Subject Name: Mobile Computing and Wireless Communication
Subject Code: 2170710

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CHAPTER NO - 1 : Introduction:

TOPIC:1 Introduction Transmission Fundamentals

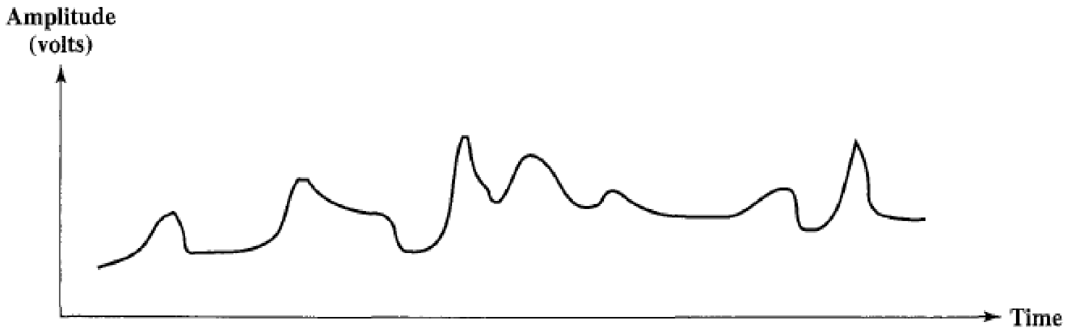
DESCRIPTIVE QUESTIONS

BASIC INFORMATION:

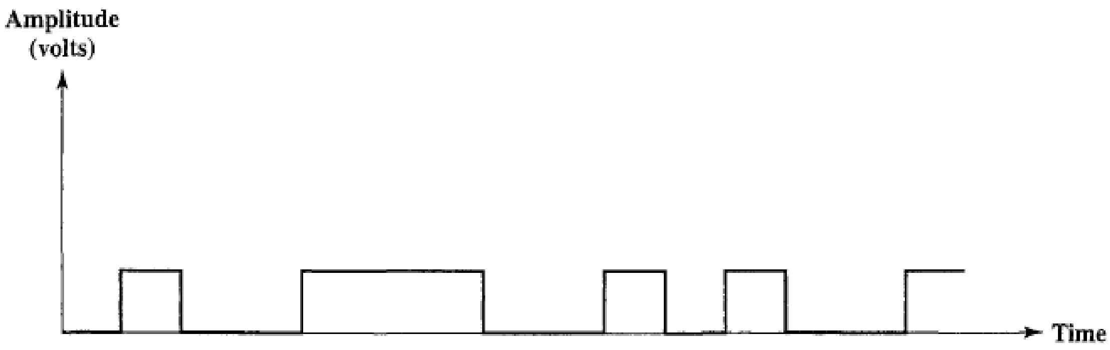
SIGNAL: An electromagnetic signal is a function of time, but it can also be expressed as a function of frequency; that is, the signal consists of components of different frequencies. It turns out that the frequency domain view of a signal is far more important to an understanding of data transmission than a time domain view.

- **Time Domain Concepts:** Viewed as a function of time, an electromagnetic signal can be either analog or digital.
  1. **Analog Signal:** An **analog signal** is one in which the signal intensity varies in a smooth fashion over time. In other words, there are no breaks or discontinuities in the signal.
  2. **Digital Signal:** A **digital signal** is one in which the signal intensity maintains a constant level for some period of time and then changes to another constant level.

  The analog signal might represent speech, and the digital signal might represent binary 1s and Os.



(a) Analog



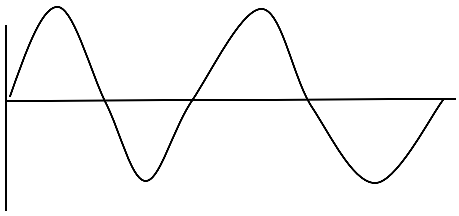
(b) Digital

Simplest sort of singnals are two:

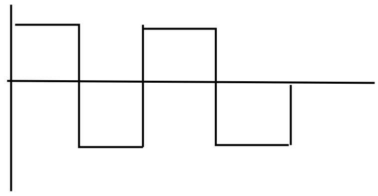
1. **Periodic Signal: periodic signal,** in which the same signal pattern repeats over time. Figure shows an example of a periodic analog signal (sine wave) and a periodic digital signal (square wave). Mathematically, a signal *s(t)* is defined to be periodic if and only if

$$S(t + T) = S(t) \qquad -\infty < t < +\infty$$

where the constant T is the period of the signal (T is the smallest value that satisfies the equation). Periodic signal can be analog or digital.



Analog Signal



Digital Signal

2. **Aperiodic Signal:** If the signal does not satisfy the periodic signal formula then it is said as aperiodic signal.

→ **A general Sinewave can be represented by 3 parameters:**

1. **Amplitude (A):** The **peak amplitude** is the maximum value or strength of the signal over time; typically, this value is measured in volts.
2. **Frequency (f):** The **frequency** is the rate [in cycles per second, or Hertz (Hz)] at which the signal repeats. An equivalent parameter is the **period** (T) of a signal, which is the amount of time it takes for one repetition; therefore, **T=1/f**
3. **Phase (ϕ): Phase** is a measure of the relative position in time within a single period of a signal, as illustrated later. The general sine wave can be written

$$s(t) = A \sin(2\pi ft + \phi)$$

- A function with the form of Equation is known as a **sinusoid.** Figure shows the effect of varying each of the three parameters. In part (a) of the figure, the frequency is 1 Hz; thus the period is $T = 1$ second. Part (b) has the same frequency and phase but a peak amplitude of 0.5. In part (c) we have $f = 2$, which is equivalent to $T = 1/2$. Finally, part (d) shows the effect of a phase shift of $\pi/4$ radians, which is 45 degrees (2π radians = 360° = 1 period).

- In Figure 2.3 the horizontal axis is time; the graphs display the value of a signal at a given point in space as a function of time. These same graphs, with a change of scale, can apply with horizontal axes in space. In that case, the graphs display the value of a signal at a given point in time as a function of distance. For example, for a sinusoidal transmission (say, an electromagnetic radio wave some distance from a radio antenna or sound some distance from loudspeaker) at a particular instant of time, the intensity of the signal varies in a sinusoidal way as a function of distance from the source.

→ **wavelength** *( ):* The **wavelength** *( )* of a signal is the distance occupied by a single cycle, or, put another way, the distance between two points of corresponding phase of two consecutive cycles. Assume that the signal is traveling with a velocity *v*. Then the wavelength is related to the period as follows: $\lambda = vT$. Equivalently, $\lambda f = v$. Of particular relevance to this discussion is the case where v = c, the speed of light in free space, which is approximately 3 x 10^8 *m/s.*

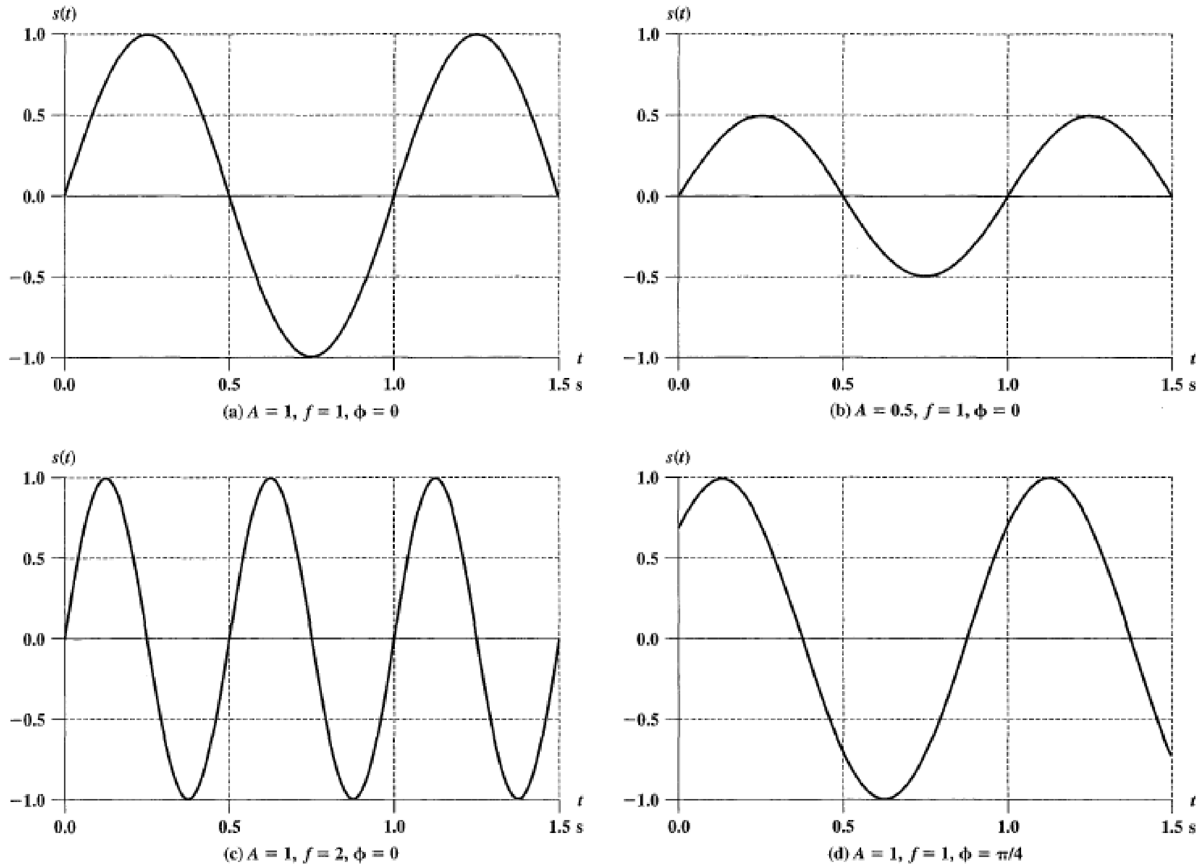


Figure 2.3 $s(t) = A\sin(2\pi ft + \phi)$

❖ **Frequency Domain Concepts:** In practice, an electromagnetic signal will be made up of many frequencies. For example, the signal

$$s(t) = (4/\pi) \times (\sin(2\pi ft) + (1/3)\sin(2\pi(3f)t))$$

is shown in Figure *2.4.* The components of this signal are just sine waves of frequencies *f* and *3f;* parts (a) and (b) of the figure show these individual components.

Fundamental frequency:" The second frequency is an integer multiple of the first frequency. When all of the frequency components of a signal are integer multiples of one frequency, the latter frequency is referred to as the **fundamental frequency.**

The period of the total signal is equal to the period of the fundamental frequency. The period of the component sin(2πft) is $T = 1/f$, and the period of *s(t)* is also *T*, as can be seen from Figure 2.4

Spectrum: The **spectrum** of a signal is the range of frequencies that it contains. For the signal of Figure 2.4c, the spectrum extends from *f to 3f.*

The **absolute bandwidth** of a signal is the xwidth of the spectrum. In the case of Figure 2.4c, the bandwidth is $3f - f = 2f$. Many signals have an infinite bandwidth, but with most of the energy contained in a relatively narrow band of frequencies. This band is referred to as the **effective bandwidth,** or just **bandwidth.**

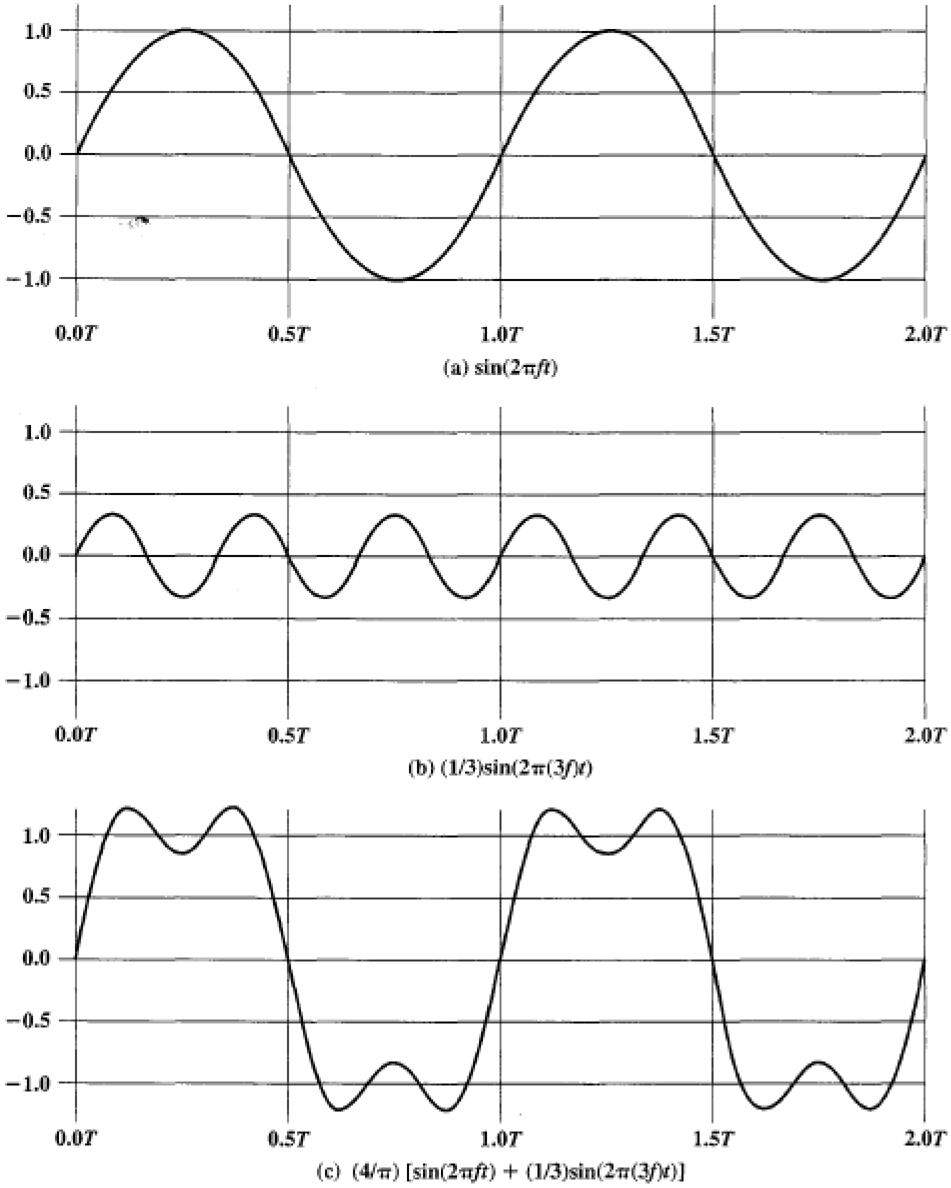


Figure 2.4 Addition of Frequency Components ($T = 1/f$)

Periodic signal	Aperiodic signal
Which repeats itself (its pattern) after specific interval of time	Does not repeat itself
Can be represented by mathematical equation	Can not be represented by mathematical equation
Their value can be determined at any point of time	Their value can not be determined at any point of time
They are deterministic signal	They are random signal
Example, Sine, Cosine, Square, Sawtooth	Example, Sound signals from radio, all types of noise signal

Analog Signal	Digital Signal
It is Continuous signal which represents physical measurements.	It is discrete time signal generated by digital modulation.
Denoted by sine wave.	Denoted by square wave.
Its processing can be done in real time and consume less bandwidth	No guarantee that processing can be done in real time and consume more bandwidth

Stored in form of wave signal.	Stored in the form of binary
Subjected to deterioration by noise during transmission	Can be noise immune without deterioration during transmission
Instruments draws large power	Instruments draw negligible power
It has infinite number of levels	Finite number of levels. [2, 4, 8…]
It observe less attenuation	It observes more attenuation
It is less efficient and reliable	More efficient and reliable
It is not possible to separate noise and original signal	It is possible to separate noise and original signal
Sources, Signal generators, Transducers, Human voice in air	Sources, Computers, A to D converter

1. Explain Signals for conveying information. **[L.J.I.E.T]** 7

Ans: Basic Information

2. Explain Analog and Digital data transmission. **[L.J.I.E.T]** 7

Ans:

Analog and *digital* correspond, roughly, to *continuous* and *discrete,* respectively. These two terms are used frequently in data communications in at least three contexts: data, signals, and transmission.

Data: we define data as entities that convey meaning, or information.

Signals: Signals are electric or electromagnetic representations of **data.**

Signaling: It is a process of physical propagation of signal along suitable medium.

Transmission: Transmission is the communication of data by the propagation and processing of signals.

Analog Data: It takes on continuous values in some interval. For example, voice and video are continuously varying patterns of intensity. Most data collected by sensors such as temperature and pressure.

Digital Data: It takes on discrete values. Example, Text and Integers.

Analog Signal: An analog signal is continuously varying electromagnetic wave signal that may be propagated over a verity of media, depending on frequency. Example, copper wire media, such as twisted pair and coaxial cable and atmosphere or space propagation.

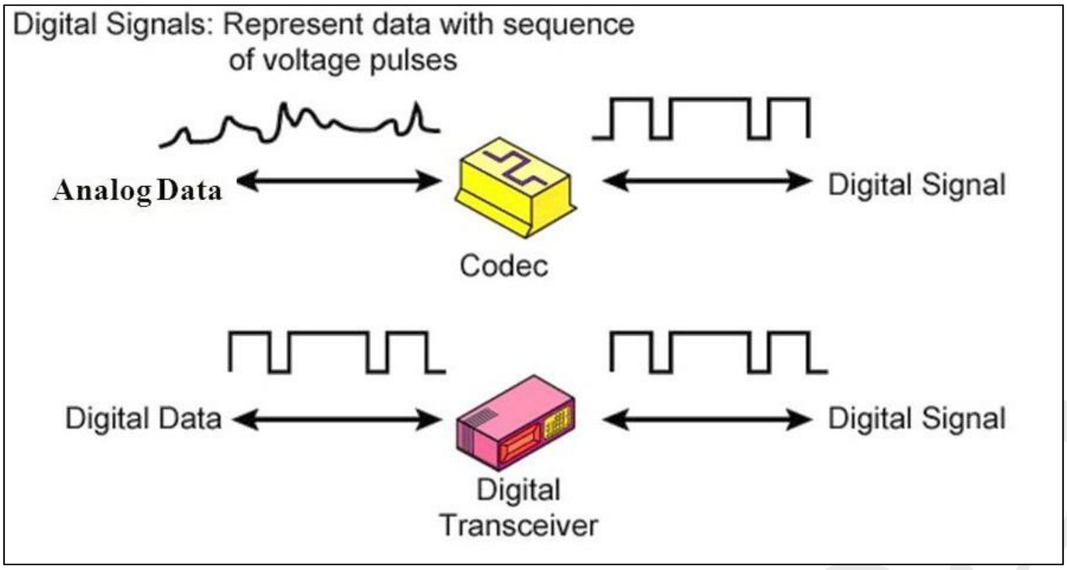
Digital Signal: It is a sequence of voltage pulses that may be transmitted over a copper wire medium. Example, a constant positive voltage level may represent binary 0 and a constant negative voltage level may represent binary 1.

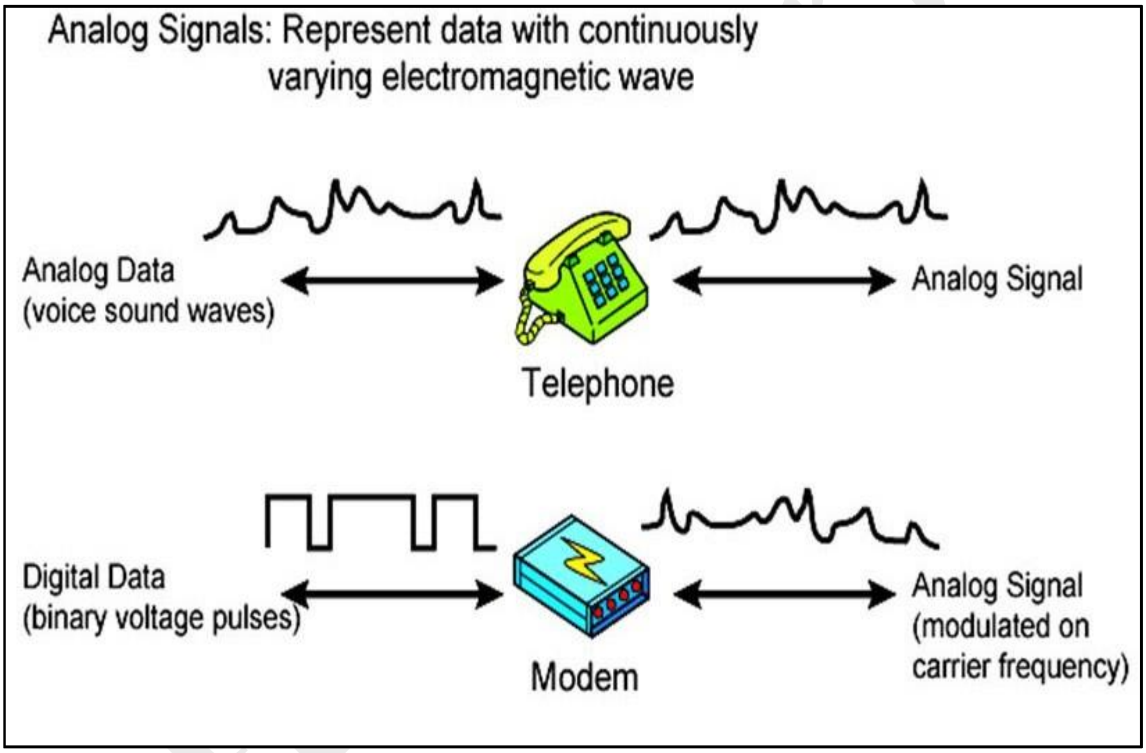
Advantage: Cheaper than analog signal and less susceptible to noise interference.

Disadvantage: suffer more from attenuation.

The reasons for choosing a particular combination for any given communications task vary. We list here some representative reasons:

- **Digital data, digital signal:** In general, the equipment for encoding digital data into a digital signal is less complex and less expensive than digital-to analog equipment.
- **Analog data, digital signal:** Conversion of analog data to digital form permits the use of modern digital transmission and switching equipment for analog data.
- **Digital data, analog signal:** Some transmission media, such as optical fiber and satellite, will only propagate analog signals.
- **Analog data, analog signal:** Analog data are easily converted to an analog signal.





Both analog and digital signals may be transmitted on suitable transmission media.

Analog Transmission: Analog transmission is a means of transmitting analog signals without regard to their content; the signals may represent analog data (e.g., voice) or digital data (e.g., data that pass through a modem).

→ In either case, the analog signal will suffer attenuation that limits the length of the transmission link. To achieve longer distances, the analog transmission system includes amplifiers that boost the energy in the signal.

→ Unfortunately, the amplifier also boosts the noise components. With amplifiers cascaded to achieve long distance, the signal becomes more and more distorted.

→ For analog data, such as voice, quite a bit of distortion can be tolerated and the data remain intelligible. However, for digital data transmitted as analog signals, cascaded amplifiers will introduce errors.

Digital transmission: Digital transmission, in contrast, is concerned with the content of the signal. We have mentioned that a digital signal can be propagated only a limited distance before attenuation endangers the integrity of the data. To achieve greater distances, repeaters are used.

→ A repeater receives the digital signal, recovers the pattern of ones and zeros, and retransmits a new signal. Thus, the attenuation is overcome.

→ The same technique may be used with an analog signal if the signal carries digital data.

Summary:

	Analog Signal	**Digital Signal**
Analog Data	Two alternatives: (l)signal occupies the same spectrum as the analog data; (2) analog data are encoded to occupy a different portion of spectrum.	Analog data are encoded using a codec to produce a digital bit stream.
Digital Data	Digital data are encoded using a modem to produce analog signal.	Two alternatives: (1) signal consists of two voltage levels to represent the two binary values; (2) digital data are encoded to produce a digital signal with desired properties.

	Analog Transmission	**Digital Transmission**
Analog Signal	Is propagated through amplifiers; same treatment whether signal is used to represent analog data or digital data.	Assumes that the analog signal represents digital data. Signal is propagated through repeaters; at each repeater, digital data are recovered from inbound signal and used to generate a new analog outbound signal.
Digital Signal	Not used	Digital signal represents a stream of 1s and 0s, which may represent digital data or may be an encoding of analog data. Signal is propagated through repeaters; at each repeater, stream of 1s and 0s is recovered from inbound signal and used to generate a new digital outbound signal.

3. Define: Peak Amplitude (*A*), Frequency (*f*) and Period (*T*). **(Nov-2017)[L.J.I.E.T]** 3

Ans: Basic Information

4. Define Channel Capacity. Define its key factors that affect it. **(Nov-2017)[L.J.I.E.T]** 3

Ans:

A variety of impairments can distort or corrupt a signal. A common impairment is noise, which is any unwanted signal that combines with and hence distorts the signal intended for transmission and reception. Noise is something that degrades signal quality.

channel capacity: The maximum rate at which data can be transmitted over a given communication path, or channel, under given conditions is referred to as the **channel capacity.**

There are four concepts here that we are trying to relate to one another:

1. **Data rate:** It is defined as the number of bits transmitted by the transmitter per second. This is the rate, in bits per second (bps), at which data can be communicated.
   This capability depends on following factors.
   1. The amount of energy put into transmitting each signal.

2. Distance to be travelled.
3. Noise
4. Channel Bandwidth

2. **Channel Bandwidth:** This is the bandwidth of the transmitted signal as constrained by the transmitter and the nature of the transmission medium, expressed in cycles per second, or Hertz. The Bandwidth of the communication medium should be large enough to transmit the digital signal reliably. An inadequate bandwidth will distort the signal and introduce errors into the received signal.

3. **Noise: T**he average level of noise over the communications path.

4. **Error rate:** This is the rate at which errors occur, percentage of time when bits are flipped. Where an error is the reception of a 1 when a 0 was transmitted or the reception of a 0 when a 1 was transmitted.

Communications facilities are expensive and, in general, the greater the bandwidth of a facility, the greater the cost. Accordingly, we would like to make as efficient use as possible of a given bandwidth. For digital data, this means that we would like to get as high a data rate as possible at a particular limit of error rate for a given bandwidth. The main constraint on achieving this efficiency is noise.

5. Define channel capacity. Write Shannon and Nyquist capacity formula. State the key factors that affect channel capacity.**[New](Nov-2016)[L.J.I.E.T]** 7

6. Explain Nyquist theorem? Find the relationship among the following terms Channel Capacity (C), Bandwidth (B) and Signal-to-Noise Ratio (SNR)**. (May-2017) (May-2018) [L.J.I.E.T]** 7, 7

Ans:

Nyquist Theorem:

→ Let us consider the case of a channel that is noise free. In this environment, the limitation on data rate is simply the bandwidth of the signal.

→ A formulation of this limitation, due to Nyquist, states that if the rate of signal transmission is 2B, then a signal with frequencies no greater than B is sufficient to carry the signal rate.

→ The converse is also true: Given a bandwidth of B, the highest signal rate that can be carried is 2B. This limitation is due to the effect of inter symbol interference, such as is produced by delay distortion.

→ If the signals to be transmitted are binary (take on only two values), then the data rate that can be supported by B Hz is 2B bps. As an example, consider a voice channel being used, via modem, to transmit digital data. Assume a bandwidth of 3100 Hz. Then the capacity, C, of the channel is 2B = 6200 bps.

→ Signals with more than two levels can be used; that is, each signal element can represent more than one bit.

→ With multilevel signaling, the Nyquist formulation becomes

$$C = 2B \log_2 M$$

→ Where M is the number of discrete signal elements or voltage levels. Thus, for M = 8, a value used with some modems, a bandwidth of B = 3100 Hz yields a capacity C = 18,600 bps.

→ So, for a given bandwidth, the data rate can be increased by increasing the number of different signal elements.

Shannon Theorem:

→ Nyquist's formula indicates that, all other things being equal, doubling the bandwidth doubles the data rate. Now consider the relationship among data rate, noise, and error rate. The presence of noise can corrupt one or more bits. If the data rate is increased, then the bits become "shorter" in time, so that more bits are affected by a given pattern of noise. Thus, at a given noise level, the higher the data rate, the higher the error rate.

→ For a given level of noise, we would expect that a greater signal strength would improve the ability to receive data correctly in the presence of noise.

→ **SNR:** the signal-to-noise ratio (SNR, or *S/N),* which is the ratio of the power in a signal to the power contained in the noise that is present at a particular point in the transmission.

→ Typically, this ratio is measured at a receiver, because it is at this point that an attempt is made to process the signal and eliminate the unwanted noise. For convenience, this ratio is often reported in decibels:

$$SNR_{dB} = 10 \log_{10} (\text{Signal power} / \text{Noise power})$$

→ A high SNR will mean a high-quality signal.

→ The signal-to-noise ratio is important in the of digital data transmission because it sets the upper bound on the achievable data rate.

→ Shannon's result is that the maximum channel capacity, in bits per second, obeys the equation

$$C = B \log_2(1 + SNR)$$

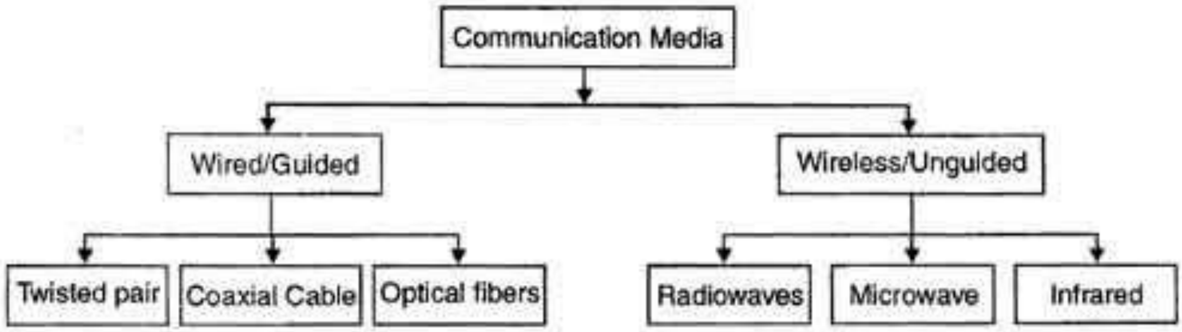
→ Where C is the capacity of the channel in bits per second and *B* is the bandwidth of the channel in Hertz.

→ The Shannon formula represents the theoretical maximum that can be achieved. In practice, however, only much lower rates are achieved. One reason for this is that the formula assumes white noise (thermal noise). Impulse noise is not accounted for, nor are attenuation distortion or delay distortion.

→ For a given level of noise, it would appear that the data rate could be increased by increasing either signal strength or bandwidth. However, as the signal strength increases, so do the effects of nonlinearities in the system, leading to an increase in intermodulation noise. Note also that, because noise is assumed to be white, the wider the bandwidth, the more noise is admitted to the system. Thus, as *B* increases, SNR decreases.

7. Explain the Transmission Media. **(May-2018)[L.J.I.E.T]** 3

Transmission medium: In a data transmission system, the **transmission medium** is the physical path between transmitter and receiver. Transmission media can be classified as guided or unguided.
Guided media: electromagnetic waves. With **guided media,** the waves are guided along a solid medium, such as copper twisted pair, copper coaxial cable, or optical fiber.
Unguided media: which provide a means of transmitting electromagnetic signals but do not guide them; this form of transmission is usually referred to as **wireless transmission** the atmosphere and outer space are examples of **unguided media.**



❖ **Guided Transmission Media:**

1. Magnetic media
2. Twisted pair

3. Coaxial cable
4. Fiber optics

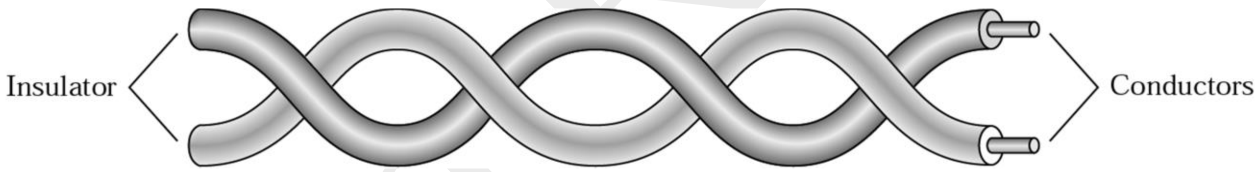
- Guided media, which are those that provide a channel from one device to another, include twisted-pair cable, coaxial cable, and fiber-optic cable.
- A signal travelling along any of these media is directed and contained by the physical limit of the medium.

Magnetic Media:

- One of the most common ways to transport data from one computer to another is to write them onto magnetic tape or removable media (e.g., recordable DVDs), physically transport the tape or disks to the destination machine, and read them back in again.
- Although this method is not as sophisticated as using a geosynchronous communication satellite, it is often more cost effective, especially for applications in which high bandwidth or cost per bit transported is the key factor.

Twisted Pair:

- A twisted pair consists of two insulated copper wires, typically about 1 mm thick.
- The wires are twisted together in a helical form, just like a DNA molecule.
- Twisting is done because two parallel wires constitute a fine antenna.
- When the wires are twisted, the waves from different twists cancel out, so the wire radiates less effectively.



Why cable is twisted?

- If the two wires are parallel, the effect of these unwanted signals is not the same in both wires because they are at different locations relatives to the noise or crosstalk sources.
- This results in a difference at the receiver.
- By twisting the pair, a balance is maintained.

Types of Twisted-Pair Cable

Unshielded twisted-pair (UTP)

- Twisted pair cabling comes in several varieties, two of which are important for computer networks.
- **Category 3** twisted pairs consist of two insulated wires gently twisted together.
- Most office buildings had one category 3 cable running from a central wiring closet on each floor into each office.
- **Category 5** is the more advanced twisted pairs were introduced.
- They are similar to category 3 pairs, but with more twists per centimeter, which results in less crosstalk and a better-quality signal over longer distances, making them more suitable for high-speed computer communication.

Shielded twisted-pair (STP).

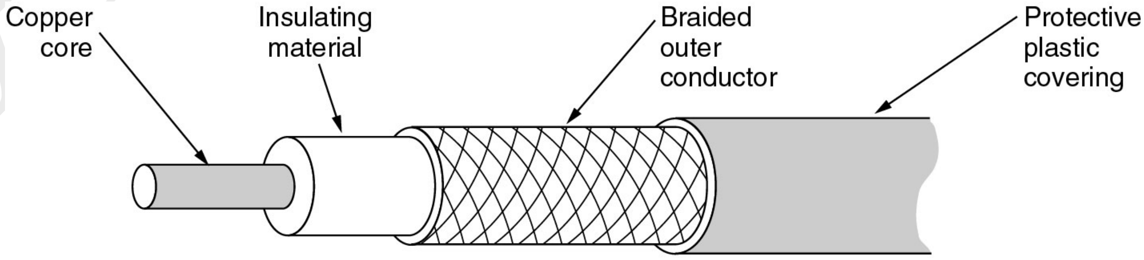
- STP cable has a metal foil or braided mesh covering that encases each pair of insulated conductors.
- Metal casing improves the quality of cable by preventing the penetration of noise or crosstalk.
- It is bulkier and more expensive.

Applications:

- Used in telephone lines to provide voice and data channels.
- The DSL (Digital Subscriber Line) lines uses by telephone companies use the high-bandwidth capability of UTP cables.
- LANs, such as 10Base-T, 100Base-T, also uses twisted-pair cables.

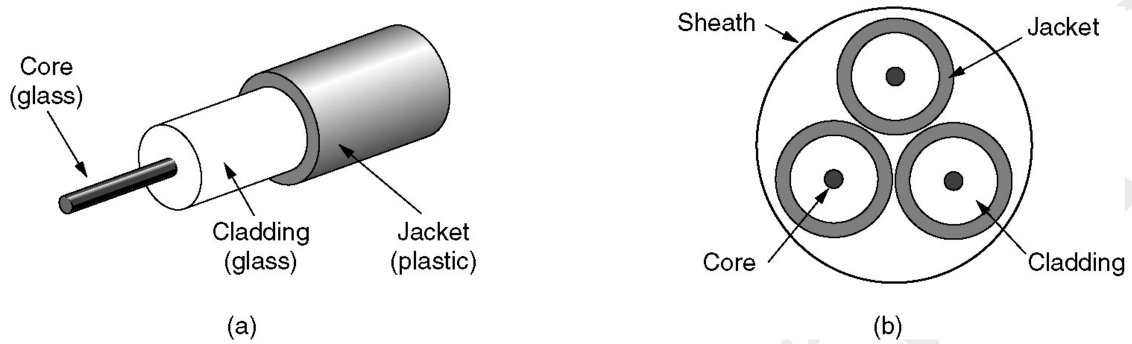
Coaxial Cable:

- It has better shielding than twisted pairs, so it can span longer distances at higher speeds.
- A coaxial cable consists of a stiff copper wire as the core, surrounded by an insulating material.
- The insulator is encased by a cylindrical conductor, often as a closely-woven braided mesh.
- The outer conductor is covered in a protective plastic sheath.
- The construction and shielding of the coaxial cable give it a good combination of high bandwidth and excellent noise immunity.
- The bandwidth possible depends on the cable quality, length, and signal-to-noise ratio of the data signal. Modern cables have a bandwidth of close to 1 GHz.
- Coaxial cables used to be widely used within the telephone system for long-distance lines but have now largely been replaced by fiber optics on long-haul routes.



Fiber Optics:

- A fiber-optic cable is made of glass or plastic and transmits signals in the form of light.
- 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 a core is reflected off the cladding instead of being refracted into it



- Fiber optic cables are similar to coax, except without the braid.
- Figure shows a single fiber viewed from the side. At the center is the glass core through which the light propagates.
- The core is surrounded by a glass cladding with a lower index of refraction than the core, to keep all the light in the core.
- Next comes a thin plastic jacket to protect the cladding. Fibers are typically grouped in bundles, protected by an outer sheath. Figure shows a sheath with three fibers.

❖ **Unguided (Wireless) transmission media**

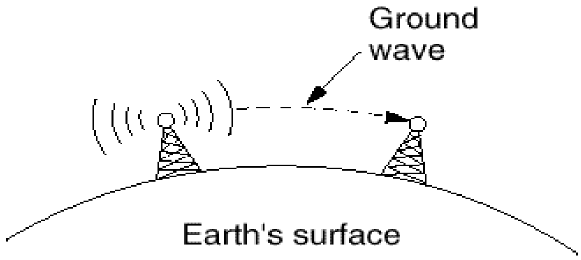
1. Radio Transmission
2. Microwave Transmission
3. Infrared
4. Light wave Transmission

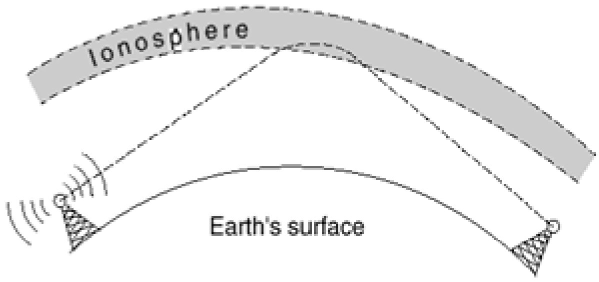
Unguided media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication.

Radio Transmission:

- Radio waves are easy to generate, can travel long distances, and can penetrate buildings easily, so they are widely used for communication, both indoors and outdoors.
- Radio waves also are omnidirectional, meaning that they travel in all directions from the source, so the transmitter and receiver do not have to be carefully aligned physically.
- The properties of radio waves are frequency dependent.
- At low frequencies, radio waves pass through obstacles well, but the power falls off sharply with distance from the source, roughly as $1/r^2$ in air.
- At high frequencies, radio waves tend to travel in straight lines and bounce off obstacles. They are also absorbed by rain.
- At all frequencies, radio waves are subject to interference from motors and other electrical equipment.

- In the VLF, LF, and MF bands, radio waves follow the curvature of the earth.
- In the HF they bounce off the ionosphere





Microwave Transmission:

- Since the microwaves travel in a straight line, if the towers are too far apart, the earth will get in the way. Consequently, repeaters are needed periodically.
- Unlike radio waves at lower frequencies, microwaves do not pass through buildings well. In addition, even though the beam may be well focused at the transmitter, there is still some divergence in space.
- Above 100 MHz, the waves **travel in straight lines** and can therefore be narrowly focused. Concentrating all the energy into a small beam using a **parabolic antenna** gives a much higher signal to noise ratio.

Advantages:

- No right way is needed (compared to wired media).
- Relatively inexpensive.
- Simple to install

Disadvantages:

- Do not pass through buildings well.
- Multipath fading problem (the delayed waves cancel the signal).
- Absorption by rain above 8 GHz.
- Severe shortage of spectrum

Infrared:

- Unguided infrared and millimeter waves are widely used for short-range communication.
- The remote controls used on televisions, VCRs, and stereos all use infrared communication.
- They are relatively directional, cheap, and easy to build but have a major drawback: they do not pass through solid objects (try standing between your remote control and your television and see if it still works).
- In general, as we go from long-wave radio toward visible light, the waves behave more and more like light and less and less like radio.
- On the other hand, the fact that infrared waves do not pass through solid walls well is also a plus.
- It means that an infrared system in one room of a building will not interfere with a similar system in adjacent rooms or buildings.
- Furthermore, security of infrared systems against eavesdropping is better than that of radio systems precisely for this reason.
- Therefore, no government license is needed to operate an infrared system, in contrast to radio systems, which must be licensed outside the ISM bands.

Light wave Transmission:

- The laser's strength, a very narrow beam, is also its weakness here.
- Aiming a laser beam 1-mm wide at a target the size of a pin head 500 meters away requires the marksmanship of a latter-day Annie Oakley. Usually, lenses are put into the system to defocus the beam slightly.
- A disadvantage is that laser beams cannot penetrate rain or thick fog, but they normally work well on sunny days. Addition, even though the beam may be well focused at the transmitter, there is still some divergence in space.
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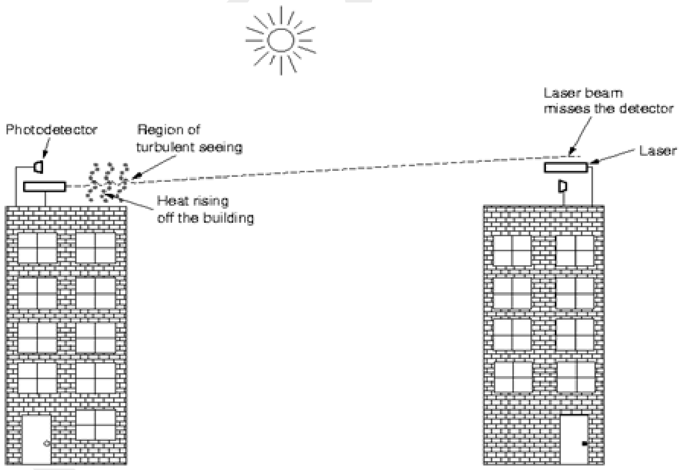

8 Briefly describe the following networks with example and application: 5

1. Wired network 2. Wireless network. **[New] (May-2015)[L.J.I.E.T]**

9

Wired Media	Wireless Media
Signal energy contained and guided within a solid medium.	Signal energy propagates in the form of unguided electromagnetic waves.
Ex, Twisted Pair wires, coaxial cable, optical fiber cable, Magetic Tape	Ex, radio wave, microwave, light wave and Infrared
Point to point communication	Radio Broadcasting in all direction
It leads to discrete network topology	Leads to continuous network topology.
Addition transmission capacity can be produce by adding more wires.	Not possible
Installation costly and time consuming.	Installation less time consuming and less money.

		Attenuation depends exponentially on the distance.	Attenuation depends on square of the distance.	
	NUMERICALS			
1.	Given a channel with an intended capacity of 50 Mbps, the bandwidth of the Channel is 5 MHz. What signal-to-noise ratio is required to achieve this capacity? **[New](Nov-2016) [L.J.I.E.T]**			3

1) C = 50 mbps, B = 5MHz are given then findout SNR.

$$C = B \log(1+SNR)$$

$$50\,m = 5\,m \log(1+SNR)$$

$$10 = \log(1+SNR)$$

$$1+SNR = 2^{10} = 1024$$

$$\therefore SNR = 1023$$

$$\therefore SNR_{db} = 10\log_{10} SNR$$

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$$= 10\log_{10} 1023$$

$$= 10 \log_{10} 1023$$

$$= 10 \times 3.0098$$

$$\boxed{SNR_{db} = 30.00\ db.}$$

Consider $C = 20$ mbps , $B = 3$ mHz
Then findout SNR & SNR in db.

$$C = B \log_2 (1+SNR)$$

$$20\ m = 3\ m \log (1+SNR)$$

$$\therefore 6.6667 = \log (1+SNR)$$

$$\therefore 1 + SNR = 2^{6.6667} = 101.66$$

$$\therefore SNR = 100.60$$

$$\therefore SNR_{db} = 10 \log_{10} SNR$$

$$= 10 \times 2$$

$$\boxed{SNR_{db} = 20 db.}$$

[2] Consider Bandwidth $= 3000$ Hz & SNR given to you is 3162 db then find out channel capacity.

$$C = B \log (1+SNR)$$
$$= 3000 \log (1+3162)$$
$$= 3000 \log_2 (3163)$$
$$= 3000 \times \frac{\ln 3162}{\ln 2} \quad \frac{8.05896}{0.69315}$$
$$= 3000 \times 11.62$$
$$= 34,860 \text{ bps.}$$

Consider spectrum 3 MHz & 4 MHz, SNR given in decibel 24, then findout the level.

$B = max - min$

$\therefore B = 4\,MHz - 3\,MHz = 1\,MHz$

$\therefore SNR_{db} = 10 \log_{10} SNR$

$\therefore SNR = 10^{\frac{SNR_{db}}{10}} = 10^{2.4} = 251.186$

$\therefore B = 1\,MHz, \quad SNR = 251$

$\therefore C = 10^6 \log(1 + 251) = 10^6 \log(252)$

$= 10^6 \times 8 \qquad = 10^6 \times \frac{5.5294}{0.6931}$

$= 8\ mbps. \qquad \times 7.977$

$\Rightarrow C = 2B \log M$

$8\,M = 2 \times 1\,MHz \log M$

$\therefore 4 = \log_2 M$

$\therefore M = 2^4 = 16$

$M = 16$ levels.

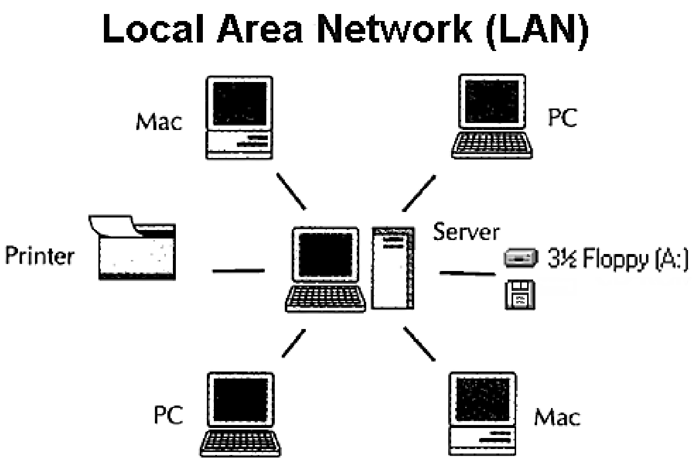
TOPIC 2. Communication

DESCRIPTIVE QUESTIONS

1.	Explain LAN, WAN, MAN. **[L.J.I.E.T]** Compare the LAN and WAN. **(May-2018)[L.J.I.E.T]** Ans:	7, 7

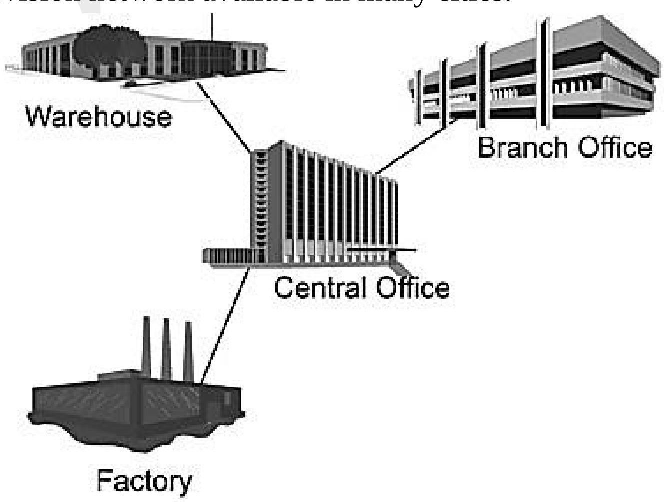
LAN (Local Area Network):

- It is privately-owned networks within a single building or campus of up to a few kilometers in size.
- They are widely used to connect personal computers and workstations in company offices and factories to share resources (e.g., printers) and exchange information.
- LANs are easy to design and troubleshoot
- In LAN, all the machines are connected to a single cable.
- Different types of topologies such as Bus, Ring, Star, and Tree are used.
- The data rates for LAN range from 4 to 16 Mbps.
- They transfer data at high speeds (higher bandwidth).
- They exist in a limited geographical area.Connectivity and resources, especially the transmission media, usually are managed by the company which running the LAN.



MAN (Metropolitan Area Network):

- A metropolitan area network, or MAN, covers a city. The best-known example of a MAN is the cable television network available in many cities.



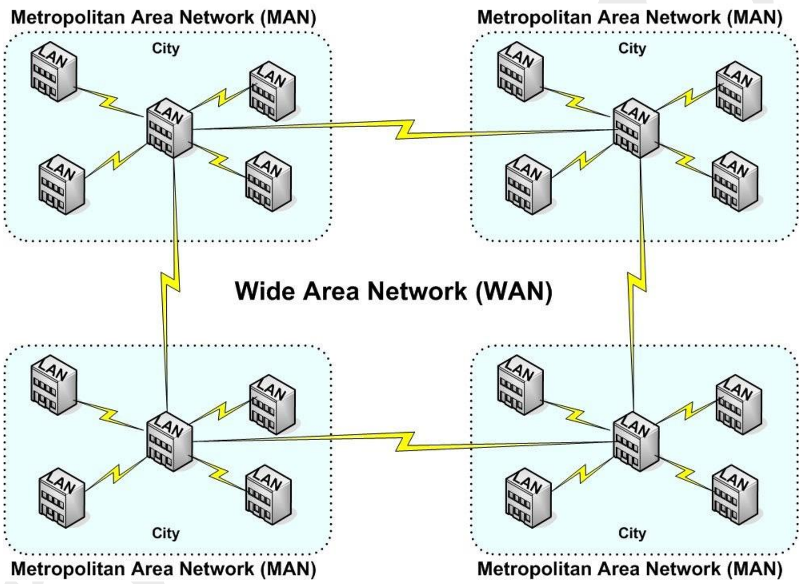
- A MAN is basically a bigger version of a LAN and normally uses similar technology.
- At first, the companies began jumping into the business, getting contracts from city

governments to wire up an entire city.

- The next step was television programming and even entire channels designed for cable only. Often these channels were highly specialized, such as all news, all sports, all cooking, and so on

WAN (Wide Area Network):

- WAN, spans a large geographical area, often a country or continent.
- It contains a collection of machines intended for running user (i.e., application) programs. We will follow traditional usage and call these machines hosts.
- The hosts are connected by a communication subnet, or just subnet for short.
- In most wide area networks, the subnet consists of two distinct components: transmission lines and switching elements. Transmission lines move bits between machines.
- The communication between different users of WAN is established using leased telephone lines or satellite links and similar channels.

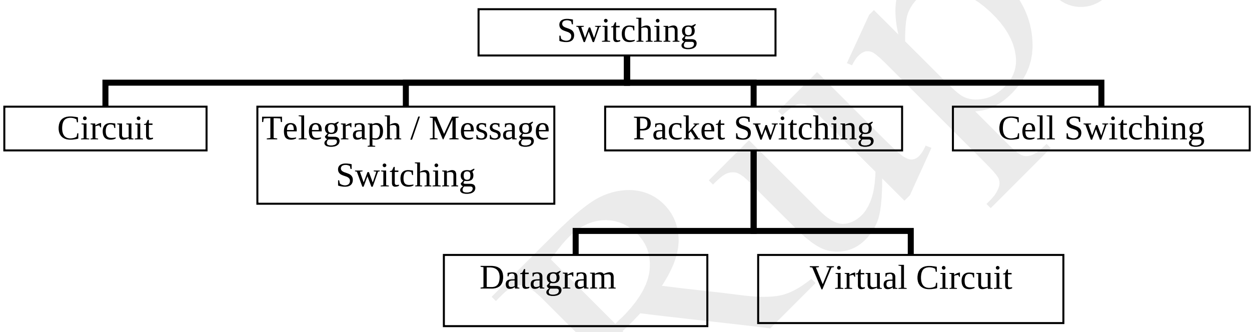


	LAN	MAN	WAN
Ownership of Netwrok	Private	Private / Public	Private / Public
Geographical Area Covered	Small	Moderate (City)	Very Large (State or Countries)
Design and Maintanance	Easy	Not easy	Not easy
Ommunication medium	Twisted Pair Cable, Coaxial Cable	Coaxial Cable, PSTN, Optical fiber, cables, wireless	PSTN or Sattelite links
Data Rates (speed)	High	Moderate	Low
Mode of communication	Each station can transmit and recieve	Each station can transmit and recieve	Each station can not transmit and recieve
Principle	Operates on the	Operates on the	Operates on the

	principle of broadcasting	principle of broadcasting and Switching	principle of Switching
Propagation delay	Short	Moderate	Long
Bandwidth	Low	Moderate	High

Switching Techniques

- → For transmission of data beyond a local area, communication is typically achieved by transmitting data from source to destination through a network of intermediate switching nodes; this switched network design is sometimes used to implement LANs and MANs as well.
- → Information may be switched as it travels from sender to receiver over multiple path through various communication channel.



Circuit Switching:

- → **Circuit switching** is a technique that directly connects the sender and the receiver in an **unbroken path**.
- → Used in Public telephone networks and is the basis for private network built on leased - basis. Telephone switching equipment, for example, establishes a path that connects the caller's telephone to the receiver's telephone by making a physical connection.
- → It is Used for voice terrify
- → Less efficient in digital data
- → Dedicated path is established
- → Connection is transparent (Once connection is established, it appears to attach devices as if there were a direct connection)
- → On each physical link, a logical channel is dedicated to channel.
- → There are three phases of circuit switching:
  1. Circuit Establishment
  2. Data Transfer
  3. Circuit Disconnect
- → Connection should established before terms begins. Nodes must have switching capacity and channel capacity to establish connection.
- → Switches must have intelligence to work out routing.
- → Circuit switching uses any of two following:
  - o Space division switching technique
  - o Time division switching technique

Application:

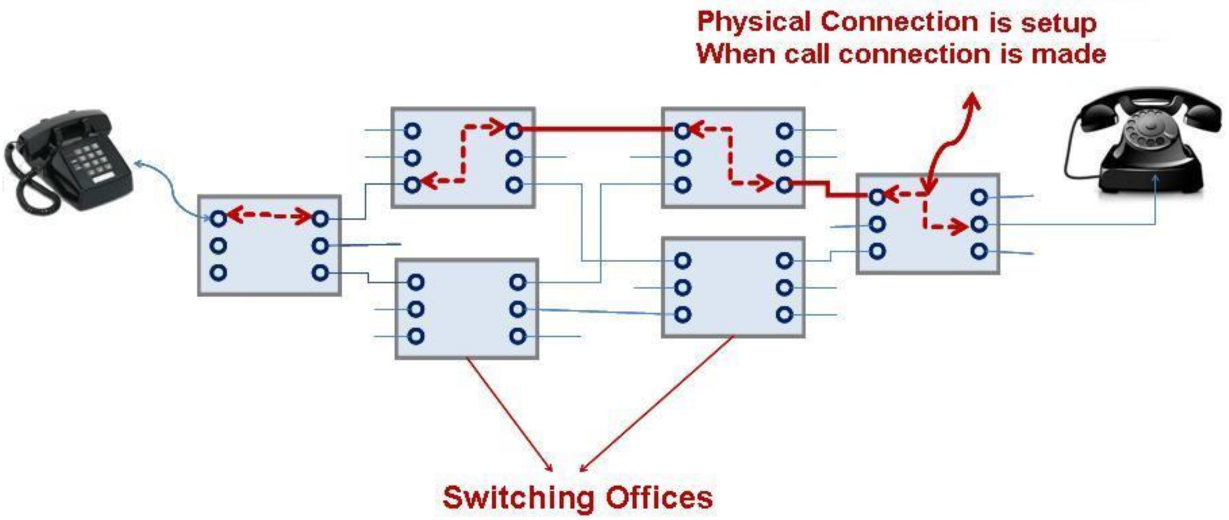
→ Developed for voice traffic
→ Private Branch Exchange (PBX) (Inter connection of telephones within a building or office)

Advantages:

→ Dedicated transmission so guaranteed data rates.
→ No delay in data flow
→ Real time transfer of voice signal

Disadvantages:

→ Can not use channel for another data transfer even if the channel is free.
→ Require more bandwidth
→ Takes long time to establish connection
→ High cost
→ Not reliable (Call can be lost)
→ Can not use reliably for Digital data.



Message Switching:

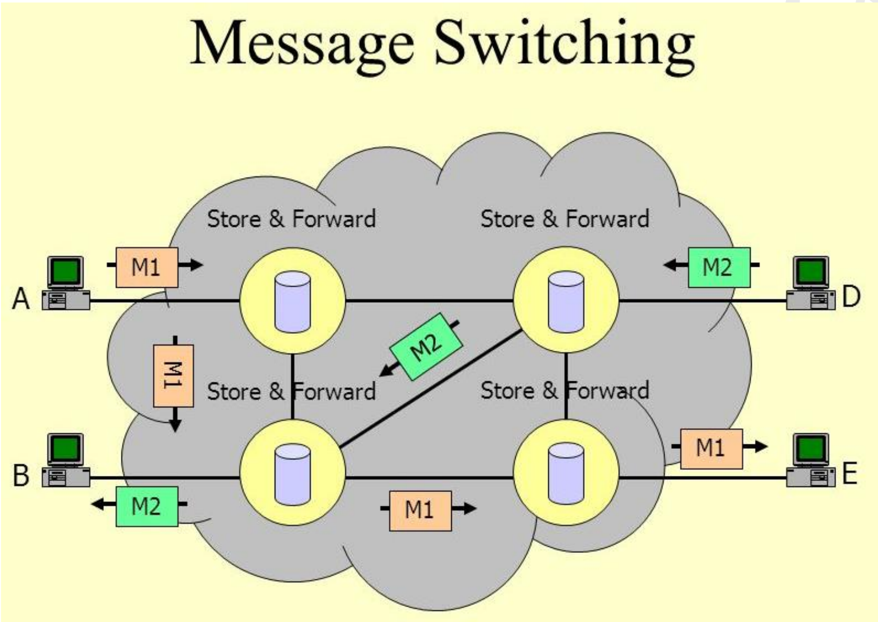
→ With message switching there is no need to establish a dedicated path between two stations.
→ When a station sends a message, the destination address is appended to the message.
→ Message Encoded in **morse** code (sequence of dots and dashes)
→ This code transmitted as short and long pulse of electrical current over a copper wire from network to switching station.
→ The message is then transmitted through the network, in its entirety, from node to node.
→ Each node receives the entire message, stores it in its entirety on disk, and then transmits the message to the next node.
→ This type of network is called a **store-and-forward** network.
→ It forwards the message when communication line is free and stores the message when line is busy.
→ Message switches can be programmed with information about most efficient routes and neighbouring switches information as switching information.
→ A message-switching node is typically a general-purpose computer. The device needs sufficient secondary-storage capacity to store the incoming messages, which could be long. A time delay is introduced using this type of scheme due to store- and-forward time, plus the time required to find the next node in the transmission path.

Advantages:

→ Efficient traffic management
→ Traffic congestion can be reduced, because messages may be temporarily stored in route.
→ Network device share the network channel.
→ Asynchronous communication across time zones.
→ Message priorities can be established due to store-and-forward technique.
→ Message broadcasting can be achieved with the use of broadcast address appended in the message

Disadvantages:

→ Store-and-forward devices are expensive, because they must have large disks to hold potentially long messages.
→ Because of store and forward network delay introduced, so can not be used for real time application like voice and video.



Packet Switching:

→ Packet switching can be seen as a solution that tries to combine the advantages of message and circuit switching and to minimize the disadvantages of both.
→ With message switching there is no need to establish a dedicated path between two stations.
→ There are two methods of packet switching: **Datagram and virtual circuit**.
→ In both packet switching methods, a message is broken into small parts, called packets.
→ Since packets have a strictly defined maximum length, they can be **stored in main memory instead of disk**; therefore access delay and cost are minimized.
→ Also the transmission speeds, between nodes, are optimized
→ At each node packets are received, stored briefly (buffered) and past on to the next node.
→ Store and forward mechanism
→ Each packet contains some portion of the user data plus control info needed for proper functioning of the network
→ Examples of packet switching networks are X.25, Frame Relay, ATM and IP.
→ Station breaks long message into packets. Packets sent one at a time to the network.
→ Packets handled in two ways:

1. Datagram

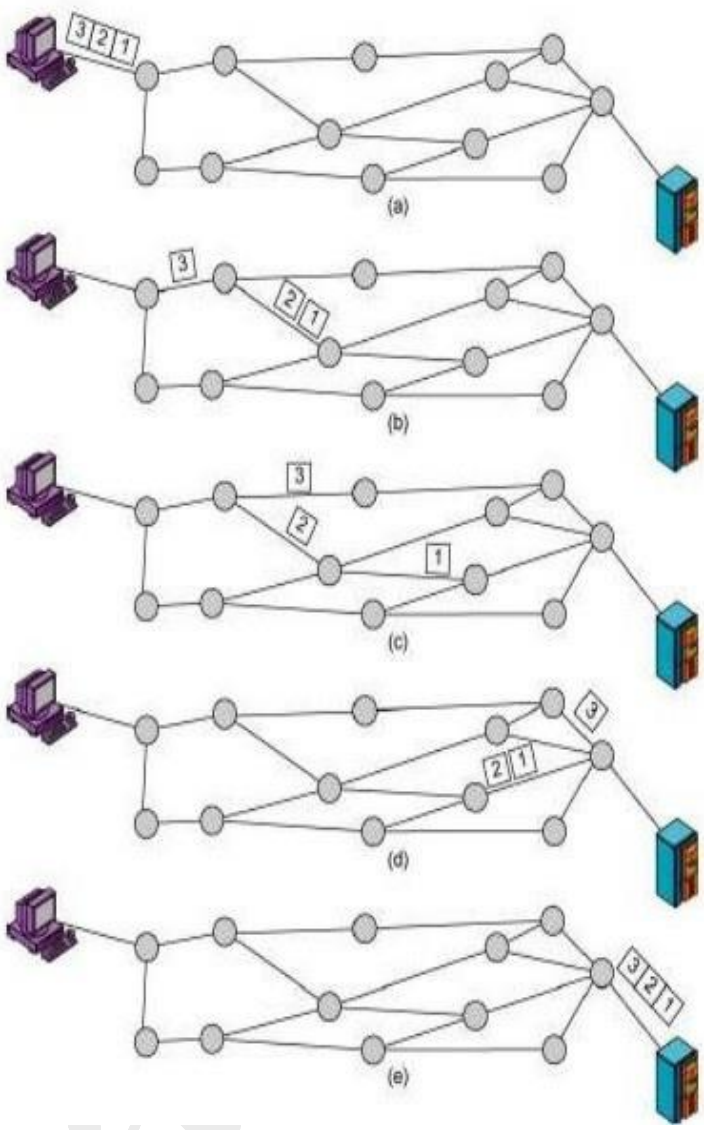
→ Each packet treated independently.
→ Packets can take any practical route
→ Packets may arrive out of order
→ Packets may go missing
→ Up to receiver to re-order packets and recover from missing packets
→ Datagram packet switching generally corresponds to the network layer. The packets are called as **Datagrams.**
→ Switching device are routers.
→ It is connection less network because the switch does not keep any information about the connection state.
→ No connection set up or tear down.

2. Virtual circuit

→ First establish virtual path between sender and receiver then sends all the data packets through that path only.
→ Call request and call accept packets establish connection (handshake)
→ Each packet contains a Virtual Circuit Identifier (VCI) instead of destination address
→ No routing decisions required for each packet
→ Clear request to drop circuit
→ Not a dedicated path

Advantages:
→ Packet switching is cost effective, because switching devices do not need massive amount of secondary storage.
→ Packet switching offers improved delay characteristics, because there are no long messages in the queue (maximum packet size is fixed).
→ Packet can be rerouted if there is any problem, such as, busy or disabled links.
→ The advantage of packet switching is that many network users can share the same channel at the same time. Packet switching can maximize link efficiency by making optimal use of link bandwidth.

Disadvantages:
→ Protocols for packet switching are typically more complex.
→ It can add some initial costs in implementation.
→ If packet is lost, sender needs to retransmit the data. Another disadvantage is that packet-switched systems still can't deliver the same quality as dedicated circuits in applications requiring very little delay - like voice conversations or moving images.



Datagram Packet Switching

Cell Switching:

- → Cell Switching is similar to packet switching, except that the switching does not necessarily occur on packet boundaries.
- → This is ideal for an integrated environment and is found within Cell-based networks, such as ATM.
- → Cell-switching can handle both digital voice and data signals

2.	Explain Circuit switching. **[L.J.I.E.T]**	7
3.	Write advantages and disadvantages of packet switching over circuit switching.**[New](Nov-2016)[L.J.I.E.T]**	7

Advantages:

- → Efficient utilization of line.
- → While heavy network packet still accepted but delivery delay increases.
- → Priorities can be given.

- → Group Sharing- Physical circuit shared among multiple sender and receiver.
- → No single user or large data block.
- → Protected against corruption or loss, errors are corrected by retransmission.
- → Can select different destinations for each virtual call, overcoming the inflexibility of point to point dedicated network.
- → Simultaneous calls allowed.
- → The cost of intermittent reduced.
- → Conference calling – new calls can be added, old ones disconnected without affecting other users.
- → Improved delay because maximum size of packets is fixed.
- → Packet can be rerouted if there is any problem, such as, busy or disabled links.

Disadvantages:

- → More complex.
- → More processing at node
- → Header overhead reduces capacity to carry user data.
- → Initial cost in implementation is high.
- → Not for real time because packet lost retransmission.
- → Increased delay due to transmission delay and variable delay due to processing and queuing.
- → Overall packet delay can vary substantially (Jitter) due to packet may vary in length, take different routes and subject to varying delay in switches.

4. Differentiate: Circuit Switching and Packet Switching. **(Nov-2017)[L.J.I.E.T]** 4, 7, 7
What is the circuit switching? Explain the communication phases of circuit switching. Differentiate between Datagram and Virtual circuit operation? **(May-2017)[L.J.I.E.T]**
Describe the Switching Techniques. Differentiate the Circuit Switching and Packet Switching. **(May-2018)[L.J.I.E.T]**

	Message Switching	Circuit Switching	Packet switching
Application	Telegraph network for transmission of telegrams	Bi- directional, Real time transfer of voice signal	Reliable stream service.
End terminal	Telegraph, teletype	Telephone, modem	Computer
Information Type	Data in the form of Morse code, ASCII Code	Analog voice and PCM digital voice	Binary Information
Transmission System	Digital data over different transmission media	Analog and digital data over different transmission media	Digital data over different transmission media
Addressing scheme	Geographical addressing	Hierarchical numbering plan	Hierarchical address space.
Routing scheme	Manual	Route selected during call setup	Each packet is routed independently
Multiplexing scheme	Character or message multiplexing	Circuit multiplexing	Packet multiplexing , shared media access network
Delay	High	Low	Moderate
Data rates	Low	High	High

TOPIC 3. Protocols and the TCP/IP Suite

DESCRIPTIVE QUESTIONS

1. What is the need of protocol architecture? Explain TCP/IP protocol in brief. **[L.J.I.E.T]** 7, 3
Describe the TCP/IP Protocol Architecture. **(May-2018) [L.J.I.E.T]**
Ans:

Network:
Network is a communication system which supports many users. A computer network is a system which allows communication among the computers connected in the network.

Protocol: There are certain rules that must be followed to ensure proper communication. A set of such rules is known as a **"Protocol".**

Need of protocol architecture:
→ Source must activate the direct data communication path or inform Computer network of the identity of desired destination.
→ Must ascertain destination is prepared to receive data.
→ File transfer application must ascertain that the file management program on the destination system is prepared to accept and store the file for particular.
→ If the file formats used on the two system are incompatible must perform a format transmission function.

Key Features of protocol:
→ **Syntax:** concerns the format of the data block.
→ **Semantics:** Control information for coordination or error handling.
→ **Timing:** Speed matching and sequencing

TCP/IP Protocol Architecture:
→ Transmission Control Protocol/Internet Protocol (TCP/IP) protocol suite is the engine for the Internet and networks worldwide.
→ TCP/IP either combines several OSI layers into a single layer, or does not use certain layers at all.
→ TCP/IP is a set of protocols developed to allow cooperating computers to share resources across the network.
→ The TCP/IP model has five layers.

1. Application Layer
2. Transport Layer
3. Internet Layer
4. Data Link Layer
5. Physical Network

Application Layer:
→ The application layer is provided by the program that uses TCP/IP for communication.
→ An application is a user process cooperating with another process usually on a different host (there is also a benefit to application communication within a single host).
→ Examples: Telnet and the File Transfer Protocol (FTP) etc.

Transport Layer:
→ The transport layer provides the end-to-end data transfer by delivering data from an application to its remote peer.

→ Multiple applications can be supported simultaneously.

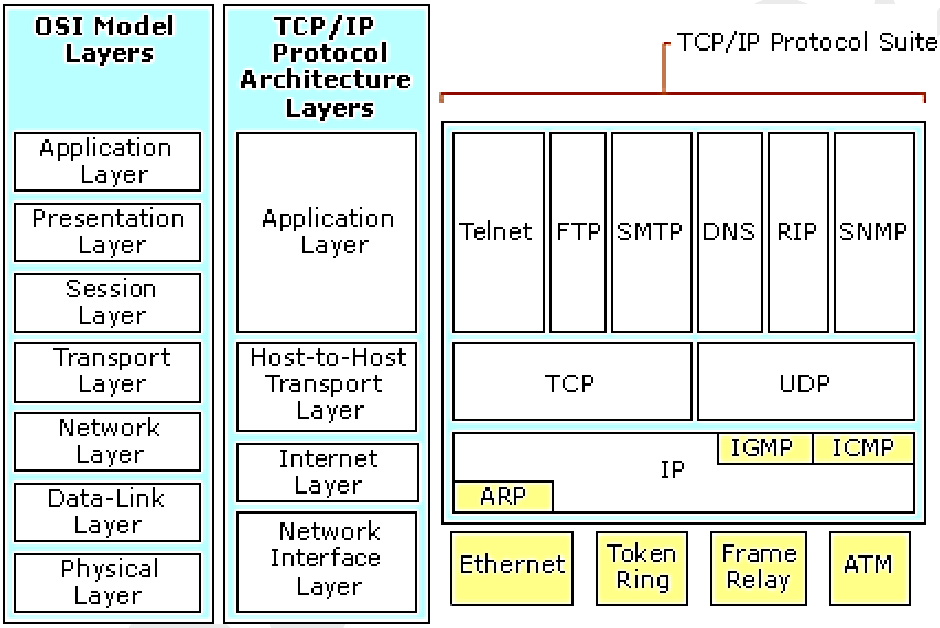
→ The most-used transport layer protocol is the Transmission Control Protocol (TCP), which provides:

- Connection-oriented reliable data delivery
- Duplicate data suppression
- Congestion control
- Flow control.

→ Another transport layer protocol is the User Datagram Protocol (UDP), which provides:

- Connectionless
- Unreliable
- Best-effort service.

→ UDP is used by applications that need a fast transport mechanism and can tolerate the loss of some data.



Internetwork Layer:

→ The internetwork layer also called the internet layer or the network layer.

→ It is provides the "virtual network" image of an internet this layer shields the higher levels from the physical network architecture below it.

→ Internet Protocol (IP) is the most important protocol in this layer.

→ It is a connectionless protocol that does not assume reliability from lower layers. IP does not provide reliability, flow control, or error recovery.

→ IP provides a routing function that attempts to deliver transmitted messages to their destination.

→ These message units in an IP network are called an IP datagram.

→ Example: IP, ICMP, IGMP, ARP, and RARP

Network Interface Layer:

→ The network interface layer, also called the link layer or the data-link layer or Host to Network Layer.

→ It is the interface to the actual network hardware. This interface may or may not provide reliable delivery, and may be packet or stream oriented.

→ Example: IEEE 802.2, X.25,ATM, FDDI

Physical Network Layer:

→ The physical network layer specifies the characteristics of the hardware to be used for the network.

→ For example, it specifies:

- The physical characteristics of the communications media
- Standards such as IEEE 802.3
- The specification for Ethernet network media, and RS-232
- The specification for standard pin connectors

2. Explain OSI model with function of each layer. List the name of layer which implemented the following Bridge, Gateway, and Repeater. **(May-2017)[L.J.I.E.T]** 7

OSI Layer Architecture:

→ OSI model is based on a proposal developed by the International Standards Organization (ISO) as a first step toward international standardization of the protocols used in the various layers.

→ The model is called the ISO OSI (Open Systems Interconnection) Reference Model because it deals with connecting open systems—that is, systems that are open for communication with other systems.

→

→ The OSI model has seven layers.

1. Physical Layer
2. Data Link Layer
3. Network Layer
4. Transport Layer
5. Session Layer
6. Presentation Layer
7. Application Layer

Physical Layer:

→ The physical layer coordinates the function required to carry a bit stream over a physical medium

→ It deals with the mechanical and electrical specifications of the interface and transmission medium

→ It also defines the procedures and functions that physical devices and interfaces have to perform for transmission to occur

→ The physical layer is concerned with the following:

- Physical characteristics of interface and medium
- Representation of bits
- Data rate
- Synchronization of bits
- Line configuration
- Physical topology
- Transmission mode

Data Link Layer:

→ The data link layer transforms the physical layer, a raw transmission facility, to a reliable link.

→ It makes the physical layer appear error-free to the upper layer .

→ The data link layer is concerned with the following:

- Framing
- Physical addressing
- Flow control
- Error control
- Access control

Network Layer:

→ The network layer is responsible for the source-to-destination delivery of a packet, possibly across multiple networks.

→ The network layer is concerned with the following:

- Logical addressing
- Routing

Transport Layer:

→ The transport layer is responsible for process-to-process delivery of the entire message.

→ A process is an application program running on a host.

→ The transport layer ensures that the whole message arrives intact and in order, overseeing both error control and flow control at the source-to-destination level

→ The transport layer is concerned with the following:

- Service-point addressing
- Segmentation and reassembly
- Connection control
- Flow control
- Error control

Session Layer:

→ The session layer is the network dialog controller.

→ It establishes, maintains, and synchronizes the interaction among communicating systems.

→ The session layer is concerned with the following:

- Dialog control
- Synchronization

Presentation Layer:

→ The presentation layer is concerned with the syntax (language rule) and semantics (meaning of each rule) of the information exchanged between two systems.

→ The presentation layer is concerned with the following:

- Translation
- Encryption
- Compression

Application Layer:

→ The application layer enables the user, whether human or software, to access the network.

→ It provides user interfaces and support for services such as electronic mail, remote file access and transfer, shared database management, and other types of distributed information services.

→ The application layer is concerned with the following:

→ Network virtual terminal:

- File transfer, access, and management

- Mail services
- Directory services

Network Devices:

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

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

Types of Hub

- **Active Hub :-** These are the hubs which have their own power supply and can clean , boost and relay the signal along the network. It serves both as a repeater as well as wiring center. These are used to extend maximum distance between nodes.
- **Passive Hub :-** These are the hubs which collect wiring from nodes and power supply from active hub. These hubs relay signals onto the network without cleaning and boosting them and can't be used to extend distance between nodes.

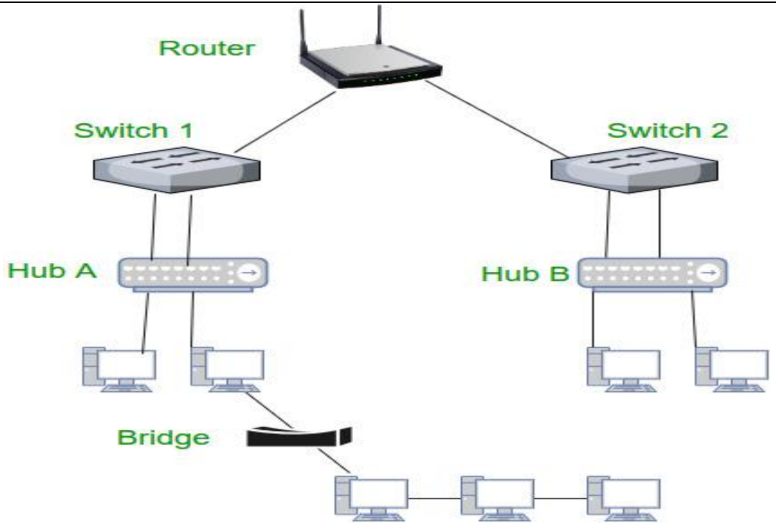
3. Bridge – A bridge operates at data link layer. A bridge is a repeater, with add on functionality of filtering content by reading the MAC addresses of source and destination. It is also used for interconnecting two LANs working on the same protocol. It has a single input and single output port, thus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

Types of Bridges

- **Transparent Bridges :-** These are the bridge in which the stations are completely unaware of the bridge's existence i.e. whether or not a bridge is added or deleted from the network , reconfiguration of the stations is unnecessary. These bridges makes use of two processes i.e. bridge forwarding and bridge learning.
- **Source Routing Bridges :-** In these bridges, routing operation is performed by source station and the frame specifies which route to follow. The hot can discover frame by sending a specical frame called discovery frame, which spreads through the entire network using all possible paths to destination.

4. Switch – A switch is a multi-port bridge with a buffer and a design that can boost its efficiency (large number of ports imply less traffic) and performance. Switch is data link layer device. Switch can perform error checking before forwarding data that makes it very efficient as it does not forward packets that have errors and forward good packets selectively to correct port only. In other words, switch divides collision domain of hosts, but broadcast domain remains same.

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



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

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

3. Compare: OSI Model and TCP/IP Protocol Architecture. **(Nov-2017)[L.J.I.E.T]** 4

4. Why is UDP needed? Why can't user program directly access IP? [**New] (Nov-2016) [L.J.I.E.T]** 7

Ans:

Advantages:

(1) Broadcast and multicast connections are available with UDP which is not the case with TCP.

(2) It does not restrict you to connection based communication model

(3) Much faster than TCP

The User Datagram Protocol (UDP) is a transport layer protocol for use with the IP network layer protocol. It provides a best-effort datagram service to an end system (IP host). UDP provides no guarantee for delivery and no protection from duplication, but the simplicity of UDP reduces overhead from the protocol and can be adequate for some applications.

A computer may send UDP packets without first establishing a connection to a recipient. The computer completes the appropriate fields in the UDP header (PCI) and forwards the data together with the header for transmission by the IP network layer.

Typically, use UDP in applications where speed is more critical than reliability. For example, it may be better to use UDP in an application sending data from a fast acquisition where it is acceptable to lose some data points. You can also use UDP to broadcast to any machine(s) listening to the server.

In general:

TCP is for high-reliability data transmissions

UDP is for low-overhead transmissions

Each layer lays on top of the other, in other words, what occurs in one, relies on the items in each next layer to exist in order to create a full connection with data sent and received.

As you can see, the Transport layer, which included UDP, sits between the Application layer, the fifth layer, and the Network/Internet Layer, which includes IP addresses.

Due to this layering of the TCP/IP Model, the application MUST go through one of the Protocols in the layer below it before it can be router up through the other layers.

This is the reason why applications, including regular applications on a system, are incapable of accessing IP and performing an operation without UDP or another protocol in the Transport Layer.

UDP--Universal Datagram Protocol.

UDP is one of the core protocols of the Internet Protocol Suite. Using UDP, programs on networked computers can send short messages, known as "datagrams", (using Datagram Sockets) to one another.

Each layer has several components which can be used to complete a sequence of connection. UDP can use any of the Network Layer protocols, and the Network Protocol can use any of the Data Link Layer Protocols, and the Data Link Layer Protocol can use any of the Physical Layer Protocols, in completing the connection and sending data over the connection.

However, one layer can not skip a protocol in the layer directly above or below that layer. So, when an application attempts to initiate a connection using IP, which is in the Network/INternet Layer, it MUST use one of the protocols in the Transport Layer, which includes the option of using UDP.