cable* systems use two cables, one for transmission in each direction: One cable (inbound) is used for receiving data. Second cable (outbound) used to communicate with headend. When a node wishes to transmit data, it sends the data to a special node called the headend. The headend then resends the data on the first cable. Thus, the headend acts as a root of the tree, and all data must be sent to the root for redistribution to the other nodes.



2. *Subsplit* systems divide the raw channel into two smaller channels, with each sub channel having the same purpose as above. The inbound band is 5 to 30 MHz and the outbound band is 40 to 300 MHz. In the *midsplit* system, the inbound band is 5 to 116 MHz and the outbound band is 168 to 300 MHz.

Properties of Coaxial Cable

- It provides high bandwidth, and hence we can transmit signals at a higher data rate. The coaxial cable has a thicker gauge which increases the available bandwidth and hence increases the transmission distance.
- A coaxial cable contains a single, two-conductor wire and has an outer shield. The shield may also have a braided covering and a plastic covering.
- We can use the BALUN (Balanced/Unbalanced) connector to increase the connectivity of a coaxial cable.
- It has a very significant bandwidth as compared to other cables. This feature makes it highly usable in high-capacity applications like data transmission and image transmission.
- Due to the presence of the outer shielding, the performance of the coaxial cable is exceptionally good. The outer shielding also avoids data loss.
- It is inheritably more secure than other cables like twisted pair cables, etc.

Applications of Coaxial Cable

1. Coaxial cables are widely used in Television. The resistance of the coaxial cable used in television is 75 ohms. We can use the RG-6 coaxial cable in televisions.
2. Coaxial cables are used on the internet for carrying electrical signals over the network. We can also use the RG-6 coaxial cable in case of internet.
3. Coaxial cables are also used in CCTV systems. We can use the RG-6 and RG-59 cables for the CCTV camera systems.
4. Analog telephone networks use coaxial cables.
5. In digital telephone networks.
6. In LANs and MANs (traditional ethernet-based).

Advantages of Coaxial cable

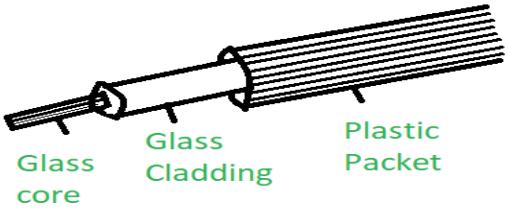
- The coaxial cables can be used to deal with both analog signals as well as digital signals.
- The coaxial cables offer high bandwidth as compared to other data transmission cables such as twisted pair cables.
- We can transfer data up to larger distances using coaxial cables.
- It is lesser expensive than optical fibers.
- It provides lower error rates than twisted pair cables.
- We cannot tap a coaxial cable easily as a coaxial cable is covered with plastic jackets.
- Coaxial cables are easy to install. Coaxial cables are also more scalable.
- In coaxial cables, the data transmission is distortionless. Coaxial cables also provide better protection from noise.

Disadvantages of Coaxial cable

- Coaxial cables are more costly than twisted pair cables.
- Coaxial cables can be easily damaged due to a lightning strike.
- These cables can transmit the data over a smaller distance as compared to optic cables.
- The bandwidth of a coaxial cable is lesser than fiber optic cable and twisted-pair cable.
- The failure of a single cable may fail the entire network.
- We need to ground the coaxial cables so that crosstalk can be prevented.
- The coaxial cable is very bulky as it contains several layers.
- A hacker can hack the coaxial cable by attaching a T-joint present in the coaxial cable. Hence, there is a question about the security of the data.

Optical Fibers

An **Optical Fiber** is a cylindrical fiber of glass which is hair thin size or any transparent dielectric medium. The fiber which is used for optical communication is waveguides made of transparent dielectrics.



Main element of Fiber Optics:

1. **Core:**
   It is the central tube of very thin size made of optically transparent dielectric medium and carries the light transmitter to receiver and the core diameter may vary from about 5um to 100 um.
2. **Cladding:**
   It is outer optical material surrounding the core having reflecting index lower than core and cladding helps to keep the light within the core throughout the phenomena of total internal reflection.
3. **Buffer Coating:**
   It is a plastic coating that protects the fiber made of silicon rubber. The typical diameter of the fiber after the coating is 250-300 um.

Types of Fiber optics:

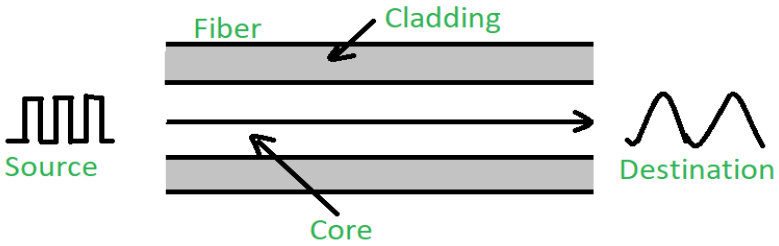
Generally optical fiber is classified into two categories based on: *the number of modes, and the refractive index*. These are explained as following below.

On the basis of the Number of Modes:

It is classified into 2 types:

i)Single-mode fiber:

In single-mode fiber, only one type of ray of light can propagate through the fiber. This type of fiber has a small core diameter (5um) and high cladding diameter (70um) and the difference between the refractive index of core and cladding is very small. There is no dispersion i.e. no degradation of the signal during traveling through the fiber. The light is passed through it through a laser diode.



ii)Multi-mode fiber:

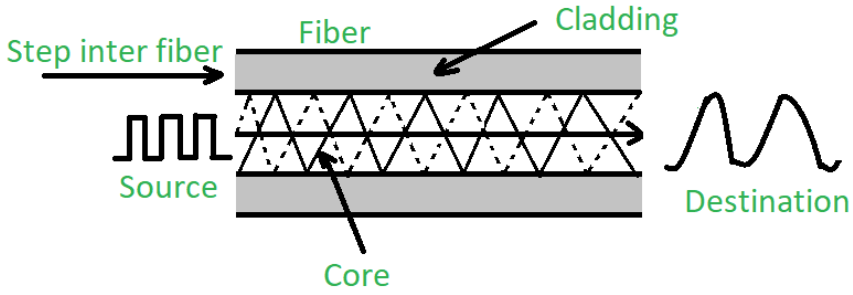
Multimode fiber allows a large number of modes for the light ray traveling through it. The core diameter is generally (40um) and that of cladding is (70um). The relative refractive index difference is also greater than single mode fiber. There is signal degradation due to multimode dispersion. It is not suitable for long-distance communication due to large dispersion and attenuation of the signal. There are two categories on the basis of Multi-mode fiber i.e. **Step Index Fiber** and **Graded Index Fiber**. Basically these are categories under the types of optical fiber on the basis of Refractive Index

2. On the basis of Refractive Index:

It is also classified into 2 types:

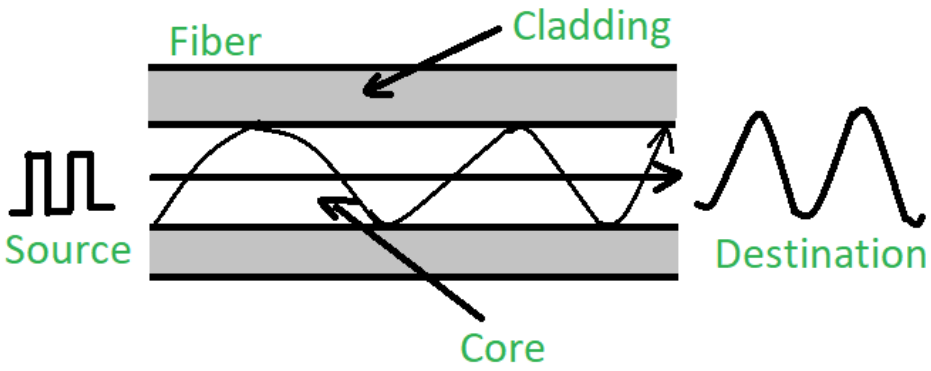
(a). Step-index optical fiber:

The refractive index of core is constant. The refractive index of the cladding is also constant. The rays of light propagate through it in the form of meridional rays which cross the fiber axis during every reflection at the core-cladding boundary.



(b). Graded index optical fiber:

In this type of fiber, the core has a non-uniform refractive index that gradually decreases from the center towards the core-cladding interface. The cladding has a uniform refractive index. The light rays propagate through it in the form of skew rays or helical rays. it is not cross the fiber axis at any time.



Advantages of Optical Fiber

Greater bandwidth & faster speed—Optical fiber cable supports extremely high bandwidth and speed. The large amount of information that can be transmitted per unit of optical fiber cable is its most significant advantage.

Cheap—Long, continuous miles of optical fiber cable can be made cheaper than equivalent lengths of copper wire. With numerous vendors swarm to compete for the market share, optical cable price would sure to drop.

Thinner and light-weighted—Optical fiber is thinner, and can be drawn to smaller diameters than copper wire. They are of smaller size and light weight than a comparable copper wire cable, offering a better fit for places where space is a concern.

Higher carrying capacity—Because optical fibers are much thinner than copper wires, more fibers can be bundled into a given-diameter cable. This allows more phone lines to go over the same cable or more channels to come through the cable into your cable TV box.

Less signal degradation—The loss of signal in optical fiber is less than that in copper wire.

Light signals—Unlike electrical signals transmitted in copper wires, light signals from one fiber do not interfere with those of other fibers in the same fiber cable. This means clearer phone conversations or TV reception.

Long lifespan—Optical fibers usually have a longer life cycle for over 100 years.

Disadvantages of Optical Fiber

Low power—Light emitting sources are limited to low power. Although high power emitters are available to improve power supply, it would add extra cost.

Fragility—Optical fiber is rather fragile and more vulnerable to damage compared to copper wires. You'd better not to twist or bend fiber optic cables too tightly.

Distance—The distance between the transmitter and receiver should keep short or repeaters are needed to boost the signal.

Difference between Twisted Pair,Fiber Optics and Coaxial Cables

Twisted pair cable	Fiber optic cable	Coaxialcable
Twisted pair wiring is a digital signal.	Fibre optics signal transmission is in the form of light signals via glass or plastic inside fiberglass cables.	Coaxial cable is an Analog signal.
Twisted Pair cable is a type of wiring technology where two conductors of a single circuit are twisted together. Data can be transmitted in the form of a circuit by a pair of wires.	Fiber optic cable is a type of Ethernet cable that consists of one or more optic fibers which are used to transmit data.	Coaxial cables, are copper cables with metal shielding designed to provide immunity against noise and greater bandwidth.
Transmission of signals: electrical form over metallic conducting wire.	Signal transmission: light forms over a glass fiber.	Signal transmission : electrical form over the inner conductor of cable.
Twisted pairs can be affected due to external magnetic fields.	Fiber optic never affected due to external magnetic field.	External magnetic field is less affected.
Twisted pair is made up of a pair of insulated copper wire.	Fiber optic made up of very thin optical fibers bundled together into a single cable. The fibers can be made of glass or plastic.	Coaxial cable is made up of solid copper, stranded copper or copper plated steel wire surrounded by an insulating layer and all enclosed by a shield
Twisted pair is low in price when compared to	Fiber optic cable is more expensive than copper	Coaxial cable is

Twisted pair cable	Fiber optic cable	Coaxialcable
both Coaxial and Fiber optical cables.	cable	moderately expensive.
Twisted pair usually not effective in rejecting noise immunity	It has highest noise immunity as the light rays are unaffected by the electrical noise.	Coaxial cable also has high noise immunity.
Attenuation is very high.	Attenuation is very much low.	In coaxial cable attenuation is low.
Installation and implementation is simple and easy.	Installation and implementation is difficult.	Installation and implementation is very easy.
Low Bandwidth.	Very high bandwidth.	Moderately high bandwidth
They are generally used in telephone networks, data networks and cable shielding.	They are installed to support long distance connections between countries and cities. They are also used in data centers where large volumes of data need to be transmitted.	Coaxial cables are used to connect radio transmitters and receivers with antennas, internet connections, digital audio and cable television signals
They transmit television, telephone and data at a relatively low speed when compared to fiber optical cable.	They transmit television, telephone and data at a relatively faster speed when compared to twisted pair and coaxial cable.	Moderately high data rate.
Attenuation is very high.	Attenuation is very low.	Attenuation is low.
Power loss due to conduction and radiation	Power loss due to absorption, scattering dispersion and bending.	Power loss due to conduction.