Unit I :-

Introduction to Data Communications

* **Data Communications :-**

Communication means sending & receiving data betn 2 people or nodes, where one acts as a sender & another is the receiver. Nodes are the computers that participate in the communications. More than 2 computers can be involved.

* **Data :-**

Data is unorganized facts and figures. It is raw, unstructured and lacks inherent meaning on it's own.

Example :- numbers, characters, symbols, text, images, audio recording, etc.

* **Information :-**

Data that has been processed, organized, structured to provide context & meaning. It is organized and carries content.

Example :-

A report summarising sales figures, A graph showing customer demographics, A news article or a weather forecast.

* **Bandwidth :-**

It is a difference between highest frequency and lowest frequency of the communication channel.

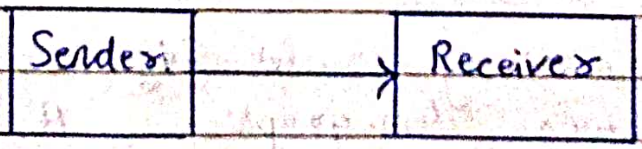
* **Data Rate (Bit Rate) :-**
Number of bits transmitted per second is called as data rate or bit rate.

* **Components of DC :-**

1) Message
2) Sender / Transmitter
3) Receiver
4) Medium / Channel
5) Protocols

* **Types of Communication :-**

1) Simplex Comm^n :-
   i) In this comm^n, sender is transmitting its information & receiver will receive information.
   ii) This is unidirectional comm^n.
   iii) Ex :- TV, radio, etc.



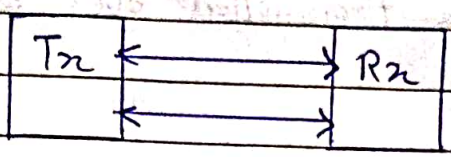
2) Half Duplex Comm^n :-
   i) In this comm^n, both devices transmit its information on comm^n channel but one at a time.
   ii) This is bidirectional Comm^n.
   iii) Ex :- Email, Walkie-Talkie, etc.

3) Full Duplex comm^n :-

i) In this comm^n, both devices (Tx & Rx) will transmit data at a time.

ii) This is bidirectional comm^n.

iii) Ex:- Mobile comm^n, video calls, satellite comm^n, etc.



* Data Representation :-

** * Characteristics of Data Communication :-

1) Delivery :-
Data is delivered accurately & reliably to the intended receipent.

2) Accuracy :-
Data is transmitted accurately, without errors or corruption.

3) Timelineness :-
Data is delivered in a timely manner, meeting the requirements of the application.

4) Integrity :-
Data is protected from unauthorized access, modifications, or deletion.

5> Jitter :-
Variations in delay between packets, affecting real time applications.

6> Throughput :- (Data Rate / Bit Rate) :-
The amt. of data transmitted over a network in a given time

7> Latency :-
The time it takes for data to travel from sender to receiver.

* Data Representation :-
It refers to the format & structure of data being transmitted over a network. It's essential for ensuring that data is accurately interpreted by the receiving device.

* Types of Data Representation :-

1> Analog :-
Continuous signal representing physical measurement.

2> Digital :-
Discrete signal representing binary data (0 & 1).

3> Text :-
Represented using character scheme, like, ASCII or unic code.

4) Numbers :-
Represented in binary, decimal, hexadecimals formats.

5) Images :-
Represented using px value, color depth, compration algorithm.

6) Audio :-
Represented using digital signal processing, sampling rates, compration algorithm.

7) Video :-
Represented using combination of Image & audio representation.

** * Network Topology :-
It refers to the physical or logical arrangement of devices, nodes within a network. It defines how devices communicate & exchange data.

* Types of Network Topologies :-

1) Bus topology :-
A single cable connects all devices.

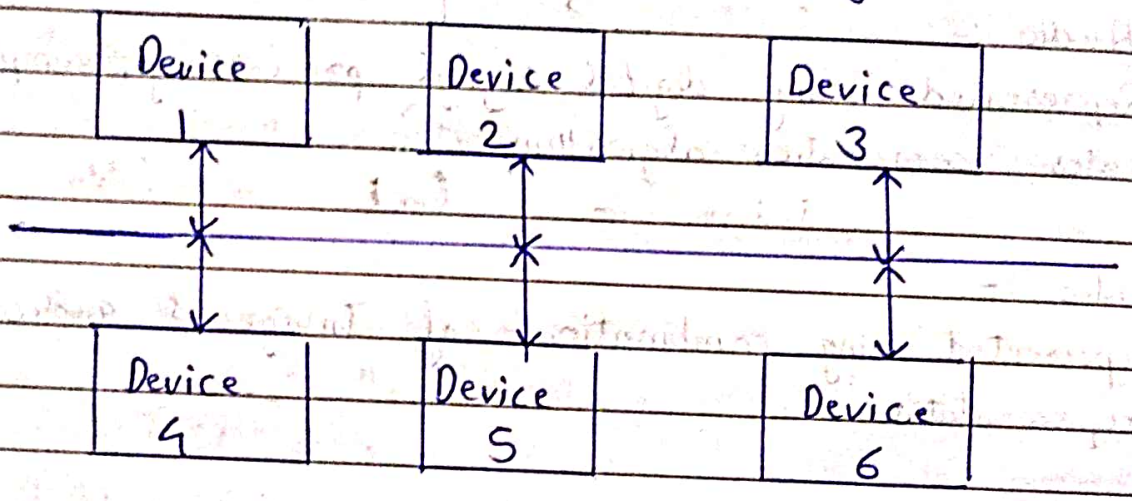
2) Star topology :-
Devices connects to a central hub or switch.

3) Ring topology :-
Devices form a circular configuration.

4) Mesh topology :-
Each device connects to every other device.

5) Hybrid topology :-
Combination of 2 or more topologies.

* Bus topology :- (Block Diagam)



Bus topology is a network configuration where all devices all connected to a single cable or back bone. Each device taps into the back-bone to send and receive data.

* Advantages of Bus Topology :-

i) Simple installation
ii) Cost effective
iii) Easy to add devices.

* Disadvantages of Bus Topology :-

i) Signal degradation :-
Signal strength decreases as data travels along the

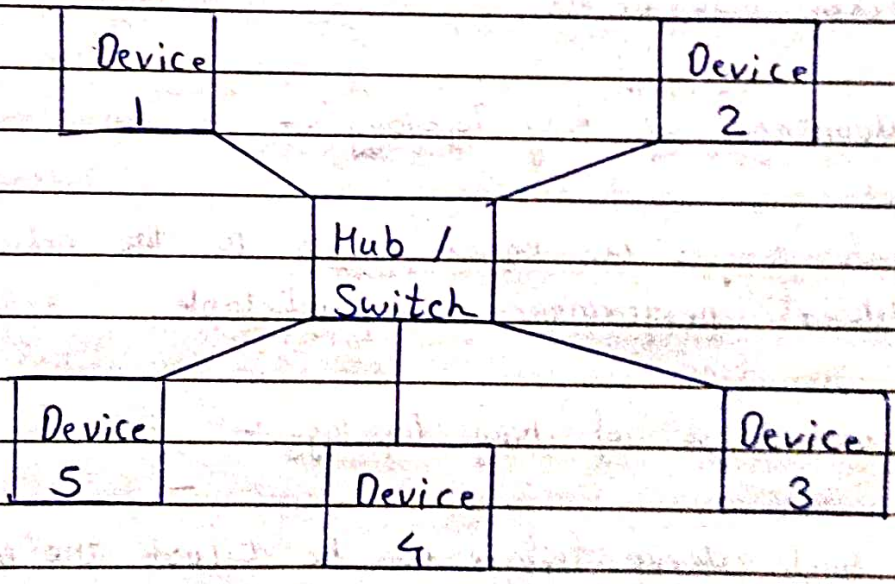
cable.

ii) Fault Tolerance :-
A single cable fault can bring down the entire network.

iii) Limited scalability :-
Limited no. of devices can be connected.

* Star Topology :-
It is a network configuration where all devices connects to a central device, such as a hub or switch. Each device has a dedicated connection to the central device.

Block Diagram



* Advantages of Star Topology :-

i) Easy to install and configure ; Simple to setup & manage.

ii) Fault Tolerance ; A single device failure will not affect the entire network.

iii) Easy to troubleshoot
iv) Scalability : Easy to add or remove device

* Disadvantages of Star topology :-

i) If the central device fails, entire network is affected.
ii) More cables are required compared to Bus topology.

* Ring Topology :-
  * Characteristics :-
1. Circular Configuration :- Devices form a close loop.
2. Unidirectional data flow
3. Token base access.

* Advantages of Ring Topology :-

i) Each devices has equal access to the network.
ii) Network performance is predictable.

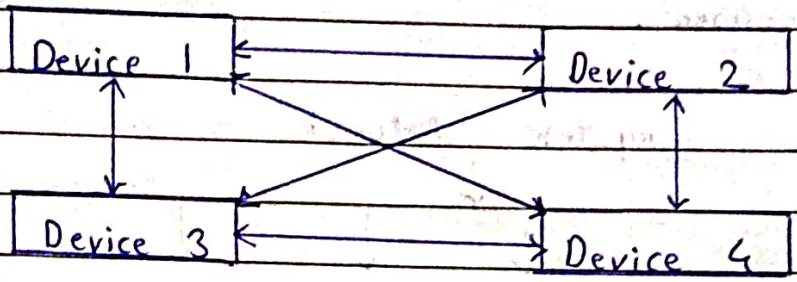
* Disadvantages of Ring Topology :-

i) A single device failure can be disturb the entire network.
ii) Fault can be hard to identify.
iii) Adding new device can be challenging.
iv) Time Consuming.

* Mesh Topology :-

Mesh Topology is network configuration where each device connect directly to every other device. This creates multiple path for data transmission.

Block Diagram :-



* Characteristics :-

1. Inter connected devices
2. Multiple paths
3. High Reliability

* Advantages of Mesh Topology :-

i) A network is highly reliable due to multiple path.
ii) Device failure do not disturb the entire network.
iii) Data can be transmitted multiple path, making it harder to intercept.

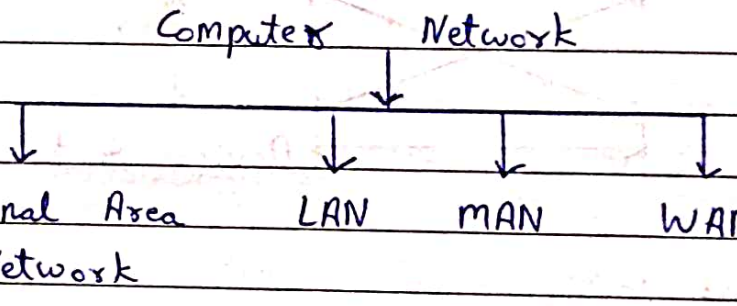
* Disadvantages of Mesh Topology :-

i) Complex installation ii) High cost

* ISM : Industrial scientific medical app.
* Piconet : n Bluetooth device (network)
* Scatternet : More than 1 piconet connection.

* Hybrid Topology :-
Hybrid Topology combines two or more different network Topology such as star, bus, ring, mesh.

** * Computer Network Types :-
Generally network are distinguish based on their geographical area.



* Personal Area Network (PAN) :-
It is smallest network. This may include bluetooth enabled devices or infra-red enabled devices. PAN has connectivity range upto 10 metres. PAN may include wireless computer keyboard & mouse, bluetooth enabled headphones, wireless printers & TV remotes.

* Local Area Network (LAN) :-
A computer network spread inside a building & operated under single administrative system is generally termed as Local Area network. Usually, LAN covers an organization offices, schools, colleges or universities. The no. of systems connected in LAN may vary from atleast 2 to as much as 16 million. LAN provides a useful way of sharing the resources between end users.

The resources such as printers, file servers, scanners and internet.

* Advantages of LAN :-

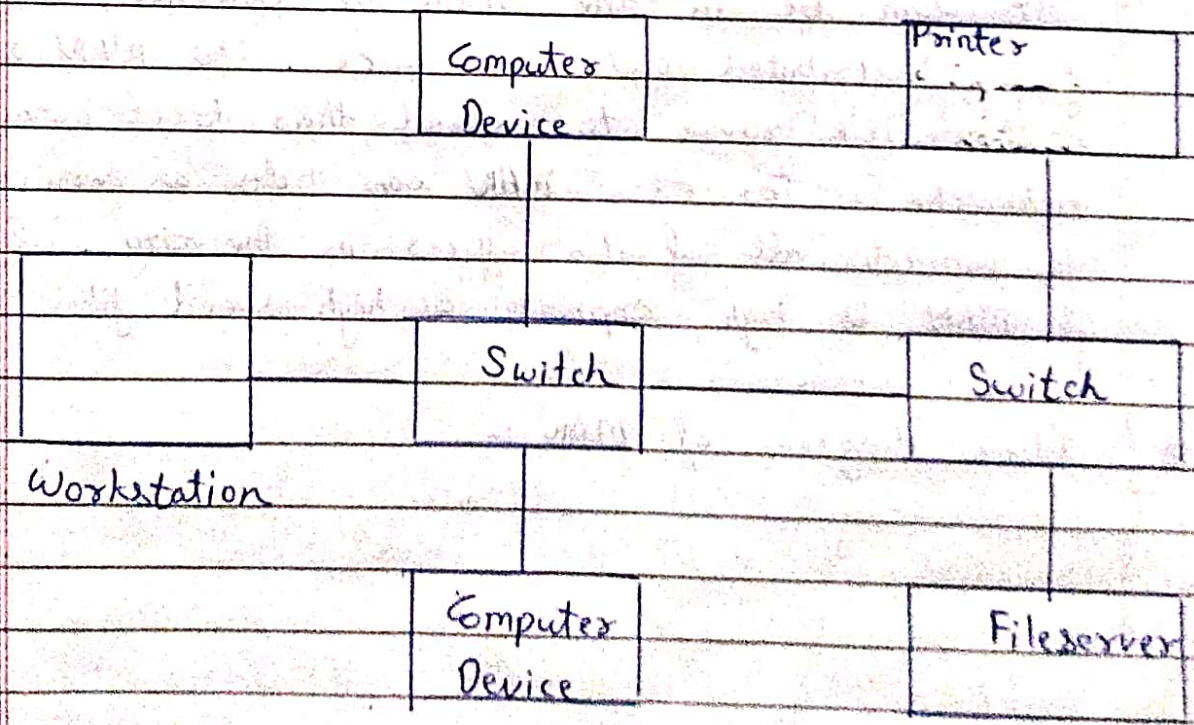
i) Privacy :-
LAN is a private network, thus no outside regulatory body controls it, giving it a privacy.

ii) High Speed :-
LAN offers a much higher speed around 100 MB/s.

iii) Supports Different transmission medium :-
Ethernet cable (thin cable, thick cable and twisted pair), Fibre optics and wireless transmission.

iv) Inexpensive and Simple :-

Block Diagram of LAN :-



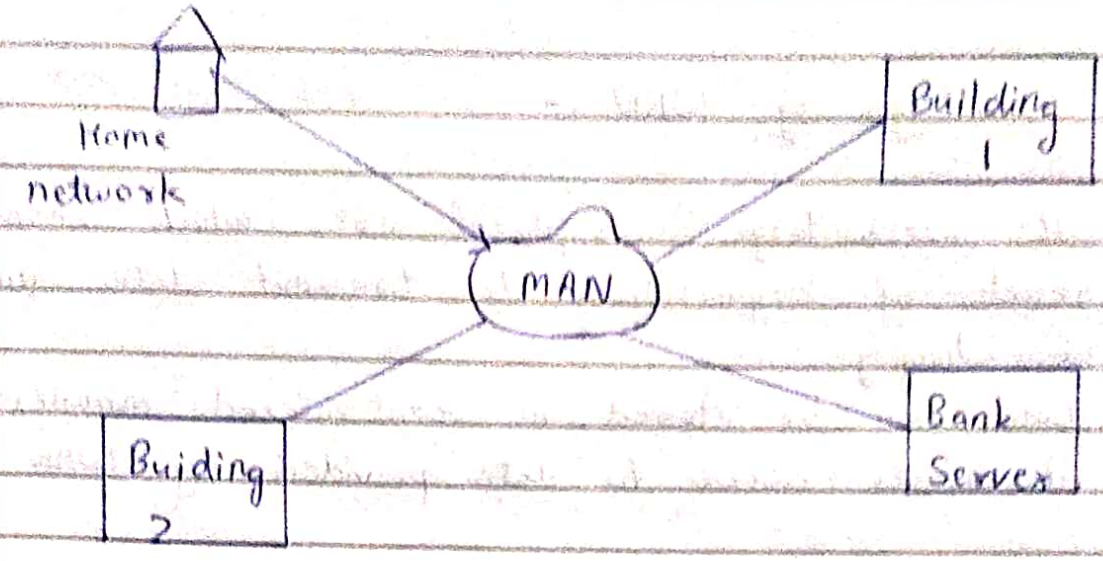
* Disadvantages of LAN :-

i) Initial setup is costly
ii) LAN Administrator can see and check personal data files as well as internet history of each & every LAN user. Hence, privacy of user are revolted.
iii) LAN are restricted in size & cover only a limited area.
iv) Since all the data is stored in single server computer. If it can be accessed by an unauthorized user, can cause a serious data security threat.

** ☆ MAN (Metropolitian Area Network) :-

The MAN generally expands throughout a city such as cable tv network. It can be in the form of ethernet, ATM or fiber distributed data interface. This MAN service enables it's users to expand their local area networks. For ex., MAN can help an organization to connect all of it's offices in the city. Backbone of MAN is high capacity & high speed fiber optics.

☆ Block diagram of MAN :-



* Advantages of MAN :-

i) MAN offers high speed connectivity in which the speed ranges from 10 - 100 mbls.
ii) The security level in the MAN is high & strict as compared to WAN.
iii) It supports to transmit data in both direction.

* Disadvantages of MAN :-

i) MAN is hard to design & maintain.
ii) This network is highly expensive.
iii) It provides less fault tolerance.
iv) The data transfer rate in MAN is low when compared to LAN network.

* Wide Area Network (WAN) :-
WAN covers wide area which may span across provinces and even a whole country. Generally, telicommunication networks are WAN networks. This networks provide connectivity to MAN's and LAN's.

* Advantages of WAN :-

i) It covers large geographical area which enhances the reach of organizations to transmit data quickly & cheaply.

ii) Data can be stored in centralized manner because of remote access to data provided by WAN.

* Disadvantages of WAN :-

i) Traffic delay in WAN is very high.

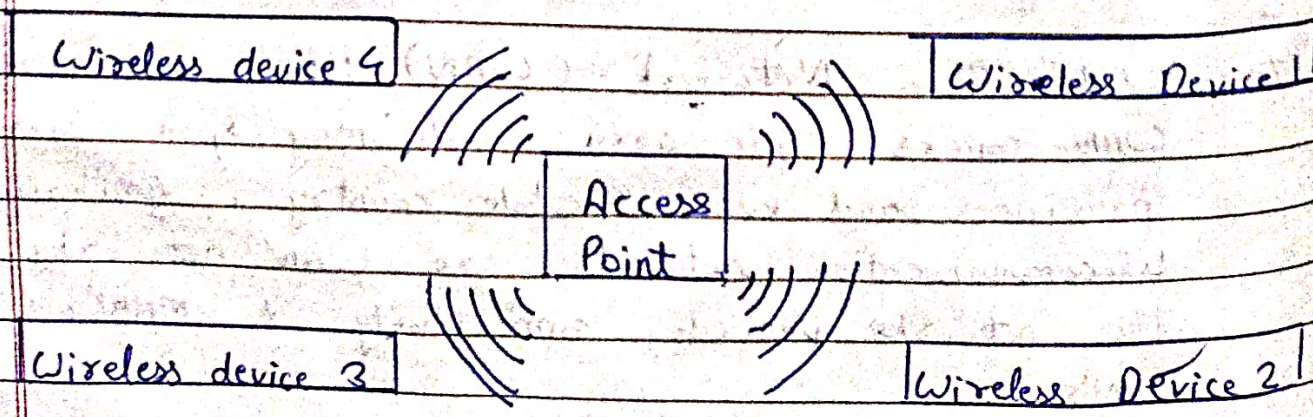
ii) The fault tolerance ability of WAN is very less.

iii) Noise & error are present in WAN.

iv) Data transfer rate is low in comparison to LAN because of large distance & high no. of connected systems within the network.

☆ Wireless LAN :-

W. LAN is a type of computer network that acts as a local area network but makes use of wireless network technology like WiFi. This network doesn't allow devices to communicate over physical cables like a LAN but allows devices to communicate wirelessly. Example :- Wifi.



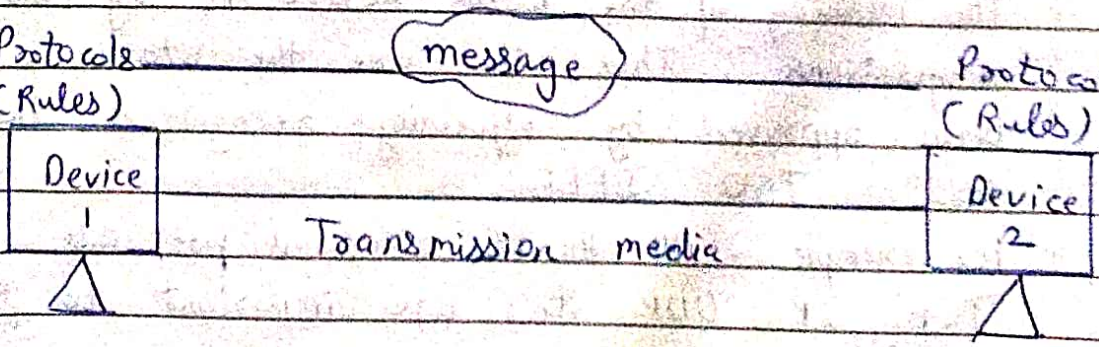
☆ Internetworks :-

A network of networks is called internetwork, or simply the internet. It is the largest network in existence on this planet. The internet hugely connects all WAN's & it can have connections to LAN's. Internet uses TCP/IP protocol & uses IP as it's addressing protocol. The internet uses very high speed backbone of fiber optics. It provides services such as :-

1) Websites
2) Emails
3) Instant messaging
4) Blogging
5) Social media
6) Resource sharing
7) Audio, video streaming.

☆ Network Protocols :-

A protocol is a set of rules that determines how data is send & receive over a network. The protocol is just like a language that computers use to talk to each other. Protocol helps to make sure data moves smoothly & securely between devices on a network.



☆ **Standards :-**

Standards are the set of rules of DC that are needed for the exchange of information among devices. It is important to follow standards which are created by various standard organizations, like IEEE, ISO, ANSI, etc.

☆ There are 2 types of Standards

- DeFacto Standards
- DeJure Standards

1) DeFacto Standards :-

The meaning of the word DeFacto is "By Fact" or "By Convention". This are the standards that have not been approved by any organizations but have been adopted as standards because of their widespread use. Also sometimes these standards are often established by manufacturers.

Example :- Apple & Google are 2 companies that establish their own rules for their products which are different.

2) DeJure Standards :-

The meaning of the word DeJure is "By Law" or "By regulations". Thus, this are the standards that have been approved by officially recognized bodies like ANSI, ISO, IEEE.

For example :- All the DC standard protocols like SMTP, TCP, IP, UDP, etc. are important to follow the

same when we need them.

★ **Request For Comment (RFC) :-**

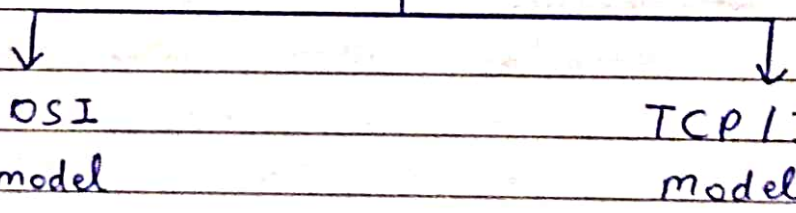
When defining the world of networking & internet protocols, an RFC is known as a Request For Comment. Essentially, an RFC is a type of technical document issued by The Internet Engineering Task Force (IETF) that describes specifications, procedures and standards in given internet technologies.

Unit - II

NETWORKS MODELS

☆ Network Models :-
Designing & Managing networks is a challenging process that requires integrating various technologies such as software, hardware, firmware and electrical signals. For example :- Bluetooth
To simplify this task, the concept of layering was introduced. Layers isolate specific task, operate independantly & rely on one another only for data exchange insuring the network functions as cohesive system.

* There are 2 types of network models :-



- Both uses Layered Architecture

* Advantages of Layered Architecture :-

i) Modulasity
As the tasks are divided into different sections, it makes understanding & maintenance of the system more simplified.

ii) Inter operability
Layers follow standard protocols & enable devices from different organizations to communicate effectively / efficiently.

iii) Scalability
New technologies or protocols can be integrated without affecting the entire system.

iv) Trouble shooting
Problems can be isolated to specific layers & each layer can be analyzed & tested individually.

★ OSI (Open System Interconnect)

★ TCP (Transmission Control Protocol)

★ IP (Internet Protocol)

★ OSI has 7 layers. They are :-

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

Block diagram of layered architecture of OSI model.

** ☆ OSI model :-

Open System interconnect is an open standard for all communication systems. OSI model is established by International Standard Organization (ISO). This model has 7 layers.

1) Application Layer :
These layer is responsible for providing interface to the application user. This layer encompasses protocols which directly interacts with the user.

2) Presentation Layer :
This layer defines how data in the native format of remote host should be presented in the native format of host.

3) Session Layer :
This layer maintains sessions between remote hosts. For example : once user/password authentication is done, the remote host maintains this session for a while and does not ask for authentication again in that time span.

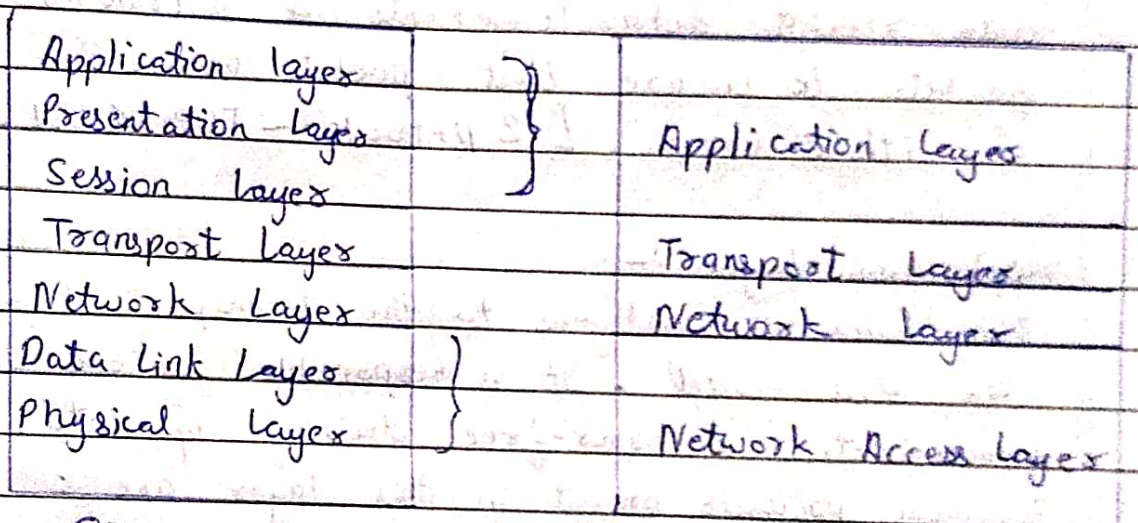
4) Transport Layer :
This layer is responsible for end to end delivery between hosts.

5) Network Layer :
This layer is responsible for address assignment & uniquely addressing host in a network.

6) Data Link Layer :
This layer is responsible for reading & writing data from and on to the line. Link errors are detected at this layer.

7) Physical Layer :
This layer defines the hardware, cabeling wiring, power output, pulse rate, etc.

★ TCP/IP Model :-



* TCP/IP is a fundamental framework for modern networking, providing the architecture that undermines the internet & most communication systems. It defines how data is Transmitted, routed and received accross interconnected networks.

★ Network Access Layer :-
It is a group of applications requiring network communications. This layer is responsible for generating the data & requesting connections. It acts on behalf of

Sender & on the behalf of receiver.

☆ Network layer :-
This layer parallels the functions of OSI's network model. It defines the protocols which are responsible for the logical transmission of the data over the entire network.

☆ Transport Layer :-
The TCP/IP Transport layers protocols exchange data receipt acknowledgements & retransmit missing packets to ensure that packets arrive in order & without error, [2 protocols – TCP & UDP]

☆ Application Layer :-
This layer is analogous to the transport layer of the OSI model. It is responsible for end to end communication & error-free delivery of data. The 3 main protocols present in this layer are :

i) HTTP
ii) SSH (Secure Shell)
iii) NTP (Network Time Protocol)

** ☆ **Encapsulation :-**

It is the process of adding additional information when data is travelling in an OSI and / or TCP/IP Model. This information has been added on the sender's side, from the application layer to the physical layer.

☆ Encapsulation in OSI model :-

1) No additional information will be added to the user's data in the application layer in TCP/IP model or the application, presentation or session layers in the OSI model.
2) The session layer sends data to the transport layer.
3) In the transport layer, the data is broken up in 2 different pieces. It adds the header in each of the broken data, which contains information like source port, destination port, sequence number, etc. Now everything is combined into a new form
4) The encapsulated data in the transport layer is called segments or datagrams. If the transmission uses TCP, then it is called segments or UDP is called Datagrams.

L4-Header	Data

5) Now the data will travel down & reach the network layer. Here Layer 3 Header is added, that contains information like source IP, Destination IP, and so on. This information combines into a new form. The encapsulated data in the network layer is called packets.

L-3 Header	L4 Header	Data

packets

6) Now the network layer sends the packet to the data link layer when it enter data link layer, a new header (layer 2) is added.

7) Also a trailer is added. It contain information like source MAC address, destination MAC address etc. The trailer is used for error checking.

8) The encapsulated data in the data link layer is called Frames.

L-2 header	L-3 header	L-4 header	Data

9) The physical Text frame from data link layer. The encapsulated data in the physical layer is called Bits.

Application Layer	Data
Presentation Layer	Data
Session Layer	Data
Transport Layer	Segments / Datagram
Network Layer	Packets
Data Link Layer	Frames
Physical Layer	Bits

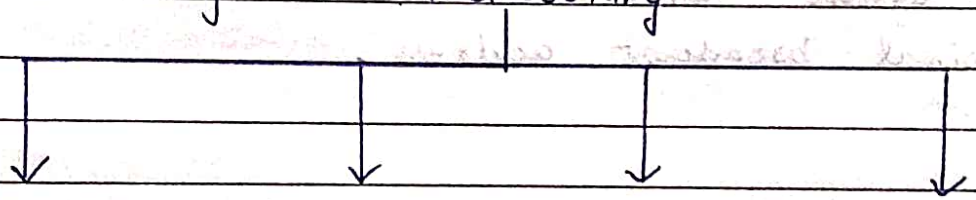
10) De-Encapsulation is the exact reverse process of Encapsulation. The additional information add sender side (during encapsulation) gets removed when it travel on the receiver side from the physical layer to the application layer.

✯ Addressing in Networking :

* What is Addressing :-

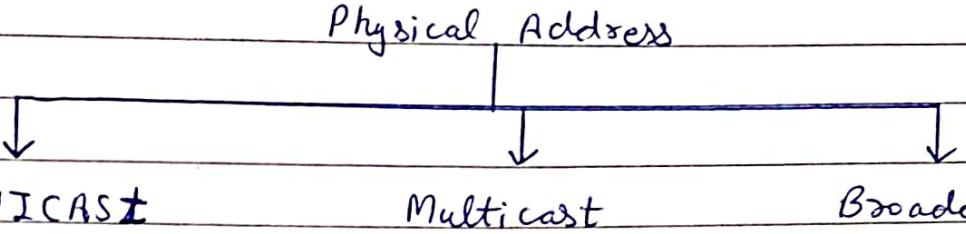
A computer network is a collection of several linked computers that share one or more resources that are provided or by network nodes.
Rules or network protocols controls the sharing & communication between machines.
A host or computer in a communication network can be uniquely identified by it's network address, which might be either logical or physical.

✯ Addressing in Networking



✯ Physical address :-

Any network you are on, whether LAN or WAN, gives each node in the network a unique address. This address is known as physical address.
Physical Address is contain in the frames that the data link layer creates from the packets that it received from the network layer.

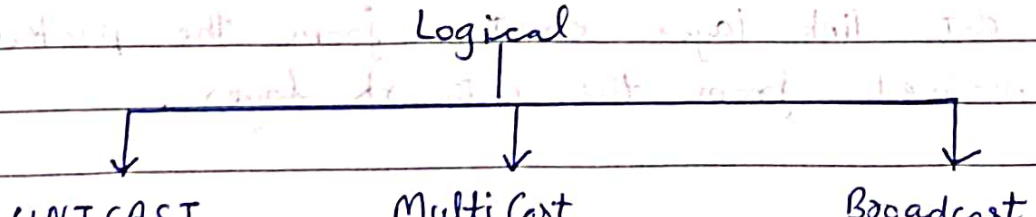


☆ Unicast Address :-
The frames that needs to be delivered to a single receiver is given a physical unicast address.

☆ Multicast :-
The frames that needs to be transmitted to a collection of receivers includes a physical multicast address.

☆ Broadcast :-
The frames that needs to be send to every node or system connected to the network includes the physical broadcast address.

☆ Logical Address :-
It is used to transfer frames across two networks. which could employ different addressing formats that are separate from one another.
The IP address assign to each node connected to the Internet is known as it's logical address & no 2 nodes in this instance may have the same IP address.



☆ Port Address :-

We have learn that in order to send & receive data between 2 nodes in the same or separate network, logical & physical addresses are needed. But things don't stop here. The next step after getting the data at the computer is to determine which computer process needs the data. The process address in TCP/IP architecture is referred to as it's port address.

☆ Application Specific Address :-

Specific Applications can be identified by their application specific addresses. For instance, the website address is www.dcuma.blogspot.com and the email address is mansmanjeet@google.com

☆ Physical Address :-

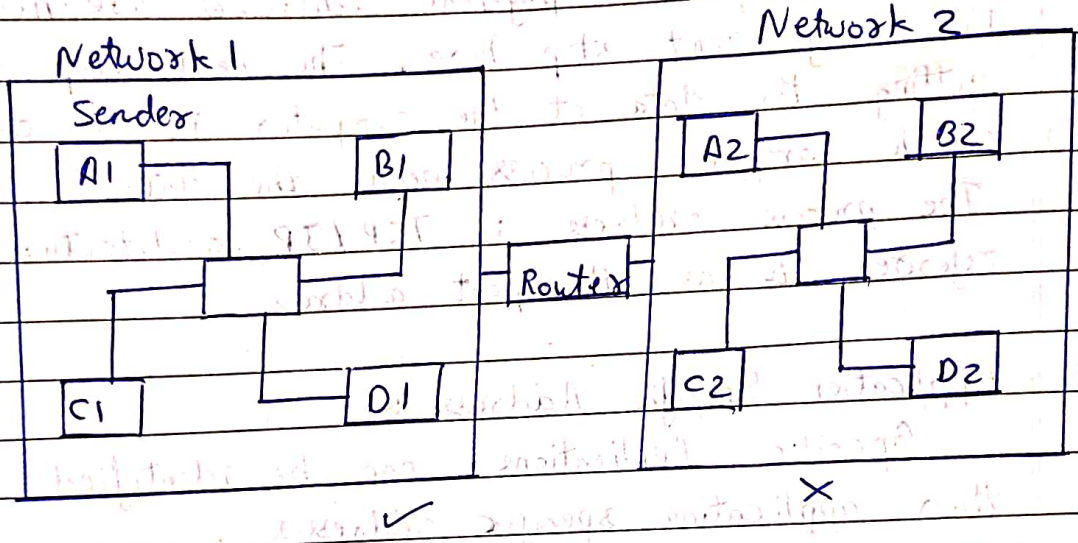
It is also known as MAC address where MAC is Media Access Control Address or Link address. It is the address of the node which is defined by it's LAN or WAN. It is used by Data Link Layer and is the lowest level of address. The size of Physical Address is 48 bits. The below is the format representing a physical address :

XX : XX : XX : YY : YY : YY

For Example :- 16 : 1A : BB : 6F : 90 : E5

The first 24 bits of a MAC address is decided by organizationally unique identifier. It represent the identity of manufacturer.

The next 24 bits of the MAC address represents the unique identity of the device. It is assigned by the manufacturer.



✓ ×

☆ Logical Address :-
It also refers to as IP address. It is an universal addressing system. It is used in network layer. ~~This address~~ There are 2 types of IP addresses :- i) IP v4
ii) IP v6
The size of IP v4 is 32 bits.
The size of IP v6 is 128 bits.

☆ Port address :-
Whenever any application in a computer sends data to another application of a different computer then it sends using IP address & MAC address. But how does our computer knows ~~data~~ that this data is for a specific application and this data is sent by any specific application. There comes the concept of port.

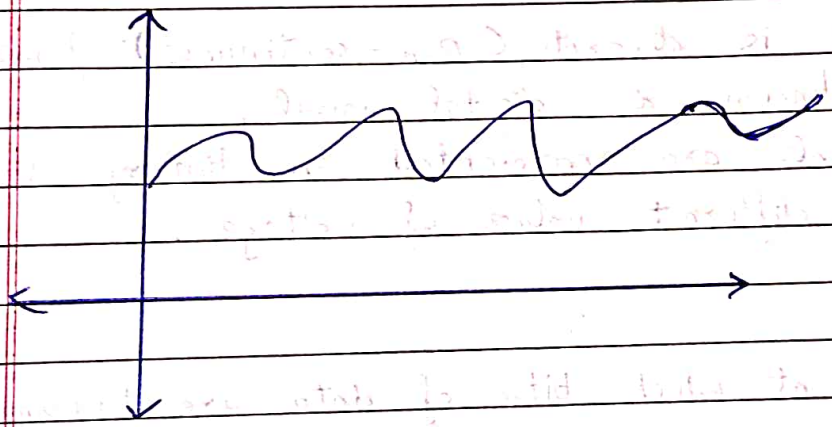
Unit - III

SIGNALS TRANSMISSION & PERFORMANCE

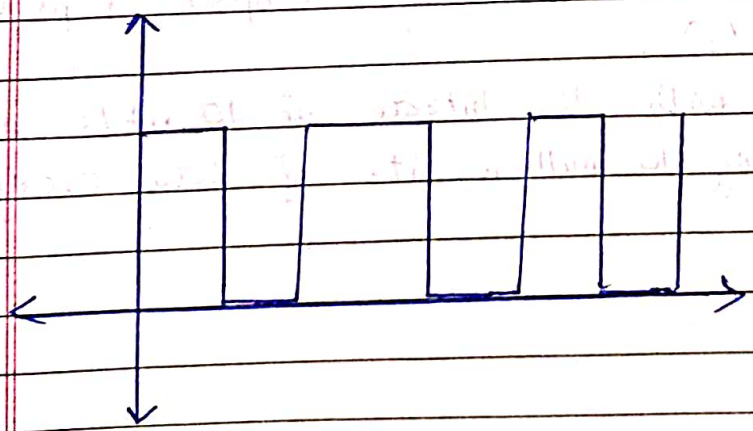
☆ Signals :-

- → Analog Signals
- → Digital Signals

1> Analog Signals



2> Digital Signals



☆ What is Signal :-
An electrical or electromagnetic quantity (current, voltage, radiowave, microwave, etc.) that carries data or info from one system to another is called a signal.

1) Analog signal :-
A signal which is a continuous function of time and use to carry the info is known as analog signal.
For eg, Human Voice, Temperature, etc.

2) Digital signal :-
A signal which is discrete (non-continuous) function of time is known as digital signal.
The digital signals are represented in binary form & consists of different values of voltage.

☆ Bitrate :-
It is the rate at which bits of data are transmitted or processed per unit of time.
It's a measure of speed.
Units : Commonly measured in bits/s (bps), kbps (Kb/s), Mbps (Mb/s).
For e.g :- A video with the bitrate of 10 mb/s means it transmitting 10 million bits of data every second.

* Disadvantage :-
1) Limited Distance
2) Single signal can be transmitted
3) Susceptible to interference.

4) Scalability issue.
5) Signal Loss

** ☆ **Broadcast Transmission** :-

It refers to a communication method that uses a wide range of frequencies to transmit multiple signals simultaneously over a single medium. Each frequency band carries a different signal such as voice, video or data.

☆ Bitlength refers to the number of bits used to represent a single data element. It determines the number of possible values that can be represented.
Eg., In a digital image, each color pixel might be represented by 24 bits (8 bit for red, 8 bit for green and 8 bit for blue) meaning the bit length of color is 24 bit.

** ☆ **Baseband & Broadband Transmission** :-

☆ Baseband Transmission :-
It refers to a method of sending digital signals over the communication medium using a single, low-frequency channel. In this type of transmission, the entire bandwidth of the medium is used for a single signal.
Eg., Ethernet, digital signaling.

DSL (Digital Subscriber Line)

☆ Advantages of Baseband :-

1) Simplicity : Baseband transmission is simple to implement because it only requires one channel for sending data, without the need for complex modulation scheme.
2) Cost effective
3) High signal integrity
4) Low Latency
5) Efficient for short distances.

☆ Examples of Broadband communication :-

1) Cable TV :
Broadcast multiple TV channels over a single cable.

2) DSL and fibre optic internet :-

☆ Advantages of Broadband Communication :-

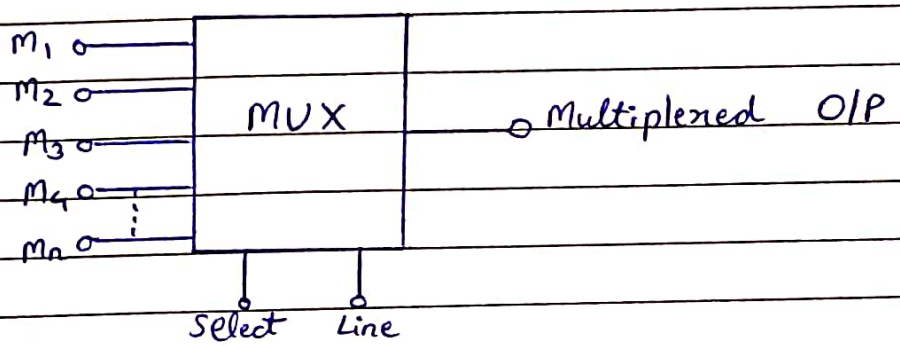
1) Supports multiple signals
2) Longer distances (covers long distances)
3) Less suseptible to interference.
4) High data transfer speed.
5) Efficient Bandwidth uses.

☆ Disadvantages of Broadband Communication :-

1) Complexity
2) Higher cost

3) Latency
4) Maintenance
5) Requires more Band width

☆ Multiplexing :-
The term multiplexing is derived from the word multiple, which means consisting or having many individual signal.
In communication, multiplexing means to combine many signals so that, that can be say over a one transmission medium.
The medium use may be a cable pair, a fibre optic cable or a microwave link.



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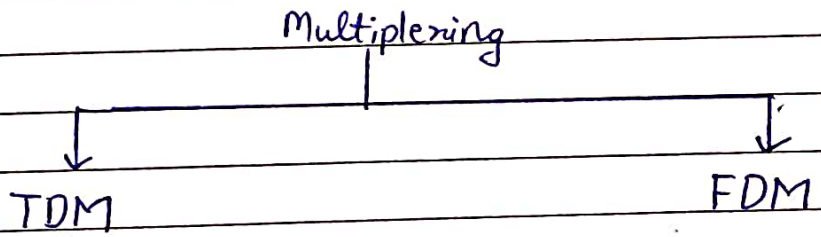


1) TDM
In TDM is signal can occupy entire bandwidth of channel but is allocated small time slate, hence multiple signal are transmitted over the channel term by term.

* The following sources of TDM :-

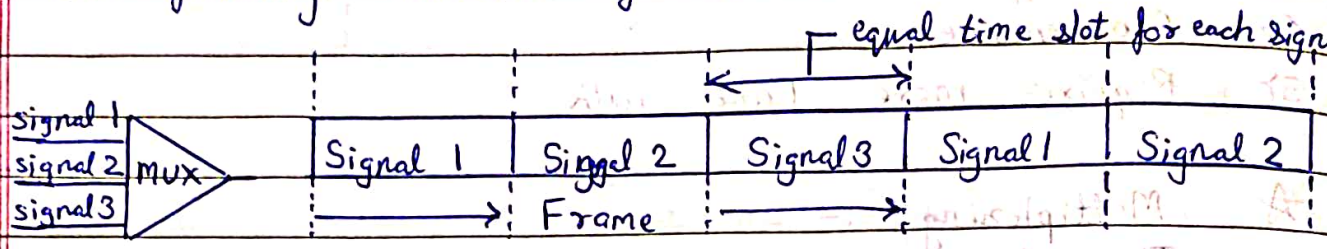


Fig. Concept of TDM.

As per new / updated syllabus

* Modulation :-

It is the process of imposing the variations of one electrical signal onto another frequency signal. The lower frequency electrical signal is called Modulating signal or baseband or message or information signal.

Higher frequency signal is called carrier signal. which may be analog or digital.

☆ Need of Modulation :-

1) Modulation for efficient transmission.
2) Modulation to overcome hardware limitation.
3) Modulation for reduce size of antenna.

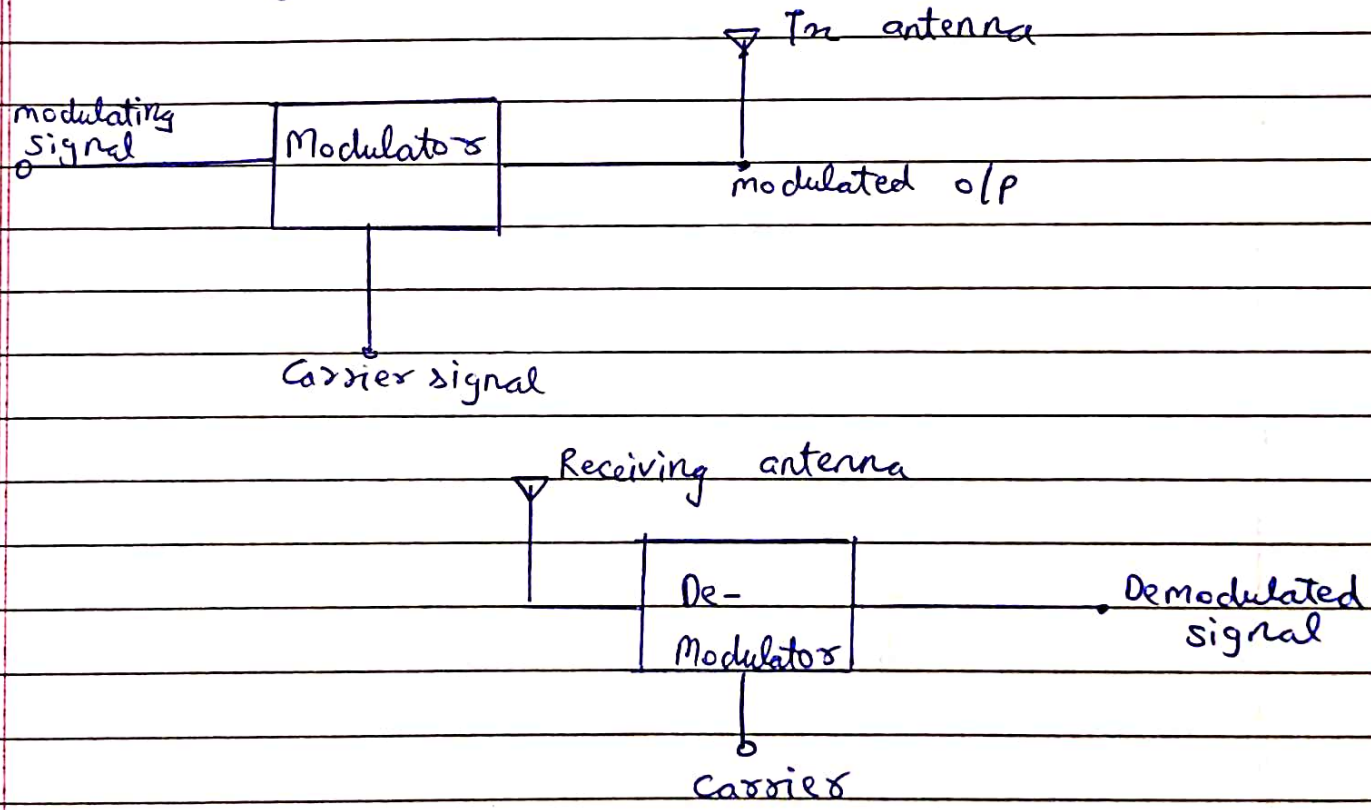
☆ Modulation Techniques :-

1) Analog Modulation :-

When the carrier wave is continuous in nature, the modulation process is known as Analog modulation. The carrier wave is usually a sinusoidal signal.

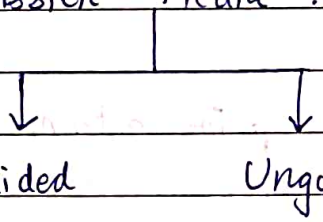
which is represented by,
$E_c = A(\sin 2\pi ft + \phi)$
The carrier sine wave is represented by 3 parameters,
i) Amplitude
ii) Frequency
iii) Phase.
Any of the 3 parameters of above iteration can be varied in accordance with the information. Accordingly, the modulation process is termed as Amplitude modulation, frequency modulation or phase modulation.

★ Block diagram :-



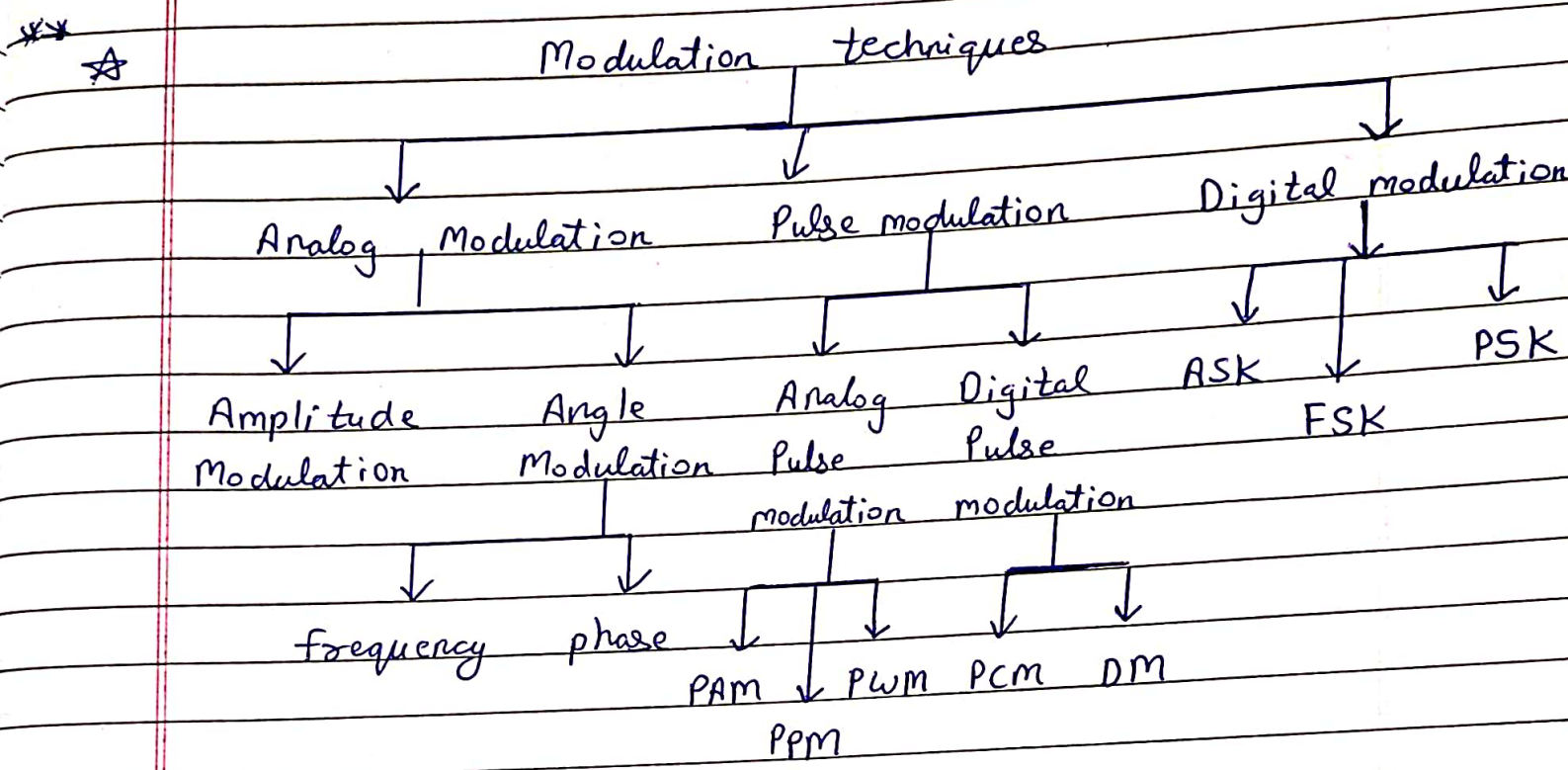
2) Digital Modulation :-
In the digital modulation, the information signal is of analog type. If digital information is modulated by carrier, the information is conveyed not in the precise value but at ~~dati~~ discrete intervals. Depending upon modified parameter of carrier, modulation techniques are as follows :
i) Amplitude shift~~ing~~ keying
ii) Frequency shift~~ing~~ keying
iii) Phase shift keying

☆ Transmission Media :-



☆ Guided Media :-
In Guided Media, transmitted data traverse through ~~gapot~~ cabeling system that has a fixed path. For ex., copper wire, fibre optic cables, coaxial cables, etc.

☆ Unguided Media :-
In Unguided Media, transmitted data travels through free space in form of electromagnetic signals. For ex., radiowaves, ultra-violet waves, lasers, etc.



Full Forms :-

- PAM :- Pulse Amplitude Modulation
- PPM :- Pulse Position Modulation
- PWM :- Pulse Width Modulation
- PCM :- Pulse Code Modulation
- DM :- Delta Modulation
- ASK :- Amplitude Shift keying
- FSK :- Frequency Shift keying
- PSK :- Phase Shift Keying

Unit 2 :- Remaining Topics

☆ Transmission Impairment in Data Communication :-

Causes of Impairment

- Attenuation
- Distortion
- Noise

☆ Attenuation :-

It means loss of energy. The strength of signal decreases with increase in distance which causes loss of energy in overcoming resistance of medium. This is also known as attenuated signal.
Amplifiers are used to amplify the attenuated signal.

☆ Attenuation is measured in decibals (db). It measures the relative strength of 2 signals or 1 signal at 2 different points.

$$\text{Attenuation db} = 10 \log 10 \left(\frac{P2}{P1}\right)$$

where, P1 is power at sending end & P2 is power at receiving end.

☆ Distortion :-

It means change in the form or shape of the signal. This is generally seen in composite signals made up with different frequencies. Each frequency component has its own propagation speed travelling through a medium.

☆ Noise :-

The random or unwanted signal that mixes up with the original signal is called noise. There are several type of noise such as induced noise, crosstalk noise, thermal noise & impulse noise which may corrupt the signal.

☆ Channel Capacity :-

The maximum rate (in bits per sec) at which information can be transmitted over a communication channel with arbitrarily low error probability.

$$\text{Channel Capacity } (C) = B \log_2 \left(1 + \frac{S}{N}\right)$$

where, B = Bandwidth (Hz)
S = Signal Power (W)
N = Noise Power (W)

☆ Nyquist Theorem :-

It describes the maximum symbol rate (data rate) in a noise-free channel of finite bandwidth.

$$C = 2B \log_2 M$$

where, B = Bandwidth (Hz)
M = No. of discrete signal levels

☆ Nyquist Rate :-

$$F_s \geq 2B$$

where, F_s = Sampling Frequency
B = Bandwidth

** ☆ Signal to Noise Ratio :-

The ratio of signal power to the noise power is called signal to noise ratio. It indicates signal quality.

$$SNR = \frac{P_{signal}}{P_{Noise}}$$

In decibels (dB) ⇒

$$SNR\,(dB) = 10 \log_{10}\left(\frac{P_{signal}}{P_{Noise}}\right)$$

☆ Key notes :-

1) Higher SNR → Better signal Quality.
2) Low SNR → Distortion, Error in Communication

☆ Example :-

The received signal power is 1 milliWatt & Noise Power is 10 microWatt, calculate Signal to Noise Ratio.

⇒ Given :-

Received Signal Power = 1 mW
Noise Power = 10 μW

$$SNR = \frac{P_{signal}}{P_{Noise}}$$

$$= \frac{1 \times 10^{-3}}{10 \times 10^{-6}} = \frac{1 \times 10^{-3} \times 10^{+6}}{10}$$

$$= \frac{1 \times 10^{3}}{10} = \frac{1000}{10} = \underline{\underline{100}}$$

$$SNR \text{ (in dB)} \Rightarrow 10 \log_{10}\left(\frac{P_{signal}}{P_{Noise}}\right)$$

$$= 10 \log_{10}(10)$$

$$= \underline{20 \text{ dB}}$$

★ Noise Figure (NF) :-

The measure of how much a device (like an amplifier) degrades the signal to noise ratio of a signal.

$$NF = \frac{SNR \text{ i/p}}{SNR \text{ o/p}}$$

In other words, NF is the ratio of Input SNR to the output SNR.

$$NF \text{ (in dB)} \Rightarrow 10 \log_{10}\left(\frac{SNR \text{ i/p}}{SNR \text{ o/p}}\right)$$

★ Example :-

Suppose an amplifier has input SNR = 30 dB and output SNR = 25 dB. Calculate NF.

⇒ Given :-

~~$NF = \frac{30 \text{ dB}}{25 \text{ dB}} = \frac{6}{5} = 1.2$~~

$SNR_{IP} = 30 \text{ dB}$

$SNR_{OP} = 25 \text{ dB}$

Convert to ratio :-

$SNR_{IP} = 10^{30/10} = 1000$

$SNR_{OP} = 10^{25/10} = 316.22$

$N.F. = \frac{1000}{316.22} = 3.162$

$$NF(dB) = 10\log_{10}\left(\frac{SNR_{IP}}{SNR_{OP}}\right)$$

$$= 10\log_{10}(3.16)$$

$$= 4.99 \approx 5\ dB$$

**

☆ Shannon's Theorem :- Max. data rate achievable over a communication channel in the presence of noise.

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

where,

C = max. capacity

B = Bandwidth of communication channel.

☆ Example :-

Channel Bandwidth is 3 KHz. The SNR of communication channel is 30 dB. Find the channel capacity using Shannon's Theorem.

⇒ Given :-

Channel Bandwidth = 3 KHz, SNR = 30 dB = 10^3 = 1000

$$C = 3 \times 10^3 \log_2(1 + 1000).$$

$$C \approx 29.9\ kbps$$

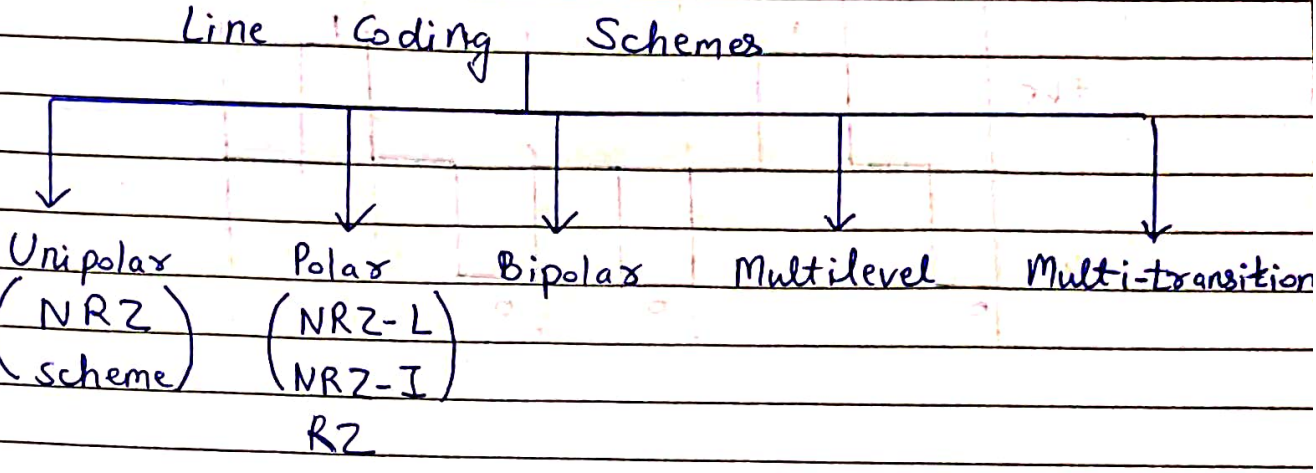
**

☆ Line Coding Schemes :-

Signals that represent data can either be digital or analog. Line coding is the process of converting digital data to digital signals. At the sender's side digital data are encoded into a digital signals and at the receiver side, the digital data are recreated by decoding the digital signals. We can roughly divide Line Coding Scheme into 5

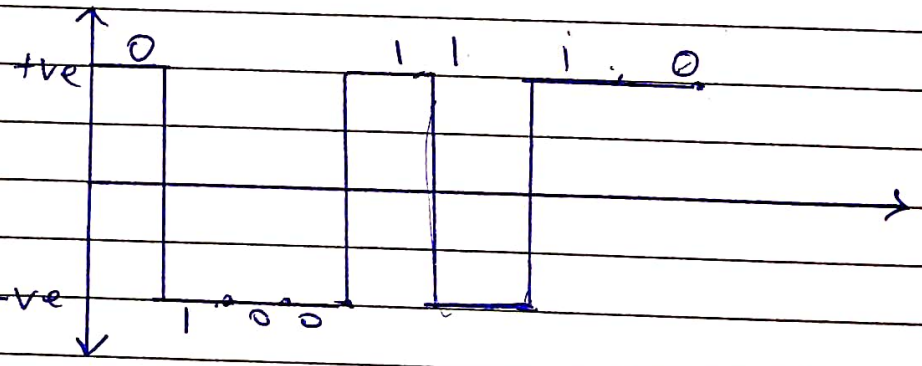
NRZ - Non Return to zero
- Signal does not return to middle of bit

Categories :-



☆ NRZ-L :- Non Return to Zero - Level
☆ NRZ-I :- Non Return to Zero - Inverte
☆ RZ :- Return to zero

☆ NRZ-I
When 1 comes, change state i.e. from +ve to -ve.
For Ex.:- Data = 01001110



☆ RZ = Return to Zero
Uses three signal values :- +ve, -ve, zero.
In middle, goes to zero.

Ex:- Data = 01001