UNIT 2 DATA TRASNMISSION BASICS & TRANSMISSION MEDIA

2.0 INTRODUCTION

Data communication not only involves transfer of information but is successful only when the information is interpreted correctly by receiver.
For any communication to be successful some set of rules has to be followed. Set of rules is called protocol. As the communicating devices most of times are heterogeneous in nature i.e. may be different in hardware or software or operating system plateformetc that is why certain rules has to be followed to bring them all on a common platform to make them capacble of communicate and understand the information. As we know that to transmit the data from one system to another separated apart from each other there is a need of medium/channel. Data transmission can takes place either through wired media or wireless media. A communication protocol is designed considering following parameters:

- Media/channel used in transmission;
- Rate at wich data to be transmitted (generally in bits per second);
- Mode of data transmission;
- Attenuation, Delay, Noise etc faced during transmission

In data communication these are used every where, whether it is comparing efficiency of protocols for data transmission, routing, security means etc. To understand these in better way we have to understand commonly used terminologies and basic concepts of data transmission first, and that is what we are going to learn in this unit.

In section 2.1 data communication terminologies like Channel, Baud, Bandwidth, and Frequency. In section 2.2 various data transmission modes are discussed. Section 2.3 covers analog and digital data transmission.Transmission Impairments: Attenuation, Delay Distortion, Noise, Signal to Noise ratio, and Concept of Delays are discussed in section 2.4. Guided and unguided transmission media are covered in section 2.5. Section 2.6 coveres wireless transmission methods: Microwave Transmission, Radio Transmission, Infrared and Millimeter Waves. Section 2.7 discusses the Wireless LAN technology. In section 2.8, summary is covered.. Some of the important Solutions/Answer covering the entire unit are discussed in section 2.9.

2.1 OBJECTIVES

After completing this unit, one should be able to:

- understand the Data Communication Terminologies;
- understand Data Transmission Modes;
- understand Analog and Digital Data Transmission;
- understand the terms Attenuation, Delay Distortion, Noise, Signal to Noise ratio etc;

  understand the Concept of Delays;
- differentiate Guided and Unguided Transmission Media;
- understand the Wireless Data Transmission Mode.

2.2 DATA COMMUNICATION TERMINOLOGY

As discussed in section 2.1 Data communication is not just to transfer the data between sender and receiver but also that the interpretation of the data should be same and correct by both the sednder and the receiver. Further we will be looking after the terminologies commonly used in data communication here:

2.2.1 Channel

A channel is the medium used to transmit the information between sender and receiver. In other words channel is the path through which the exchange of information between devices takes place. Channel is classified into two categories: wired and wirless. In metal wired channel the electrons present within the metal carry the information. In fiber optics based guided media concept of total internal reflection of light is used to transmit the information in a fiber glass cable. Wired channels are guided media i.e. as the electrons can move in the metal in restricted way in certain direction carrying the information, whereasin the wireless channels the air particals are responsible for data transmission.

Every channel has the channel capacity which limits its maximum data carrying capacity over a certain time period. Based on the type of information could be propagated through channel, there are two types of channels used in data communication namely: Analog and Digital. Analog form of data is transmitted through analog channels and digital data is transmitted through digital channel.

2.2.2 Baud

It is a unit of data transmission speed. Symbol rate or modulation rate of a signal is measured in bauds. Symbole rate is one of the elementsconsidered to measure the data transmission speed of a data channel.

In a second how many times a signal changes its state is known as the baud. For digital signals with two states, baud and bita per second are equal i.e.1 Bd = 1 bit/s.

The symbol 'Bd' is used to represent the unit baud. For example: Transmission at baud rate 100 *Bd* means, 100 symbols are are transmitted in a second i.e. a symbol is transmitted for 100^{th} fraction of a second.

Baud rate is related to bit rate as following:

Bit rate = Baud rate x bits in a Baud

2.2.3 Bandwidth

Bandwidth is the data carrying capacity of the channel/media per unit time (It can be defined for the bus within a computer or the channel of computer network). Bandwidth of a channel is the amount of data or signals transmitted in a time interval. Bandwidth of a channel depends on the length of the channel, media considered, and the signaling method used. More is the bandwidth higher is the throughput of the medium. Bandwidth ofmedium is the range of the frequencies used to transmit the data i.e. the difference between highest and the lowest frequencies the medium can carry. The bandwidth for digital devices is typicallyconsidered as number of bits per second whereas, expressed in Hertz (Hz) or number of cycles per second for analog devices.

2.2.4 Frequency

Frequency is the rate of repeatition of an event per second of duration. Unit of frequency is Hz which is number of cycles per second.
In data communication, the frequency of a signal is number of cycles completed by the signal per unit time.Some times there is confusion between period and frequency. Period and frequency are exactly opposite of each other. Period is defined as the minimum time in which a signal repeates itself and denoted as seconds per cycle whereas, frequency is the number of periods a signal completes within a specified time duration and denoted as cycles per second.

$$f = 1/T$$

For example, consider the following figure:

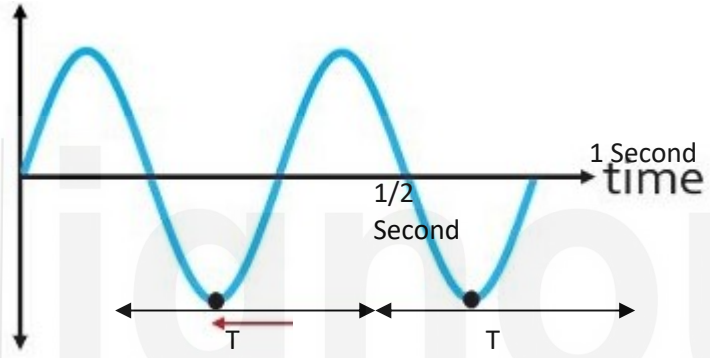


Figure: Time Period and Frequency of a Signal.

In this figure the signal repeates itself after ½ second so, the time period (T) of the signal is ½ second.
Frequency of this signal is: the number of cycles completed in a second i.e. the signal completes 2 cycles in a second hence, the frequency (f) of the signal is 2 Hz.

2.3 MODES OF DATA TRANSMISSION

Data transmission mode is how data is transferred from sender to receiver over a communication channel in the network. Mode of transmission defines the direction of flow of data. Based on the mode of data transmission a communication can be classified as:

- Simplex Mode,
- Half duplex mode and
- Full duplex mode.

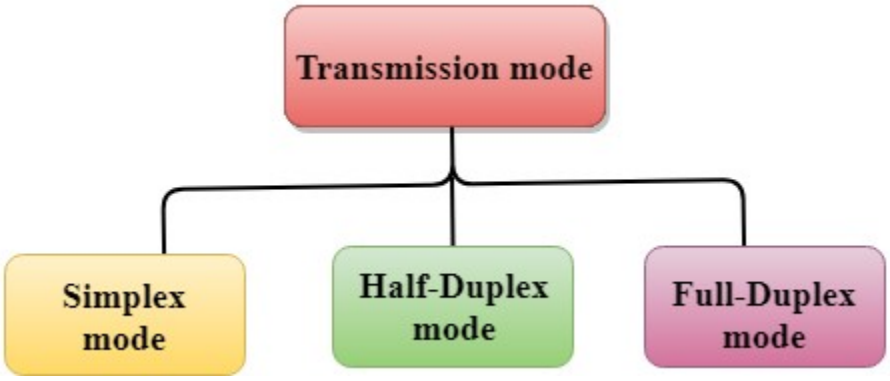


Figure: Data Transmission Modes

Other ways of data transmission are: Serial transmission and Parallel transmission. Further serial transmission is classified into three categories namely: Asynchronous, Synchronous and Isochronous transmission.

2.3.1 Simplex mode, Half Duplex mode and Full Duplex mode

Simplex mode of data transmission:

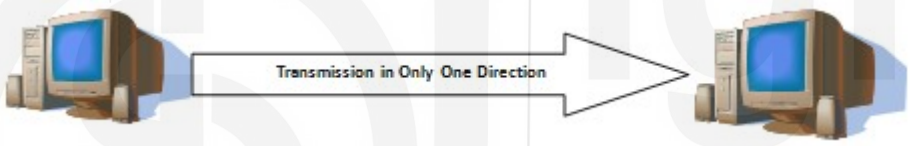


Figure:Simplex Mode

In Simplex mode of data transmission, the data through the channel can be transferred in one direction only. This mode of transmission is useful when one device always acts as the transmitter and another as the receiver. The channel used in radio (AM/FM) communication is type of simplex channel where the radio station always transmits the signals and the listeners always receives the signal. In computer system the keyboard, mouse, printer, scanner and monitor also uses the simplex mode transmission, data is always transferred in one direction only. Simplex mode of data transmission is not very useful in computer networking as data is to be sent and received in both ways. One of the advantage of simplex mode is that the station (acting as transmitter) can utilize the full bandwidth of the channel. Simplex mode is not suitable for intercommunication among systems due to the constraint of unidirectional transmission.

Duplex Mode of data transmission:contrast to the simplex mode in duplex mode of transmission data is allowed to flow in both the direction over the channel. Further duplex mode of transmission is classified into two categories namely: Half duplex mode and Full duplex mode.

Half Duplex Mode of Data Transmission: In half duplex mode of transmission the data can flow in both the direction but can be allowed in one direction at a time i.e. at a time one of the communicating devices acts as transmitter and another as receiver. Both cannot act as transmitter simultaneously.

Unlike the simplex mode in which one way communication takes place i.e. one device acts as a transmitter and another as receiver, the half-duplex is two-way communication, but only one device is allowed to send data at a time.

The full bandwidth is used by either of the communicating devices. One of the example of half duplex communication is the walkie-talkie, in which one end speaks and another listens, both are not allowed to transmit voice signals simultaneously.

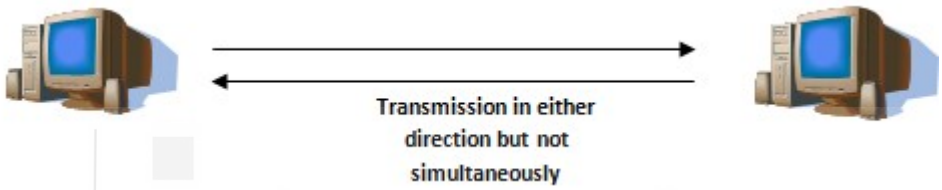


Figure: Half Duplex Mode

Full Duplex Mode of Data Transmission: In full duplex mode both the devices can act as transmitter and receiver simultaneously. Both the ends should be capable of transmitting and receiving the data simultaneously. In this mode of transmission the data can flow in both directions at a time. The bandwidth of the channel is divided between both end devices. The most popular full duplex communication is the telephone network where both ends can transmit and receive voice signals simultaneously.

Figure: Full Deplex Mode

2.3.2 Serial and Parallel Communication

Digital devices works on digital data in the form of binary bits. Data is transmitted among digital devices in the form of binary bits in two ways namely: serial transmission and parallel transmission. In serial transmission bits are transmitted in serial manner i.e. one after another through a channel whereas, in parallel transmission bits are transmitted in parallel manner i.e. multiple bits are transmitted simultaneously through multiple channels.

Serial data communication:

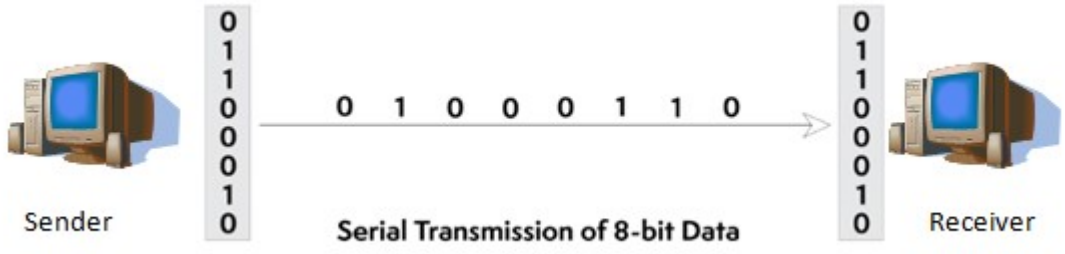


Figure: Serial Data Transmission

As shown in figure, in serial transmission between sender and receiver the data is sent bit by bit on the channel. In order to interpret the data correctly both ends mutually agree on transmitting the data from LSB (least significant bit) to MSB (most significant bit). On the sender side an extra hardware component is required to convert the bytes of characters (i.e.parallel) to serial. Simillarly on the receiver side some mechanism is to be applied to convert the received serial data into parallel to form the character bytes as sent. Serial transmission is most suitable for transferring small amount of data over long distance. Serial transmission further classified into two categories: asynchronous transmission, synchronoustransmissison and isochronous transmission which are discussed in section 2.3.3.

Parallel data communication: In parallel communication multiple bits are transmitted in parallel over multiple channels simultaneously. Data transmission through parallel data communication is much faster in comparision to transmitting the data through serial communication methods.

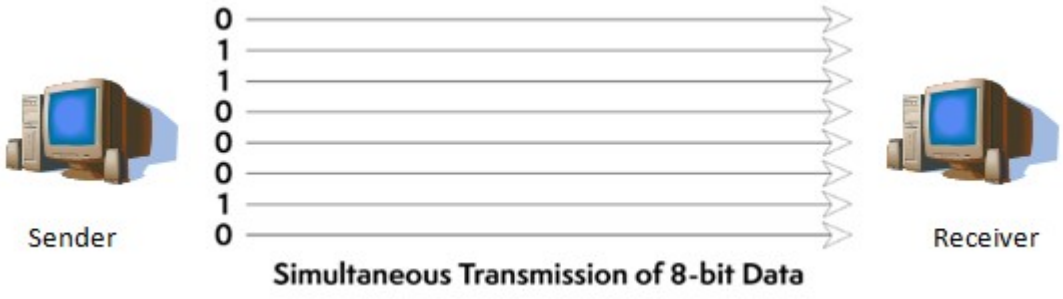


Figure: Parallel Data Transmission

In parallel data communication many bits are transmitted simultaneously hence, it is very important to note that the speed of transmission of bits on parallel channel

should be always in synch with the speed of receiving of parallel bits on the receiver side. Due to this constraint parallel communication is usually not suitable for long distances instead is suitable for transmission over short distances. The data transmission of takes place in parallel making it faster, it is best suitable for transferring huge amount of data over short distances.

2.3.3 Synchronous, Asynchronous and Isochronous Communication

In general serial data transmission technioque is commonly used to transfer data in Internet over long distance. The biggest issue of serial communication is the synchronization of the transmission speed of sender and the receiving speed of the receiver. If the transmission speed and receiving speed of sender and receiver mismatches, the receiver will not be able to interpret the received bit stream correctly. In serial communication another issue is that, how to correctly detect the end of a character and beginning of next character. To synchronize sender and receiver some mechanism is to be applied. In general sender and receiver are synchronized with three methods namely: Synchronous, Asynchronous and Isochronous Communication.

Synchronous Communication: An external agent (a clock) regulates the data transmission. In synchronous way of data communication, data is transmitted in the form of frames or chunks instead of characters. A special signal named: synch signal is transmitted before sending the actual data notifying the receiver about transmission of a new frame to get synchronized with sender. Sync signal, in general is a unique bit pattern such that it cannot be a part of user data to avoid confusion between synch signal and user data. Similar to the start of the frame signal an end of the frame signal is also used to indicate that where a frame ends. Seral synchronous transmission is suitable for transferring large amount of data at a high speed. For transferring small size frames due to the overhead of start and end of frame signals the utilization of channel is not optimum.

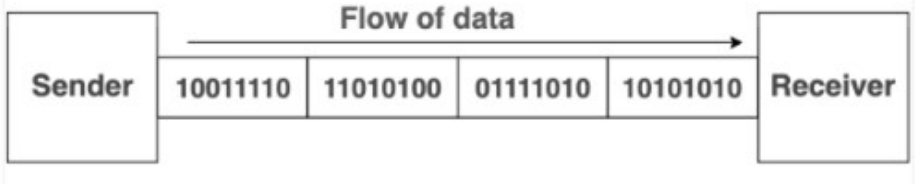


Figure: Synchrnonous Data Transmission

Synchronous transmission is preferred where characters are generated at irregular intervals because the characters are not simply transmitted as they received, they will be holded back to collect enough data to form the frame. A complex circuitry is to be installed in synchronous transmission making it expensive and difficult to implement.

As the data it transmitted in the form of frames or blocks, if any bit is found in, the whole frame or block is to be retransmitted. Cyclic Redundancy Check (CRC)

error control technique is used in synchronous transmission instead of parity bit due to its capability to transmit long size frames.

Asynchronous Communication: No external agent regulates the data transmission. In synchronous communication data is sent character by character. Start and stop bits are added to each character forming a frame before sending. On receipt of start bit the receiver adjusts itself in accordance to the timing of the transmitted signal. A sender can transmit the frame at any time. In asynchronous transmission, the size of frames is should be kept as small as possible. Asynchronous communication is commonly used to transmitcharacters generated at irregularintervals. When user inputs characters with keyboard to the computer is a typical example of asynchronous communication. As the size of frame is small so, the parity bit is used to handle error control. A frame is structured with following components:

1) S**tart bit:** it enables the receiver to synchronise itself with the frame (message) sent.

2) **Data Bits:** these are the actual user data to be transmitted.

3) **Parity Bits:** it is optional to use and is used to handle error encountered during transmission. Parity bit is capable of detecting single bit error only.

4) **Stop bit:** it enables receiver to detect the ned of a frame.

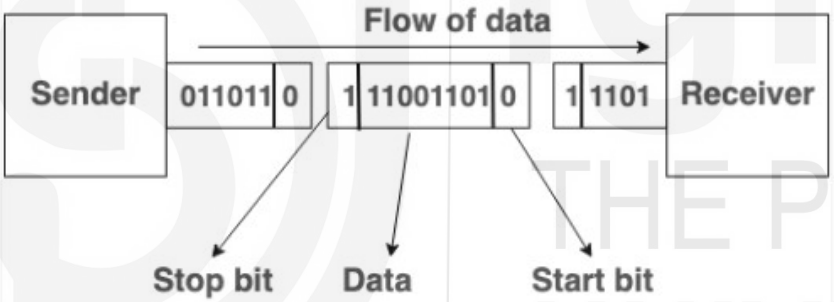


Figure: Asynchronous Data Transmission

In synchronous transmission, when the data is received by the receiver it must be handled immediately without any delay. Whereas, in asynchronous data transmission the receiver is not bound to handle the reveived data in real time instead a buffe is placed at the incoming line. Today, irrespective of serial or parallel communication, most of the transmission takes place in asynchronous manner.

In asynchronous transmission no special hardware is required to be installed makes it simple, inexpensive technique. Asynchronous communication is suitable for transmitting small size frames generated at irregular intervals (for example, characters generated by user from a keyboard).

In asynchronous communication a frame is generated from a character so, if an error occurs in a frame only a character is retransmitted contrast to the synchronous communication by restransmitting the whole block or frame (comprising many characters). The insertion of extra bits (start bit, stop bit, and

parity bit), the overhead to the channel is more degrading the overall performance of transmission hence, asynchronous communication is not suitable for transmission of large amount of data. Also, the success rate of asynchronous transmission is highly depends on the on the recognition of the start and stop bits. The transmission speed of asynchronous communication is slower than that of synchronous communication.

Differentiating synchronous communication from asynchronous communication:

S.NO	Synchronous Transmission	Asynchronous Transmission
1.	Data is transmitted as frames or blocks.	Data is transmitted as characters or bytes.
2.	Transmission rate is faster.	Transmission rate is slower.
3.	It is expensive.	It is economical.
4.	The time interval between blocks is constant.	time interval is random.
5.	It is regulated by an external clock signal also shared with the receiver.	No need of synchronized clocks, as start and end bits are used.

Isochronous Communication: isochronous communication is the hybrid version of both synchronous and asynchronous communication. It inherits the start and stop bit from asynchronous communication i.e. start and stop bits are added to each character before transmission. Characters are transmitted at fix intervals i.e. between twocharacters an exact multiple of one character time interval is added instead of a random time interval, e.g. say t is the transmission time of a character frame with start bit, stop bits and parity bit, then the interval between any two charater frames could be n, where n belongs to positive integer.

2.4 ANALOG AND DIGITAL DATA TRANSMISSION

Data can be transferred in the form of analog signal or digital signal. In data communication, the data is represented in the form of electromagnetic signal like micro ware, radio wave, infrared for wireless, electrical voltage for metallic wires and light for fiber optical cable. ,radiowave, microwave, or infrared signal. Continuous data (like voice, data, image, signal or video) is transmitted through

analog signals and called as analog transmission and discrete data is transmitted through digital signals.

Analog Data Transmission: Analog signals are generally represented in the form of sinusoidal wave. Analog signals are continuous in nature i.e. either amplitude or the frequency are continuous in nature and capable to represent continuous data. Video and audio data are transmitted as analog signals.

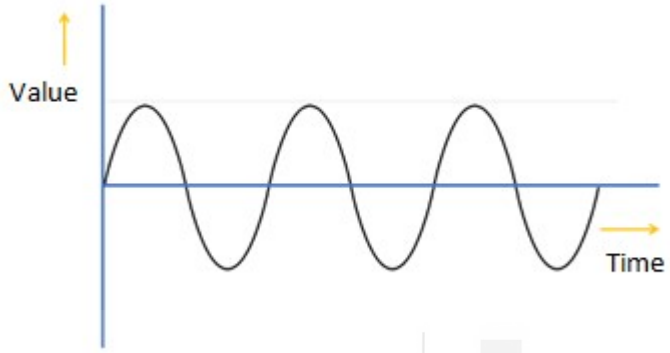


Figure: Analog Signal

As shown in figure the signal value is continuous function of time. Over the distance, signal strength decreases so, to regain the signal strength amplifiers are installed along the transmission line. One of the major issue with analog signals is the accumulation of error during the journey. Signal is distorted during the journey due to external factors and amplifiers are dumb devices which simply increases the strength of input signal carrying noise also. So, along with the data signal, noise level is also regained which is very difficult to separate from the original signal.

Analog signals are not suitable for the transmissions require high level of accuracy. Analog signals can be transformed into digital signals by quantizing or sampling techniques.

Digital Data Transmission: contrast to analog signal being a continuously variable wave form, digital signal is a series of discrete pulses. Digital signals are used to transmit discontinuous data or events.

All the computing devices are based on digital data. Computers generate data in form of digital signals.

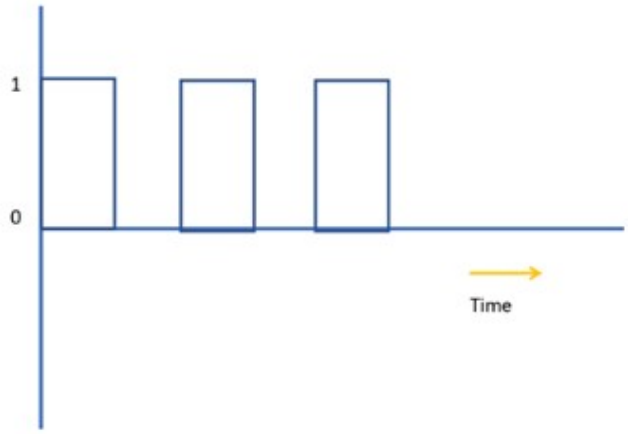


Figure: Digital Signal

As shown in figure above, digital signals are represented in the form of square waves. Digital signals also loss their signal strength or power over the distance. Repeater devices are used to regain the energy level of the signal. Repeater regenerates original level (0 or 1) by measuring the signal values at regular intervals hence the loss of information due to attenuation during transmission does not affect the original signals.
Let us compare analog and digital signals:

Analog	Digital
It is a continuous signal representing real time measurements.	It is dicreteor time separated signal generated by digital modulation.
Sine wave is used to denote the analog signal.	Digital signals represented by square waves
Analog signal can represent continuous range of values.	Discrete values can be represented with digital signal.
Data produced by light sensors, FM radio, temperature sensors, etc are analogin nature and could be represented as analogsignals.	Compact Drives, Digital video Disks and Computers etc. digital signal.
Bandwidthofanalog signal is low	Bandwidth of digital signal is high.

Over the distance analogsignal is deteriorated by noise.	Digital signal is less deteriorated compared to analog signal.
Analog signal is best suitable to transmit video and audio data.	Most of the computing devices works on digital values/signals.
Analog signal is prune to observational errors.	Digital signal is not prune to observational errors.
Analog signal represents the complete range taken by signal.	Digital signal represents the values with finite /limited number.

2.5 TRANSMISSION IMPAIRMENTS

As discussed in presious section, in general analog signals are used to transmit the data because of its simplicity and ease. As the media or channel is not reliable, during the transmission of analog signal, it gets deteriorate i.e. the signal changes its form over the distance leading to change of the data/measurement values represented by this analog signal. During the transmission signal may suffer impairments like: attenuation, delay distortion and noise may occure in signal.

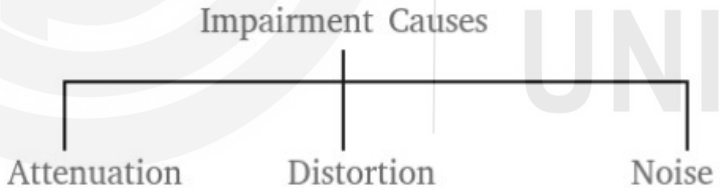


Figure: Causes of transmission inmpairments

2.5.1 Attenuation

The loss in enegy over the distance due to resistance of the medium is termed as attenuation. Hardware device: Amplifiers are installed in between to compensate the losses and regain the signal strength. Attenuation in a signal is measured in decibel and the symbole used for it is dB.Attenuation value is used to compare the signal strengths of different signals. It is also used to evaluate the signal strength of a signal at different positions.

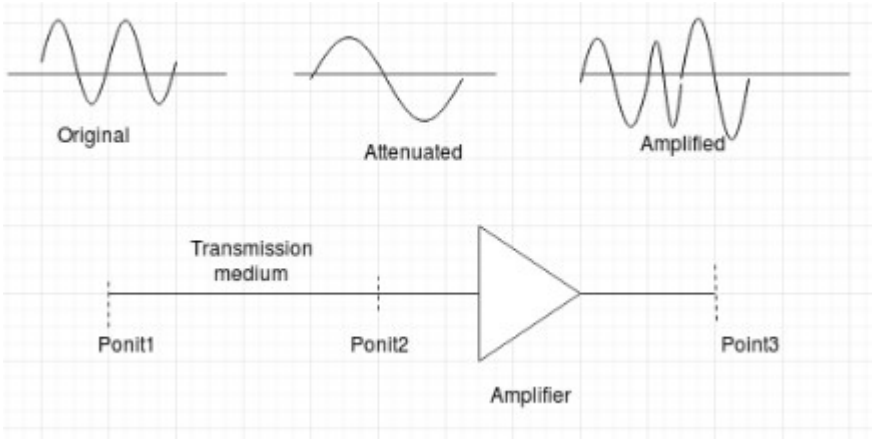


Figure: Effect of attenuation and amplification on a signal

The attenuation or dB of a signal can be calculated as follows:

$$dB(Attenuation) = 10log_{10}[P_2/P_1]$$

Where $P_1$and P_2 are the powers of the signal at sending end and the position where attenuation is to be compared respectively.

For signals where voltage is considered instead of the power, attenuation is calculated using following formula:

$$dB(Attenuation) = 20log_{10}(V_2/V_1)$$

Where, V_1 and V_2 are the voltage at he voltage at sending end and the position where attenuation is to be compared respectively.

The reason for attenuation is the resistance of the medium. Some energy is lost to propagate through the medium (wired or wireless) and this loss in energy is termed as attenuation. Attenutaion is less for short distanace and increases with distance. The extent of energy lossdirectly proportional to the frequency i.e. higher attenuationis observed in signals with higher frequencies. An attenuated signal can never be reconstructed to its original form.

2.5.2 Delay Distortion

Distortion is some change in the original. In data communication data is transmitted with a range of frequencies known as the bandwidth of the channel. In general delay distortion is observed in complex or composite signals. A complex/composite signal can be decomposed into many signals of different frequencies. Each frequency component travels with different speed through a medium.Therefore, signals with different frequencies experience different amount of delay during transmission through a channel. This phenomina is usually noticed in fiber optical cable.

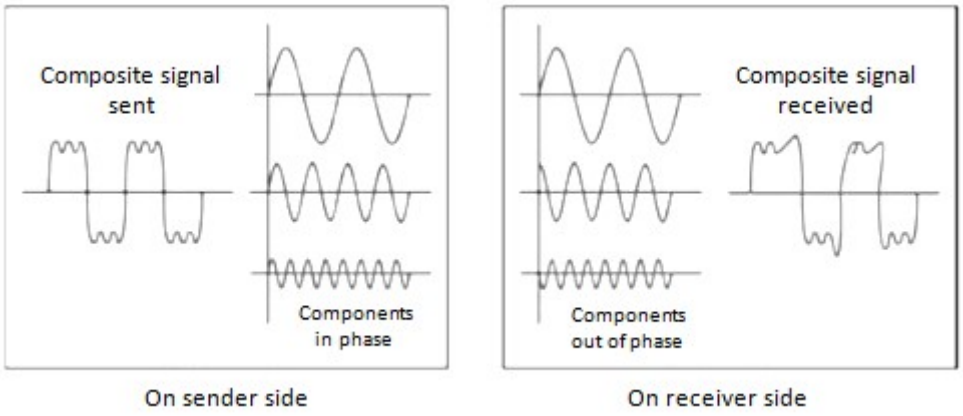


Figure: Delay distortion in a signal

2.5.3 Noise

Noise includes all signals other than the signal transmitted by the source or transmitter. During transmission many types of noise like thermal noise, induced noise, impulse noise and crosstalk noise may mix up with original signal.

Thermal noise: when potential difference is applied across a wire, electrons come into random motion within the wire generating an extra signal, causing thermal noise in the propagating signal.
Induced noise: Sometimes you might have experienced the sound distortion in the speakers when placed into the near vicinity of a mobile and is in use for making a call. This is known as the induced noise.
Impulse noise: sometimes during the transmission the signal may experience energy or voltage spikes. Due to impulse noise in digital signal, sometimes many bits may be lost
Crosstalk noise: it is the interference of one wire with the other. When two wires come into nearby vicinity of each other, signals in one affects the signal of other, it is called as the crosstalk noise. For example, it is often observed that during conversation on telephone, chat of another conversation is heared, it is due to the crosstalk noise between two wires.

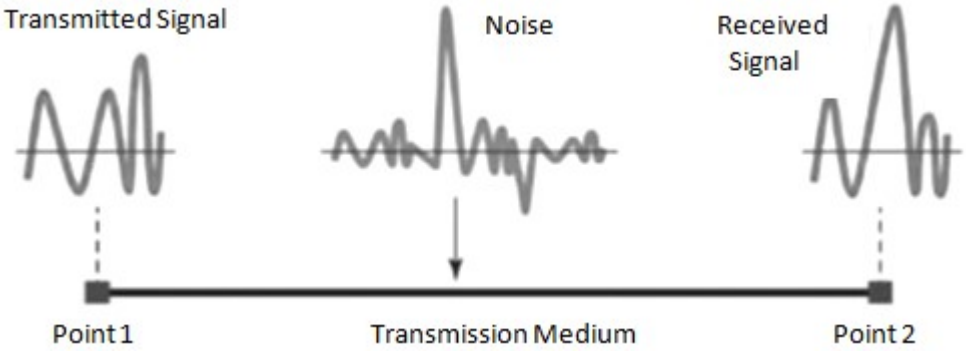


Figure: Noise in transmitted signal

2.5.4 Signal to Noise ratio

Signal to Noise Ratio (SNR) is defined in terms of dB. SNR is used to define the quality of a signal at any point. It is the measure of signal strength at a point along transmission path. It is the ratio of signal power and noise power. Lower the noise, higher the SNR value, and better is the signal quality.

SNR = Avg Signal Power / Avg Noise Power.

SNR = S/N dB

2.5.5 Concept of Delays

The amount of time taken to reach a packet from source to destination is termed as delay. Delay isone of the major factor in networking considered for evaluation of Quality of Service of a system. Delay is considered as performance evaluation parameter of network algorithms, like flow control and routing. A packet has TTL (time to live) value, on expery the packet will be dropped by router, if the delay is more than TTL, the packet will be dropped and transmission is required. Therefor, a large delay is disastrous for data transfer.

In the network a packet may experience delay due to many factors i.e.buffering, link capacity, congestion etc. Some of the delay components are: Transmission delay, Propagation delay, Queuing delay, and Processing delay. Two major delay components: Transmission delay and Propagation delay are discussed here.

Transmission delay: It is the time taken to put the packet on the channel or link. Transmission delay is dependent on the link capacity or the link bandwidth and the data size to be transmitted. Usuallytransmssion delay is caused due to the queuing capability of the intermediate routers. If intermediate routers are using store and forward method of forwarding, transmission delay will be experienced on each intermediate router i.e. transmission delay is not a constant quatity, it is a variable quantity and depends on the traffic load on router as well as the number of routersin the transmission path. Transmission delay can be calculated as:

T_{trans} = Packet size / Bandwith of channel

Propagation delay: Data signal travel through channel over long distances in the Internet, starting from computer to local ISP to satellite to another end ISP station to destination computer. It consumes time to complete this journey and is termed as the propagation delay. Travelling of a signal depends on how easily and with what energy a signal propagates through channel. This delay is experienced in all types of channels and is dependent on physical property of the channel. It is the time duration between: the last bit of packet transmitted at sender and the last bit is received at receiver.

Propagation delay can be calculated as follows:

T_{prop}= Distance between two ends/ Speed of signal in the channel

2.6 TRANSMISSION MEDIA AND ITS CHARACTERISTICS

A medium is required to transmit the data from one place to another. Transmission mediua are classified into two major categories: guided media and unguided media. Guided media like: metal wire and fiber optics guide the signal in which direction to propagate whereas, unguided media like: wireless signals such as radio waves, Inrared etc.

2.6.1 Guided media

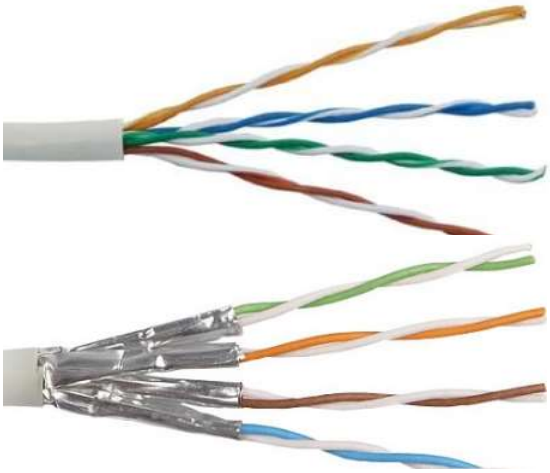
Guided media are the channels in which an instrument or an agent or a conduit is provided to transmit the data between devices. A signal traveling through guided media is restricted by the physical boundaries of the channel. Commonly used channels of guided media in networking are twisted-pair cable, coaxial cable, and fiber optical cable.

Twisted pair and coaxial cable use metallic (copper) conductors that accept and transport signals in the form of electric current. Optical fiber is a cable that accepts and transports signals in the form of light.

Twisted Pair cable: in twisted pair cables, copper metal is used and responsible to carry the data signal in the form of electic current. It is the oldest transmission channel and widely used in todays scenario also due to easy and simple installation and maintenance and the lower cost.

Twisted pair cable used in networking consists of 4 pairs of copper wires, each pair consisting of 2 wires. The pairs are twisted to overcome the noise induced by electromagnetic effect of nearby similar pairs. The in total 8 wires are provided with fixed color coding, as shown in figure below. Further, twisted pair cable is also divided into two categories: UTP and STP.

UTP is unshielded twisted pair, in which each pair is not shielded separately whereas, in Shielded Twisted Pair (STP) each pair is shielded as shown in fibure below.



(a) (b)

Figure: Twisted Pair Cable (a) UTP (b) STP.

Both analog and digital transmission is possible through twisted pair cable. The capacity or bandwidth of the channel is defined by the thickness of the metal cable and the distance travelled. The adaptor used forthese cable is termed as RJ45. UTP cable is able to transmit the data upto 100 meters of distance without any repeater or switch. Twisted pair cables are used in Ethernet/LAN technology.

Coaxial Cable: In coaxial cable two conducting wires are used and both are coaxial to each other. Cross section of acoaxial cable is shown in figure below.

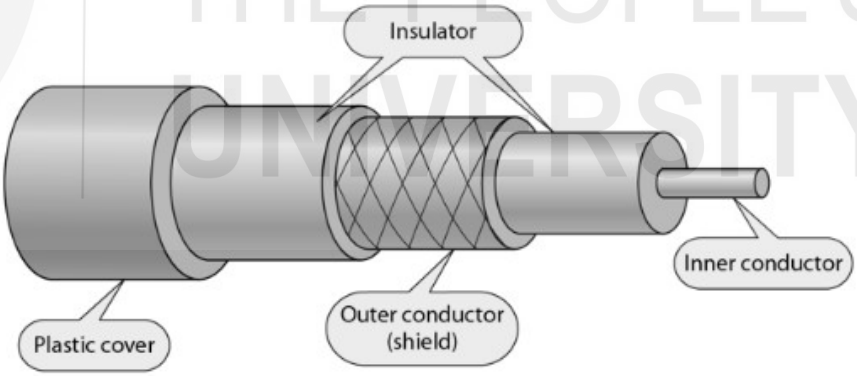


Figure: Coaxial cable

The inner wire also termed as core wire is used for signal transmission is generally of copper metal. The core wire is surrounded by an insulator. Outside the insulator metal net (outer conductor) coaxil with the inner or core wire. The outermost layer is the plastic cover providing the insulation and protection to conductors.
The bandwidth of coaxial cable is more than the twisted pair cable. Connectors used in coaxial cable is BNC (Bayonet Neill-Concelman). In figure widely used

coaxial cable connectors: BNC Connector, the BNC T connector and the BNC terminator are displaced.

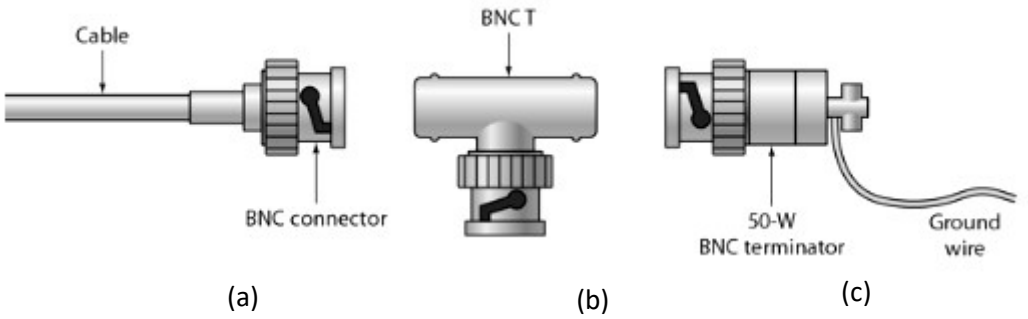


Figure: Coaxial cable BNC connectros

Based on the type of signal a coaxial cable carry, it can be further classified as: Baseband coaxial cable and Broadband coaxial cable.

Baseband coaxial cable is used to transmit digital signals. With baseband coaxial cable data can be transmitted over 1 km at a rate of 1 to 2 Gbps.

Broadband coaxial cable system is used to transmit analog signals over standard television cable network. Broadband term is taken from the telephone system, which means anything wider than 1 MHz. In networking broadband cable is defined as the cable carrying analog transmission.

Fiber Optic Cable: Fiber optic cable works on the total internal reflection principal of light. The data is transmitted in the form of laser light through fiber optics. As shown in figure below, it composed of very thin (even thinner than hair) silicon glass termed as fiber and is coated with a reflective surface (restricts the light signal to escape). Each fiber optic strand can support thousands of speech channels and multiple TV channels. Fiber optic cable provides data transmission at a very high speed. It provides a bigger bandwidth space. One of the biggest advantage of fiber optic cable is its immunity towards electromegnatic interference. The installation and maintenance is costly and require skills.

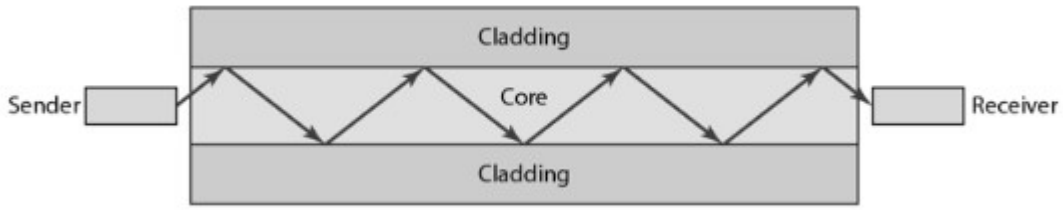


Figure: Fiber optical cable internal view

In fiber optic cable based on its physical characterstics can transmit the data in the form of light in two modes namely: multimode and single mode, where multimode further can be classified as: Step-index and Graded-index.

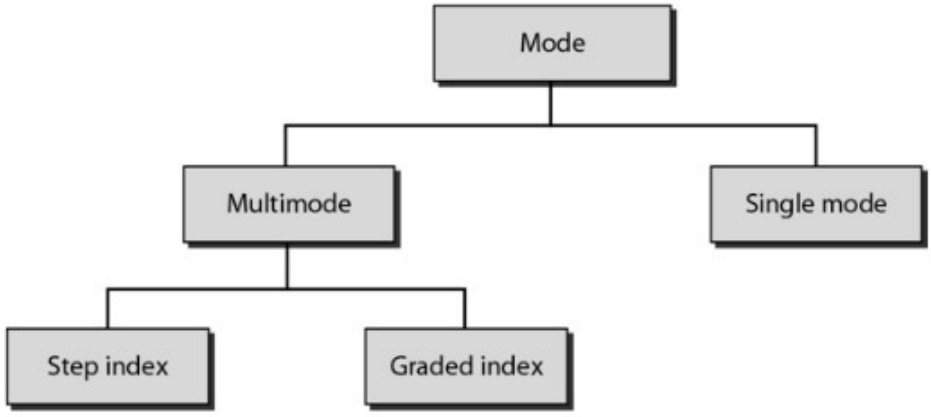


Figure: Fiber optic cable transmission modes

In multimode fiber optic cable multiple light beams or rays can propagate in the core (glass) following different paths.

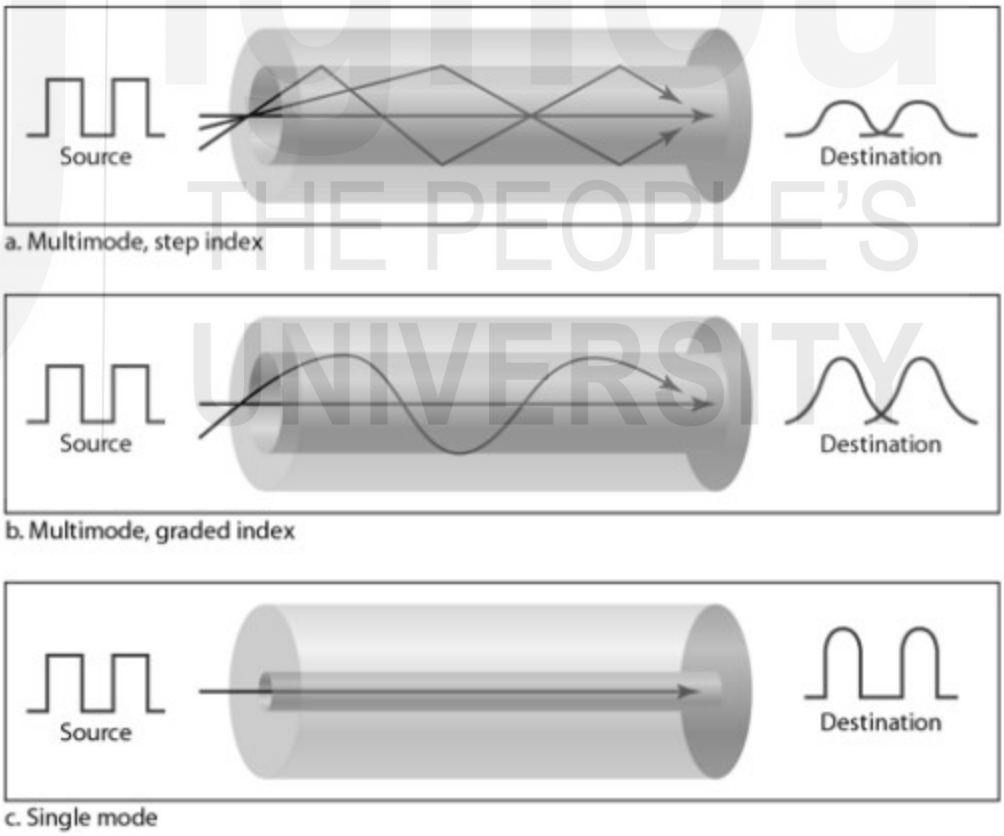


Figure: Light propagation through fiber optic cable

Multimode step index fibre optic cable: as shown in figure above the light signals propagates in straight lines. The core of multimode step index fiber is madeup of constant density throughout the glass fromcentre to edge. In this the light signals

face a sudden change in the direction (at the boundaries of glass), which distort the signal.
Multimode graded index fibre:the light signals propagates some how like a wave form. The light signal doesnot face a sudden change in direction which reduces the distortion of signal. The core of multimode graded index fiber is madeup of varying density with highest density value at the centre and decreases progressivelytill edge of the core.
Connector used in fiber optic cable are shown in figure below is SC connectors.

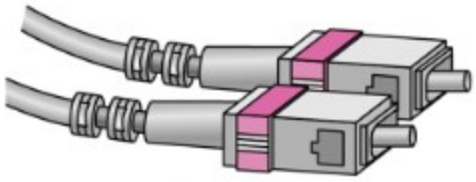


Figure: SC connector for fiber optic cable

Single Mode
In single mode fiber cable the light beam propagates almost horizontal. In single mode fiber cable the core is based on stepindex fibre with very small size diameter as compared to that in multimode fiber. The density of core is very less as compared to multimode core.

2.6.2 Unguided media

This is also termed as unbounded media. There is no instrument or agent or any physical entity to transmit the data through unguided media. The signal is broadcasted through air and is open to access to all, one has a device with capability to receive the signal can have access to data. The data is transmitted in the form of electromagnetic waves through unguided media. Electromagnetic waves transmits through free space in unrestricted manner. The communication through unguided media is in general termed as wireless communication. Data transmission through unguided media can take place in many ways:gound propagation, sky propagation and line-of-sight propagation.
Ground Propagation: Ground propagation takes place through radio waves close to the earth surface. In these type of propagation, radio wave signals with low frequency in general from the spectrum below 2 MHz are used. These signals propagates in all directions termed as omni directional propagation. In this, the signals traverse in the curvature same as the that of the planet.

Figure: Ground Propagation

Sky Propagation: In sky propagation as name suggests, the radio waves with frequencies higher than ground propagation (in the range 2 MHz to 30 MHz) are used to transmit the data. In this, radio waves are emitted towards the sky and after hiting ionosphere are reflected back towards earth. Sky propagation type of transmission is used for sending data over large distances.

Figure: Sky Propagation

Line-of-sight Propagation: Line of sight propagation is used to transmit the signals in a straight line between transmitting and receiving antennas. This type of transmission uses signals of very high frequency in the range above 30 MHz.In line of sight propagation both end (transmitter and the receiver) should be visible to each other that is, no object should be there in between the line of sight of both ends.

Figure: Line of signt propagation

The wireless transmission can be classified as follows:

Radio waves
Micro waves
Infrared waves

2.7 WIRELESS TRANSMISSION

Wireless transmission is one in which data is propagated through air medium (atmospheric space) In wireless transmission the two communicating devices are not required to be connected through any physical channel. Wirelesscommunication is easy to setup/install and maintain. Wireles channel is helpful and convenient to rach locations otherwise difficult to laydown or install the physical or wired channel. In general following wireless media are widely used:

- Microwave
- Radio wave, and
- Infrared.

2.7.1 Microwave Transmission

Microwaves are the electromagnetic waves of freaquencies in the range 1 and 300 GHz. Due to high frequency these narrow focused and unidirectional. As the signal is narrow focused, the both ends transmitter and receiver antennas should be in line of sight to each other. To transmit the signals at long distances the height of antennas need to be very tall. Wicrowave signals cannot paas through obstacles due to its high freqhency band, hence the signals can not be delivered if the receiver is not in open area. As the frequency band is wide with range 1 to 300 GHz, data transmission can take place at very high speed. Many simultaneous transmissions can take place by allocating frequency sub bands separated apart

from each other to overcome the interference of each other. Some of the frequency bands are reserved and need to take permission before use from authorities.

As shown in figure below, antennas used to transmit and reeive microwaves are classified into two categories: **Parabolic Dish antenna**and **Hornantenna** .

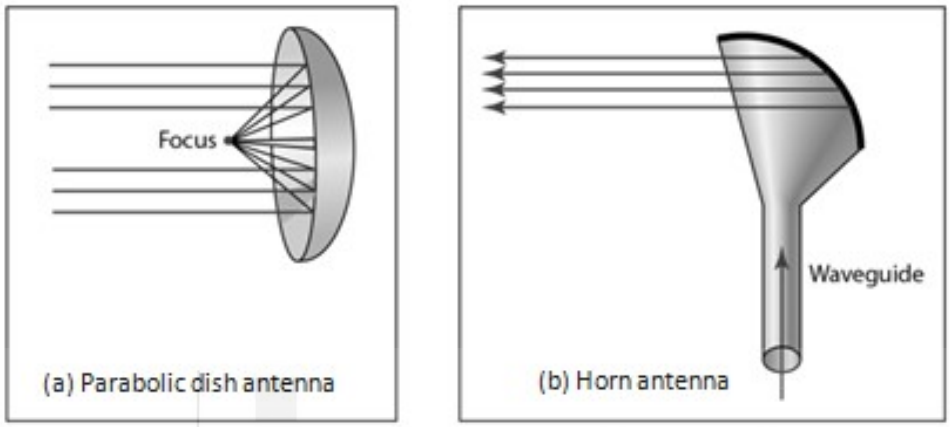


Figure: Microwave antennas

The design of a parabolic antenna is such that a wide range of waves are collected and concentrated to a point forming the high strength signal otherwise would not possible with a single point receiver. The parabolic antennas are good for receiver end.

Aother antenna used in microwave transmission is the horn antenna. The physical shape of horn antenna is like a huge scoop as shown in figure above. The signals transmitted hits the inner surface and transmitted as a narrow parallel beams. At the receiver end the signals hit the scooped shape of the horn, and collected back.

Further the microwave transmission is classified into two categories as:

1. Terrestrial Microwave

   Terrestrial Microwaves are used to communicate the data between transmitter and receiver both located on Earth with lower endfrequency typically between 2-6GHz or 21-23GHz of microwave range. The terrestrial microwave transmission follows line of sight transmission. In terrestrial microwave transmission, parabolic antennas are used, installed in line of sight with each other.
   Environmental factors like rain, fog and wind do not affect the microwave signal transmission Eventhough as the wireless communication is open to all and is vulnerable to electronic eavesdropping.

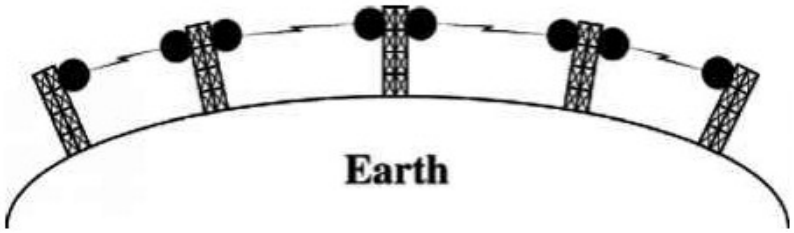


Figure: Terrestrial microwave transmission

2. Satellite Microwave

   Satellite Microwaves are used to trnamsmit the data between the locations not in line of sight to each other i.e. on opposite side of Earth. In this system, depending on the geophysical locations of the two ends the communication may take place between two satellites or beween transmitter on Earth to satellite or beween the satellite or the receiver on the Earth. The parabolic antennas are used on Earth.

   Satellite microwave transmission uses lower end of the frequencies in the microwave frequency band typically in the range 4-6 GHz. Due to lower frequencies environmental factors affect the transmission of satellite microwave signals. Many of the times you might have noticed that in bad weather TV signals become very poor.

2.7.2 Radio Transmission

Radio waves are electromagnetic waves of frequencies in the range 3 KHz and 1 GHz. Radio waves are propagated in omnidirection that is in all directions. Due to propagation of radio waves in omnidirectionthe communicating antennas at both ends need not to be in line-of-sight to each other. Due to omnidirection propagation of radio waves, antennas transmitting and receiving signals with same or nearby frequencies may experience interference i.eunlike microwave where same frequencies can be reused, in radio waves frequency reuse for another transmission is not possible.
Low frequency radio waves are capable to penetrate the walls and can be received even within the building. This advantage some times also becomes disadvantage as signals cannot be restricted so a communication cannot take place in isolation. Radio wave communication is useful in AM and FM radio, TV, maritime radio and cordless phones communication.

2.7.3 Infrared and Millimeter Waves

Infrared waves are used in short range communication limited to some feet. Infrared waves have frequencies in the range 300 GHz- 400 THz. These waves cann’tpenetrate walls making it line-of-sight communication. Infrared waves are

generally used in remote control systems. Sun's rays also have infrared waves, which can interfere the other communication making communication in open space impractical.

2.8 WIRELESS LAN

Wireless LAN is a type of local area network in which systems are connected to each other wirelessly and communicate through radio wave channel. The radio waves propagate in omni directional way so, in wireless LAN systems are not to be in line-of-sight with transmitter. Wireless LAN is easy to install and maintain. Wireless LAN is generally installed in places where computers or end devices are located in close proximity like computer lab in school and college etc. It provides a bandwidth of 1 to 2 Mbps.

2.9 SUMMARY

In this unit, we have discussed about the data communication technologies. Starting from what is data communication, we have studied about the basic terminologies used in data communication i.e. channel, baud, bit rate, bandwidth, and frequency etc. Channel is the medium or the path carrying the data signals from source to destination. Baud is the number of symbols transmitted per unit time and the bit rate can be defined as [baud rate x bits in a baud]. The frequency is measured in Hz and is the number of cycles completed by a signal in one second.

Data transmission can take place through two modes: simplex mode and duplex mode. In simplex mode, the data can be transmitted through channel in one direction only. Duplex mode can further classified as: Half duplex mode and Full duplex mode. In half duplex mode, data can be transmitted in both direction but in one direction at a time whereas in full deplex mode, data can be transmitted in both directions simultaneously. Further we have studied various data communication types: parallel communication and serial communication. Serial communication further can be classified as Asynchronous, Synchronous and Isochronous communication. Based on the type of values a signal can represent, signals can be classified into two categories namely: analog signals and digital signals. during he signal propagation through channel, it may get distorted due to which the original signal may experience errors in the form of: attenuation, delay distortion, and noise. The loass of signal strength over distance is termed as attenuation. Delay distortion is due to the varied speed of signal of different frequencies. All unwanted signals in the data signal are considered as noise. A signal strength at any point is measured in terms of SNR (signal to noise ratio) which is the ratio of powers of signal and that of the noise. During transmission of

the signal, itexperiences certain delays like: transmission delay, propagation delay etc. Transmission delay is the time required to put all the data bits to be transmitted on the channel and propagation delay is the time taken by the signal to travel from source to destination in the channel.
Further, two types of transmission media namely: guided and unguided are discussed. Guided media are the physical medias like conductor wires and fiber optic cable whereas, unguided media is the open sky. In general, coaxial cables, twisted pair cables and fiber optic cables are widely used guided media in communication. Microwave Transmission, Radio Transmission, Infrared and Millimeter Waves are types of wireless media. Depending on the distance, security and installation cost one of the wireless channels could be used.

2.10 SOLUTIONS/ANSWERS

Q1. What is Data Communication?
Solution: Exchange of information among devices located over various geographically distant locations is termed as data communication. Data communication systemiscombinationof both softwares and hardwares. The characterstics of an efficient data communication system are: correct, accurate and timely data delivery.

Q2. Explain the term bandwidth and why it is useful?
Solution: Bandwidth is the data carrying capacity of the channel/media per unit time (It can be defined for the bus within a computer or the channel of computer network).
More is the bandwidth higher is the throughput of the medium. Bandwidth of medium is the range of the frequencies used to transmit the data i.e. the difference between highest and the lowest frequencies the medium can carry.
The bandwidth for digital devices is represented as bps (bits per second) whereas, expressed in Hertz (Hz) or number of cycles per second for analog devices.
Q3.Calculate the frequency of a sine wave which completes one cycle in 3 sec?
Solution: Period of the signal (T) = 3 sec
frequency (f) = 1/T
= 1/3 = 0.33Hz.
Q4. Compare Parallel and Serial transmission methods and mention the situation
Solution: where Parallel transmission is a better choice as compared to serial transmission.
Solution:

Parallel Transmission	**Serial Transmission**

In parallel transmission all the data bits are transferred parallel at a time.	In serial transmission data bits are transferred one by one serially.
Data bits are transmitted on multiple wires parallely.	Data bits are transmitted on a single wire serially.
Data transferred at a very high speed.	Data transmission rate is slower than that in parallel transmission.
It is costly and complex system.	It is cheaper and simpler than parallel transmission.
Best for transmitting largeamount data over short distance with high accuracy.	Best suitable for transmitting data over long distances.

Q5. How Full duplex data transmission mode is more challenging than other two modes? Solution: In Full duplex transmission data can be transmitted in both directions simultaneously. In full duplex both ends should be capable of transmission and receiving capabilities.

Q6. Bring out the difference between Synchronous, Asynchronous transmission.
Solutions:

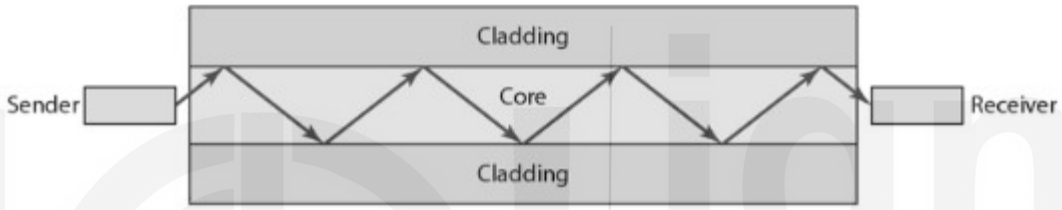
S.NO	Synchronous Transmission	Asynchronous Transmission
1.	Data is transmitted as frames or blocks.	Data is transmitted as characters or bytes.
2.	Transmission rate is faster.	Transmission rate is slower.
3.	It is expensive.	It is economical.
4.	The time interval between blocks is constant.	time interval is random.
5.	It is regulated by an external clock signal also shared with the receiver.	No need of synchronized clocks, as start and end bits are used.

Q7. What is Analog data transmission?
Solution.Analog data transmission takes place through analog signals. Analog

signal are used to transmit continuous data and are represented by sine wave. Audio, video and music etcare types of analog signal.

Q8. Describe the structure of optical fiber and mention its advantages and disadvantages.

Solution. Fiber optic cable works on the total internal reflection principal of light. The data is transmitted in the form of laser light through fiber optics. As shown in figure below, it composed of very thin (even thinner than hair) silicon glass termed as fiber and is coated with a reflective surface (restricts the light signal to escape). Each fiber optic strand can support thousands of speech channels and multiple TV channels. Fiber optic cable provides data transmission at a very high speed. It provides a bigger bandwidth space. One of the biggest advantage of fiber optic cable is its immunity towards electromegnatic interference. The installation and maintenance is costly and require skills.



Q9 Explain the working of Wireless LAN's.

Solution. Wireless LAN is a type of local area network in which systems are connected to each other wirelessly and communicate through radio wave channel. The radio waves propagate in omni directional way so, in wireless LAN systems are not to be in line-of-sight with transmitter. Wireless LAN is easy to install and maintain. Wireless LAN is generally installed in places where computers or end devices are located in close proximity like computer lab in school and college etc. It provides a bandwidth of 1 to 2 Mbps.

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