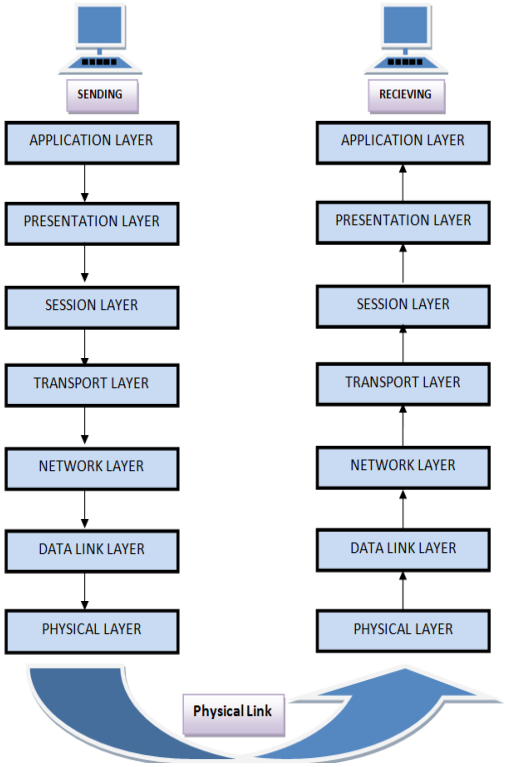
Unit II

ISO/OSI Model in Communication Networks

There are n numbers of users who use computer network and are located over the world. So to ensure, national and worldwide data communication, systems must be developed which are compatible to communicate with each other. ISO has developed this. ISO stands for **International organization of Standardization**. This is called a model for **Open System Interconnection** (OSI) and is commonly known as OSI model.

The ISO-OSI model is a seven layer architecture. It defines seven layers or levels in a complete communication system.



Feature of OSI Model :

1. Big picture of communication over network is understandable through this OSI model.
2. We see how hardware and software work together.
3. We can understand new technologies as they are developed.
4. Troubleshooting is easier by separate networks.

5. Can be used to compare basic functional relationships on different networks.

Merits of OSI reference model:

1. OSI model distinguishes well between the services, interfaces and protocols.
2. Protocols of OSI model are very well hidden.
3. Protocols can be replaced by new protocols as technology changes.
4. Supports connection oriented services as well as connectionless service.

Demerits of OSI reference model:

1. Model was devised before the invention of protocols.
2. Fitting of protocols is tedious task.
3. It is just used as a reference model.

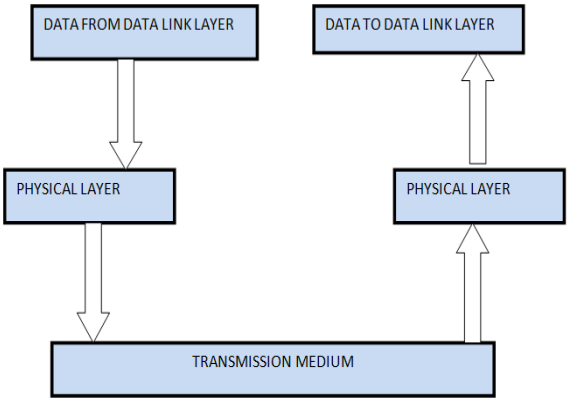
Physical Layer

Physical layer is the lowest layer of all. It is responsible for sending bits from one computer to another. This layer is not concerned with the meaning of the bits and deals with the physical connection to the network and with transmission and reception of signals.
This layer defines electrical and physical details represented as 0 or a 1.

FUNCTIONS OF PHYSICAL LAYER:

1. **Representation of Bits:** Data in this layer consists of stream of bits. The bits must be encoded into signals for transmission. It defines the type of encoding i.e. how 0’s and 1’s are changed to signal.
2. **Data Rate:** This layer defines the rate of transmission which is the number of bits per second.
3. **Synchronization:** It deals with the synchronization of the transmitter and receiver. The sender and receiver are synchronized at bit level.
4. **Interface:** The physical layer defines the transmission interface between devices and transmission medium.
5. **Line Configuration:** This layer connects devices with the medium: Point to Point configuration and Multipoint configuration.

6. **Topologies:** Devices must be connected using the following topologies: Mesh, Star, Ring and Bus.
7. **Transmission Modes:** Physical Layer defines the direction of transmission between two devices: Simplex, Half Duplex, Full Duplex.



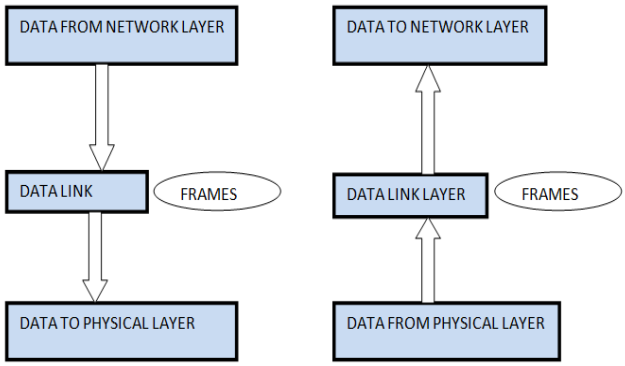
Data Link layer

Data link layer is most reliable node to node delivery of data. It forms frames from the packets that are received from network layer and gives it to physical layer. It also synchronizes the information which is to be transmitted over the data. Error controlling is easily done. The encoded data are then passed to physical layer.
Error detection bits are used by the data link layer. It also corrects the errors. Outgoing messages are assembled into frames. Then the system waits for the acknowledgements to be received after the transmission. It is reliable to send message.

FUNCTIONS OF DATA LINK LAYER:

1. **Framing:** Frames are the streams of bits received from the network layer into manageable data units. This division of stream of bits is done by Data Link Layer.
2. **Physical Addressing:** The Data Link layer adds a header to the frame in order to define physical address of the sender or receiver of the frame, if the frames are to be distributed to different systems on the network.
3. **Flow Control:** A flow control mechanism to avoid a fast transmitter from running a slow receiver by buffering the extra bit is provided by flow control. This prevents traffic jam at the receiver side.

4. **Error Control:** Error control is achieved by adding a trailer at the end of the frame. Duplication of frames are also prevented by using this mechanism. Data Link Layers adds mechanism to prevent duplication of frames.
5. **Access Control:** Protocols of this layer determine which of the devices has control over the link at any given time, when two or more devices are connected to the same link.

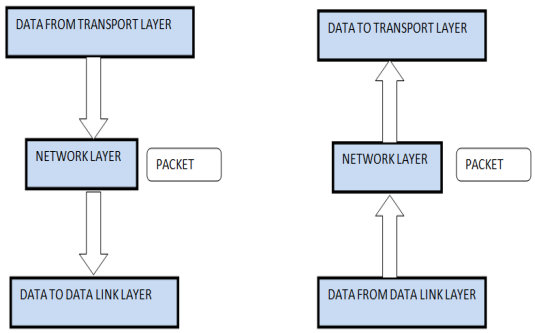


Network Layer

The main aim of this layer is to deliver packets from source to destination across multiple links (networks). If two computers (system) are connected on the same link then there is no need for a network layer. It routes the signal through different channels to the other end and acts as a network controller.
It also divides the outgoing messages into packets and to assemble incoming packets into messages for higher levels.

FUNCTIONS OF NETWORK LAYER:

1. It translates logical network address into physical address. Concerned with circuit, message or packet switching.
2. Routers and gateways operate in the network layer. Mechanism is provided by Network Layer for routing the packets to final destination.
3. Connection services are provided including network layer flow control, network layer error control and packet sequence control.
4. Breaks larger packets into small packets.

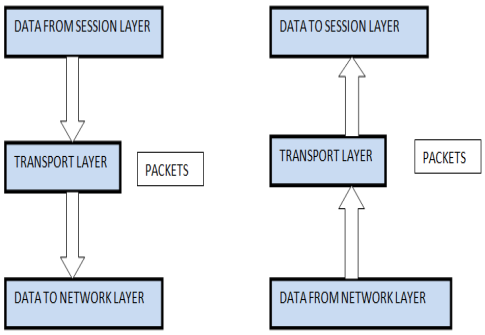


Transport Layer

The main aim of transport layer is to deliverthe entire message from source to destination. Transport layer ensures whole message arrives intact and in order, ensuring both error control and flow control at the source to destination level. It decides if data transmission should be on parallel path or single path
Transport layer breaks the message (data) into small units so that they are handled more efficiently by the network layer and ensures that message arrives in order by checking error and flow control.

FUNCTIONS OF TRANSPORT LAYER:

1. **Service Point Addressing :** Transport Layer header includes service point address which is port address. This layer gets the message to the correct process on the computer unlike Network Layer, which gets each packet to the correct computer.
2. **Segmentation and Reassembling :** A message is divided into segments; each segment contains sequence number, which enables this layer in reassembling the message. Message is reassembled correctly upon arrival at the destination and replaces packets which were lost in transmission.
3. **Connection Control :** It includes 2 types :
    - Connectionless Transport Layer : Each segment is considered as an independent packet and delivered to the transport layer at the destination machine.
    - Connection Oriented Transport Layer : Before delivering packets, connection is made with transport layer at the destination machine.
4. **Flow Control :** In this layer, flow control is performed end to end.
5. **Error Control :** Error Control is performed end to end in this layer to ensure that the complete message arrives at the receiving transport layer without any error. Error Correction is done through retransmission.

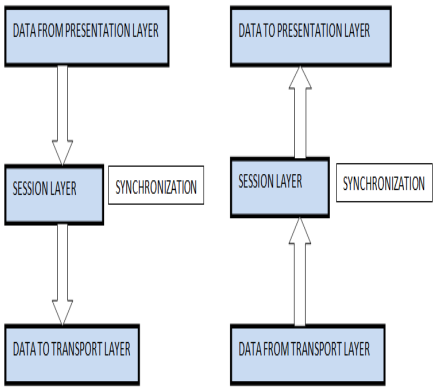


Session Layer - OSI Model

Its main aim is to establish, maintain and synchronize the interaction between communicating systems. Session layer manages and synchronize the conversation between two different applications. Transfer of data from one destination to another session layer streams of data are marked and are resynchronized properly, so that the ends of the messages are not cut prematurely and data loss is avoided.

FUNCTIONS OF SESSION LAYER:

1. **Dialog Control :** This layer allows two systems to start communication with each other in half-duplex or full-duplex.
2. **Synchronization :** This layer allows a process to add checkpoints which are considered as synchronization points into stream of data. Example: If a system is sending a file of 800 pages, adding checkpoints after every 50 pages is recommended. This ensures that 50 page unit is successfully received and acknowledged. This is beneficial at the time of crash as if a crash happens at page number 110; there is no need to retransmit 1 to100 pages.



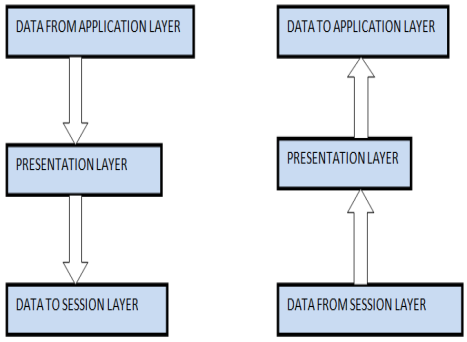
Presentation Layer

The primary goal of this layer is to take care of the syntax and semantics of the information exchanged between two communicating systems. Presentation layer takes care that the data is sent in such a way that the receiver will understand the

information (data) and will be able to use the data. Languages (syntax) can be different of the two communicating systems. Under this condition presentation layer plays a role translator.

FUNCTIONS OF PRESENTATION LAYER:

1. **Translation :** Before being transmitted, information in the form of characters and numbers should be changed to bit streams. The presentation layer is responsible for interoperability between encoding methods as different computers use different encoding methods. It translates data between the formats the network requires and the format the computer.
2. **Encryption :** It carries out encryption at the transmitter and decryption at the receiver.
3. **Compression :** It carries out data compression to reduce the bandwidth of the data to be transmitted. The primary role of Data compression is to reduce the number of bits to be 0transmitted. It is important in transmitting multimedia such as audio, video, text etc.



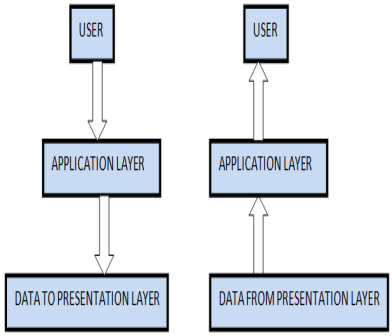
Application Layer

It is the top most layer of OSI Model. Manipulation of data (information) in various ways is done in this layer which enables user or software to get access to the network. Some services provided by this layer includes: E-Mail, transferring of files, distributing the results to user, directory services, network resource etc.

FUNCTIONS OF APPLICATION LAYER:

1. **Mail Services :** This layer provides the basis for E-mail forwarding and storage.
2. **Network Virtual Terminal :** It allows a user to log on to a remote host. The application creates software emulation of a terminal at the remote host. User’s computer talks to the software terminal which in turn talks to the host and vice versa. Then the remote host believes it is communicating with one of its own terminals and allows user to log on.

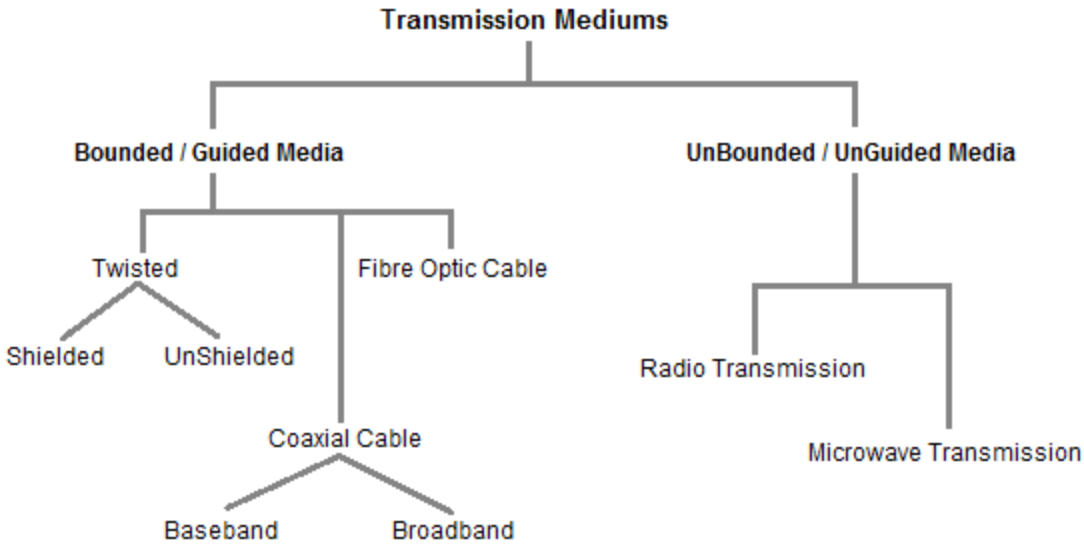
3. **Directory Services :** This layer provides access for global information about various services.
4. **File Transfer, Access and Management (FTAM) :** It is a standard mechanism to access files and manages it. Users can access files in a remote computer and manage it. They can also retrieve files from a remote computer.



Transmission Mediums

Data is represented by computers and other telecommunication devices using signals. Signals are transmitted in the form of electromagnetic energy from one device to another. Electromagnetic signals travel through vacuum, air or other transmission mediums to travel between one point to another (from source to receiver).

Transmission medium is the means through which we send our data from one place to another. The first layer (physical layer) of Communication Networks OSI Seven layer model is dedicated to the transmission media,



Factors be considered while choosing Transmission Medium

1. Transmission Rate
2. Cost and Ease of Installation
3. Resistance to Environmental Conditions
4. Distances

Bounded/Guided Transmission Media

It is the transmission media in which signals are confined to a specific path using wire or cable. The types of Bounded/ Guided are discussed below.

Twisted Pair Cable

This cable is the most commonly used and is cheaper than others. It is lightweight, cheap, can be installed easily, and they support many different types of network. Some important points :

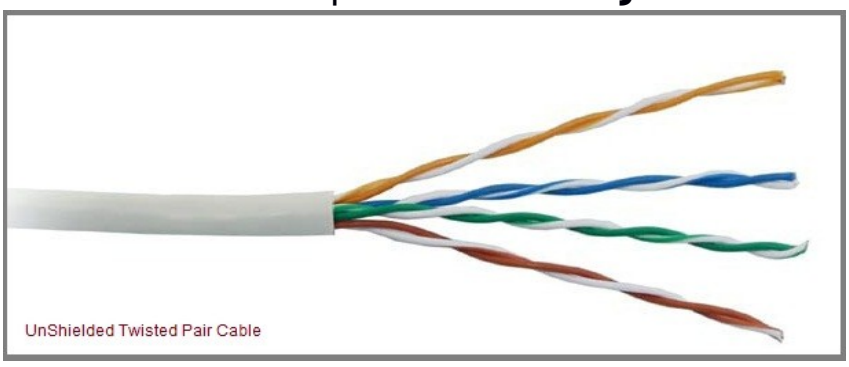
- Its frequency range is 0 to 3.5 kHz.
- Typical attenuation is 0.2 dB/Km @ 1kHz.
- Typical delay is 50 μs/km.
- Repeater spacing is 2km.

Twisted Pair is of two types :

- **Unshielded Twisted Pair (UTP)**
- **Shielded Twisted Pair (STP)**

Unshielded Twisted Pair Cable

It is the most common type of telecommunication when compared with Shielded Twisted Pair Cable which consists of two conductors usually copper, each with its own colour plastic insulator. Identification is the reason behind coloured plastic insulation.
UTP cables consist of 2 or 4 pairs of twisted cable. Cable with 2 pair use **RJ-11** connector and 4 pair cable use**RJ-45** connector.



Advantages :

- Installation is easy
- Flexible
- Cheap
- It has high speed capacity,
- 100 meter limit
- Higher grades of UTP are used in LAN technologies like Ethernet.

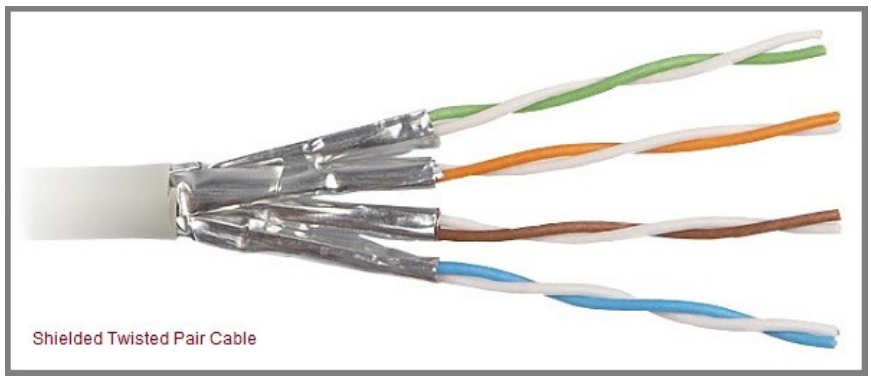
It consists of two insulating copper wires (1mm thick). The wires are twisted together in a helical form to reduce electrical interference from similar pair.

Disadvantages :

- Bandwidth is low when compared with Coaxial Cable
- Provides less protection from interference.

Shielded Twisted Pair Cable

This cable has a metal foil or braided-mesh covering which encases each pair of insulated conductors. Electromagnetic noise penetration is prevented by metal casing. Shielding also eliminates crosstalk .
It has same attenuation as unshielded twisted pair. It is faster than unshielded and coaxial cable. It is more expensive than coaxial and unshielded twisted pair.



Advantages :

- Easy to install
- Performance is adequate
- Can be used for Analog or Digital transmission
- Increases the signalling rate
- Higher capacity than unshielded twisted pair
- Eliminates crosstalk

Disadvantages :

- Difficult to manufacture
- Heavy

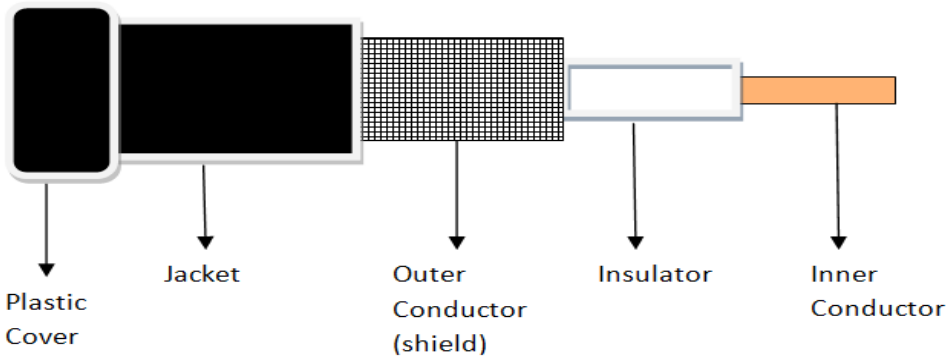
Coaxial Cable

Coaxial is called by this name because it contains two conductors that are parallel to each other. Copper is used in this as centre conductor which can be a solid wire or a standard one. It is surrounded by PVC installation, a sheath which is encased in an outer conductor of metal foil, barid or both.

Outer metallic wrapping is used as a shield against noise and as the second conductor which completes the circuit. The outer conductor is also encased in an insulating sheath. The outermost part is the plastic cover which protects the whole cable.

The most common coaxial standards are.

- 50-Ohm RG-7 or RG-11: used with thick Ethernet.
- 50-Ohm RG-58 : used with thin Ethernet
- 75-Ohm RG-59 : used with cable television
- 93-Ohm RG-62: used with ARCNET.



There are two types of Coaxial cables:

BaseBand

This is a 50 ohm (Ω) coaxial cable which is used for digital transmission. It is mostly used for LAN's. Baseband transmits a single signal at a time with very high speed. The major drawback is that it needs amplification after every 1000 feet.

BroadBand

This uses analog transmission on standard cable television cabling. It transmits several simultaneous signal using different frequencies. It covers large area when compared with Baseband Coaxial Cable.

Advantages :

- Bandwidth is high
- Used in long distance telephone lines.
- Transmits digital signals at a very high rate of 10Mbps.
- Much higher noise immunity
- Data transmission without distortion.
- The can span to longer distance at higher speeds as they have better shielding when compared to twisted pair cable

Disadvantages :

- Single cable failure can fail the entire network.
- Difficult to install and expensive when compared with twisted pair.
- If the shield is imperfect, it can lead to grounded loop.

Optical Fiber

In case of coaxial cables and twisted cable the maximum signal frequency, and hence the information rate that can be transmitted

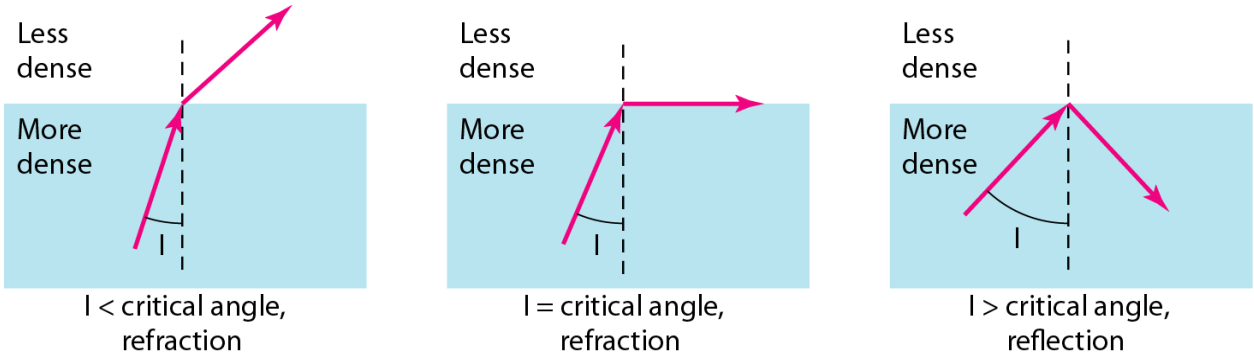
using a solid conductor is limited. Optical fiber differs from both these transmission media in that it carries the transmitted information in the' form of a fluctuating beam of light in a glass fiber rather than as an electrical signal on a wire. This type of transmission has become strong support for digital network owing to its high capacity and other factors favorable for digital communication.

There are two basic types of fibers used today and many different types of Fiber Optic Cable. These are Single Mode (SM) and Multi-Mode (MM). Single mode is more expensive but more efficient than multi-mode. Single mode fiber is generally used where the distances to be covered are greater. These come in a variety of configurations determined by a variety of factors and light propagates along the optical fiber core in one of the following ways as given below depending on the type and width of core material used.

Principle

A fibre-optic cable is made of glass or plastic and transmits signals in the form of light. To understand optic firber we first need to explore several aspects of the nature of light.

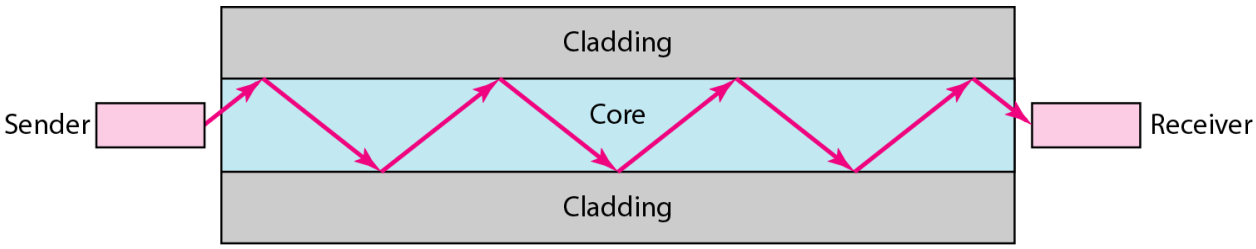
Light travels in a straight line as long as it is moving through a single uniform substance. If a ray of light traveling through one substance suddenly enters another substance(of a different density), the ray changes direction. Figure below shows how a ray of light changes direction when going from a more dense to a less dense subsgtance



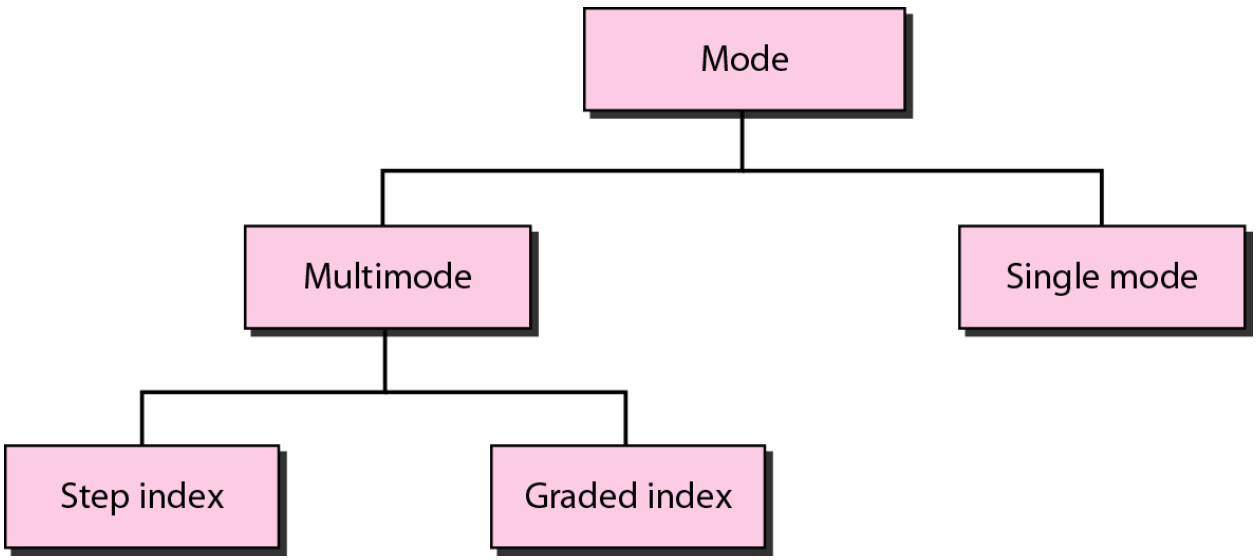
As the figure shows, if the angle of incidence I (the angle the ray makes with the line perpendicular to the interface between the two substances) is less than the critical angle(the angle of incidence which provides an angle of refraction of 90 degree) , the ray refracts

and moves closer to the surface. If the angle of incidenceequal to the critical angle, the light bends along the interface. If the angle is greater than the critical angle, the ray reflects(makes a turn) and travels again in the denser substance.

Optical fibers use reflection to guide light through a channel. A glass or plastic core is surrounded by a cladding of less dense glass or plastic. The difference in density of the two materials must be such that a beam of light moving through the core is reflected off the cladding instead of being refracted into it as shown in fig. below



Different Types of Optical Fibers



Multi-mode Fiber

In the case of a multi-mode fiber, the core diameter is relatively large compared to a wavelength of light. Core diameter ranges from

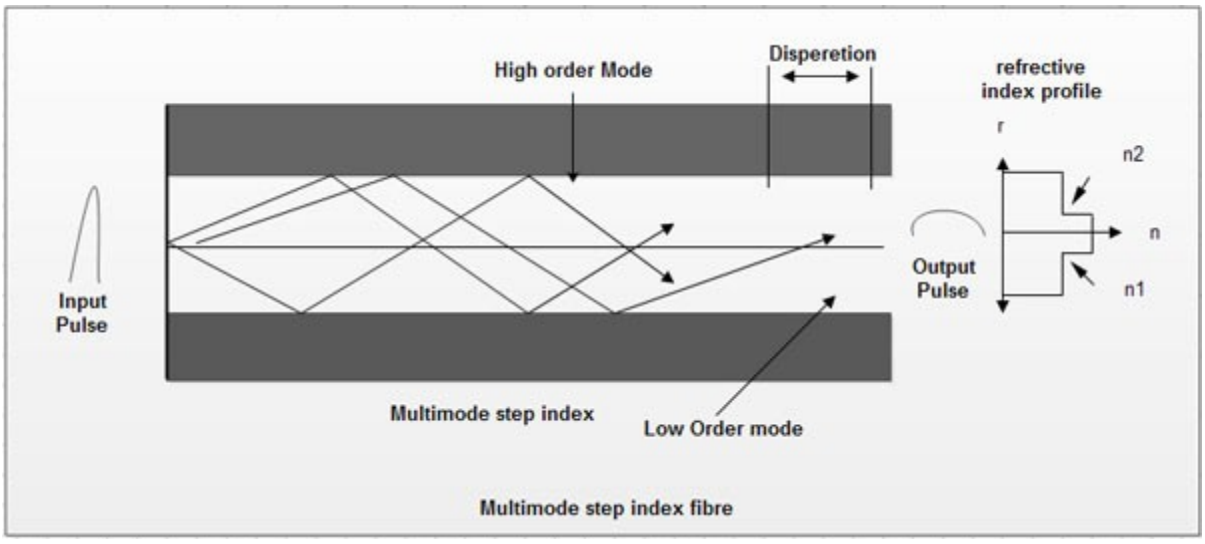
50 micrometers (pm) to 1,000 pm, compared to the wavelength of light of about 1 pm. It means that light can propagate through the fiber in many different ray paths, or modes, hence the name multimode.

Multi-mode fiber is less expensive to produce and inferior in performance because of the larger diameter of the inner core. When the light rays travel down the fiber, they spread out due to a phenomenon known as modal dispersion. Although reflected back into the inner core by the cladding, they travel different distances and, therefore, arrive at different times. The received signal thus has a wider pulse width than the input signal with a corresponding decrease in the speed of transmission. As a result, multimode fiber is relegated to applications involving relatively short distances and lower speeds of transmission, for example, LANs and campus environments.

Two basic types of multi-mode fibers exist. The simpler and older type is a "step index" fiber, where the index of refraction (the ability of a material to bend light) is the same all across the core of the fiber and the second one is graded index fiber with varying index of refraction across the core.

Step Index Multi-mode Fiber

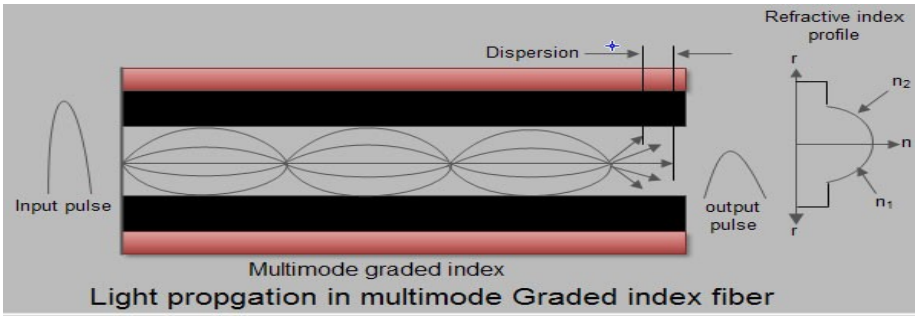
Step index has a large core, so the light rays tend to bounce around inside the core, reflecting off the cladding. This causes some rays to take a longer or shorter path through the core. Some take the direct path with hardly any reflections while others bounce back and forth taking a longer path. The result is that the light rays arrive at the receiver at different times. The signal becomes longer than the original signal. LED light sources are used. Typical Core: 62.5 microns.



With all these different ray paths or modes of propagation different rays travel different distances, and take different amounts of time to transit the length of a fiber. This being the case, if a short pulse of light is injected into a fiber, the various rays emanating from that pulse will arrive at the other end of the fiber at different times, and the output pulse will be of longer duration than the input pulse. This phenomenon is called modal dispersion (pulse spreading), and limits the number of pulses per second that can be transmitted down a fiber and still be recognizable as separate pulses at the other end. This, therefore, limits the bit rate or bandwidth of a multi-mode fiber. For step index fibers, where in no effort is made to compensate for modal dispersion, the bandwidth is typically 20 to 30 MHz over a length of one kilometer of fiber, expressed as "MHz =km",

Graded Index Multi-mode Fiber

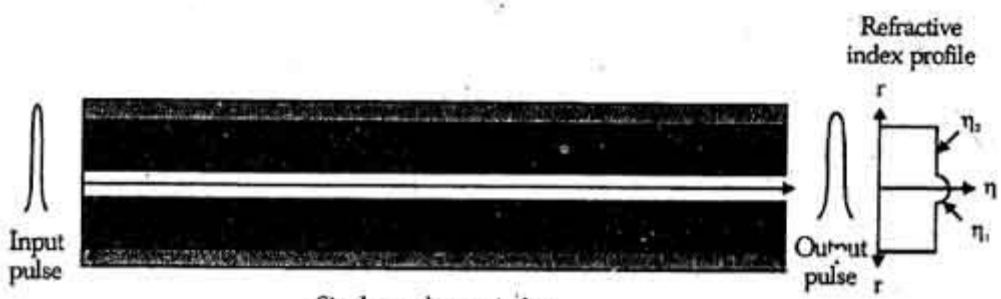
In the case of a graded index multi-mode fiber, the index of refraction across the core is gradually changed from a maximum at the center to a minimum near the edges, hence the name graded index. This design takes advantage of the phenomenon that light travels faster in a low-index-refraction material than a high-index material. If a short pulse of light is launched into the graded, index fiber, it may spread some during its transit of the fiber, but much less than in the case of a step index fiber. Therefore, dispersion can be reduced using a core material that has a variable refractive index. In such multi-mode graded index fiber light is refracted by an increasing amount as it moves away from the core. This has the effect of narrowing the pulse width of the received signal compared with stepped index fiber, allowing a corresponding increase in the speed of transmission. These, therefore, can support a much higher bit rate or bandwidth. Typical bandwidths of graded index fibers range from 100 MHz-km to well over 1 GHz-km. The actual bandwidth depends on how well a particular fiber's index profile minimizes modal dispersion, and on the wavelength of light launched into the fiber.



Light propgation in multimode Graded index fiber

Monomode / Single-Mode Fiber

This has a thinner inner core. In this case, the core diameter of about 9 pm is much closer in size to the wavelength of light being propagated, about 1.3 pm. This limits the light transmission to a single ray or mode of light to propagate down the core of the fiber .All the multiple-mode or multi-mode effects described above are eliminated. However; one pulse-spreading mechanism remains. Just as in the multi-mode fibers, different wavelengths of light travel at different speeds, causing short pulses of light injected into the fiber to spread as they travel. This phenomenon is called "chromatic dispersion".



Light propagation in single mode step index fiber

It performs better than does multi-mode fiber over longer distances at higher transmission rates. Due to reduced core diameter all the emitted light propagates along a single path. Consequently, the received signal is of a comparable width to the input signal. Although more costly, mono mode fiber is used to advantage in long haul and especially in high bandwidth applications. Single-mode fibers have the very broadest bandwidth, lowest cost and lowest attenuation of any available optical fiber. Therefore, they are universally used in long-distance telephony and cable television applications.

Advantages of Optical Fiber

1. Noise resistance: It is immune to electromagnetic interference and crosstalk and external light, the only possible interference, is blocked from the channel by the outer jacket.
2. Less signal Attenuation: It has transmission distance significantly greater than that of other guided media.
3. Higher bandwidth: Currently, data rates and bandwidth utilization over fiber optic cable are limited not by the medium but by the signal generation and reception technology even though it offers a large bandwidth compared to other media. Larger bandwidth offers larger capacity and faster transmission rate.

4. High security: Using fiber optic cables prevents the emanation of radiation and therefore, radiation-containing signal becomes difficult to tap. This makes fiber cable secure against signal leakage and interference.
5. Free from electrical problems: It does not require electrical ground loop preventing it from short circuit as light waves are being used the carrier of data signal. It is also safe in combustible areas (no arching) and offers immunity to lightning and electrical discharges.
6. Less number of repeaters: A repeater used to strengthen a signal is always required during the Course of signal transmission. Compared to copper media, it requires less number of repeaters.
7. Physical structure: It has small size, lightweight, flexibility, high strength, potential high temperature operation and no electrical hazard when cut or damaged.

Disadvantages of Optical Fiber

1. Cost-The cost of optical fiber is a trade-off between capacity and cost. At higher transmission capacity, it is cheaper than copper. At lower transmission capacity, it is more expensive. As this transmission medium becomes more popular and in demand, economies of scale will decrease the cost of installation and profits will increase.
2. Installation/Maintenance-It is difficult to splice. Special equipment and expertise are required to splice and install the cables.
3. Fragility-It has limited physical arc of cable, if it is bent too much it will break. Physical vibration will show up as signal noise.

WANS

A **wide area network** (**WAN**) is a telecommunications network or computer network that extends over a large geographical distance. Wide area networks are often established with leased telecommunication circuits.

Business, education and government entities use wide area networks to relay data among staff, students, clients, buyers, and suppliers from various geographical locations. In essence, this mode of telecommunication allows a business to effectively carry out its daily function regardless of location. The Internet may be considered a WAN.

Related terms for other types of networks are personal area networks (PANs), local area networks (LANs), campus area networks (CANs), or metropolitan area networks (MANs) which are

usually limited to a room, building, campus or specific metropolitan area respectively.

WANs are used to connect LANs and other types of networks together, so that users and computers in one location can communicate with users and computers in other locations. Many WANs are built for one particular organization and are private. Others, built by Internet service providers, provide connections from an organization's LAN to the Internet. WANs are often built using leased lines. At each end of the leased line, a router connects the LAN on one side with a second router within the LAN on the other. Leased lines can be very expensive. Instead of using leased lines, WANs can also be built using less costly circuit switching or packetswitching methods.

Network protocols including TCP/IP deliver transport and addressing functions. Protocols including Packet over SONET/SDH, MPLS, ATM and Frame Relay are often used by service providers to deliver the links that are used in WANs.

WAN Technologies

CIRCUIT SWITCHING

Switched circuits allow data connections that can be initiated when needed and terminated when communication is complete. This works much like a normal telephone line works for voice communication. Integrated Services Digital Network (ISDN) is a good example of circuit switching. When a router has data for a remote site, the switched circuit is initiated with the circuit number of the remote network. In the case of ISDN circuits, the device actually places a call to the telephone number of the remote ISDN circuit. When the two networks are connected and authenticated, they can transfer data. When the data transmission is complete, the call can be terminated.