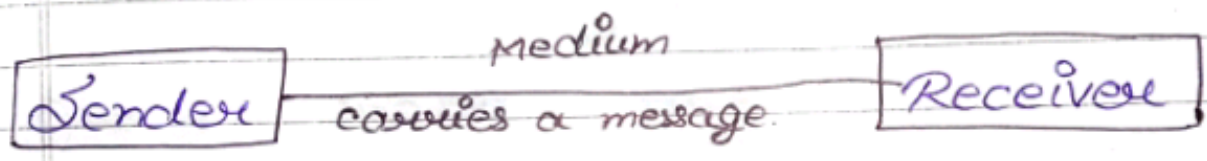


## Computer Network :-

A computer network is a network of computers that are geographically distributed but connected in a manner to enable meaningful transmission and exchange of data among them.

## Elements Of A Computer Network :-



## Network Types :-

### 1. Local Area Network (LAN) :-

A LAN is a computer network covering a small geographical area like a home, office or groups of buildings.

- i) It connects work station personal computer printers servers & many other devices.
- ii) LAN uses low speed communication lines for connections like twisted pair cable, coaxial and fiber optic.
- iii) The cost of sending & receiving data is negligible.
- iv) LAN is owned by a single organization because of its limited area.

## 2. MAN (Metropolitan Area Network) :-

A MAN is a network covering a town or city.

- i) MANs are larger LANs in terms of geographical area covered.
- ii) MANs used high speed connections using coaxial cable & microwave links.
- iii) An example of MAN is cable TV network in many cities.
- iv) MANs is form by connect server lens which may belongs to various organization.

## 3. WAN (Wide Area Network) :-

A WAN is a computer network covering a very large geographic area like a country or contain.

- i) WAN used very high communication like satalight, communication, Telephone lines and microwave links etc.
- ii) The cost of sending data in a WAN may be very high because of public communication systems such as telephone lines microways links or satalight communication.
- iii) The largest WAN in existance is the internet.

## Uses Of Computer Network :-

### 1. Business Application :-

A company may have computers for each worker and use them to design product write documents and do the payroll. All these computers may need to share a resources such as printer. In this situation a computer network plays an important role.

### 2. Home Applications :-

Internet access provide user with connectivity to remote computer. A user can access information communicate with other people by products & services with e-commerce etc.

### Internet :-

The internet is a global network of billions of computers and other electronic devices.

## Data Transmission Mode :-

### 1. Simplex Mode :-

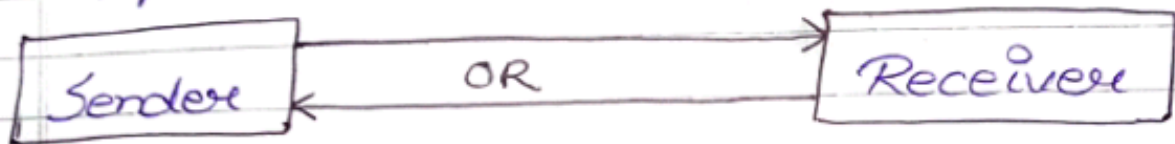
A simplex communication system can transmit data in one direction only. Devices connected to such a circuit can either send or receive only.



Ex :- Keyboard → Computer  
Computer → Printer

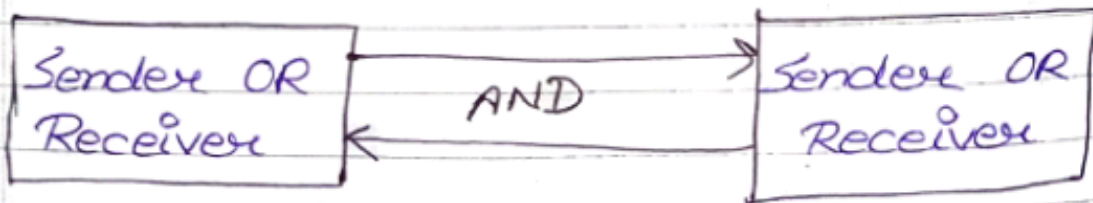
## 2. Half Duplex :-

A Half Duplex communication system can transmit data in both directions, but only one direction at a time. Hence it can alternately send & receive data. It requires two wires. It is most suitable for voice communication using telephones in which one person can speak at a time.



## 3. Full Duplex :-

This mode requires 4 wires that allow data to flow in both directions simultaneously. Modern computers & internet are most popular examples of this mode. It improves efficiency because it eliminates the direction switching delay of a half-duplex system.



## Network Topology :-

Topology of a network refers to the way in which the network nodes (computers)

are other devices need to communicate) are link together.

i) It determines various data paths available between any pair of nodes in the network.

ii) Choose of a topology for a computer network depends on a combination of factors such as →

a) Desized performance of the system.

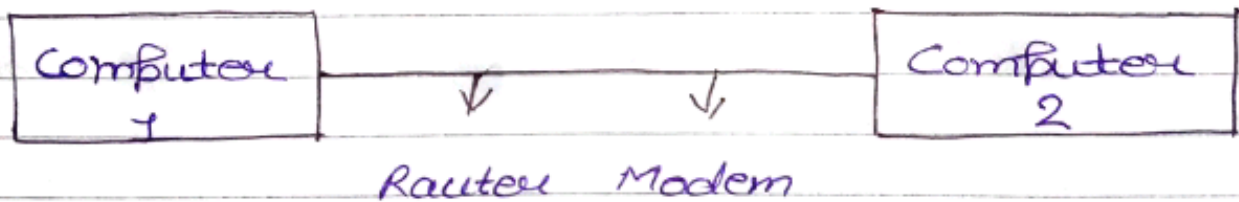
b) Reliability of the system size.

c) Size (number of nodes & their geographical distribution).

d) Cost of components & services to required implement network.

e) Ability of communication lines.

12/10/22 Point to Point :-

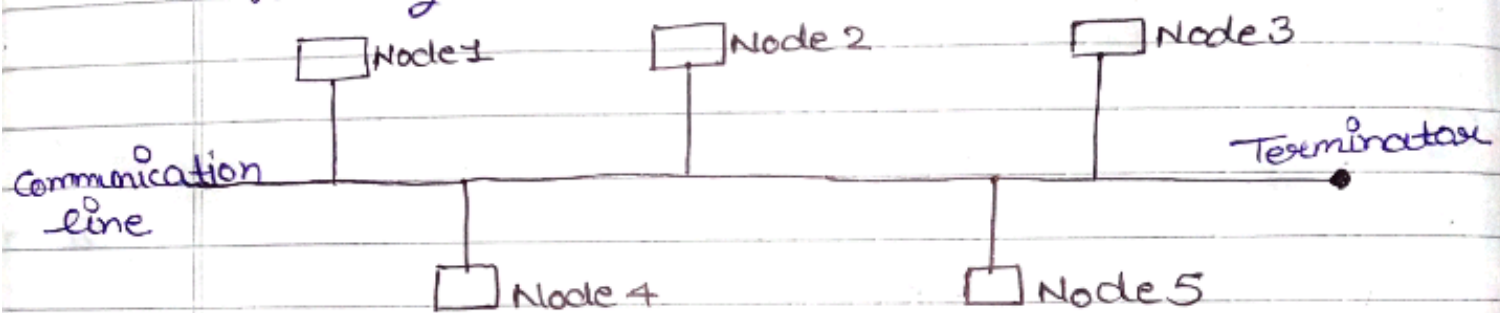


Point to point network contains to hosts such as computer switches or routers in this type of network nodes are connected back to back using a single piece of cable. If the hosts are connected point to point logically then may have multiple intermediate devices. In this network the end hosts are unaware of underline network and

see each other as they are connected directly

## Bus Topology :-

In case of bus topology all devices share single communication line or cable. Bus topology may have problem while multiple hosts sending data at the same time.

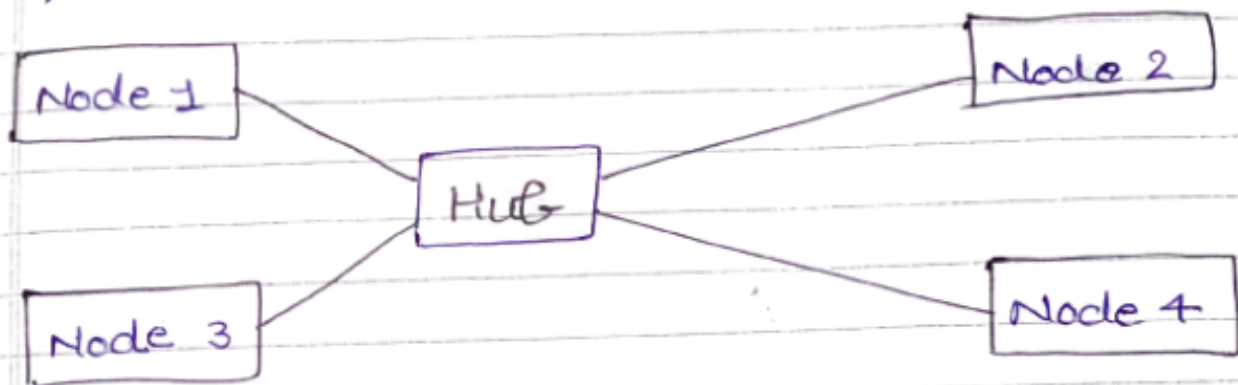


It is one of the simple form of networking where a failure of a device does not affect the other devices but failure of the shared communication line can make all other devices stop functioning. Both ends of the shared channel have line terminator. The data is send in only one direction and as soon as it reaches the extreme end the terminator remove the data from the line.

## Star Topology :-

All hosts in star topology are connected to a central device known as hub device using a

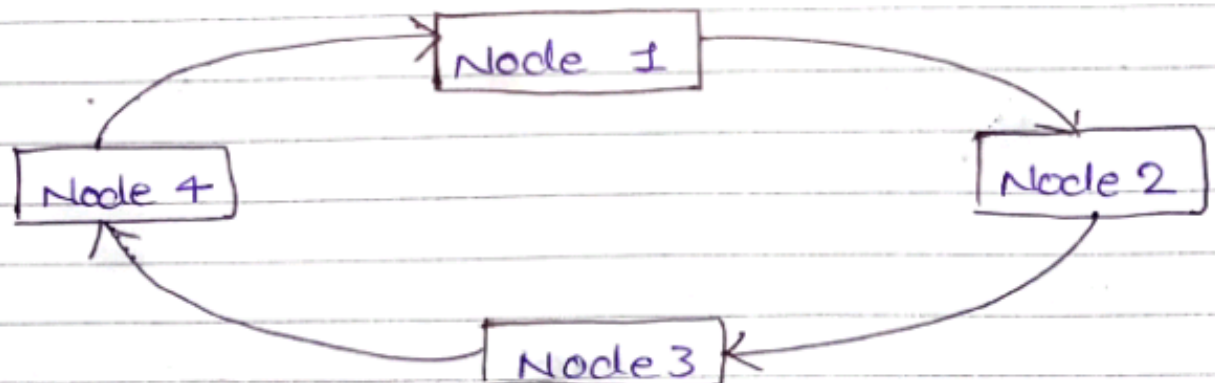
point to point connection.



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### Ring Topology :-

In ring topology each host machine connects to <sup>exactly</sup> other machines creating a circular network structure. When one host tries to communicate or send message to a host which is not adjacent to it the data travels through all the intermediate host.



Failure of any host results in failure of whole all ring thus any every connection in the ring is a part of failure.

### Mesh Topology :-

In this type of topology

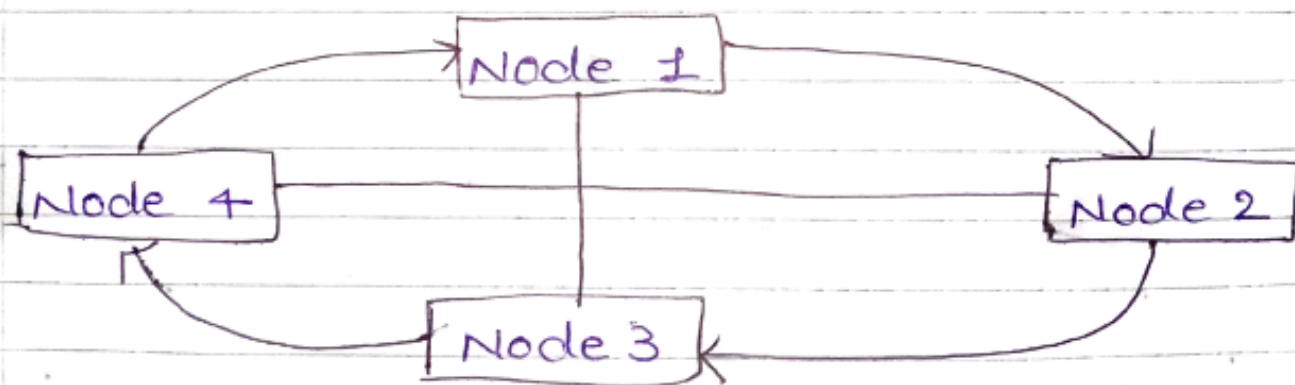
a host is connected to one or multiple host. This topology has host in point to point connection with every other host.

Host in mesh topology also works as really to to other host which don't have direct point to point links.

Mesh topology comes in two types.

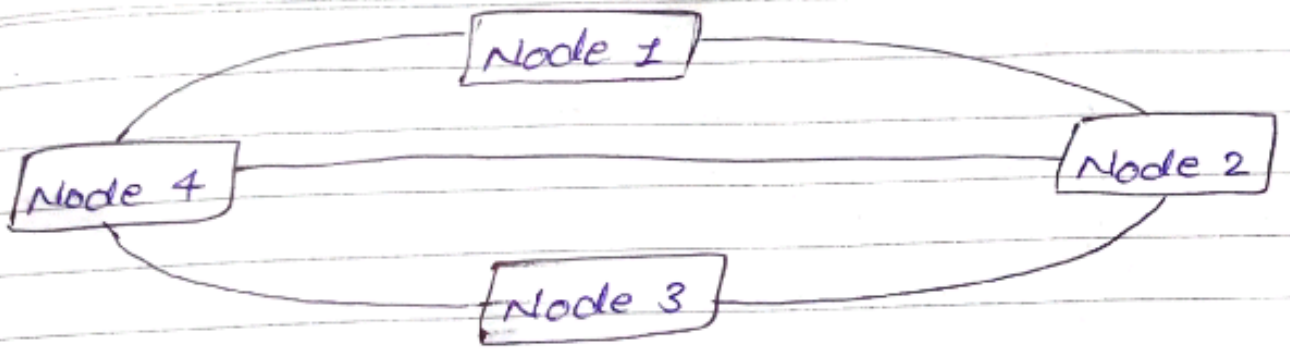
### 1. Full Mesh:-

All hosts have the point to point connection to every other host in the network. It provides the most reliable network structure among or network topology.



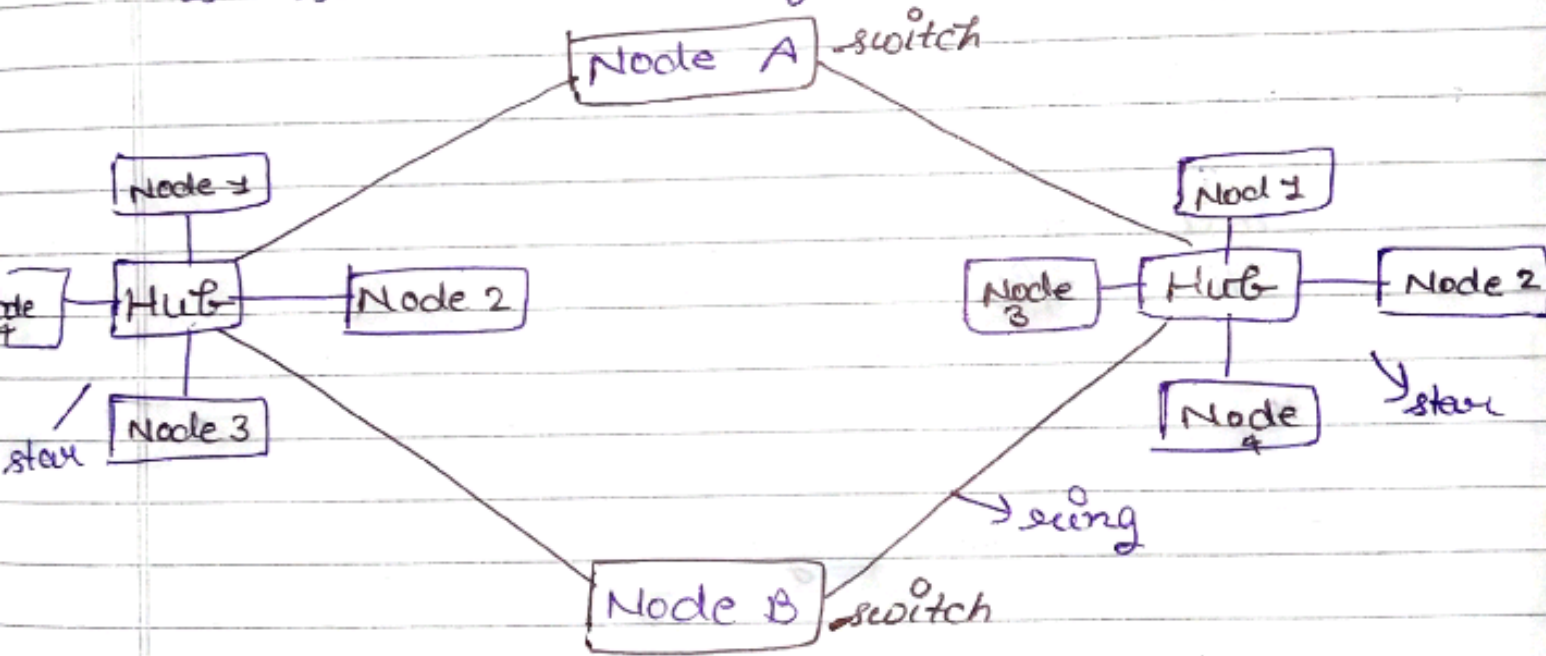
### 2. Partially Mesh:-

Node all host have point to point connection to every other host. Hosts connect to each other in some arbitrary fashion. This topology exact where we need to provide reliability in a network of all.



### Hybrid Topology :-

A network structure whose design contains more than one topology is said to be hybrid topology.



Most WANs are connected by means of ring topology, and networks connected to them are mostly star topology network. Internet is the best example of largest hybrid topology.

### Open System Interconnect Model (OSI) :-

Open system inter-connect is an open standard for communication.

OSI model is established by international standard organization (ISO).

This ~~say~~ model has ~~for~~ Seven layers

1. Application layer.
2. Presentation layer.
3. Session layer.
4. Transport layer
5. Network layer.
6. Data link layer.
7. Physical layer.

### 1. Application layer :-

This layer is responsible for providing interface to the application user.

This layer encompasses protocol to directly interact with 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 maintenance this session for a while

and doesn't ask for authentication 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 and uniquely addressing host in the network.

#### 6. Data Link layer :-

This layer is responsible for reading and writing data from and on to the line link errors are detected at the layer.

#### 7. Physical layer :-

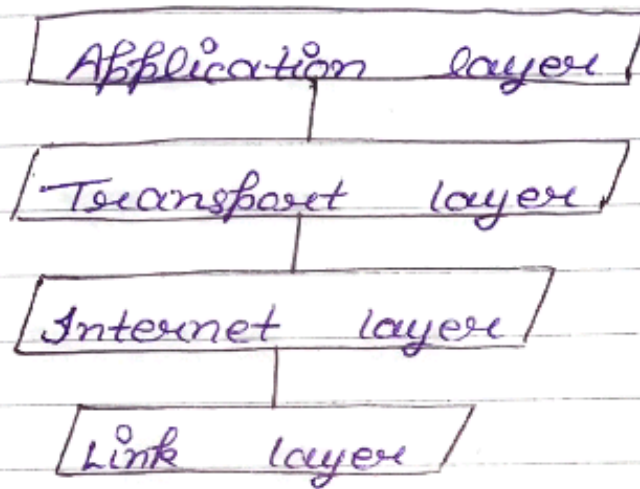
This layer defines the hardware cabling, wiring, power output etc.

### TCP/IP Model (Transmission Control Protocol / Internet Protocol) :-

Internet uses TCP/IP protocol suite also known as internet suite. This defines a model which contains four layered architecture model but OSI model is general

communication model but internet model is what the internet use for all its communication.

The internet is independent of its underline network architecture. It have four layers.



### 1. Application Layer :-

This layer defines the protocol which enables users to interact with each other via network. HTTP, FTP (File Transport Protocol) are common protocol use in this layer.

### 2. Transport layer :-

This layer defines how data should flow between hosts. Major protocol at this layer is transmission control protocol.

This layer ensure data delivered between host is in order it is also responsible for end-to-end delivery.

22/0  
3. Internet layer :-

Internet protocol works on this layer. This layer facilitates host addressing and recognition this layer defines routing.

4. Link layer :-

This layer provides mechanism of sending and receiving actual data unlike its OSI model counterpart, this layer is independent of underline network architecture and hardware.

OSI	TCP/IP
1. It stand for open system interconnection.	1. It stand for Transmission Control Protocol / Internet Protocol.
2. OSI model has been developed by ISO.	2. TCP model is developed by ARPANET (Advanced research project agency network).
3. It is an independent standard & generic Protocol use as a communication gateway b/w the network & the end user.	3. It consist of standard protocol that lead to the development of an internet.
4. In the OSI model the transport layer provides a guaranty for the delivery of the packets	4. The transport layer does not provide the security of the delivery of packet but still we can say that it is a reliable model.

5. The OSI model was developed first then protocol were create to fit the network architectures needs.

5. The protocol work create first and then ICP/IP model came in existance.

6. The protocol of OSI model are better unseen.

6. ICP/IP model protocol are not hidden and we cannot fit in new protocol in it.

7. OSI model has 7 layers.

7. ICP/IP model has 4 layers.

## Signals :-

These are the ways of communicating one to other ~~in~~. A signal is a way of communicating by sending information from one system to other system. Signal is an electromagnetic waves that carries ~~to~~ through physical medium. Here the data is converted into electromagnetic signal and send from sender to receiver.

Signals are divided into two categories Based on there nature.

b

1. Analog Signal :-

Analog signal :-

continuous as time varying in nature  
Analog signal is a form of electric energy. (voltage, current or electro-magnetic power).

## 2. Digital Signal :-

Digital Signal are discrete they contain only distinct values. Digital signal carries binary data i.e. 0 and 1, in form of bits. It can only contain one value at a period of time. Transmission of digital data in analog channel is done by a process modulation.

### UNIT-2

#### Data Transmission :-

Data transmission refers to the process of transferring data between two or more devices.

Data is transmitted from one device to another in analog or digital format.

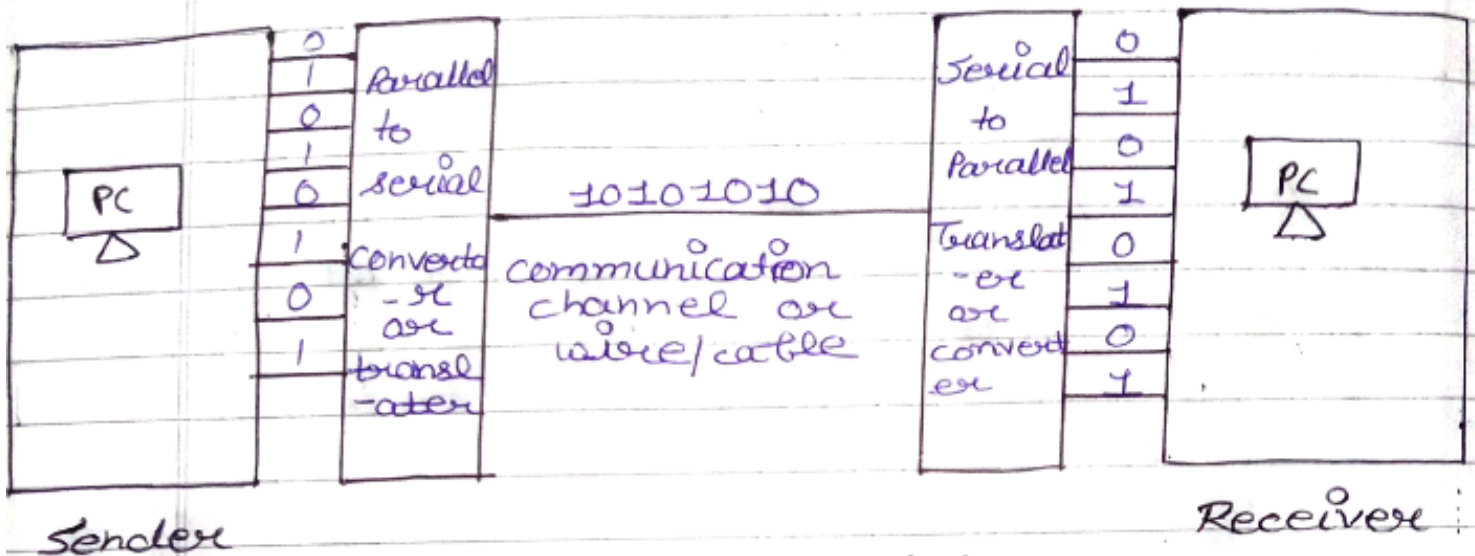
There are two methods use to transmitted data between devices such as

1. Serial Transmission
2. Parallel Transmission.

#### 1. Serial Transmission :-

When transferring data between to physical separate devices, specially if the separation is a few kilometers

Data is transmitted as a single bit at a time using a fixed time interval for each bit. This mode of transmission is known as bit serial transmission.



Serial Transmission

### Advantage Of Serial Transmission:-

Use of single communication channel or wire reduce the transmission cost by the factor of 'n' line as compare to parallel transmission.

### Disadvantage Of Serial Transmission:-

a) Use of conversion resources or devices at source & destination may need lead to increase in over all transmission cost.

b) The method is slower as compare to parallel transmission as bit are transmitted serially one after the other.

## Types of Serial Transmission:-

There are two types of serial transmission that is synchronous & asynchronous. Both these transmission use bit synchronization.

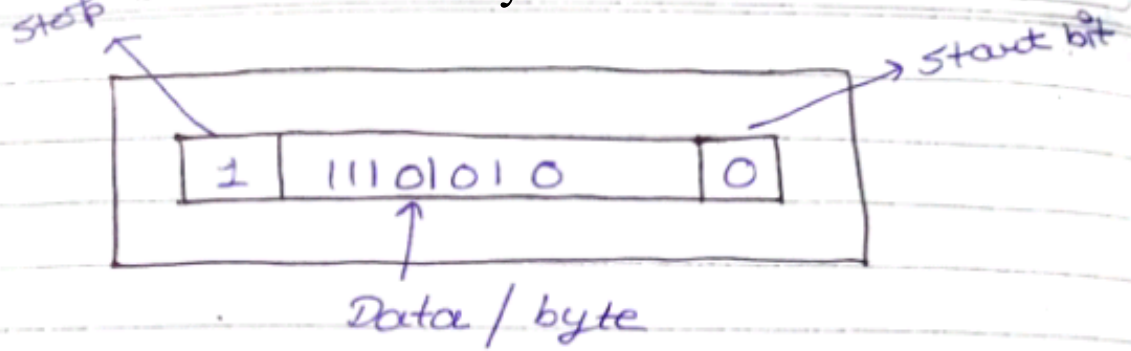
NOTE:- Bit synchronization is a function that is require to determine when the beginning and end of the data transmission occur.

Bit synchronization help the receiving computer to know when data beginning and end during a transmission.

### i) Asynchronous Transmission:-

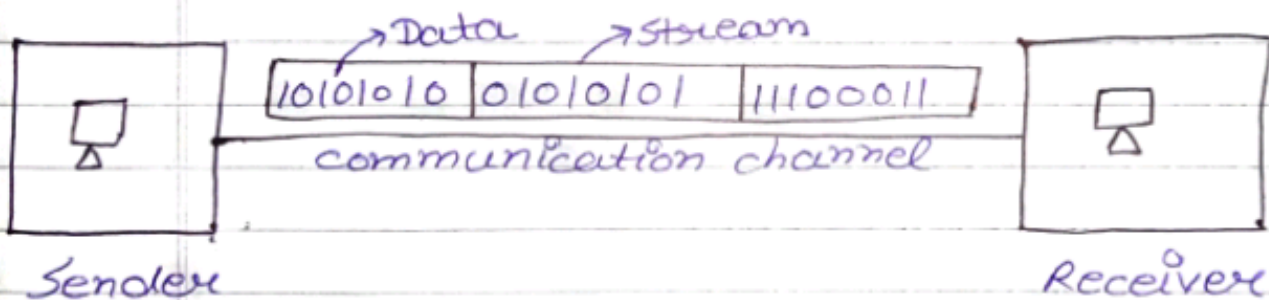
Asynchronous transmission send only one character at a time where a character either a letter of alphabates or number. Bits synchronous b/w two devices made possible ~~to~~ using start or stop bit. Start bit refer to beginning data that is alert the receiver to the arrival of new group of bits. A start bit usually zero is added to the beginning ~~to~~ of each byte. A stop bit refers the end of data that is alerts the receiver that byte is finished. This bit usually one. that is called stop bit.

for example:-



## ii) Synchronous Transmission :-

Synchronous Transmission does not use start and stop bits, in this method bit stream is combine into longer frame that may contain multiple bites. There is no gap between the various bytes in the data stream.



## Comparison Between Asynchronous & Synchronous Transmission :-

Factor	Synchronous	Asynchronous
Data send at a time	Multiple byte	Usually one byte.
start and stop bit	Not use	Used.
Gap b/w data unit	Not present.	Present.

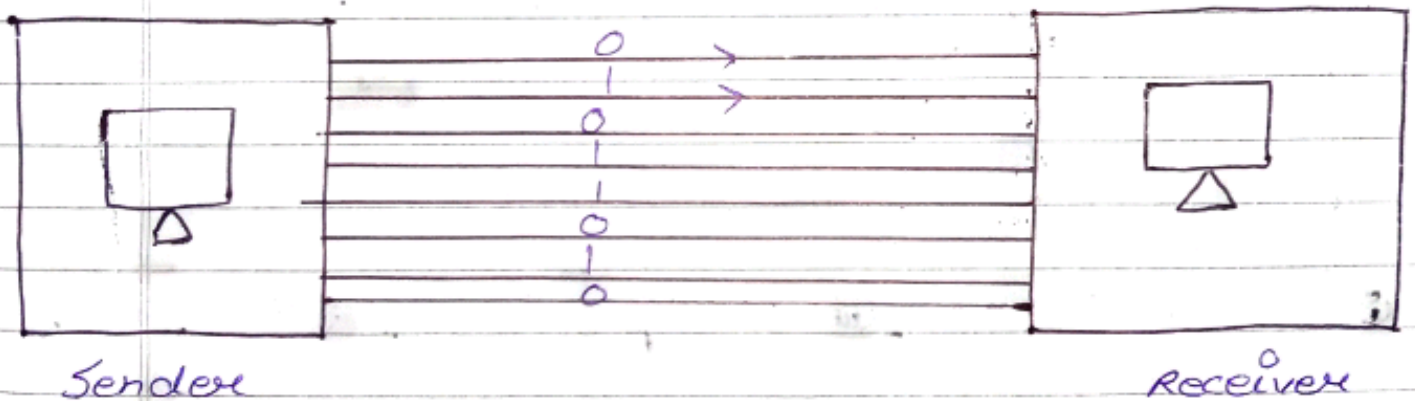
Data transmission speed

high

Low

## 2. Parallel Data Transmission :-

In parallel transmission all the bits of data are transmitted simultaneously on separate communication line. In order to transmit 'n' bits, 'n' wires or lines are used. Thus each bit has its own line. Parallel transmission is used for short distance communication.

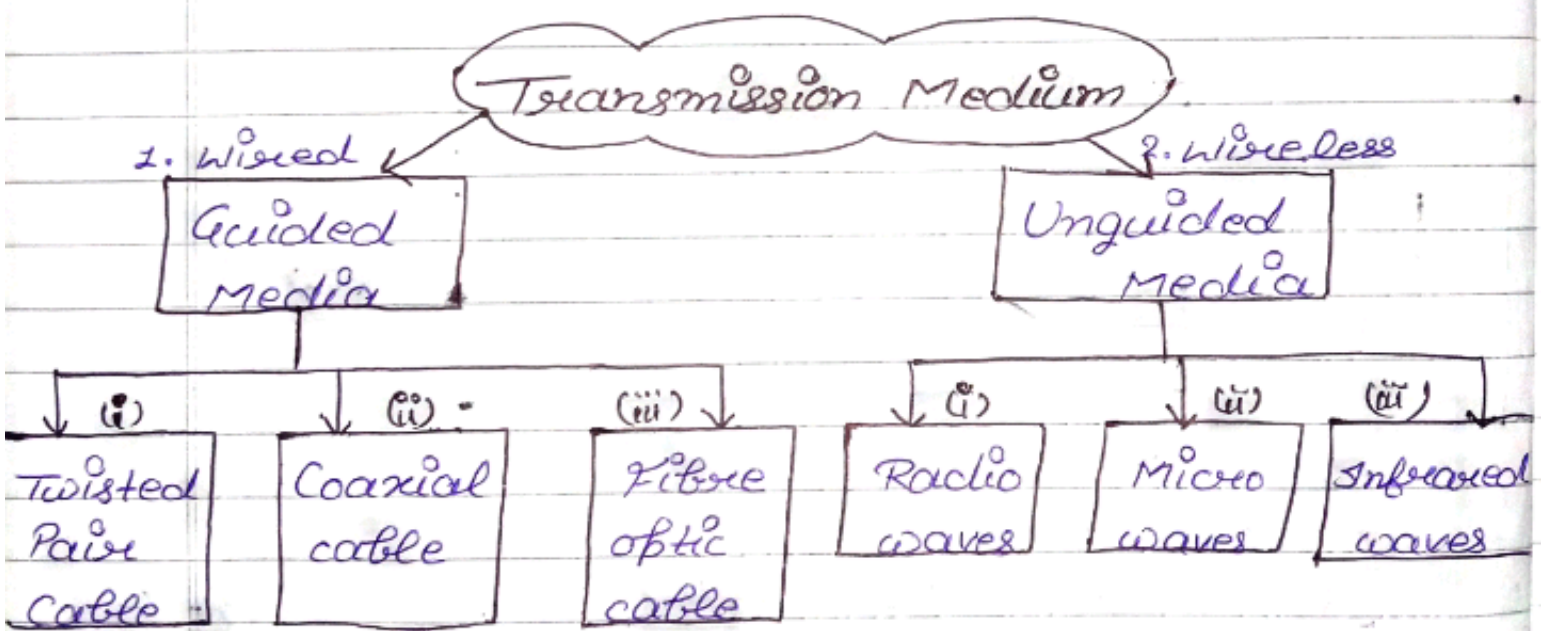


Advantage Of Parallel Transmission :-  
Speed  
is very fast.

Disadvantage :-  
Costly.

## Data Transmission Medium/Media :-

Transmission medium/media is the way to transmit data from source to destination or one place to another. It provides a path way over which the message can be transmitted from sender to receiver. Each of the message can be send in the form of data by converting them into binary digits. These binary digits are then encoded into a signal that can be transmitted over the appropriated medium.



### 1. Guided Media/Wired :-

Guided media are the cable that are tangible or physical existence. Guided transmission medium refers to the following cable such as

i) Twisted Pair cable

i) Twisted Pair Cable:-

A twisted pair cable is pair of copper wires. Copper wires are the most common wire used for transmitting signal because of good performance at lower cost. A twisted pair cable consist of two connectors / conductor. (normally copper).

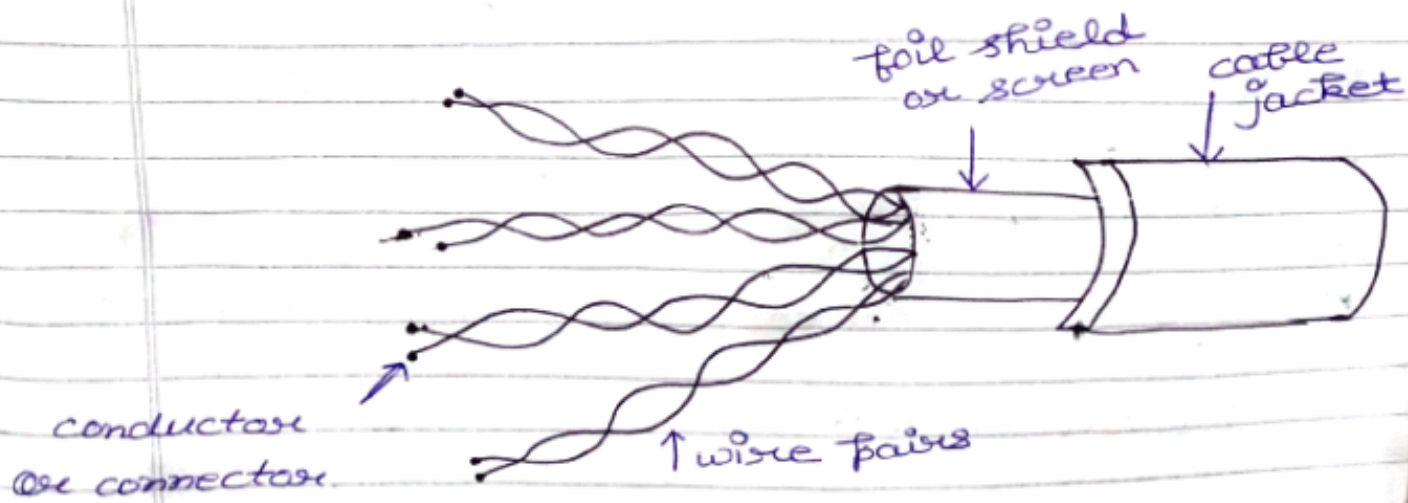
Each with its own plastic insulation, twisted together to form a single medium. To identify every cable are colour code-d. This type of wire is used in telephone lines.

Advantage:-

Reliable and easy to instal-all.

Disadvantage:-

Low durability durability.



## ii) Coaxial Cable:-

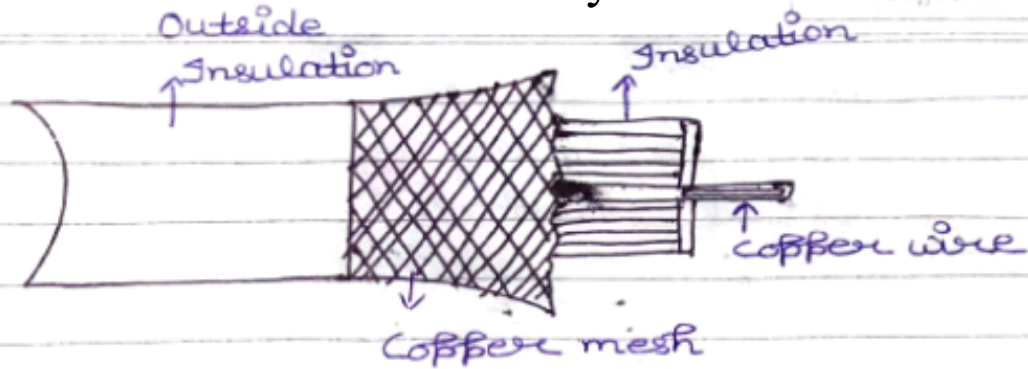
Coaxial cable are copper cable with better shielding than twisted pair cable, so that transmitted signal may travel longer distance at higher speed. The shield minimized ~~or~~ electrical and radio frequency interference. Coaxial cable is the primary type of cable used by the television industry, and is also widely used for computer networks such as ethernet. Coaxial cable has two wires of copper. The core / inner cable in center and is made of solid conductor. It is enclosed in two insulators. The second outer copper wire is wrapped around, & is used to protect from external interference (noise). This all is cover by plastic cover used to protect the inner layer from physical damaged such as fire and water. This type of wire is used in television.

### Advantage:-

i) Durable  
ii) Best performance insure data transmission

### Disadvantage:-

Signal loss at long distance



### iii) Fibre Optic Cable :-

A fibre optic cable is made of high quality of thin glass or plastic and is used to transfer digital data signal in the form of light upto distance of thousand of miles. Fibre optic cables are not affected by electro-magnetic interference.

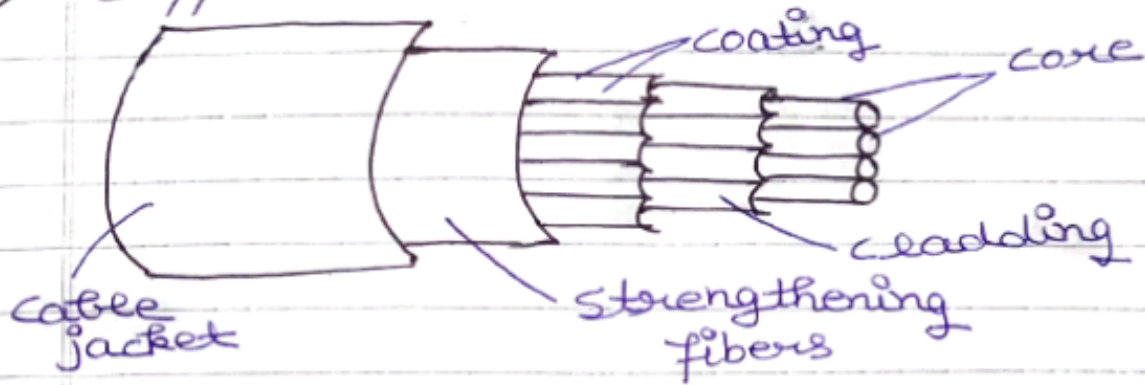
The cable consist of one or more strands of glass, each only shieldly thicker than human hair. The center of each strands in ~~core~~ is called the core, which provides the path way for light to travel. The core is round by a layer of glass called cladding. This type of wire is used in internet.

#### Advantage:-

- i) Small size and lighter weight.
- ii) Suitable for industrial and noisy ~~are~~ areas.
- iii) Carry data at longer distance without weakening.

### Disadvantage:-

- i) Expensive or costly
- ii) Difficult to install.



### Comparison among Twisted Pair cable, coaxial cable and Fibre optic cable:-

The following list shows the differences among all these cable wise or cable.

<u>Twisted Pair</u>	<u>Coaxial</u>	<u>Fibre optic</u>
1. Noise immunity is low.	Noise immunity is higher than twisted pair cable	Highest noise immunity.
2. Cheapest medium.	Expensive.	Very expensive.
3. Low bandwidth	High bandwidth	Very high bandwidth
4. Installation easy	Installation is easy	Difficult to install.
5. Used for Telephone lines	Used for television	Used for internet

6. bandwidth up to  
47 hundred MHz

Bandwidth up to  
7 hundred MHz

Bandwidth up to  
47 hundred MHz

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## 2. Unguided Transmission :-

Unguided Transmission medium or wireless transmission medium refers transmission of data in waves. In other word unguided transmission doesn't use any physical medium or wires. Unguided Transmission used to transmit the data following way. such as

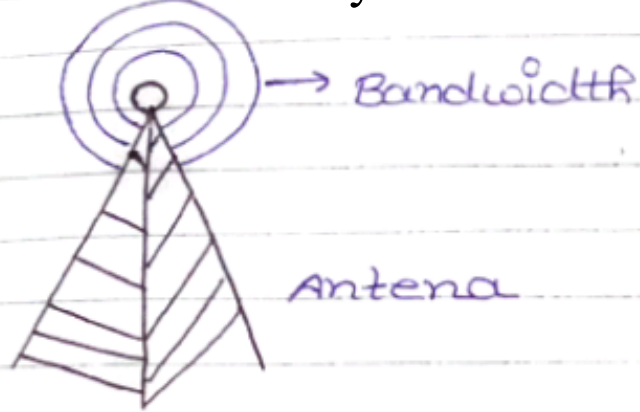
- i) Radio waves
- ii) Micro waves
- iii) Infrared waves

### Waves :-

First of all we need to know about waves. A wave can be describe as a disturbance that travel without a medium like radio wave and micro wave.

### i) Radio Waves :-

Radio wave are used for multi-cast communication such as radio & TV. Radio waves can penetrates through walls. The radio wave is highly regulated and it used omni directional antenna receive the signals



### Advantage i:-

1. High bandwidth.
2. Signals pass through walls.
3. Inexpensive and easy to install.

### Disadvantage i:-

1. Creates electrical interference problems.
2. Susceptible to snooping unless encrypted.

### ii) Micro Waves i:-

Micro waves are used for <sup>communication</sup> unicast such as telephone & wireless lane. Micro wave used single directional antennas. In other hand point-to-point communication is possible through micro waves.

### Advantage i:-

- i) Low power requirement.
- ii) Minimum cross talk.
- iii) More secure.

### Disadvantage i:-

- i) Unidirectional

i) Difficult to analysis and design.



point-to-point

iii) Infrared Waves :-

Infrared waves can be used for short range communication in a closed area using line of sight propagation.

for Example :- TV remote & wireless speaker.

Due to short range it is consider to be more secure transmission ~~area~~ <sup>media</sup>.

Advantage :-

- Secure communication
- Low power consumption.

Disadvantage :-

- It does not work through walls or doors.

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DTE - DCE Interface :-

DTE (Data terminal Equipment) :-

DTE is any device that function either as a source or as a destination for binary digital data. A terminal equipment means it is at ~~end~~ end of the source or at end of destination.

So this data terminal may be a computer, printer and fax machine or any other device that generate or consume digital data.

DTE does not communicate directly with one another, they generate and consume information but need an intermediate device to be able to communicate.

### DCE (Data Circuit Terminating Equipment)

DCE is any device that transmits or receives data in the form of analog or digital signal through a network.

To make communication possible both the sending & receiving DCE must use the same modulating method.

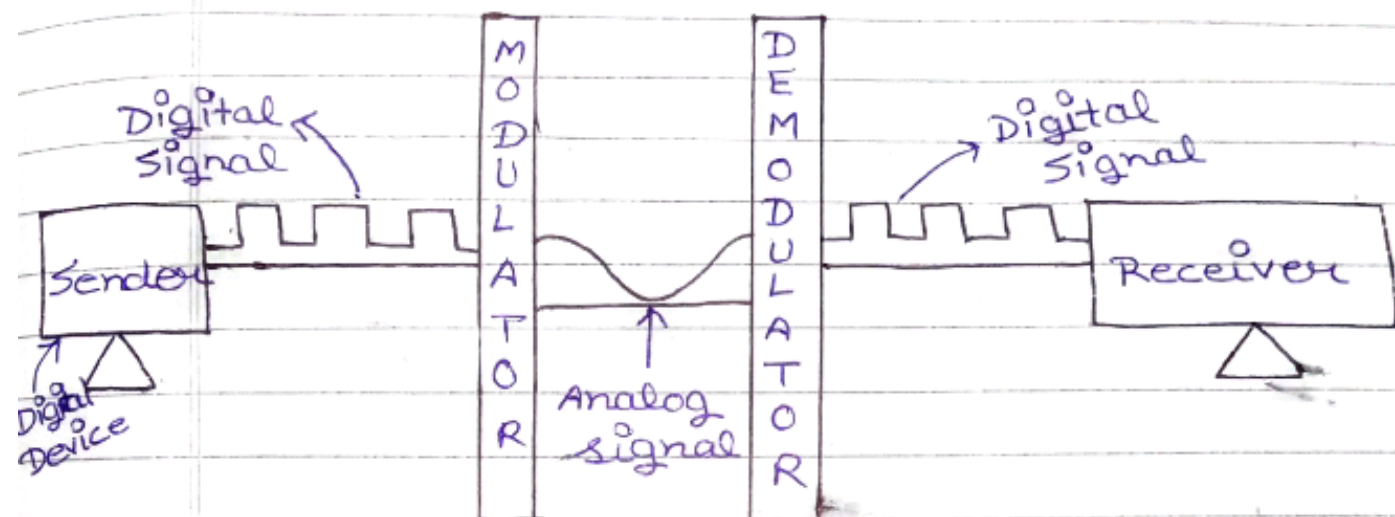
computer, terminal, fax, printer, etc. Modem, etc.



### Modem :-

Modem stands for modulator and demodulator, it is a network device that is placed between the computer system and transmission medium. It has two parts such as modulator and demodulator, modulator refers conversion of data from digital to analog and demodulator refers conversion of data from analog

to digital signal. It allow the computer to connect the internet.



### Transmission Impairment:-

When a signal transmitted from one medium to another, the signal that is receive may differ from the signal that is transmitted due to various empairments. On the other hand the transmission impairment is nothing but whatever the anatoge signal you are sending to the receiver, the receiver may receive the data in the form of degradation in data quality (the receiver may not receive the exi quality information). If you take digiti-al signal, bit may be come the error that is the bit error. The most significant impairment given below

1. Attenuation
2. Distortion
3. Noise

### 1. Attenuation :-

It refers to loss of energy by a signal



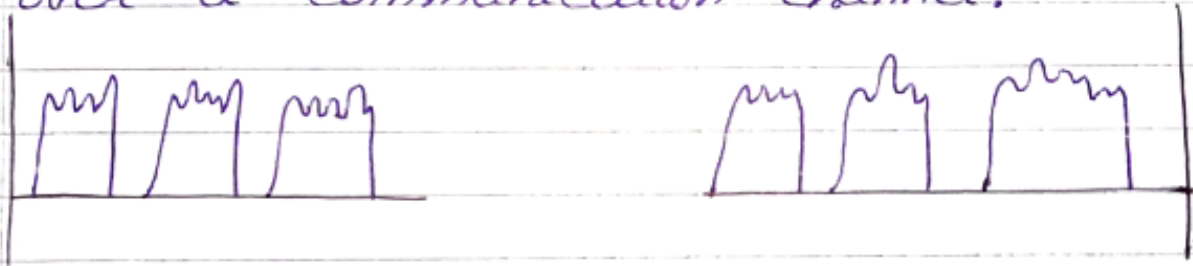
Sender



Receiver

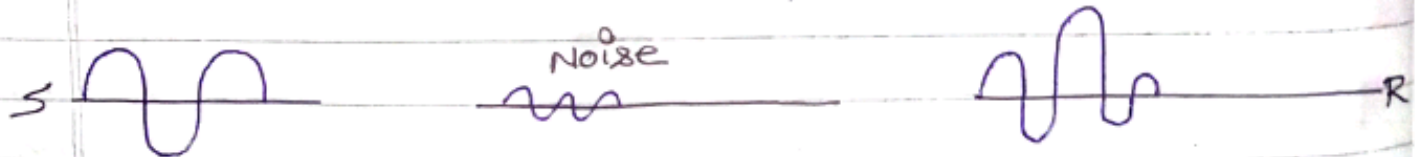
### 2. Distortion :-

It means signal changes its shape or form when it is transmitted over a communication channel.



### 3. Noise :-

It means signal may corrupt that is transmitted from sender to receiver



### 11/Nov/21 Performance :-

Performance of media can be measured in through-put, speed and time.

### 1. Throughput :-

How fast data can pass

through a point in the medium.  
Throughput is the actual number of bits passing through a network connection in a given period of time. The throughput is always less than or equal to bandwidth but can never exceed bandwidth.

2. Speed :-

The distance a signal can travel through media in one second. It depends on medium.

3. Time :-

The time a signal to travel from one point of medium to another point.

Wavelength :-

Wavelength refers to the distance a simple signal can travel in one sec/period.

Frequency :-

The number of cycle per second by an alternating quantity is called frequency. It is measure in cycle per second (C/S) or (Hz) and is denoted by (f).

$$f = \frac{C}{S}$$

$$f = \frac{2 \text{ cycles}}{1 \text{ second}} \Rightarrow 2 \text{ hertz}$$

$$f = \frac{1 \text{ cycle}}{1 \text{ sec}} \Rightarrow 1 \text{ Hz}$$

## Comparison Of Medium :-

Let's see the difference between guided and unguided media.

Guided	Unguided
1) The signal energy propagates through wires in guided media.	The signal energy propagate through air in unguided media.
2) Guided media is used for point-to-point communication.	Unguided media is generally used for radio broadcasting in all direction.
3) Signals are in the form of voltage, current in guided media.	Signals are in the form of electromagnetic waves in unguided media.
4) Example of guided media are twisted pair cable, coaxial cable & fibre optic	Example of unguided media are Radio wave, Infrared wave.

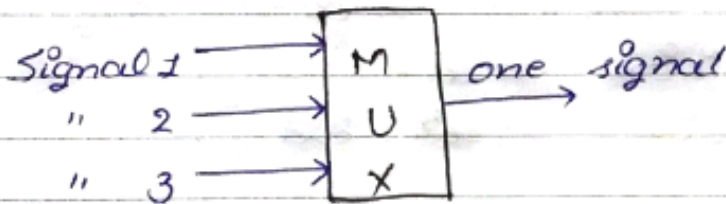
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## Multiplexing and Demultiplexing :-

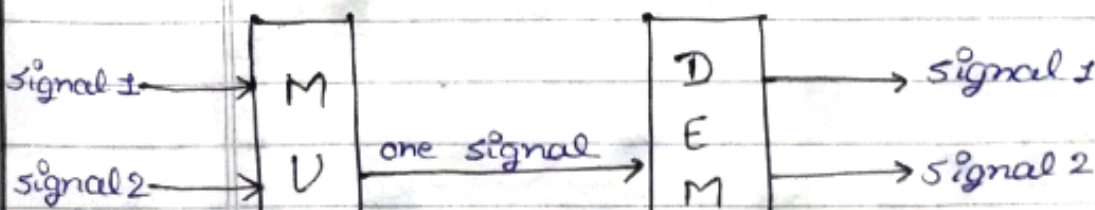
Multiplexing is a technique used to combine and send the multiple signal or data streams over a single medium. The process of combining data stream is known as multiplexing. And hardware used for multiplexing is known as multiplexer.

Multiplexing is achieved by using a device called multiplexer (MUX) that combines 'n' input lines to generate a single output line. Multiplexer follow many-to-one approach that is 'n' input lines and one output line.



## Demultiplexing :-

Demultiplexing is achieved by using a device called demultiplexer (DEMUX) that separate a signal into its components signals there for we can say that demultiplexing follows the one-to-many approach.



NOTE :-

Multiplexer is used at the user (sender) <sup>end</sup> and demultiplexer is used at the receiver end.

### Advantage of a Multiplexing :-

1. More than one signal can be send over a signal medium.
2. The bandwidth of a medium can be utilized efficiently.

### Types Of Multiplexing :-

There are different

type of multiplexing such as

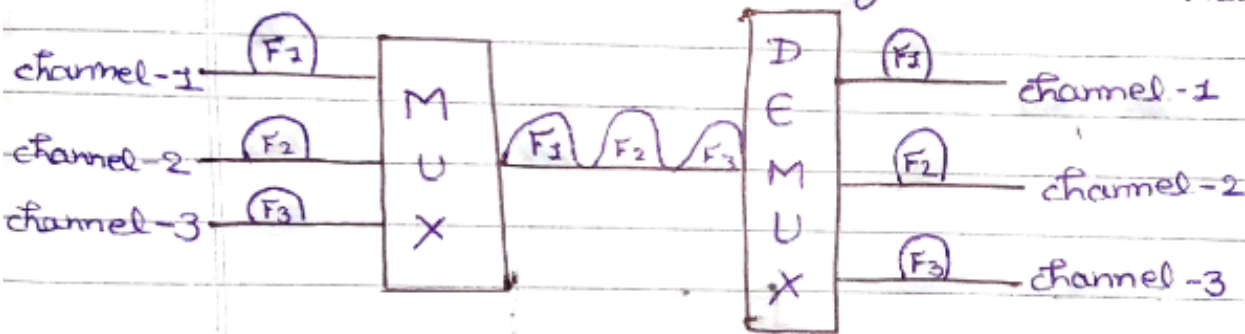
1. Frequency division multiplexing.
2. Wave division multiplexing
3. Time division multiplexing.



### 1. Frequency Division Multiplexing (FDM) :-

FDM is an analog technique. FDM is a technique in which the available bandwidth of signal transmission medium is sub divided in several channel. FDM divides the bandwidth

in a logical channel and locate one user to each channel. Each user can use the channel frequency independently and has exclusive access of it. All channels are divided in such a way that they don't overlap with each other. Channels are separated by guard bands. Guard-band is a frequency which is not use by either channel.



### Advantage of FDM:-

1. FDM process is very simple and easy modulation.
2. A large number of signal can be send through FDM simultaneously.
3. It doesn't require any synchronization b/w sender and receiver.

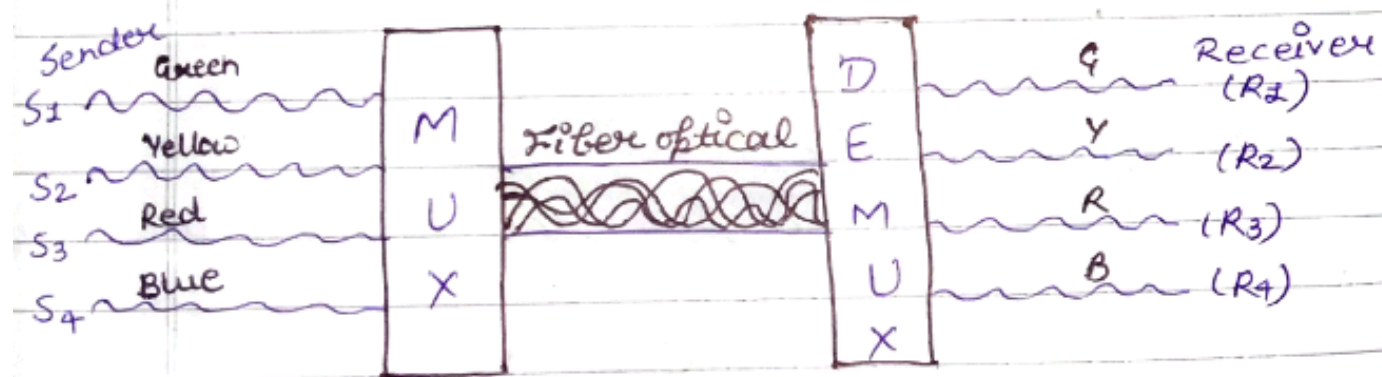
### Disadvantage of FDM:-

1. FDM technique is used only when low channel speed are required.
2. A large number of modulators are require.
3. It requires a high bandwidth channels.

## 2. Wave Division Multiplexing (WDM)

WDM is an analog technique. WDM is same as FDM except that the optical signals are transmitted through the fiber optical cable. WDM is used on fiber optics to utilize the high data rate capability of fiber optic cable.

Optical signals from different source are combine in the form of a wider band of light with the help of multiplexer at the receiving end, demultiplexer separate the signal to transmit them to their respective destination.



### Advantage of WDM :-

- i) Full duplex transmission is possible.
- ii) Easier to reconfigure.
- iii) Optical components are similar and more reliable.
- iv) It provide higher bandwidth.
- v) It is high secure.

### Disadvantage of WDM :-

- i) Signal cannot be very close.

### 3. Time Division Multiplexing (TDM):-

It is a digital multiplexing technique. In time division multiplexing the total time available in the channel is distributed among different users. Therefore, each user is allocated with different time interval known as a time slot.

At which data is to be ~~allocated~~ transmitted by the sender. A user takes control of the channel for a fixed amount of time. In time TDM data is not transmitted simultaneously either the data is transmitted one by one. In TDM the signals is transmitted in the forms of frames. Frames contain a cycle of time slots in which each frame contains one or more slots dedicated to the user. It can be used to multiplex both digital and analog signal but mainly use to multiplex digital signals.

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There are two types of TDM such as

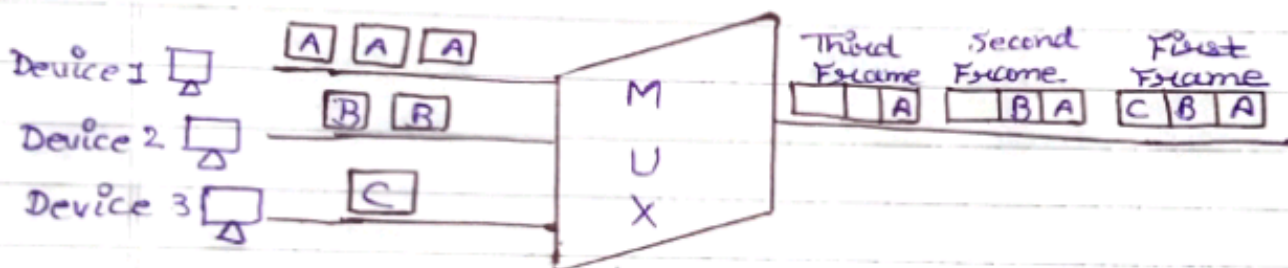
1. Synchronous TDM
2. Asynchronous TDM

#### 1. Synchronous TDM:-

Synchronous TDM is a technique in which time slots are preassigned to every device. Synchronous TDM, each device is given some time slot in a regular interval. The fact that the

If the device doesn't have any data then the slot will remain empty.

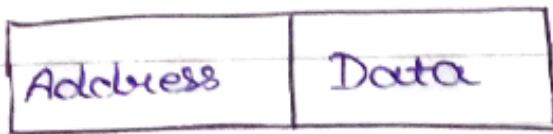
In synchronous TDM, signals are sent in the form of frame. Time slots are organized in the form of frame. If a device doesn't have data for a particular time slot then the empty slot will be transmitted. The most popular synchronous TDM are ISDL multiplexing and SONET multiplexing. If there are  $n$  devices then there are  $n$  slots.



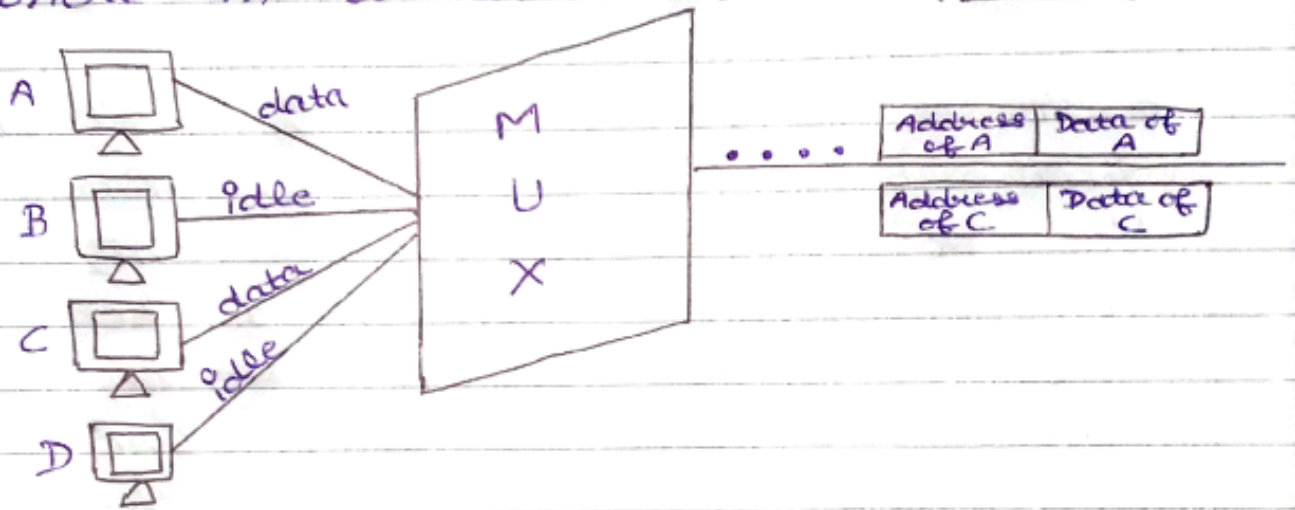
## 2. Asynchronous TDM:-

Asynchronous TDM is a technique in which time slots are allocated to only those devices which have the data to send. Therefore we can say that asynchronous TDM transmitted only the data from active work station or devices. In asynchronous TDM total speed of the input lines can be greater than the capacity of the channel. Asynchronous TDM accepts the incoming data and create a frame that contain only data with no empty slots. In asynchronous TDM, each slot contain an address part that identifies the sources of the

data.



In synchronous TDM if there are 'n' sending device then there are 'n' time slots. In asynchronous TDM if there are 'n' sending devices then there are 'm' time slots. ( $m = \text{machine}$ ) where  $m$  is less than  $n$  ( $m < n$ )



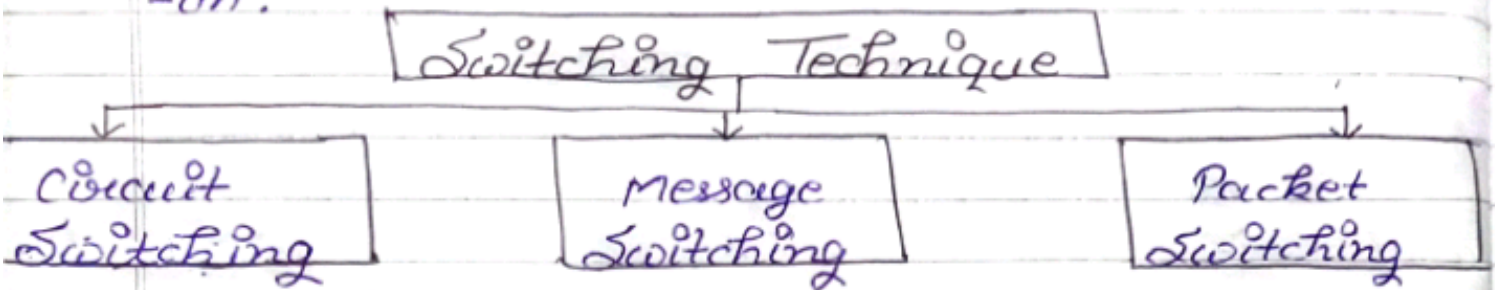
In the above diagram, there are four devices but only two devices are sending the data that is A and C. Therefore the data of A & C are only transmitted through the transmission line.

The above figure shows that the data part contains the address to determine the sources of data.

### Switching Techniques:-

In large network there can be multiple path from sender to receiver the switching techniques will help in data transmissi

Switching technique is used to connect the system for making one to one communication.

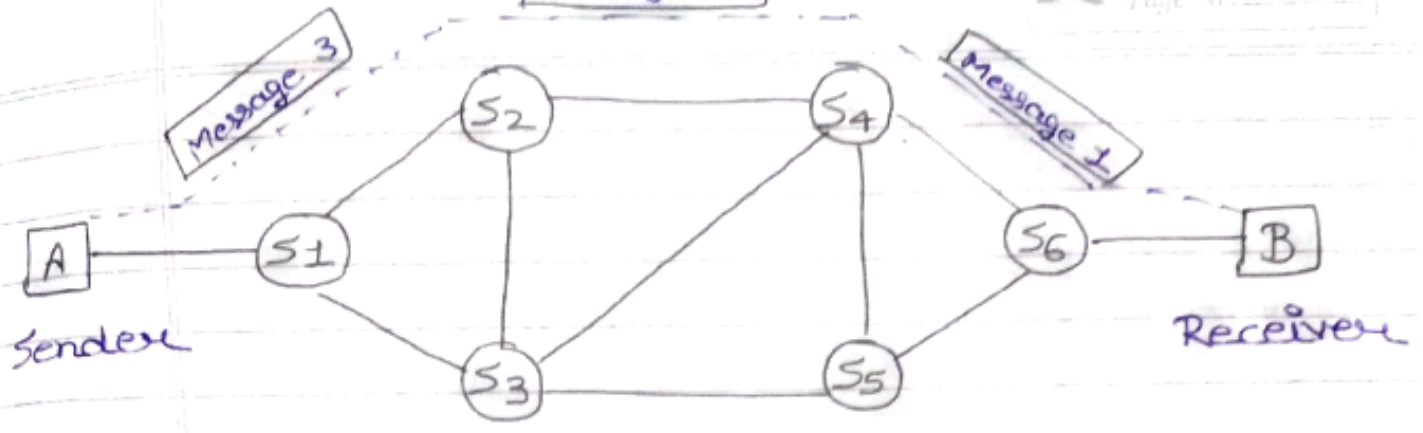


### 1. Circuit Switching :-

C.S. is a switching technique that establish a dedicated path between sender and receiver. In the circuit switching technique once a connection is established then the dedicated path will ~~remain~~ <sup>continue</sup> to exist until the connection is terminated. A complete end to end path must ~~access~~ <sup>exist</sup> before the communication take place.

In case of C.S. technique when any user wants to send the data, voice, video a request signal is send to the receiver then the receiver send back the acknowledgement to answer the ability of the dedicated path. After receiving the acknowledgement dedicated path transfer the data. Fixed data can be transfer at a time in CS Technique.

Ex:- Telephone



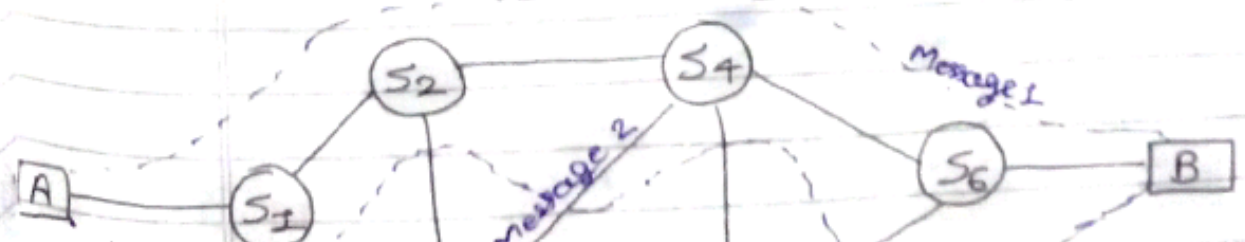
## 2. Message Switching :-

M.S. is a message switching technique in which a message is transfer as a single unit and routed through intermediate nodes at which it is stored and forward.

In message switching technique, there is no establishment of a dedicated path between the sender and receiver.

The destination address is appended to the message. Message switching provide a dynamic routing as the message is routed through the intermediate nodes based on the information available in the message.

M.S. is program in such a way that they can provide the most efficient route. Each and every nodes stores the entire message and then forward it to the next node.

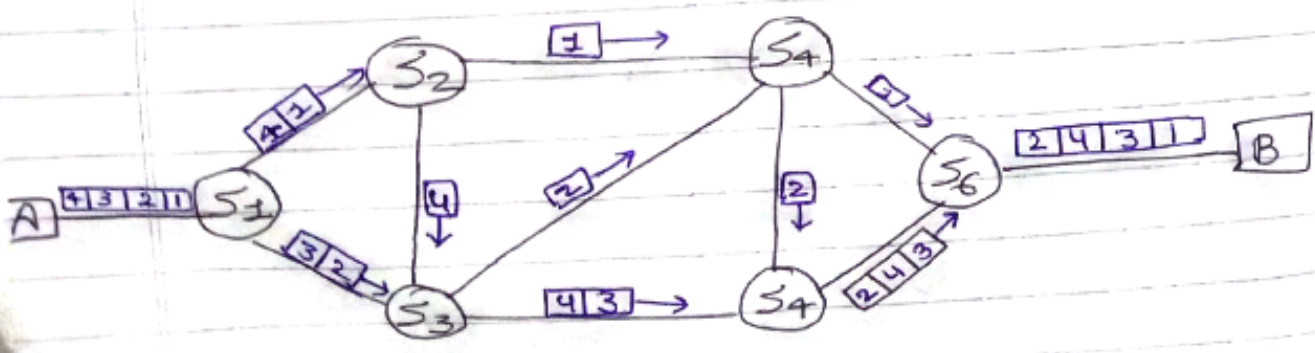


### 3. Packet Switching :-

Packet switching is a switching technique in which message are divided into smaller unit called packet, and they are send individually. The message splits into smaller pieces know as packets and packets are given a unique number to identify their order at the receiving end. Every packet contains some information in its headers such as a source address, destination address and sequence number.

Packets will travel across the network, taking the ~~st~~ shortest path as possible. All packets are ~~resamble~~ reassemble at the receiving end in correct order.

NOTE :- If any packet is missing or corrupt then the message will be send to resend the message. If the correct the order of the packet is reached then the acknowledgement message will be send.



Error detection  
technique is used to detect the error from the data which is transmitting. When data is transmitted from one device to another device the system does not guarantee whether the data received by device is identical to the data transmitted by another device. An error is a situation when the message received at the receiving end is not identical to the message to the message transmitting.

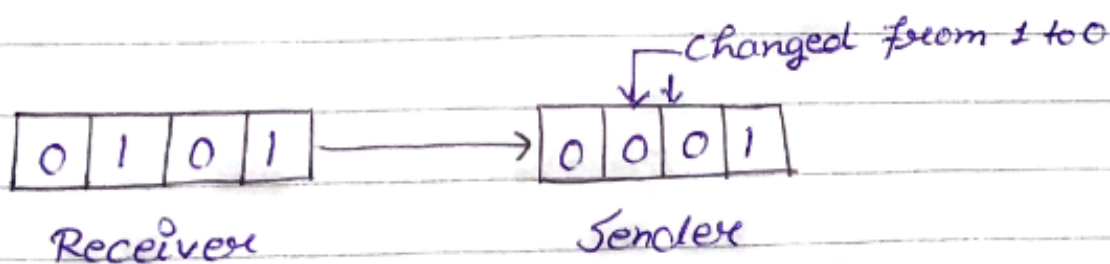
### Types Of Error :-

There are two types of error which are given below

1. Single bit error
2. Burst error

### 1. Single Bit Error :-

Only one bit of a given data unit is changed from 1 to 0 or 0 to 1.



In the above diagram the message which is corrupted as a single bit

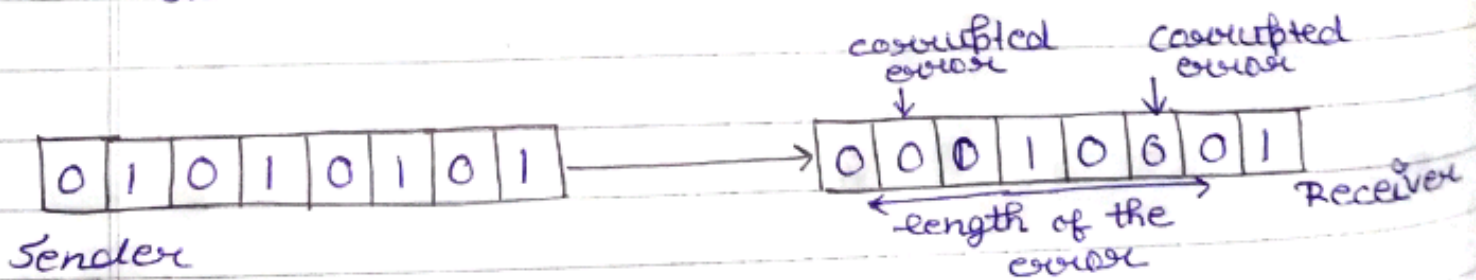
⇒ Single bit error does not appear more likely in serial data transmission.  
 For example → Sender send the data at 10 Mbps this means that the bit last only for 1 or 0. If 0 changed to 1 or 1 changed to 0 as called single bit error. ⇒ Single bit error mainly occurs in parallel data transmission.  
For Example:-

If 8 wires are used to send the data the 8 bits of a byte, if one of the wire is noisy then single bit is corrupted per byte

## 2. Burst Error:-

The two or more bits are changed from 1 to 0 or 0 to 1 is known as burst error.

The burst error is determine from the first corrupted bit to the last corrupted bit.



In the above diagram we can show the duration of noise in burst error is more than the duration of noise in single bit error.

The number of affected bits depends on the duration of the noise and data rate.

## Error Correction :-

Error correction codes are used to detect and correct the errors when data is transmitted from the sender to the receiver. Error correction can be handled in two ways.

1. Backward Error Correction
2. Forward Error Correction

### 1. Backward Error Correction :-

Once the error is discovered, the receiver requests to the sender for retransmitting the data. On the other hand, if receiver finds out the error in the data unit or entire data then receiver sends an acknowledgement to the sender to retransmit the data, and sender sends the data again.

### 2. Forward Error Correction :-

In this case the receiver uses the data correcting algorithm to correct the data which is ~~correct~~ corrupted. Some of the correcting algorithms are single parity check, long parity check, check -

and soon.

## Line Discipline :-

Line discipline is a functionality of the data link layer that provides a coordination among the link system. It determine which device can send data and when it can send data.

Line discipline can be achieve in two ways.

1. ENQ/ARQ
2. Poll/Select

### 1. ENQ/ARQ :-

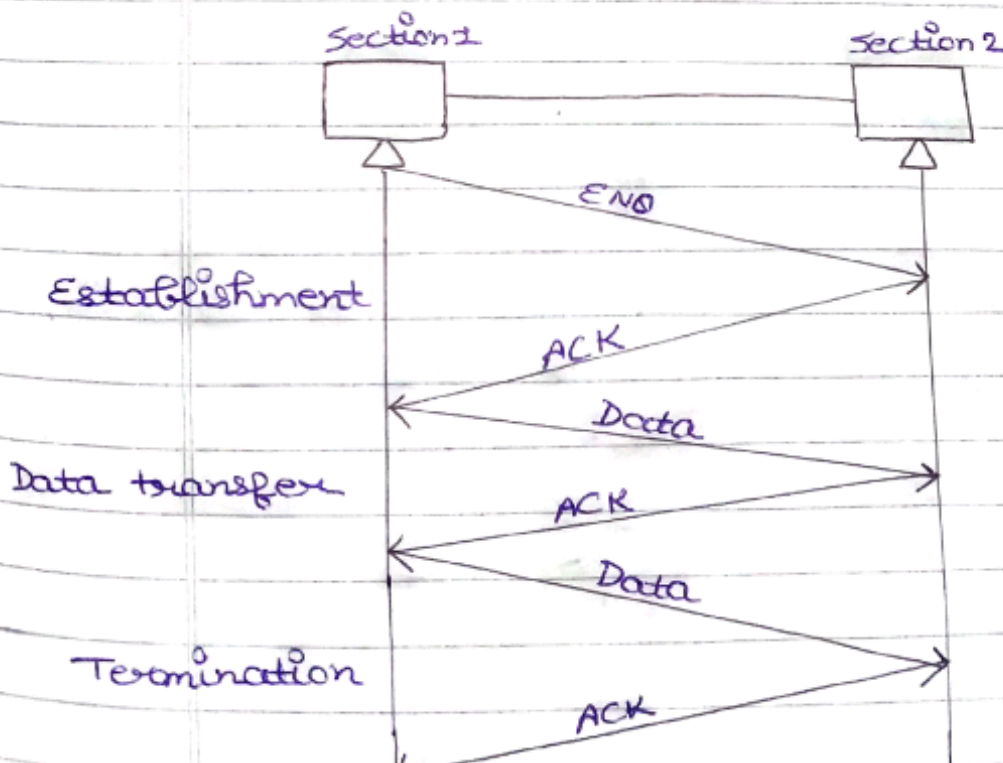
AN ENQ/ARQ stands for Enquiry / Acknowledgement is used when there is no wrong receiver available on the link and having a dedicated path between two devices so that the device capable of receiving the transmission, is the intended one.

ENQ/ARQ or ENQ/ACK coordinates which device will start the transmission and whether the recipient is ready or not. The transmitted transmit the frame called an enquiry (ENQ) asking whether the receiver is available to receive the data or not.

The receiver responses either with the positive acknowledgement or with the negative acknowledgement. where positive acknowledgement means that the receiver

is ready to receive the transmission and negative acknowledgement means that the receiver is unable to accept the transmission.

- ⇒ If the response to the ENQ is positive, the sender will transmit its data and once all of its data has been transmitted. The device finishes its transmission with an EOT (End of transmission) frame.
- ⇒ If the response to the ENQ is negative, then the sender will restart the transmission at another time.
- ⇒ If the response is neither negative nor positive the sender assume that the ENQ frame was lost during the transmission and max three attempt to establish a link before giving up.

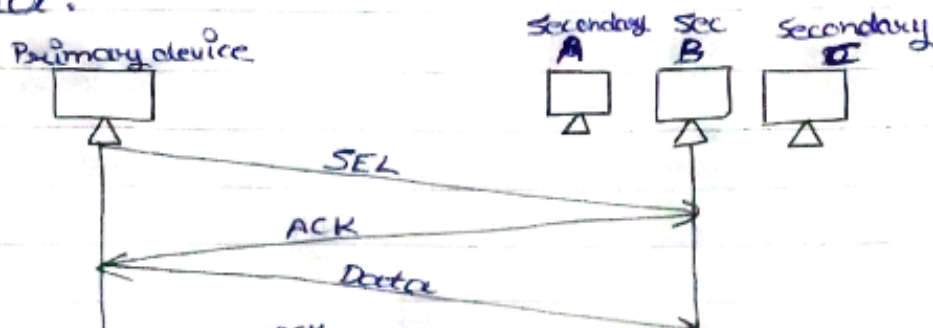


## 2. Poll/Select :-

In this, the primary device & multiple secondary devices consist of a single transmission line, & all the exchange are made through the primary device even those the destination is a secondary device.

- ⇒ The primary device has control over the communication link, and the secondary devices follow the instruction of the primary device.
- ⇒ The primary device determines which device is allow to use the communication channel.
- ⇒ Therefore we can say that it is an critical - task of the selection.
- ⇒ If the primary device want's to receive the data from the secondary device, it asked the secondary device that they have anything to send, this process is know as polling.

If the primary device want's to send some data to the secondary device, then it tells the target secondary device to get ready to receive the data, this process is known as selecting. The select mode is used when the primary device has something to send.



## Flow Control :-

It is a set of process - or that tells the sender how much data it can transmit. The receiving device has limited speed and limited memory to store the data. Therefore the receiving device must be able to inform the sending device to stop the transmission temporarily before the limit are reached. It requires a buffer, a block of memory for storing the information until they are process.

There are two ways to control the flow of data which are given below.

### 1. Stop-and-wait :-

In the stop-and-wait method, the sender gets wait waits for an acknowledgement after every frame it sends. When acknowledgement is received, then only next frame is send. The process of alternately sending and waiting of a frame continues until the sender transmits the EOT (End of transmission) frame.

### Advantage of Stop-and-wait :-

The stop-and-wait method is simple as

## Disadvantage of Stop-and-wait:-

Stop-and-wait technique is efficient to use as each frame must travel across all the way to the receiver. and an acknowledgement travels all the way before the next frame is send. Each frame send and receive use the entire time needed to traverse the need time link.

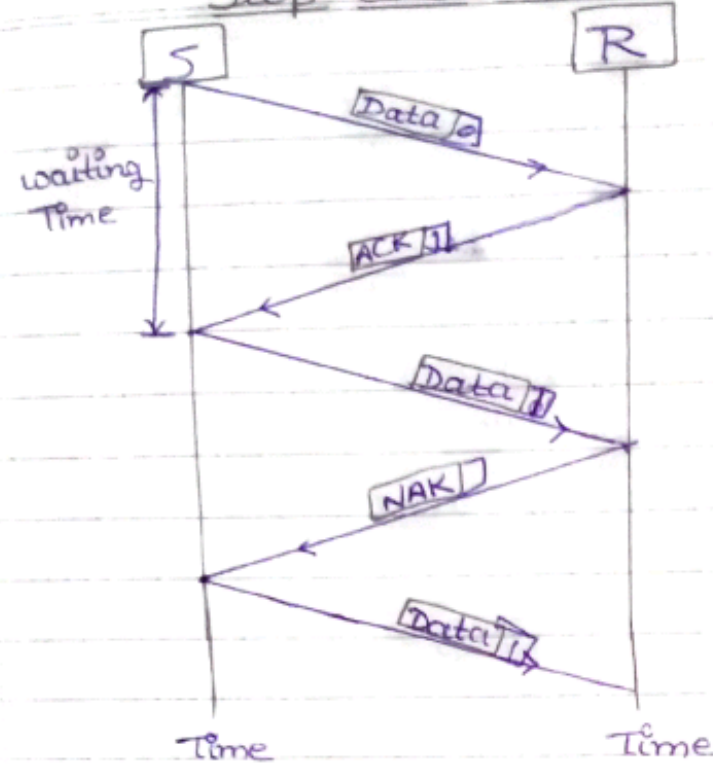
## 2. Sliding Window:-

The sliding window is a method of flow control in which a sender can transmit the data or frame before getting an acknowledgement. In sliding window control, multiple frame can be send one after the another due to which capacity of the communication channel can be utilized efficiently.

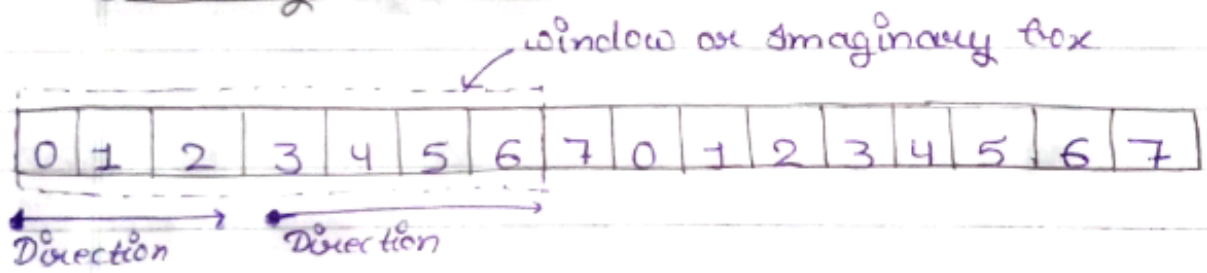
NOTE:- A single acknowledgement (ACK) multiple frame.

Sliding window refers to imaginary at both the sender<sup>end</sup> and receiver end the window can hold the frames at either end and it provides the upper limit on the numbers of frames that can be transmitted before the ACK. Frames can be ~~ACK~~ acknowledged even when the window is not completely field filled.

### stop-and-wait



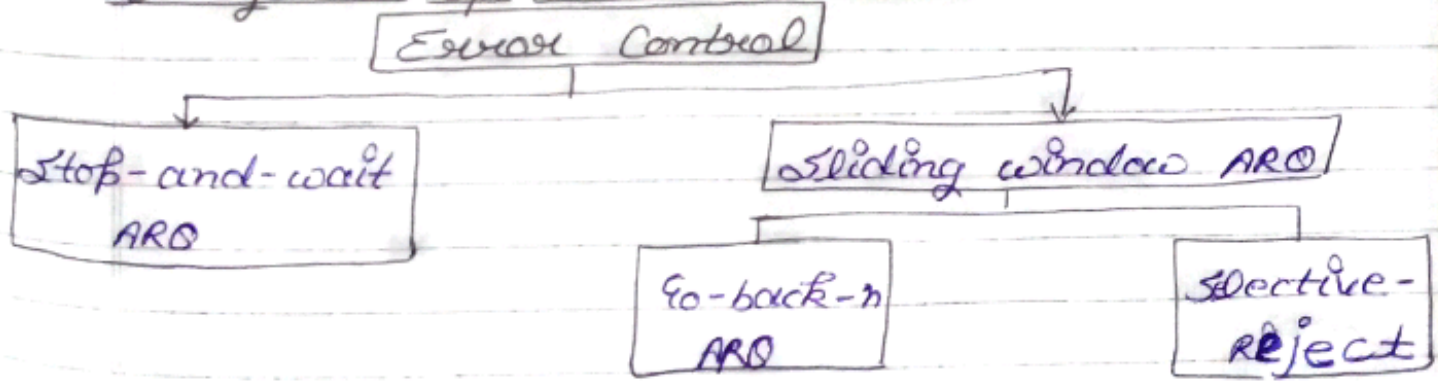
### Sliding Window :-



### Error Control :-

Error Control is a technique of error detection and retransmission.

### Categories Of Error Control :-



## 1. Stop-and-wait ARQ :-

Stop-and-wait ARQ is a technique used to retransmit the data in case of damage or lost frame.

This technique works on the principle that the sender will not transmit the next frame until it receives the acknowledgment of the last transmitted frame.

Four features are required for the retransmission :-

i) The sending device keeps a copy of the last transmitted frame until the acknowledgment is received. Keeping the copy allows the sender to retransmit the data if the frame is not received correctly.

ii) Both the data frame and the acknowledgment alternate 0 and 1. So that they can be identified individually. Suppose data 1 frame acknowledgment the data 0 frame means that data 0 frame has been received correctly and expects to receive data one frame.

iii) If an error occurs in the last transmitted frame then the receiver sends the ~~no~~ NAK (Negative Acknowledgement) frame which is not numbered. On receiving the NAK frame sender retransmits the data.

iv) It works with the timer. If the ACK is not received within the allocated time

is lost during the transmission so it will retransmit the frame.

## 2. Sliding Window ARQ :-

Sliding window ARQ is a technique used for continuous transmission error control.

Three features used in transmission.

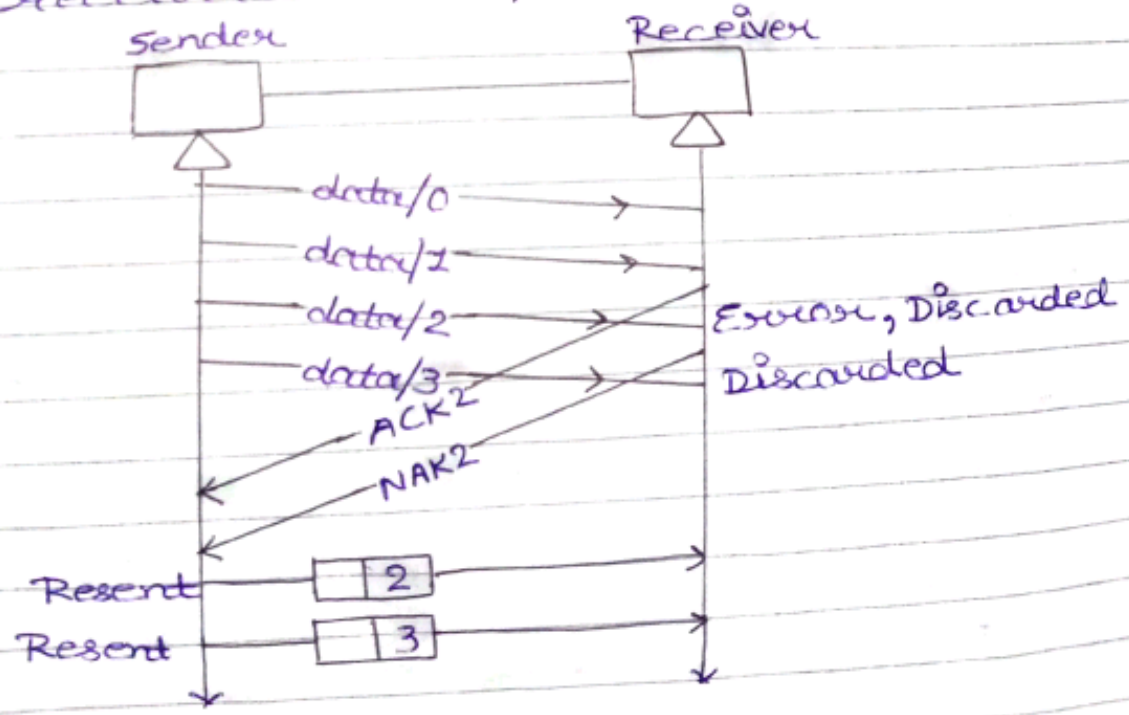
1. In the sliding window ARQ, the sender keeps the copies of all the transmitted frames, until they have been acknowledged. Suppose the frame from 0 to 4 have been transmitted and the last ACK was for frame 2. The sender has to keep the copies of frames three and four until they receive correctly.
2. The receiver can send either positive ACK or negative ACK (NAK) depending on the condition. The NAK frame tells the sender that the data have been received damaged. Since the sliding window is a continuous transmission mechanism both ACK and NAK must be numbered for the identification of a frame. The ACK frame consist of a number that represents the next frame which the receiver accepts to receive. The NAK frame consist of a number that represents the damaged frame.

3. The sliding window ARQ is occupied with the timer to handle the last ACK. Suppose then  $n-1$  frames have been send before receiving any ACK. The sender waits for the ACK so it starts the timer and wait before sending any frame. If the allocated, run out the sender retransmits one or all the frames depending on the protocol used.

Two Protocol used in sliding window ARQ

i) Go-Back-n ARQ :-

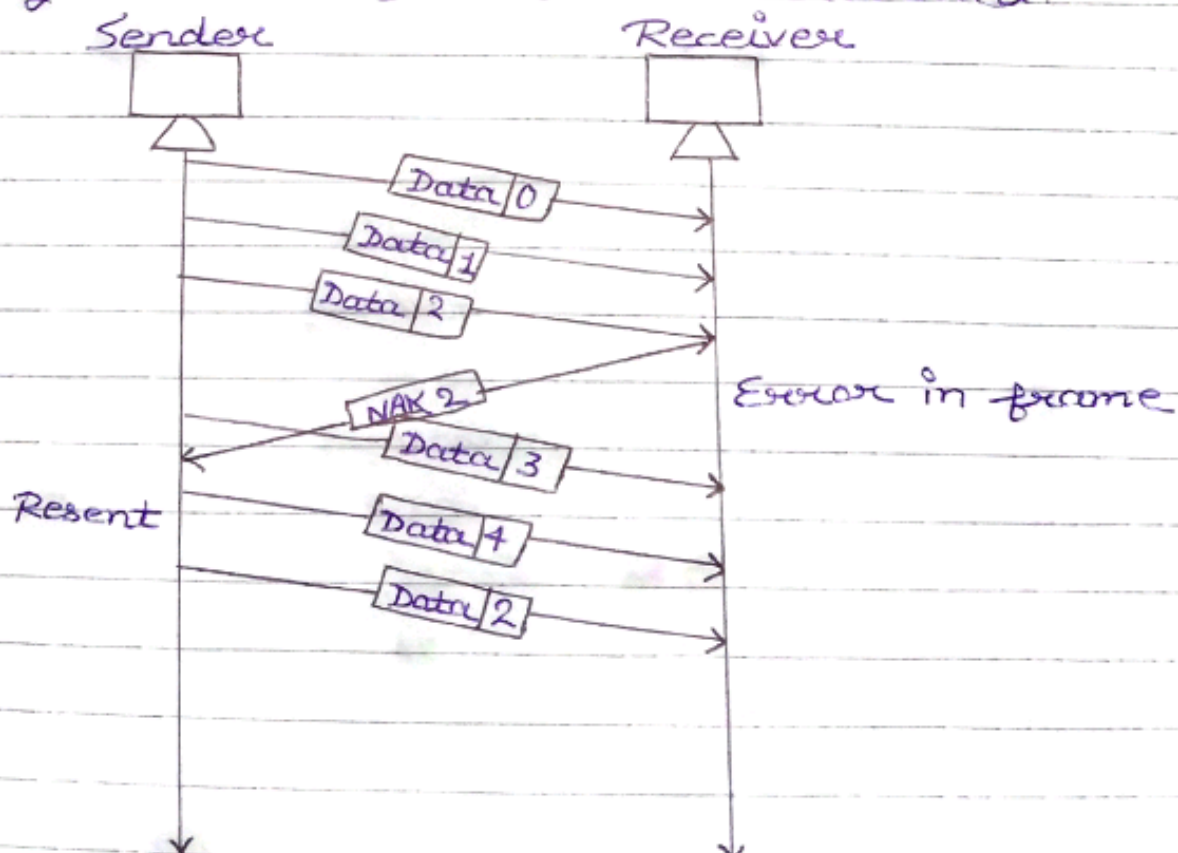
In go-back-n ARQ protocol, if 1 frame is lost or damage, then it retransmit all the frames after which it does not received the positive ACK.



In the above diagram, 3 frames have been transmitted before an error occurred in the 3 frame. In this case, ACK 2 has been returned telling that the frame 0, 1 have been received successfully without any error. The receiver discovers the error in data/2 frame so it returns the NAK 2 frame. The frame 3 is also discarded as it transmitted after the damaged frame. Therefore the sender retransmits the frame 2 and 3.

## ii) Selective - Reject ARQ :-

Selective Reject ARQ technique is more efficient than Go-back-n ARQ. In this technique only those frames are retransmitted for which negative acknowledgement (NAK) has been received.



## Protocol :-

In computer networking a protocol is a set of rules for formatting and processing data. A protocol is a set of rules and a guideline for communicating data. There are different types of protocol which can be used in networking.

For Example :- Point-to-point protocol, Transfer Control protocol, Internet protocol, Hyper text transfer protocol and etc.

## ★ Point-to-Point Protocol :-

Point-to-point Protocol (PPP) is a protocol that is used to connect one computer system to another computers use point-to-point protocol (PPP). Comps to communicate over the telephone network are the inter-net.

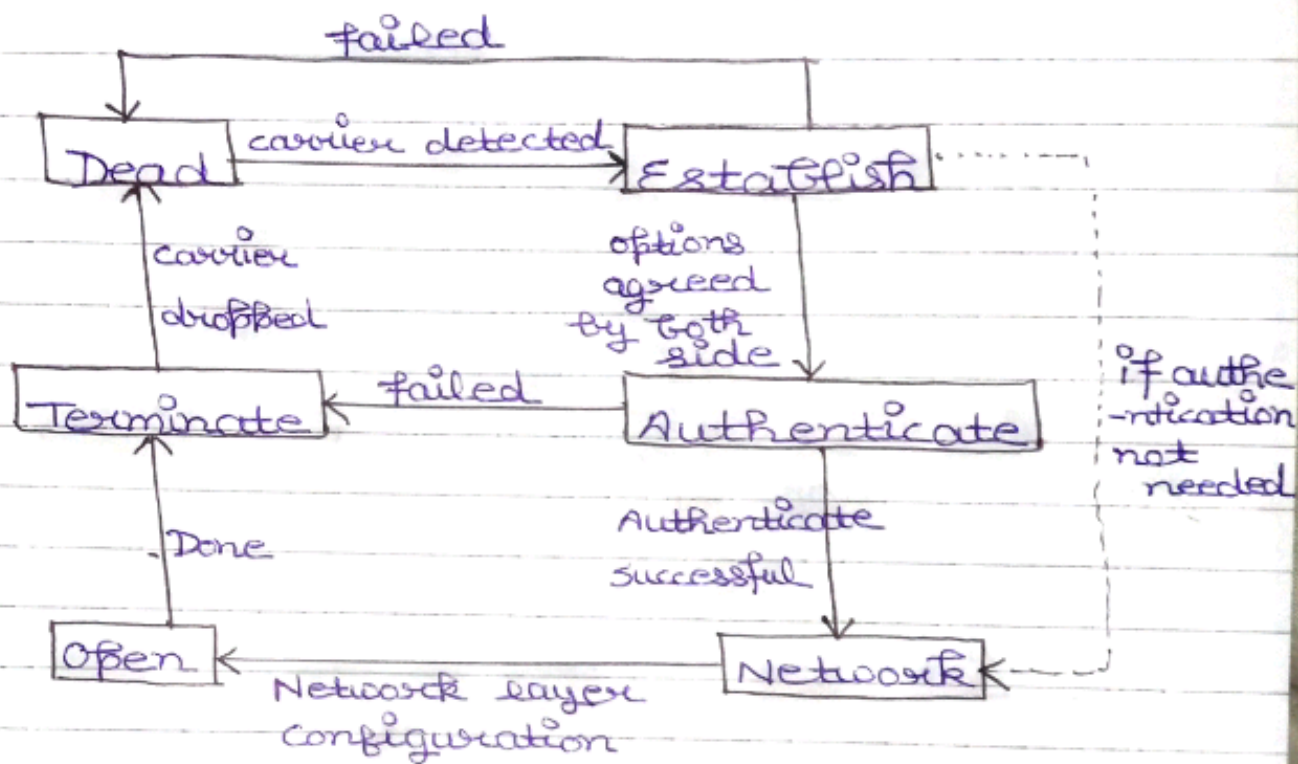
A PPP connection exist when two system physically connect through a telephone line. You can use PPP to connect one system to another.

For Example :- An establish PPP connection between a branch office and a central office allows either office to transfer data to the other through the network.

In computer networking PPP is a data link layer communication protocol between two devices directly.

without any host or any other networking in between.

## Transition Phases Of Point-to-Point Protocol :-



### 1. Dead :-

Dead is transition phase which means that the link is not used as there is no active carrier at the physical layer.

### 2. Establish :-

If one of the nodes start working then the phase goes to the establish phase. In short we can say that when the node start communication or carrier is detected then it moves from the dead to the established phase.

### 3. Authentication :-

It is an optional phase which means the communication can also move to the authenticate phase.

The phase moves from the establish to the authenticate only when both the communicating nodes agree make the communication authenticated.

### 4. Network :-

Once the authentication is successful the network is established and phase is in network. In this phase is the negotiation of network layer protocol take place.

### 5. Open :-

After establishment of the network phase it moves to the open phase and communication take place.

### 6. Terminate :-

If the authentication phase become fail this phase is execute - ~~at~~ in other words the terminate phase is active if the authentication phase fail or open phase is completed steps of Point-to-Point Protocol.

### Link Control Protocol :-

The goal of

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links. LCP is considered a data link layer protocol because it works at the data link layer of the OSI model.

Before establishing communication over a point-to-point link each end of the point-to-point link send out LCP packets. The LCP packet either accept or reject the identity of its link. Agree upon packet size limit and look for communication miss configuration errors. It checks the connection to see whether its good ~~is~~ enough to sustain data transmission at the intended rate.

## ii) Authentication :-

In computing authentication is the process of ~~very~~ ~~fi~~ verifying of a person or device. A common example is entering the a user name & password when you login to a website.

Entering the correct login information ~~lets~~ the website know who you are that is actually you ~~exersing~~ accessing the website. While a user name or password combination is a common way to authenticate your identity, many other types of authentication exist.

for ex → You might use a 4 or 6 digit passcode to unlock your phone. A single password may be required to log on to your laptop or work

mail server verifies your identity by matching your email address with the correct password. This information is often saved by your web-browser or email program so you do not have to enter it each time.

⇒ Biometrics may also be used for authentication.

for Example → Many smartphones have a fingerprint sensor that allow you to unlock smartphone with a simple tap of your thumb or finger.

### iii) Network Control Protocol (NCP):-

After the establishment of the link and authentication the next step is to connect to the network layer. To point-to-point use another protocol known as NCP.

The NCP is a set of protocols that facilitate the encapsulation of data which is coming from the network layer to the point-to-point frames.

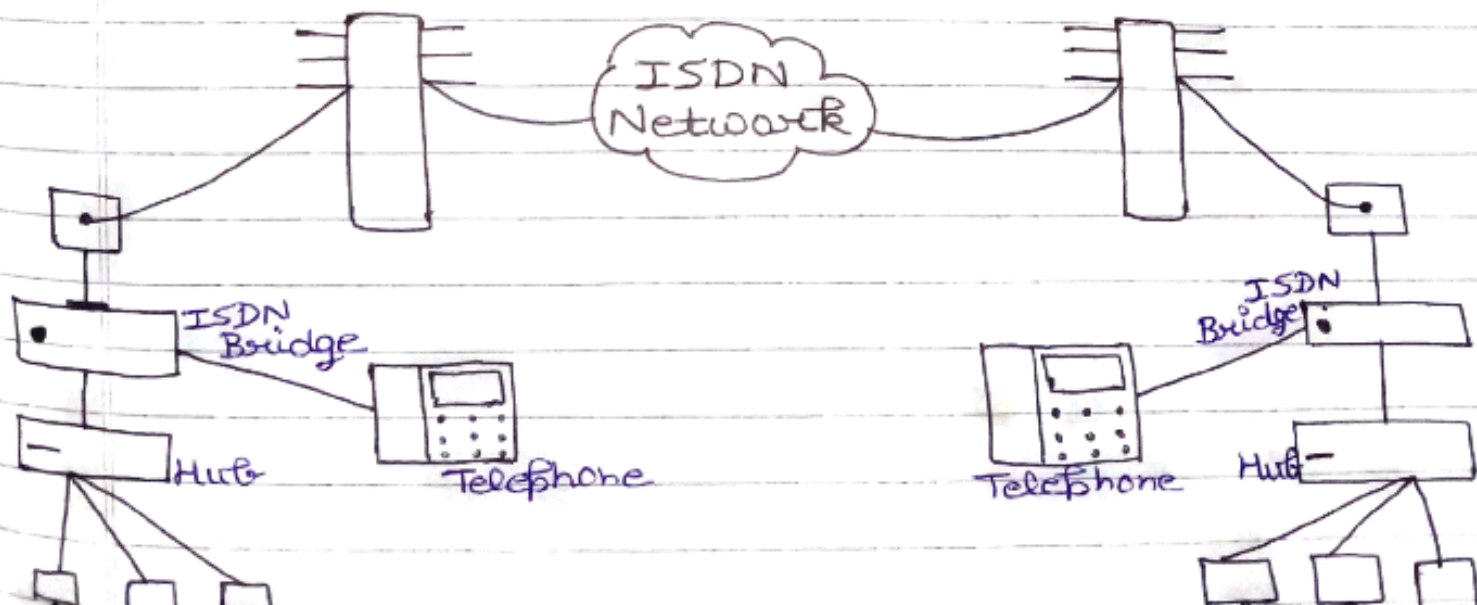
### ISDN :-

ISDN stand for Integrated services digital network. It is the name for Digital telephone service that works over existing copper telephone wire. Thus ISDN is the high speed service.

ISDN was developed by ITU (International telecommunication Union) in 1980. It is a set of protocols that combines digital telephony and data transport service. ISDN permits voice, data, text, graphic, music, video and other resources material to be transmitted over existing telephone wire.

### Advantage of ISDN :-

1. It offers multiple digital services that operate through the same copper wire.
2. It provides digital signals broadcast through telephone lines.
3. ISDN provides a higher data transfer rate.
4. It can connect devices and allow them to operate over a single line.  
For example → fax machine.
5. It is running faster than other models.



## Types Of ISDN:-

There are two types of ISDN networks which are given below.

### 1. BRI:-

BRI stands for Basic Rate Interface. It is the lower tier of service. It only provides basic needs at a lower cost.

### 2. PRI:-

PRI stands for Primary Rate Interface. It is the main service it provides a better connection, more reliable service and faster speed.

## Services Of ISDN:-

There are three services provided by ISDN which are given below.

### 1. Bearer Services:-

These services are used to transfer the data or information b/w user. Bearer service correspond to the first three layers of OSI model.

### 2. Telex Services:-

Telex services refers to the telephony services in other words we can say that in these type of services all the telephony are performed.



Date \_\_\_\_\_

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like voice calling, telfax and soon.

3. Elementary Services:-

It is a additional functionality of the ISDN. →  
for Ex → Call waiting, call diverted, message handling etc.

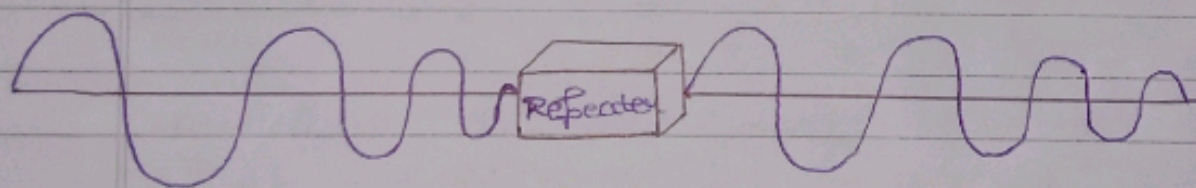
Devices:-

A Network device is a node in the wire & wireless message network. It can transmit & receive wireless HART data and perform the basic function.

1. Repeater:-

Repeaters are network devices operating at physical layer of the OSI model the regenerated incoming signals before retransmitting.

Repeaters are also known as signal booster. In other words a repeater is a network device that is used in transmission system to regenerate signal distorted by transmission loss.



Advantage:-

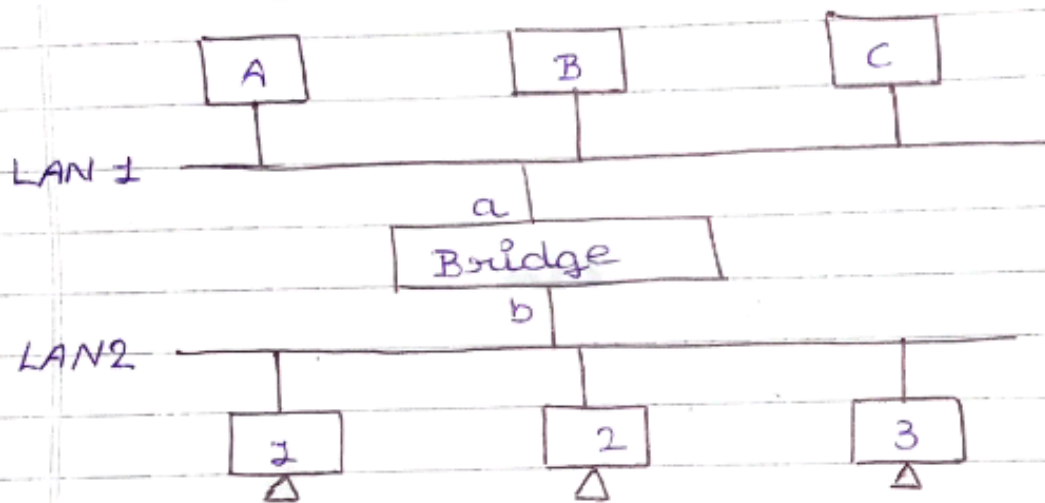
1. Repeaters are simple to install and can easily extend the length or the coverage area of a network.
2. Repeaters are cost effective.

Disadvantage:-

1. ~~Repeaters~~ Repeaters can not differentiate b/w actual signal & noise.

## 2. Bridge :-

Bridge also a network device that connects multiple LANs together to form a larger LAN (Local area network). A bridge connects the different computers so that they appear as parts of a single network. Bridge operates at the data link layer of the OSI model.



## Advantage Of Bridge :-

1. The length of the network can be increased.
2. Collision can be reduce.

## Disadvantage :-

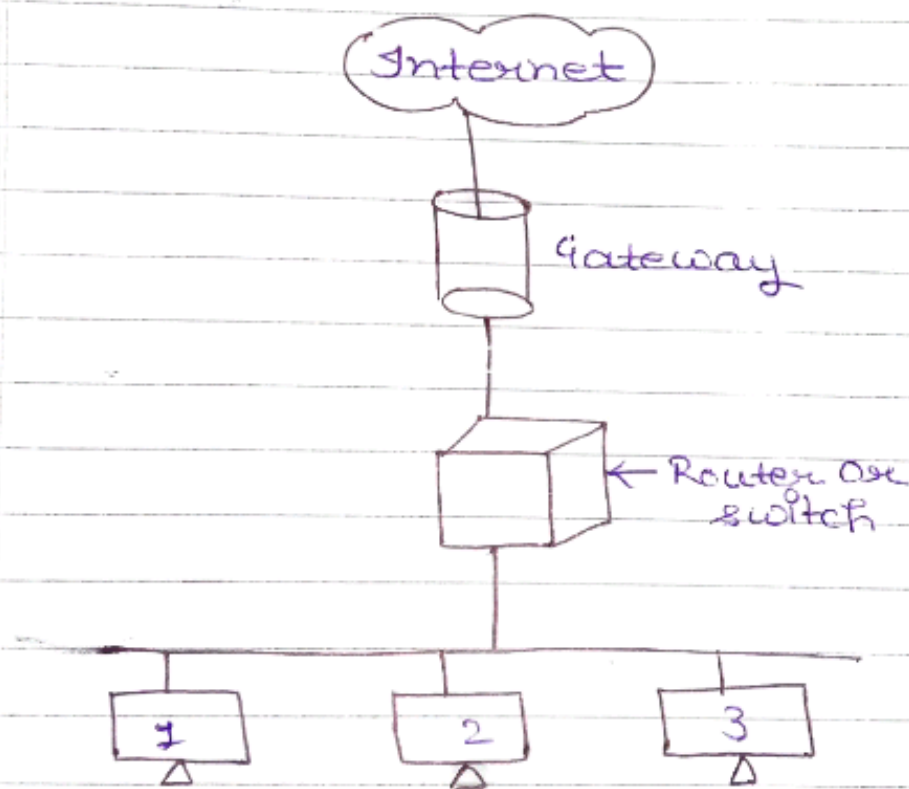
1. Slower than repeater.
2. Expensive as compare to repeater.

## 3. Gateway :-

Gateway is a kind of networking device that connects two devices in different network so that they can communicate with each other.

for another network. It contains both hardware and software components. The main purpose of gateway is to control routing of different networks.

Gateway is located at the boundary of a network & manage all the data that inflow or outflow from the network. Gateway can be represented in the router in the form of software or hardware components.



### Advantage :-

1. The main benefit of gateway is the connectivity it provides. A gateway can expand the network by connecting computers with different systems together.

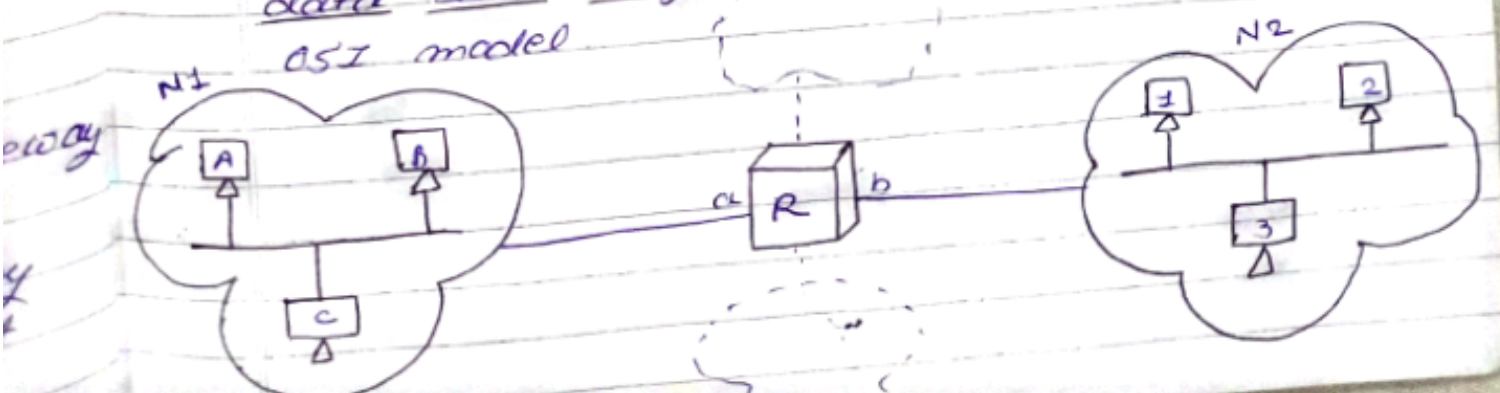
2. Gateway provide security since they allow user authentication.

Disadvantage:-

- 1. high. Implementation cost is
- 2. If there are possibility of failure occurring at the gateway it can lead to communication lost.

29/Dec | Routers :-

Routers are networking devices, they are responsible for receiving, analysing and forwarding data packet among the connected computers or networks. When the data packets arrives, the routers inspect the destination address and decide the optimal route and then transmit the packet along this route. It transfers data in the form of IP packets. In order to transmit data it uses IP address mention in the destination field of the IP packets. Routers operates at the physical layer, data link layer and network layer of OSI model.



## Advantages:-

1. Router is useful to reduce network traffic because it provide dynamic routing method.
2. A router is enabled with packet switching and packet filtering services.

## Disadvantages:-

1. Router has less speed compare to repeaters.
2. Routers are expensive compare to other networking hardware devices like repeater switch.

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## Quality Of Services:-

Quality of service is the description or measurement of the all performance of a service such as a telephony, computer network services. Particularly the performance seen by the user of the network. The quantitative measure quality of service several related aspects of the network service are often consider such as packet loss, bitrate, through put, transmission delay etc.

In the field of computer networking and other teley communicate network quality of service refers to traffic and resource reservation control mechanism either then the achieve service quality.

In the case of networking implies the ability of a network to provide reliable service to the traffic over various technology for example - either net, wireless network etc.

## Ways To Improve Quality Of Services:-

There are number of ways to improve quality of services for a network based application and they are explained below.

1. Use protocols to know the best way to implement a network based application.
2. Use the best and intelligent routing algorithm.
3. Always try to separate functionality to different layer of the network.

Quality of service is the overall performance according to many users of a service over a network. QoS is that technique technology which reduce the packet loss and traffic.

## Parameters Of Quality Of Services:-

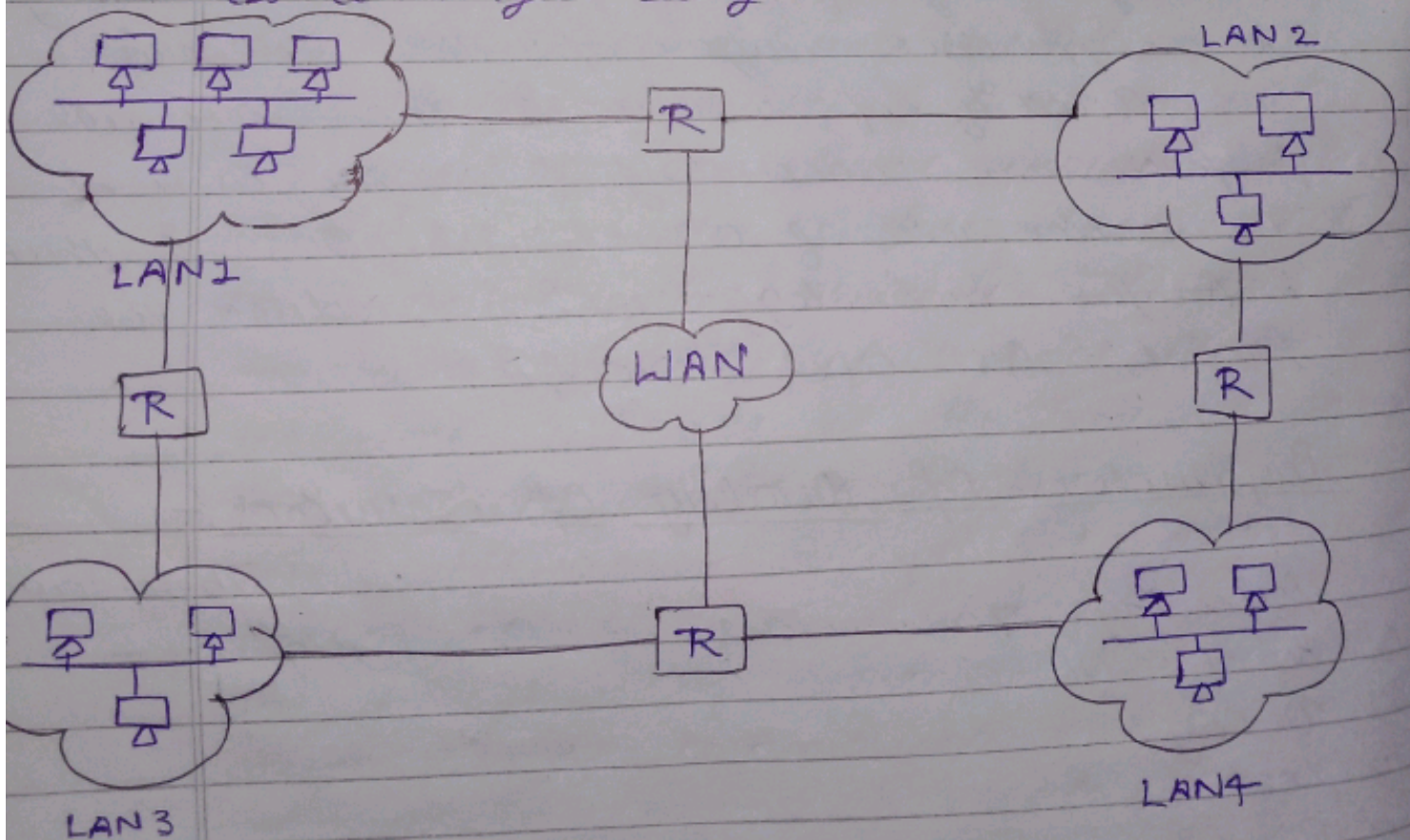
There are following parameters of QoS such as -

- i) Bandwidth
- ii) Delay
- iii) Loss rate
- iv) Blocking probability

# Internetworking :-

Internetworking is the process or technique of connecting different networks by using connecting devices such as routers or gateway devices. The standard reference model for internetworking is open system interconnection (OSI). Any interconnection among or between public, private, commercial, industrial or governmental computer networks may also be define as an interconnection or internetworking.

An internetwork is a connection of individual network connected by inter-mediate networking devices that function as a single large network.



## Requirement of Internetworking :-

1. Provide a link between networks. At minimum, a physical and link control connection is needed.
2. Provide for the Routing and delivery of data between process on different networks.
3. Provide an accounting service that it track of the use of the various networks - R's and routers and maintain status information.

New Year  
03/Jan/2022

## Network Layer :-

The network layer is the third layer of the OSI model. It handles the service request from the transport layer and further forwards the service request to the data link layer.

The network layer translate the logical <sup>(IP) (Host-to-host)</sup> address into physical <sup>(MAC address) (P-to-P Conn)</sup> addresses. It determines the route from the source to destination and also manage the traffic problem such as switching, routing and controls the congestion of data packets. The main goal of the network layer is to move the packet from sending host to the receiving host.

The main functions perform by the Network Layer :-

function performed by the network layer which are given below.

### 1. Routing :-

When a packet reaches the routers input link the router will move the packet to the router output link.

Example :- A packet from  $S_1$  to  $R_1$  must be forwarded to the next router on the path to  $S_2$ .

### 2. Logical Addressing :-

The data link layer implements the physical addressing & network layer implements the logical addressing. Logical addressing is also used to distinguish between source and destination system. The network layer adds a header to the packet which includes the logical addresses of both the sender and the receiver.

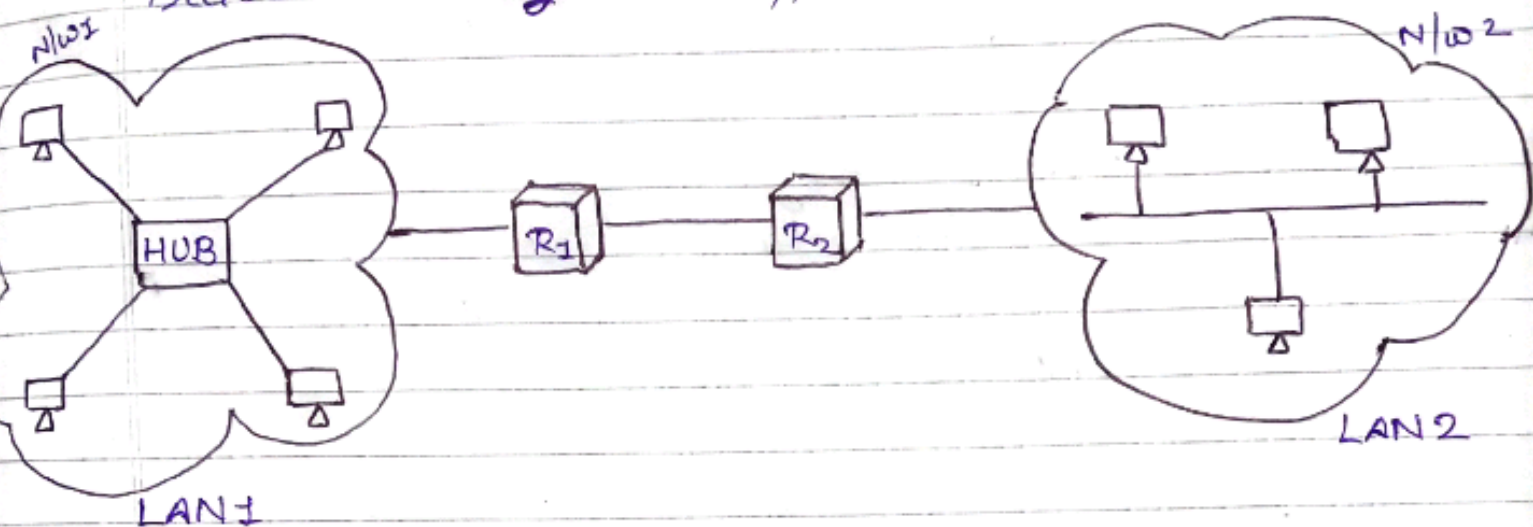
### 3. Internetworking :-

This is the main role of the network layer that it provides the logical connection b/w different types of network.

### 4. Fragmentation :-

The fragmentation is a process of breaking the packet into the

smallest individual data units that travel through different network.



### Routing Algorithm :-

In order to transfer the packet from source to destination the network layer must determine the best route through which packets can be transfer.

The main job of the network layer is to provide the best route. The routing protocol provides this job. The routing protocol is a routing algorithm that provides the best path from the source to the destination. The best path is the path that has the least cost path from source to the destination.

Routing is the process of forwarding the packet from source to the destination.

The best path is the best path to send the packet is determine by the routing algorithm.

# Classification of a Routing algorithm:-

The routing algorithm is divided into two categories such as.

1. Adaptive routing algorithm.
2. Non-adaptive routing algorithm.

## 1: Adaptive Routing Algorithm:-

An routing algorithm is also known as dynamic R.A. This algorithm makes the routing decision based on the topology and network traffic. The main parameters related to this algorithm are distance and estimated transmitted time.

## 2. Non-Adaptive Routing Algorithm:-

The Non-A. R.A is also known as a static routing algorithm. When routing up the network, the routing information stores to the routers. Non-adaptive R.A. do not take the routing decision based on the network topology or network traffic.

## Congestion :-

Congestion is an important issue that can arise in packet switch network. Congestion is a situation in communication network in which too many packets are present in a part of sub-net, performance degrades.

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Congestion in a network may occur when the load on the network is greater than the capacity of the network. Network congestion occurs in case of traffic overloading. In other words when too much traffic is offered congestion sets in and performance degrades sharply.

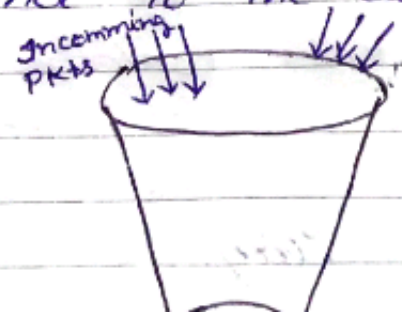
### Congestion Control Algorithm:-

There are two congestion algorithms which are as follows.

1. Leaky Bucket Algorithm
2. Token Bucket Algorithm.

#### 1. Leaky Bucket Algorithm:-

The L.B.A. discovers its use in the context of network traffic. The algorithm allows controlling the rate at which a record is injected into a network and managing burstiness in the data rate. A LBA and a Token bucket algorithm are used for traffic shaping in the network. The LBA is used to control the network rate at which traffic is sent to the destination.



In the above diagram a bucket with a volume of  $B$  bits and a hole in the bottom is considered. If the bucket is ~~is~~ null it means  $B$  bits are available as storage. A packet with a size smaller than  $B$  bits arrives at the bucket and will forward it. If the packet's size increases more than  $B$  bits, it will either be discarded or queued. It is also considered that the bucket leaks through the hole in its bottom at a constant rate of ~~one~~  $R$  bits per second.

## 2. Token Bucket Algorithm:-

The Leaky B.A has a regulated output design at the average rate independent of the bursty traffic. In some application when large burst arrive the output is allowed to speed-up. Therefore a TBA finds its issue in network traffic shaping or rate limiting.

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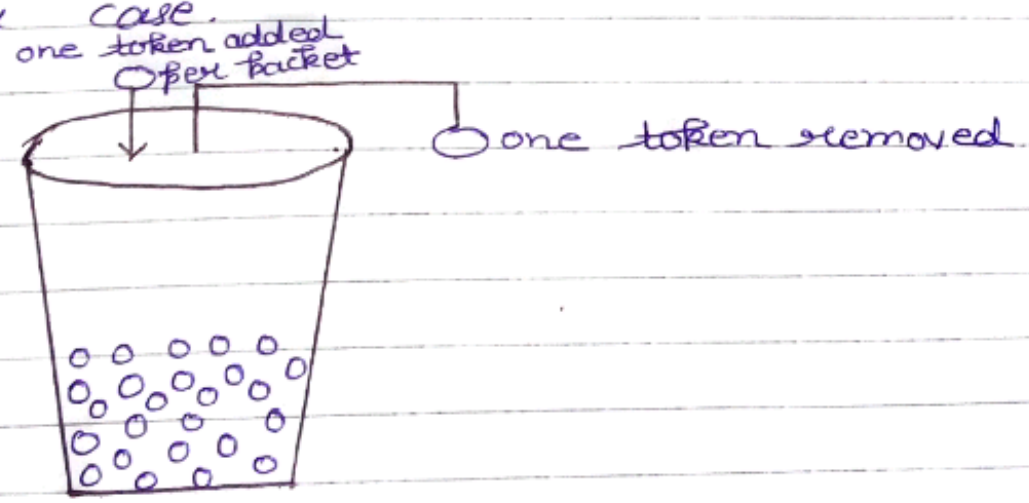
It is a control algorithm that indicates when traffic should be sent. This order comes based on the display of token in the bucket. The bucket contains token each of the tokens defines a packet of fixed ~~size~~ - ~~mine~~ size. Tokens in the bucket are deleted for the availability to share a packet.

When tokens are shown, a follow to

transmit traffic appears in the display of tokens. No token means no flow sends its packets. Hence a flow transmits traffic upto its peak burst rate in good token in the bucket.

Thus the token bucket algorithm adds a token to the bucket each  $1/r$  seconds. The volume of the bucket is  $B$  tokens. When a token appears, and the bucket is complete, the token is discarded. If a packet of  $N$  bytes appears and  $N$  tokens are deleted from the bucket, the network forwards the packet.

When a packet of  $N$  bytes appears but fewer than  $N$  tokens are available, no tokens are removed from the bucket in such a case.

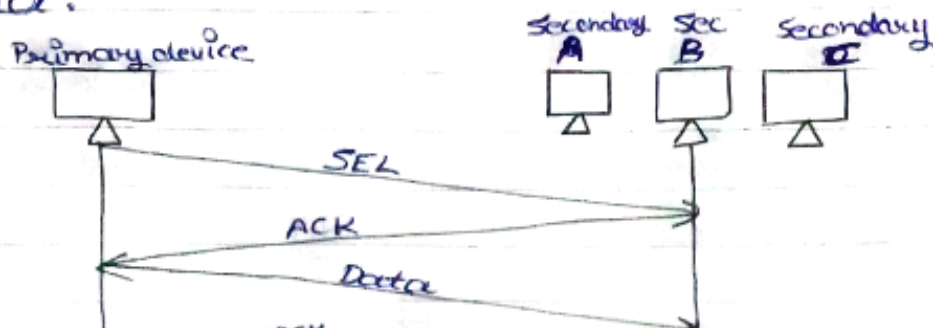


## 2. Poll/Select :-

In this, the primary device & multiple secondary devices consist of a single transmission line, & all the exchange are made through the primary device even those the destination is a secondary device.

- ⇒ The primary device has control over the communication link, and the secondary devices follow the instruction of the primary device.
- ⇒ The primary device determines which device is allow to use the communication channel.
- ⇒ Therefore we can say that it is an critical - task of the selection.
- ⇒ If the primary device want's to receive the data from the secondary device, it asked the secondary device that they have anything to send, this process is know as polling.

If the primary device want's to send some data to the secondary device, then it tells the target secondary device to get ready to receive the data, this process is known as selecting. The select mode is used when the primary device has something to send.



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## **Session Layer in OSI model**

## **Introduction :**

The Session Layer is the 5th layer in the Open System Interconnection (OSI) model. This layer allows users on different machines to establish active communications sessions between them. It is responsible for establishing, maintaining, synchronizing, terminating sessions between end-user applications. In Session Layer, streams of data are received and further marked, which is then resynchronized properly, so that the ends of the messages are not cut initially and further data loss is avoided. This layer basically establishes a connection between the session entities. This layer handles and manipulates data which it receives from the Session Layer as well as

## **Functions of Session Layer :**

The session layer being the fifth layer in the OSI model performs several different as well as important functions which are need for establishing as well as maintaining a safe and secure connection.

Data from Presentation Layer    Session la

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Following are some of the functions which are performed by Session Layer –

allowing the process of adding checkpoints, which are considered as synchronization points to the streams of data.

- This layer is also responsible for session checkpointing and recovery.
- This layer basically provides a mechanism of opening, closing and managing a session between the end-user application processes.
- The services offered by Session Layer are generally implemented in application environments using remote procedure calls (RPCs).
- The Session Layer is also responsible for synchronizing information from different sources.
- This layer also controls single or multiple connections for each-end user application and directly communicates with both Presentation and transport

# Transport Layer

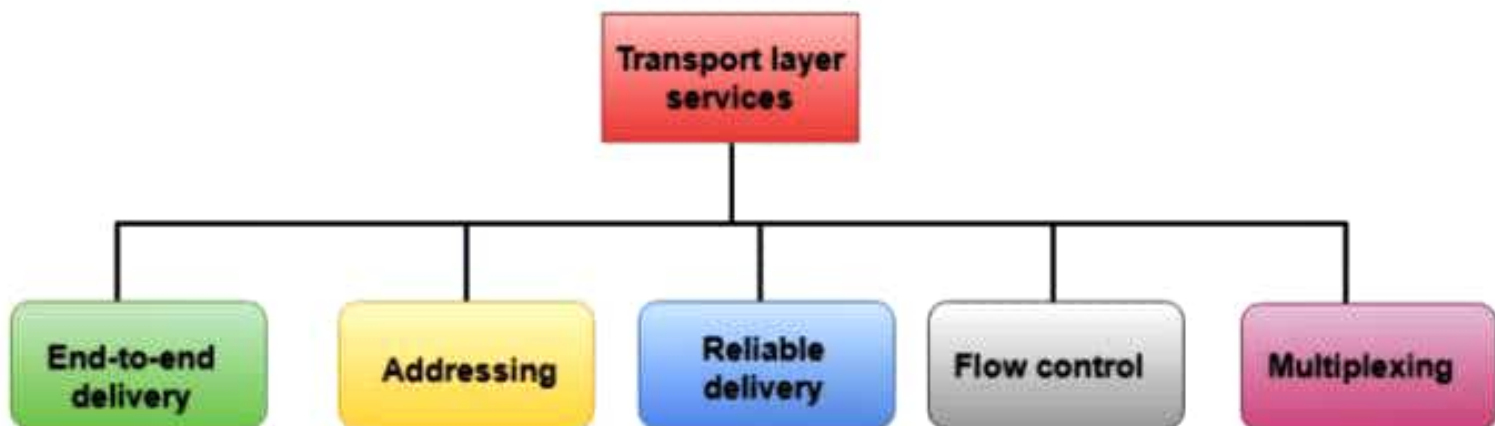
- The transport layer is a 4<sup>th</sup> layer from the top.
- The main role of the transport layer is to provide the communication services directly to the application processes running on different hosts.
- The transport layer provides a logical communication between application processes running on different hosts. Although the application processes on different hosts are not physically connected, application processes use the logical communication provided by the transport layer to send the messages to

- The transport layer protocols are implemented in the end systems but not in the network routers.
- A computer network provides more than one protocol to the network applications. For example, TCP and UDP are two transport layer protocols that provide a different set of services to the network layer.
- All transport layer protocols provide multiplexing/demultiplexing service. It also provides other services such as reliable data transfer, bandwidth guarantees, and delay guarantees.
- Each of the applications in the application layer has the ability to send a message by using TCP or UDP. The application communicates by using either of these two protocols. Both TCP and UDP will then communicate with the internet protocol in the internet layer. The

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- Each of the applications in the application layer has the ability to send a message by using TCP or UDP. The application communicates by using either of these two protocols. Both TCP and UDP will then communicate with the internet protocol in the internet layer. The applications can read and write to the transport layer. Therefore, we can say that communication is a two-way process.

# The services provided by the transport layer protocols can be divided into five categories:

- End-to-end delivery
- Addressing
- Reliable delivery
- Flow control
- Multiplexing



## End-to-end delivery:

The transport layer transmits the entire message to the destination. Therefore, it ensures the end-to-end delivery of an entire message from a source to the destination.

## Reliable delivery:

The transport layer provides reliability services by retransmitting the lost and damaged packets.

### **The reliable delivery has four aspects:**

- Error control
- Sequence control
- Loss control
- Duplication control

- The primary role of reliability is **Error Control**. In reality, no transmission will be 100 percent error-free delivery. Therefore, transport layer protocols are designed to provide error-free transmission.
- The data link layer also provides the error handling mechanism, but it ensures only node-to-node error-free delivery. However, node-to-node reliability does not ensure the end-to-end reliability.
- The data link layer checks for the error between each network. If an error is introduced inside one of the routers, then this error will not be caught by the data link layer. It only detects those errors that have been introduced between the beginning and end of the link. Therefore, the transport layer performs the checking for the errors end-to-end to ensure that

## Sequence Control

- The second aspect of the reliability is sequence control which is implemented at the transport layer.
- On the sending end, the transport layer is responsible for ensuring that the packets received from the upper layers can be used by the lower layers. On the receiving end, it ensures that the various segments of a transmission can be correctly

## Loss Control

Loss Control is a third aspect of reliability. The transport layer ensures that all the fragments of a transmission arrive at the destination, not some of them. On the sending end, all the fragments of transmission are given sequence numbers by a transport layer. These sequence numbers allow the receiver's transport layer to

## Duplication Control

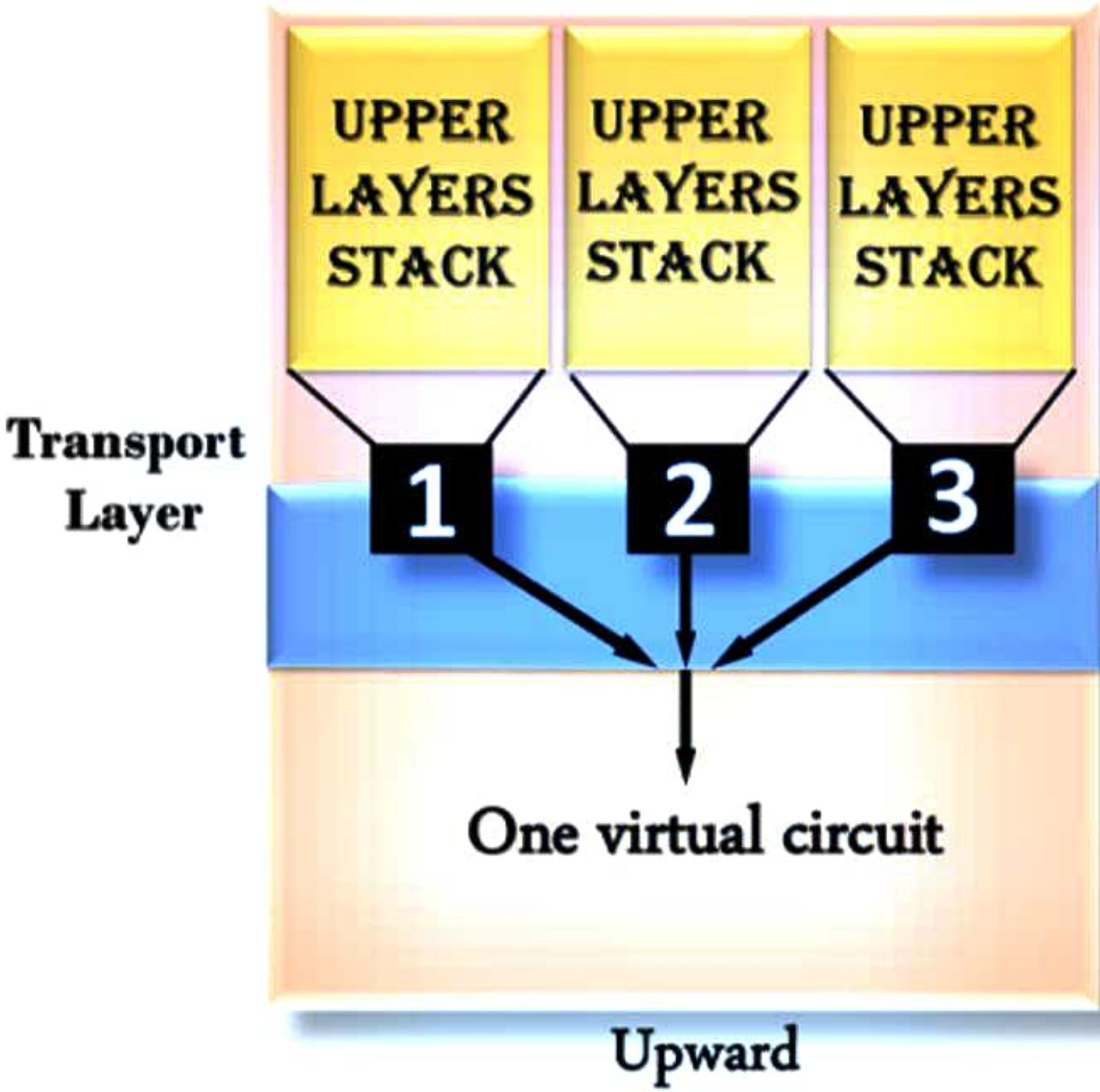
Duplication Control is the fourth aspect of reliability. The transport layer guarantees that no duplicate data arrive at the destination. Sequence numbers are used to identify the lost packets; similarly, it allows the receiver to identify and discard duplicate segments.

Flow control is used to prevent the sender from overwhelming the receiver. If the receiver is overloaded with too much data, then the receiver discards the packets and asking for the retransmission of packets. This increases network congestion and thus, reducing the system performance. The transport layer is responsible for flow control. It uses the sliding window protocol that makes the data transmission more efficient as well as it controls the flow of data so that the receiver does not become overwhelmed. Sliding window protocol

The transport layer uses the multiplexing to improve transmission efficiency.

**Multiplexing can occur in two ways:**

- **Upward multiplexing:** Upward multiplexing means multiple transport layer connections use the same network connection. To make more cost-effective, the transport layer sends several transmissions bound for the same



- **Downward multiplexing:** Downward multiplexing means one transport layer connection uses the multiple network connections. Downward multiplexing allows the transport layer to split a connection among several paths to improve the throughput. This type of multiplexing is used when networks have a low or slow capacity.

