Transmission Mediums in Computer Networks

Transmission media is a pathway that carries the information from sender to receiver. We use different types of cables or waves to transmit data. Data is transmitted normally through electrical or electromagnetic signals.

An electrical signal is in the form of current. An electromagnetic signal is series of electromagnetic energy pulses at various frequencies. These signals can be transmitted through copper wires, optical fibers, atmosphere, water and vacuum. Different Medias have different properties like bandwidth, delay, cost and ease of installation and maintenance. Transmission media is also called Communication channel.

Types of Transmis ion Media

Transmission media is broadly classified into two groups.

1 **Wired or Guided Media or Bound Transmission Media:** - Wired or Guided Media or Bound Transmission Media. Bound transmission media are the cables that are tangible or have physical existence and are limited by the physical geography. Popular bound transmission media in use are twisted pair cable, co-axial cable and fiber optical cable. Each of them has its own characteristics like transmission speed, effect of noise, physical appearance, cost etc.

2. **Wireless or Unguided Media or Unbound Transmission Media:** - Wireless or Unguided Media or Unbound Transmission Media. Unbound transmission media are the ways of transmitting data without using any cables. These media are not bounded by physical geography. This type of transmission is called Wireless communication. Nowadays wireless communication is becoming popular. Wireless LANs are being installed in office and college campuses. This transmission uses Microwave, Radio wave, Infra red are some of popular unbound transmission media.

The data transmission capabilities of various Medias vary differently depending upon the various factors. These factors are:

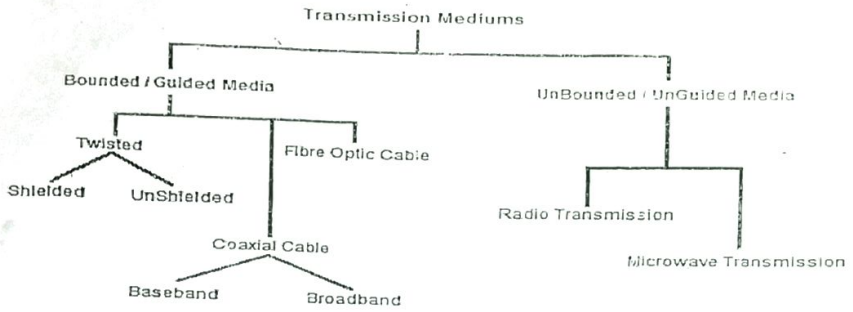
1. Bandwidth. It refers to the data carrying capacity of a channel or medium. Higher bandwidth communication channels support higher data rates.

2. Radiation. It refers to the leakage of signal from the medium due to undesirable electrical characteristics of the medium.

3. Noise Absorption. It refers to the susceptibility of the media to external electrical noise that can cause distortion of data signal.

4. Attenuation. It refers to loss of energy as signal propagates outwards. The amount of energy lost depends on frequency. Radiations and physical characteristics of media contribute to attenuation

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



Factors to 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 :

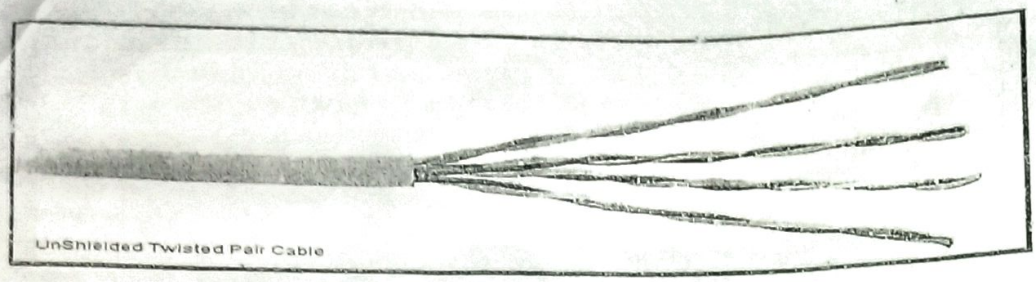
- Its frequency range is 0 to 3.5 kHz.
- Typical attenuation is 0.2 dB/Km @ 1kHz.
- Typical delay is 50 µs/km.
- Repeater spacing is 2km.

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.

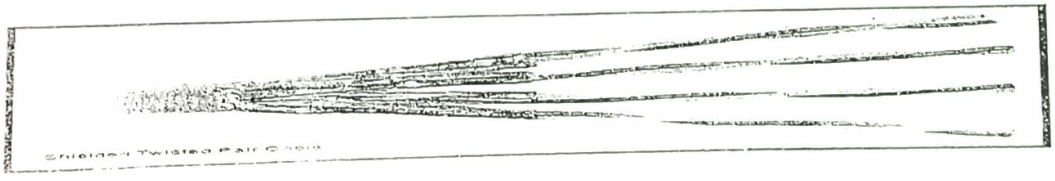
Disadvantages :

- 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

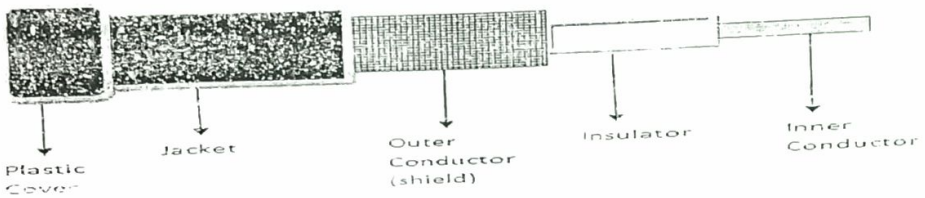
Coaxial is called by this name because it contains two conductors that are parallel to each used in this as centre conductor which can be a solid wire or a standard one. It is surrounded installation, a sheath which is encased in an outer conductor of metal foil, barid or both.

↳ a close-fitting covering to protect something.

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

Here the most common coaxial standards.

- 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. ✓
- They can span to longer distance at higher speeds as they have better shielding when compared to twisted pair cable.
- More resistant to noise

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.

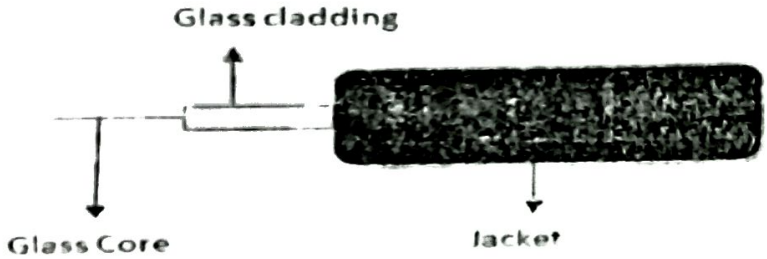
Fiber Optic Cable

These are similar to coaxial cable. It uses electric signals to transmit data. At the centre is the glass core through which light propagates.

In multimode fibres, the core is 50microns, and In single mode fibres, the thickness is 8 to 10 microns.

The core in fiber optic cable is surrounded by glass cladding with lower index of refraction as compared to core to keep all the light in core. This is covered with a thin plastic jacket to protect the cladding. The fibers are grouped together in bundles protected by an outer shield.

Fiber optic cable has bandwidth more than **2 gbps (Gigabytes per Second)**



Advantages :

- Provides high quality transmission of signals at very high speed.
- These are not affected by electromagnetic interference, so noise and distortion is very less.
- Used for both analog and digital signals

Disadvantages :

- It is expensive
- Difficult to install.
- Maintenance is expensive and difficult.
- Do not allow complete routing of light signals.

UnBounded/UnGuided Transmission Media

Unguided or wireless media sends the data through air (or water), which is available to anyone who has a device capable of receiving them. Types of unguided/ unbounded media are discussed below :

- Radio Transmission
- MicroWave Transmission

Radio Transmission

Its frequency is between 10 kHz to 1GHz. It is simple to install and has high attenuation. These waves are used for multicast communications.

Types of Propogation

Radio Transmission utilizes different types of propogation :

- **Troposphere :** The lowest portion of earth's atmosphere extending outward approximately 30 mi from the earth's surface. Clouds, jet planes, wind is found here.
- **Ionosphere :** The layer of the atmosphere above troposphere, but below space. Contains electrically charged particles.

Microwave Transmission

It travels at high frequency than the radio waves. It requires the sender to be inside of the receiver. It operat in a system with a low gigahertz range. It is mostly used for unicast communication.

There are 2 types of Microwave Transmission :

1. Terrestrial Microwave
2. Satellite Microwave

Advantages of Microwave Transmission

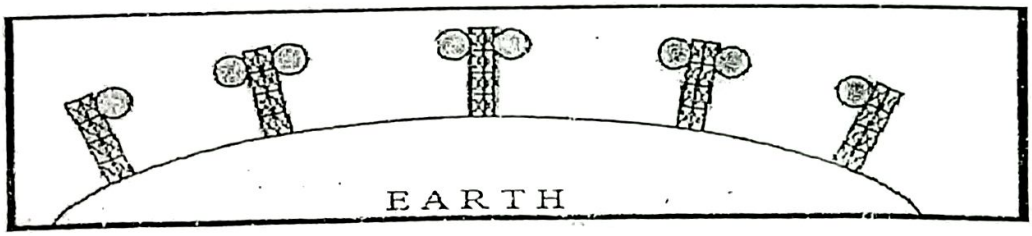
- Used for long distance telephone communication
- Carries 1000's of voice channels at the same time

Disadvantages of Microwave Transmission

- It is Very costly

Terrestrial Microwave

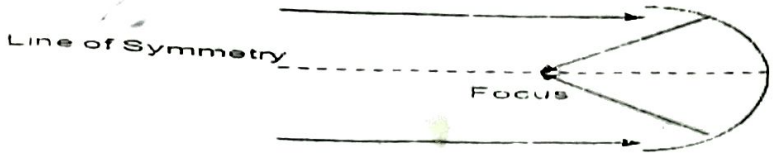
For increasing the distance served by terrestrial microwave, repeaters can be installed with each antenna . Th signal received by an antenna can be converted into transmittable form and relayed to next antenna as show in below figure. It is an example of telephone systems all over the world



There are two types of antennas used for terrestrial microwave communication :

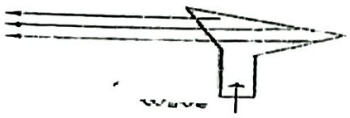
1. Parabolic Dish Antenna

In this every line parallel to the line of symmetry reflects off the curve at angles in a way that they intersect at a common point called focus. This antenna is based on geometry of parabola.



2. Horn Antenna

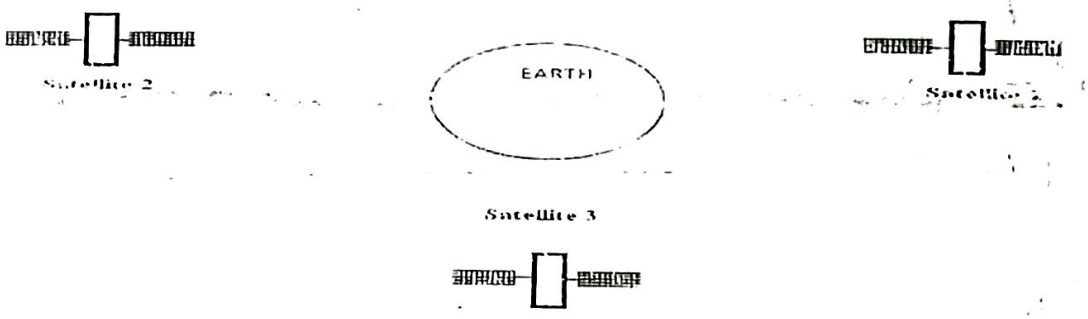
It is a like gigantic scoop. The outgoing transmissions are broadcast up a stem and deflected outward in a series of narrow parallel beams by curved head.



Satellite Microwave

This is a microwave relay station which is placed in outer space. The satellites are launched either by rockets or space shuttles carry them.

These are positioned 3600KM above the equator with an orbit speed that exactly matches the rotation speed of the earth. As the satellite is positioned in a geo-synchronous orbit, it is stationery relative to earth and always stays over the same point on the ground. This is usually done to allow ground stations to aim antenna at a fixed point in the sky.



Features of Satellite Microwave :

- Bandwidth capacity depends on the frequency used.
- Satellite microwave deployment for orbiting satellite is difficult.

Advantages of Satellite Microwave :

- Transmitting station can receive back its own transmission and check whether the satellite has transmitted information correctly.
- A single microwave relay station which is visible from any point.

Disadvantages of Satellite Microwave :

- Satellite manufacturing cost is very high
- Cost of launching satellite is very expensive
- Transmission highly depends on whether conditions, it can go down in bad weather conditions

Multiplexing → Unit II.

Multiplexing is a technique by which different analog and digital streams of transmission can be simultaneously processed over a shared link. Multiplexing divides the high capacity medium into low capacity logical medium which is then shared by different streams.

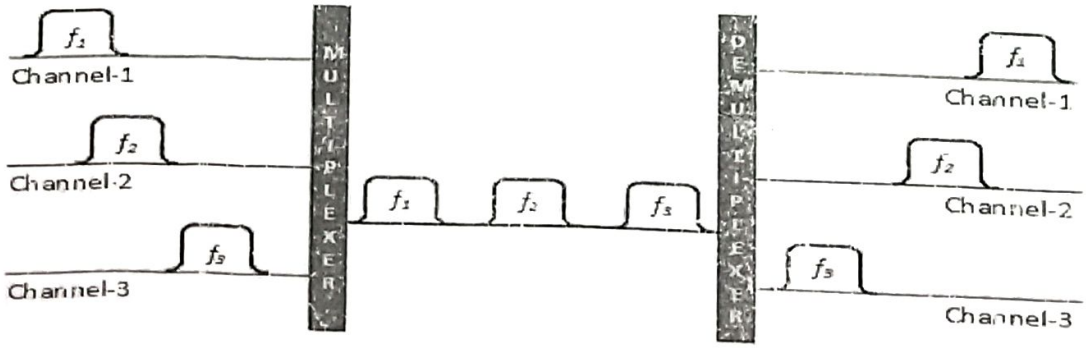
Communication is possible over the air (radio frequency), using a physical media (cable), and light (optical fiber). All mediums are capable of multiplexing.

When multiple senders try to send over a single medium, a device called Multiplexer divides the physical channel and allocates one to each. On the other end of communication, a De-multiplexer receives data from a single medium, identifies each, and sends to different receivers.

Networks use multiplexing to make it possible for any network device to talk to any other network device without having to dedicate a connection for each pair. This requires shared media.

Frequency Division Multiplexing

When the carrier is frequency, FDM is used. FDM is an analog technology. FDM divides the spectrum or carrier bandwidth in logical channels and allocates one user to each channel. Each user can use the channel frequency independently and has exclusive access of it. All channels are divided in such a way that they do not overlap with each other. Channels are separated by guard bands. Guard band is a frequency which is not used by either channel.



In analog radio transmission, signals are commonly multiplexed using frequency-division multiplexing (FDM), in which the bandwidth on a communications link is

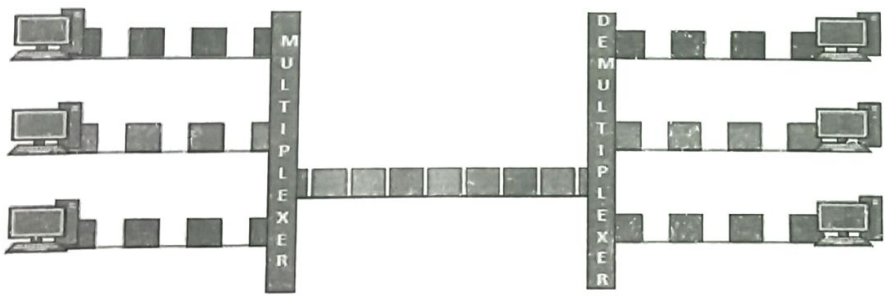
divided into subchannels of different frequency widths, each carrying a signal at the same time in parallel. Analog cable TV works the same way, sending multiple channels of material down the same strands of coaxial cable.

Time Division Multiplexing

TDM is applied primarily on digital signals but can be applied on analog signals as well. In TDM the shared channel is divided among its user by means of time slot. Each user can transmit data within the provided time slot only. Digital signals are divided in frames, equivalent to time slot i.e. frame of an optimal size which can be transmitted in given time slot.

TDM works in synchronized mode. Both ends, i.e. Multiplexer and De-multiplexer are timely synchronized and both switch to next channel simultaneously.

When channel A transmits its frame at one end, the De-multiplexer provides media to channel A on the other end. As soon as the channel A's time slot expires, this side switches to channel B. On the other end, the De-multiplexer works in a synchronized manner and provides media to channel B. Signals from different channels travel the path in interleaved manner.



Types of TDM: Time division multiplexing is classifieds into four types:
Synchronous time-division multiplexing

Asynchronous time-division multiplexing

Interleaving time-division multiplexing

Statistical time-division multiplexing

College

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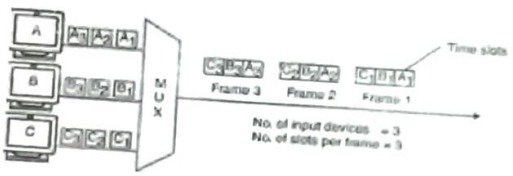
(iii)

Synchronous Time Division Multiplexing

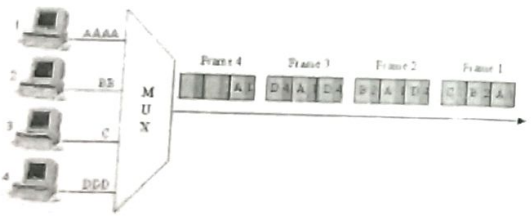
Synchronous time division multiplexing can be used for both analog and digital signals. In synchronous TDM, the connection of input is connected to a frame. If there are 'n' connections, then a frame is divided into 'n' time slots – and, for each unit, one slot is allocated – one for each input line. In this synchronous TDM sampling, the rate is same for all the signals, and this sampling requires a common clock signal at both the sender and receiver end. In synchronous TDM, the multiplexer allocates the same slot to each device at all times.



Synchronous Time Division Multiplexing

Asynchronous Time-Division Multiplexing

In asynchronous time-division multiplexing, the sampling rate is different for different signals, and it doesn't require a common clock. If the devices have nothing to transmit, then their time slot is allocated to another device. Designing of a commutator or de-commutator is difficult and the bandwidth is less for time-division multiplexing. This type of time-division multiplexing is used in asynchronous transfer mode networks.

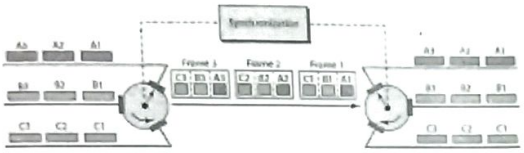


Asynchronous Time-Division Multiplexing

Interleaving

Time-division multiplexing can be visualized as two fast rotating switches on the multiplexing and demultiplexing side. At the same speed these switches rotate and synchronize, but in opposite directions. When the switch opens at the multiplexer

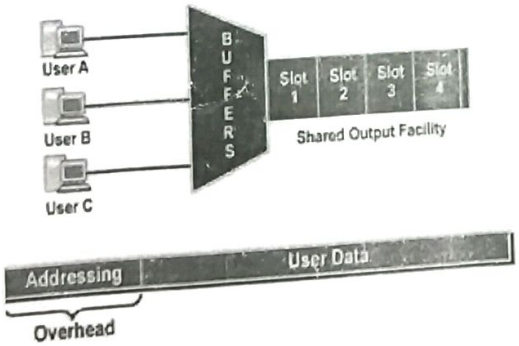
side in front of a connection, it has the opportunity to send a unit into the path. In the same way, when the switch opens on the demultiplexer side in front of a connection that has the opportunity to receive a unit from the path. This process is called interleaving.



Interleaving

Statistical Time-Division Multiplexing

Statistical time-division multiplexing is used to transmit several types of data concurrently across a single transmission cable. This is often used for managing data being transmitted via LAN or WAN. The data is simultaneously transmitted from the input devices that are connected to the network including printers, fax machines, and computers. This type of multiplexing is also used in telephone switch board settings to manage the calls. Statistical TDM is similar to dynamic bandwidth allocation, an in this type of time-division multiplexing, a communication channel is divided into an arbitrary number of data streams.



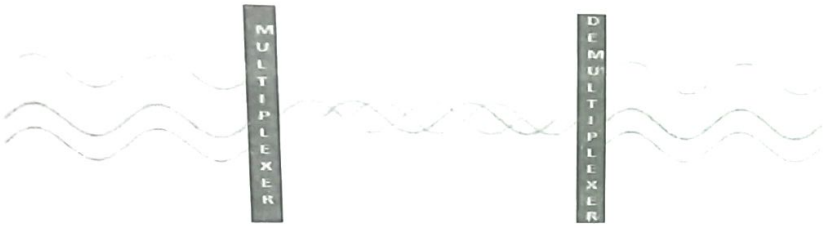
Statistical Time-Division Multiplexing

Wavelength Division Multiplexing

Light has different wavelength (colors). In fiber optic mode, multiple optical carrier signals are multiplexed into an optical fiber by using different wavelengths. This is an

analog multiplexing technique and is done conceptually in the same manner as FDM but uses light as signals.

Further, on each wavelength time division multiplexing can be incorporated to accommodate more data signals.



Similarly, in some optical networks, data for different communications channels are sent on lightwaves of different wavelengths, a variety of multiplexing called wavelength division multiplexing (WDM).

Code Division Multiplexing

Multiple data signals can be transmitted over a single frequency by using Code Division Multiplexing. FDM divides the frequency in smaller channels but CDM allows its users to full bandwidth and transmit signals all the time using a unique code. CDM uses orthogonal codes to spread signals.

Each station is assigned with a unique code, called chip. Signals travel with these codes independently, inside the whole bandwidth. The receiver knows in advance the chip code signal it has to receive.

Code Division Multiplexing (CDM) uses identifying codes to distinguish one signal from another on a shared medium. Each signal is assigned a sequence of bits called the spreading code that is combined with the original signal to produce a new stream of encoded data; a receiver that knows the code can retrieve the original signal by subtracting out the spreading code (a process called dispreading). CDM is widely used in digital television and radio broadcasting and in 3G mobile cellular networks. Where CDM allows multiple signals from multiple sources, it is called Code-Division Multiple Access (CDMA).

Modulation

It is the process of varying one or more properties of a periodic waveform called carrier signal, with a modulating signal that typically contains information to be transmitted. In telecommunication, modulation is the process of conveying a message signal for eg. a digital bit stream or an analog audio signal, inside another signal that can be physically transmitted. Modulation of a sine waveform transform a narrow frequency range baseband message signal into passband signal, one that can pass through a filter.

Modulation is of two types:-

① Analog Modulation:- The aim of analog modulation is to transfer an analog baseband signal, for example an audio signal or TV signal over an analog bandpass channel at a different frequency (over a limited radio frequency band or cable TV network)

② Digital Modulation:- The aim of Digital Modulation is to transfer a digital bit stream over the analog bandpass channel, for ex over the public switched telephone network.

Modulator - It is a device that perform modulation.
Demodulator - It is a device that perform demodulation
modem perform both the task.

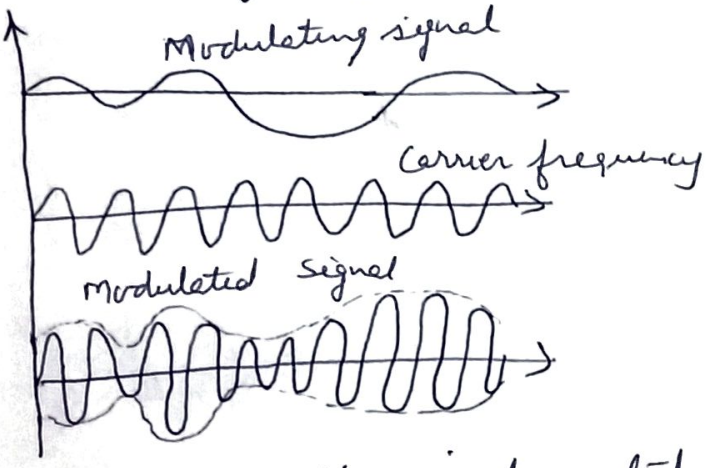
① Analog to Analog Conversion:- [Analog Modulation]
It is the representation of analog information by an analog signal. Modulation is needed if the medium is bandpass in nature or if only a bandpass channel is available to us. For example Radio, the government assign a narrow bandwidth to each radio station. The analog signal produced by each station

is a low pass signal, all in the same ra... able to listen to different station, the low pass... need to be shifted, each to a different range.

It can be accomplished by three ways -

① Amplitude Modulation ② Frequency Modulation ③ Phase Modulation

① Amplitude Modulation:- In this, the carrier signal is modulated so that its amplitude varies with the changing amplitudes of the modulating signals. The frequency & phase of the carrier remain the same, only the amplitude changes to follow variations in information. The modulating signal is the envelop of the carrier.

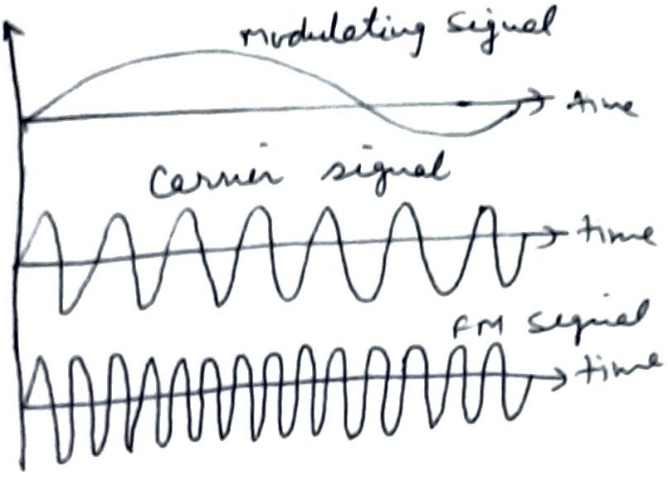


AM is normally implemented by using a simple multiplier because the amplitude of the carrier signal needs to be changed according to the amplitude of the modulating signal. The modulation creates a bandwidth that is twice the bandwidth of the modulating signal & covers a range centered on the carrier frequency.

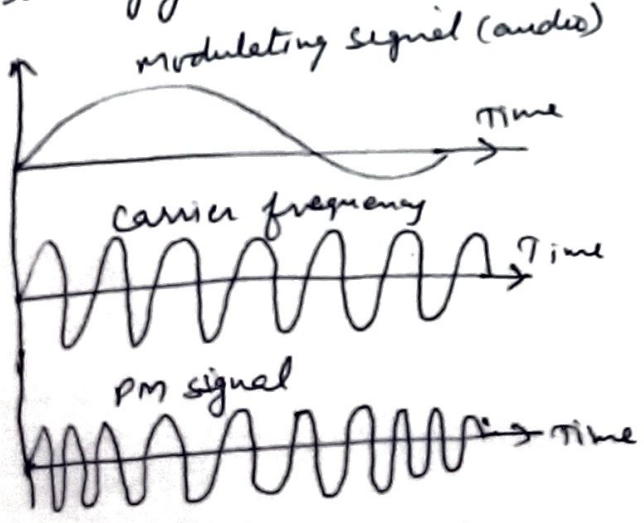
* The total bandwidth required for AM can be determined from the bandwidth of the audio signal: $B_M = 2B$.

② Frequency Modulation:- In FM, the frequency of the carrier signal is modulated to follow the changing voltage level (amplitude) of the modulating signal. ... amplitude & phase of the carrier

remain constant, but as the amplitude of the information signal changes, the frequency of the carrier changes correspondingly. FM is normally implemented by using a voltage-controlled oscillator as with FSK. The frequency of the oscillator changes according to the input voltage which is the amplitude of the modulating signal.



(3) Phase Modulation:- In PM, transmission, the phase of carrier signal is modulated to follow the changing voltage level (amplitude) of the modulating signal. The peak amplitude and frequency of the carrier signal remain constant, but as the amplitude of the information signal changes, the phase of the carrier changes correspondingly



PM is same as FM but the difference is that, the instantaneous change in the carrier frequency is

proportional to the amplitude of the modulating signal; in PM the instantaneous change in the carrier frequency is proportional to the derivative of the amplitude of the modulating signal. PM is normally implemented by using a voltage-controlled oscillator along with a derivative. ~~of the input~~ The frequency of the oscillator changes according to the derivative of the input voltage which is the amplitude of the modulating signal.

(II) Digital-to-Analog Conversion :- It is the process of changing one of the characteristics of an analog signal based on the information in digital data. A sine wave is ~~the~~ defined by three characteristics

(I) Amplitude (II) Frequency (III) Phase

When we vary one of these characteristics, we create a different version of that wave; so by changing one characteristics of the simple electric signal, we can use it to represent digital data. Any of the three characteristics can be altered, giving at least three mechanism for modulating digital data into analog signal

(1) Amplitude shift keying (ASK) :- In this, the amplitude of the carrier signal is varied to create signal elements. Both frequency & phase remains constant while the amplitude changes.

(2) Frequency shift keying (FSK) - In this the frequency of the carrier signal is varied to represent data. The frequency of the modulated signal is constant for the duration of one signal element, but changes for the next signal element if the data element changes.

(3) phase shift keying (PSK) - Here the phase of the carrier is varied to represent two or more different signal elements. Both peak amplitude & frequency remain constant as the phase changes. Today PSK is more common than ASK or FSK.