- Andrew Tanenbaum — Computer Networks.
- Forouzen → Data communication & Networking.

- **Computer Networks** → These can be understood in terms of 4 important entities →
  1. Data communication
  2. Network
  3. Internet
  4. Protocols & Standards

  (2) & (3) — homogeneity — heterogeneity.

- There is a trade of between heterogeneity & homogeneity in case of computer networks.

- **Data Communication** → Data communication can be understood in the form of Data &

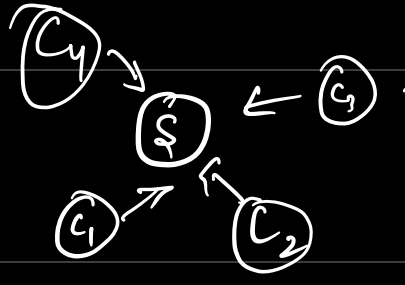
communication and is defined in terms of parameters such as
- delivery
- Accuracy
- Timeliness
- Jitter

→ Characteristics of Data communication

• Components of Data Communication

1. Sender
2. Reciever (ex- TV) (All the devices that communicate)
3. Message → It consits of Data and its types
4. Transmission Medium → Physical part through which data communication take place.
5. Protocol → set of rules.

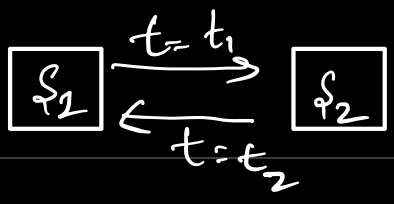
• Data Flow → 1. Simplex



↳ Data communication is unidirectional.

↳ • Client doesn't have memory & processor
• Server have know-how parameters

② Half Duplex → Each station can transmit & recieve but not at the same time.



③ Full Duplex → Transmission and reception can be done simultaneously.

• Performance Parameters → These are the parameters affecting performance of a particular network.

They are → ① Transmission time = $\frac{\text{data}}{\text{B.w.}}$
② response time
③ number of Users
④ Type of transmission medium

⑤ " " hardware

⑥ Type of software

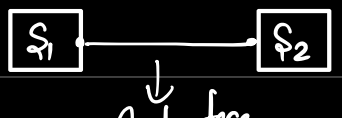
⑦ Throughput → no. of packets sent in unit time

⑧ Delay.

Note → There is a trade of between throughput and delay in a network.

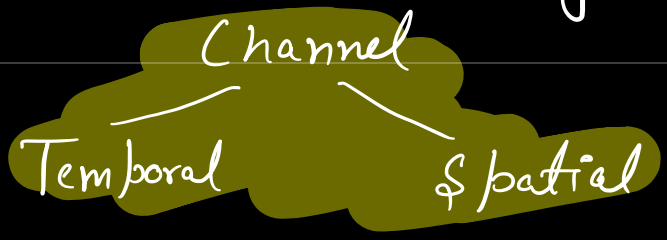
- Increase in throughput results in transmission of more data in the network.
- Inc. in delay results in congestion of network.

- **Types of Connections** → ① P2P (point to point)



② Multipoint ⇒

- **Capacity of channel** →



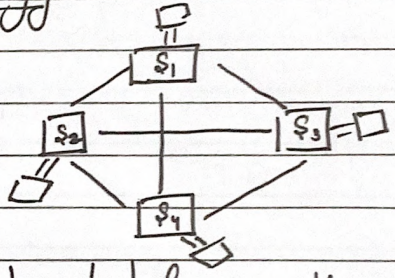
- Temporal → Time slots are different
- Spatial → Simultaneous access of Links are there.

- **Physical Topology** → A topology is the geometric representation of the relation b/w the devices and links in the network

It is of 4 types

1. Mesh
2. Bus
3. Ring
4. Hybrid
5. Star

→ **Mesh Topology**



In a mesh topology there is a dedicated link b/w each station.

Total (PL)
No. of Physical links in the network
$= n(n-1)$

If there is a duplex mode communication b/w each station no. of PL $= n(n-1)/2$

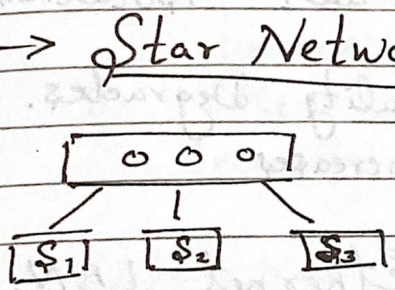
Advantages → ① Dedicated Links
② Privacy / Security
↳ Authentication
Integrity
Confidentiality
No Loss of Data

optical fibre route of Indian subcontinent

③ Fault isolation will be easy.
④ Robust Topology (Imp).
↳ There are alternatives

Disadvantages → ① Cost Increases
↳ No. of Links.
② Wiring is too much.

→ Star Network ⇒



If some signal comes to hub it is sent to all other terminals

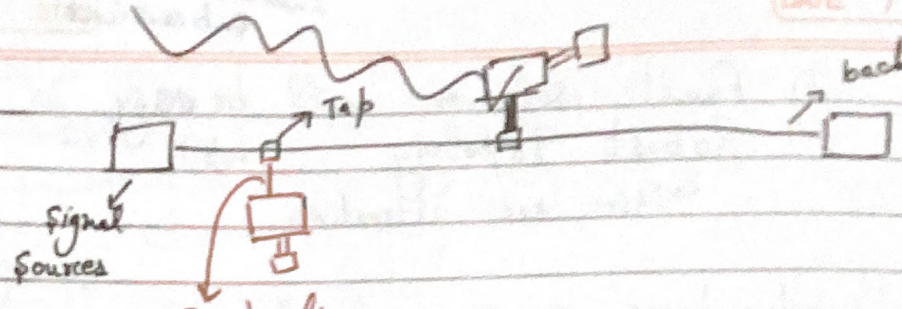
If hub is down Topology will be broken.
→ Used in broadcasting.

• Advantages → ① Less expensive than mesh
② Cabling will be less
③ It provides robustness

• Disadvantages → If hub fail, network fails.

• Use ⇒ Used in LANs.

→ Bus Topology ⇒ Adv. → ① Ease of installation
② Cabling is less than mesh and star.

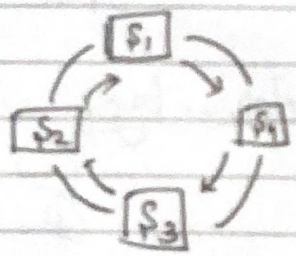


↳ Process is known as splicing / puncturing

- Disadvantages ⇒ ① Fault isolation is difficult
  ② Signal quality Degrades.
  ③ Cost increases

Application ⇒ Ethernet LAN.

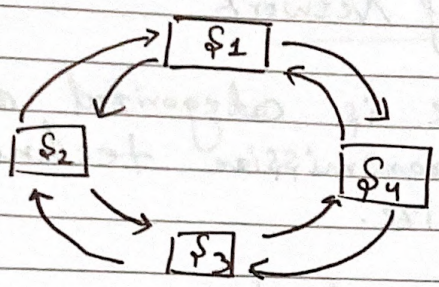
→ Ring Topology ⇒



Advantage → ① Easy to install & fault isolation is easy

Dis Advantage → ① Link is unidirectional

- Full Duplex Ring Topology → Also known as Dual ring Topology.



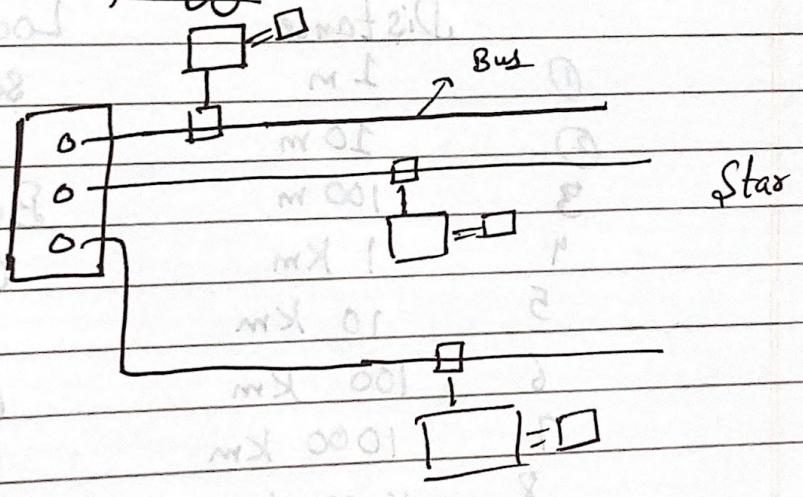
- Every link offer redundancy in network

↓

It provides redundancy in the network by the virtue of reachability, security and stability

Application → IBM LAN

- Hybrid Topology



• Categories of Network

The network is categorized on the basis of transmission technology and scale or size.

On the basis of transmission tech the network can be categorized based on types of communication i.e
unicasting
multicasting
Broadcastion

On the basis of scale / size network can be categorized based on → 1. no. of devices
· Distance among devices.

	Distance	Location	
1	1 m	Sq. meter	← PAN
2	10 m	Room	←
3	100 m	Building	← LAN
4	1 Km	Campus	←
5	10 Km	City	← MAN (metropolitan)
6	100 Km	Country	← WAN
7	1000 Km	Continent	←
8	10,000 Km	Planet.	← Internet

• PAN → It expands to personal Area network. It is a short range network. i.e the devices operating in this network will only be able to communicate to short distances. Examples. Infrared remotes, Bluetooth etc.

IEEE 802.15.4 →

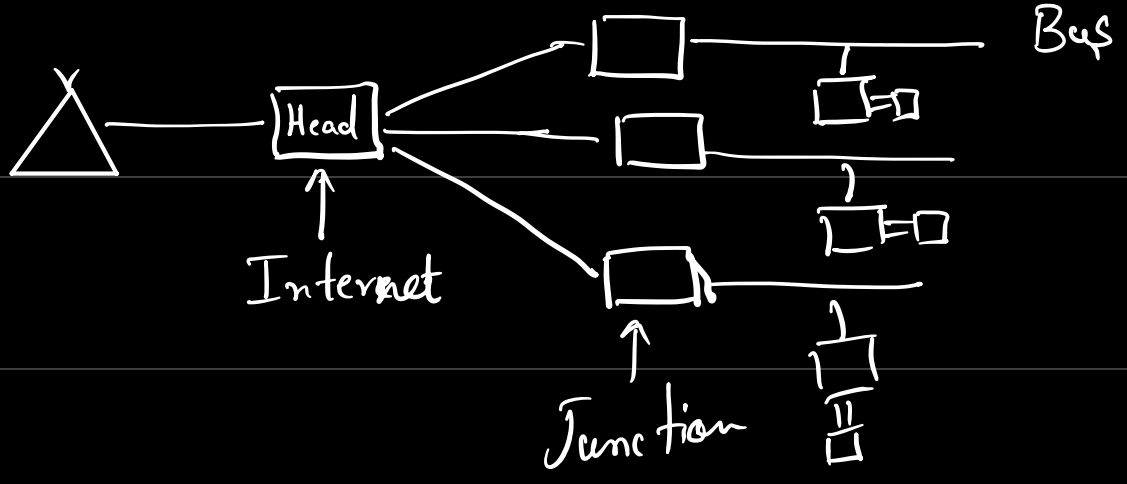
DIY (Line of sight
non-line of sight
Obstructed Line of sight (cond")

LAN → (used in star, bus and ring) Local Area network. Most common topologies used in LAN are star, bus and ring. LAN is utilized where sharing of resources is the priority.

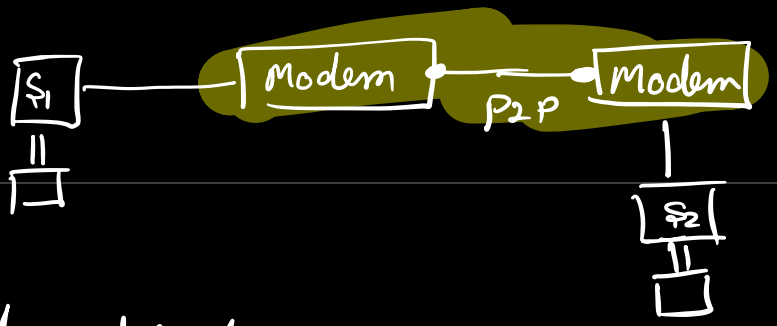
• The data rate supported by LAN are 4-16 Mbps, 100-1000 Mbps and 1 Gbps.

• MAN → Metropolitan Area network

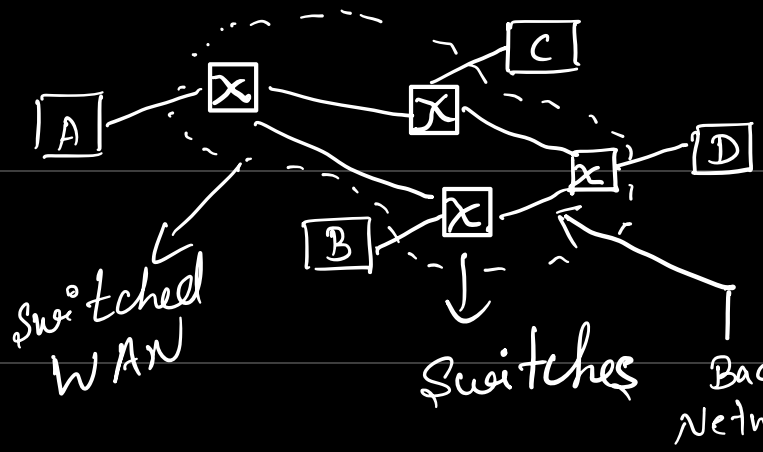
(IEEE 802.16)
Y_{max} (Search)



WAN → Wide Area Network. It is of two types → ① P2P WAN



② Switched WAN →



Example of switched WAN → X.25

② ATM relay ← Asynchronous transmission machine

③ Frame Relay

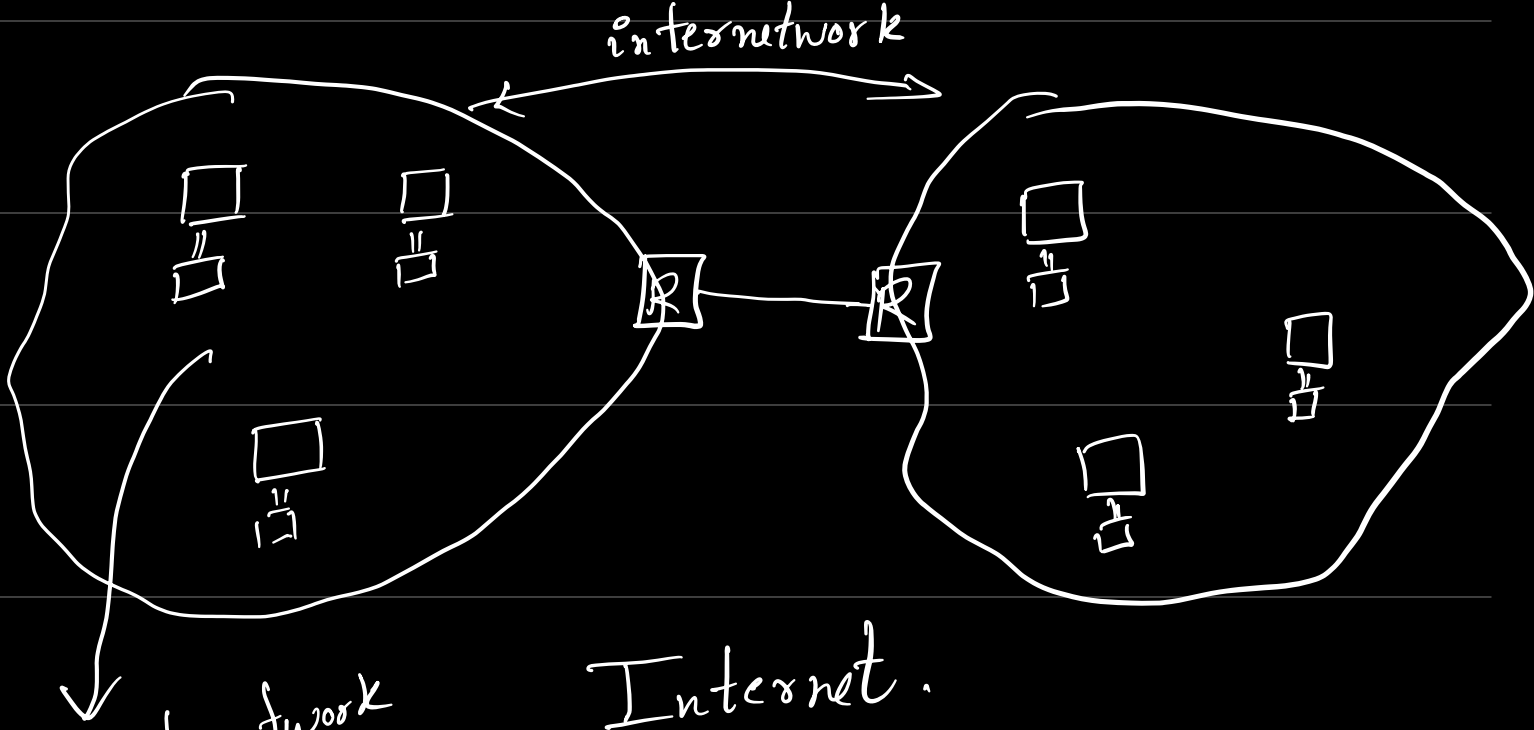
① Intranetwork → It is a single interconnected network within one organisation that uses HTTP or web technology to share information interally.

② internet → Any group of networks that are connected together.

③ Internet → It is the entire Internet which is the biggest collection of networks in the world.

There is a need to string the intranets together due to which interet results which is a

private network. That will again be connected to each other which results into Internet.



Intranetwork Internet.

Internet → ① 1960s ⇒ ARPA
↑
D.D of USA

② 1967 → ACM meeting
↳ ARPANET
NCP

③ 1972 → internetting project.

ISP (Internet service provider) → It is divided into 4 entities
① Local
② Regional
③ National
④ International

- Types of Communication → ① Unicast (one-one)
  ② Multicast (one to many)
  ③ Broadcast (one to all)
  ④ Anycast
  - Limited
  - Direct

Standards & Protocols →

	Cost	Reliability	Efficiency
Bus	✓	×	×
Ring	×	×	✓
mesh	×	✓	✓
Star	✓	✓	✓

- Protocol → Important parameters (Set of Rules)
  - Syntax → deals with structure
  - Semantics → meaning
  - Timeliness → when the data must be sent and how fast the data must be sent.

- Standards → i) defacto → They are by convention or fact. i.e they are adopted as standards through

widespread use

ii) de jure is a standard by law or regulation i.e it is legislated by an officially recognized body.

Some committees are ISO, IEEE, ANSI

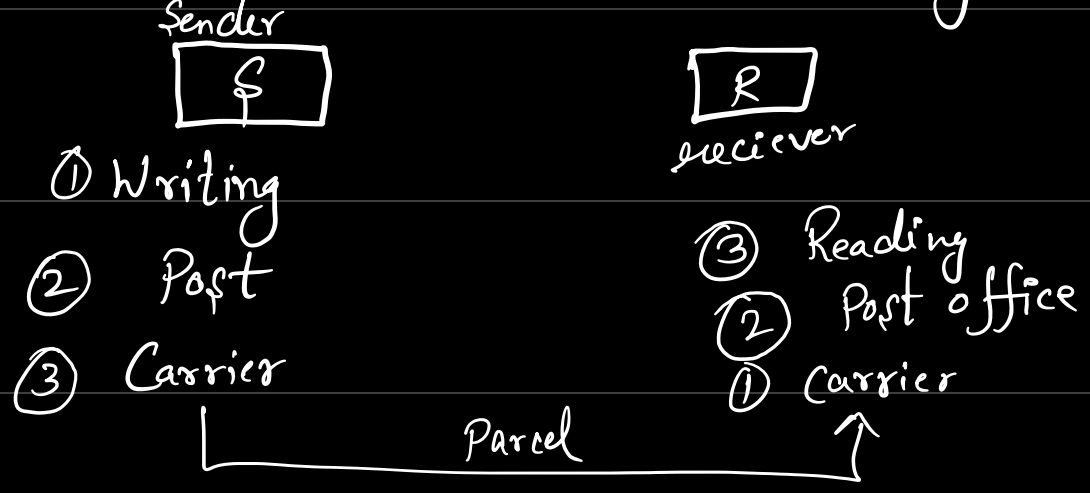
- IEEE → Institute for electrical and electronics engineers
- ISO → International organisation for standarization
- ANSI →
- EIA → Electronic industries association
- ITU-T → International telecommunication Union- Telecommunication standards sector.
- CCITT → Consultative commitee for international telegraphy and telephony.

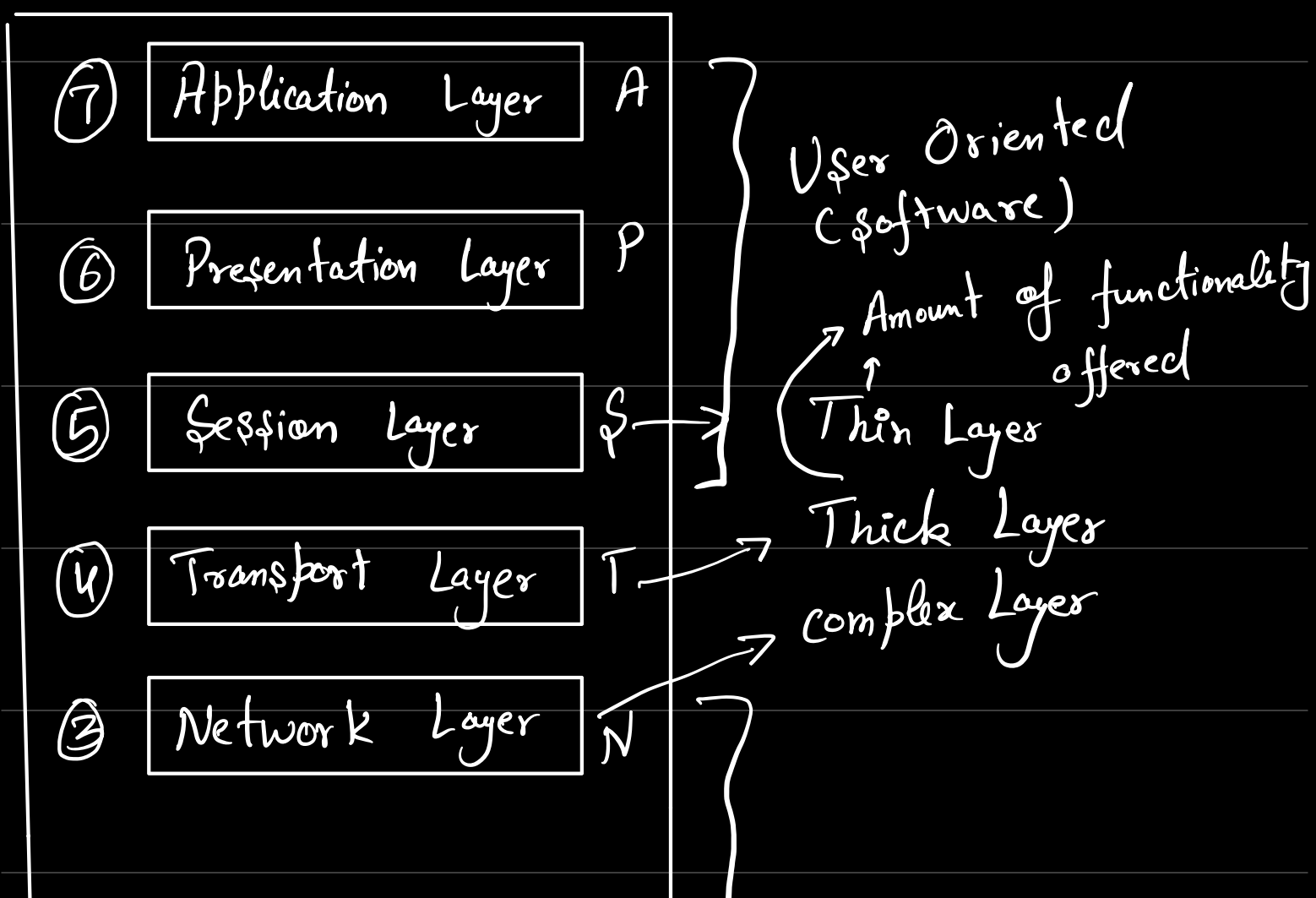
- Regulatory agency → ex. FCC

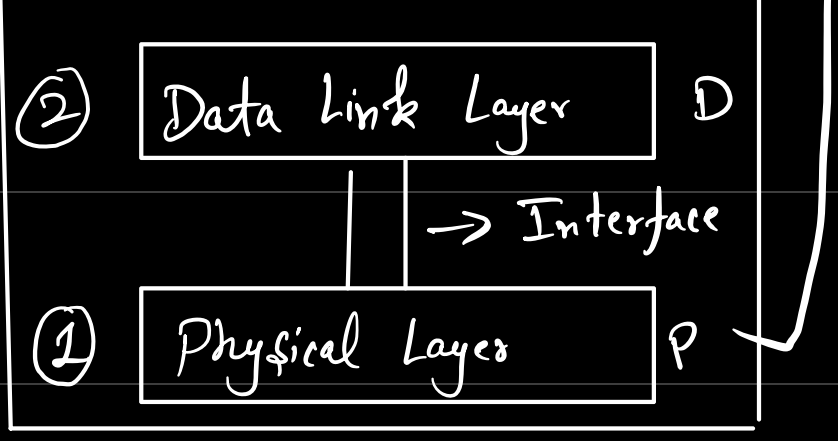
- Request for Comments (RFC) → IETF/RFC

Open Systems Interconnection

- **OSI Model** → ISO was established in 1947 and OSI came in 1970s. ISO is an organisation whereas OSI is a model. OSI isn't a protocol rather it is a model to understand and design a network

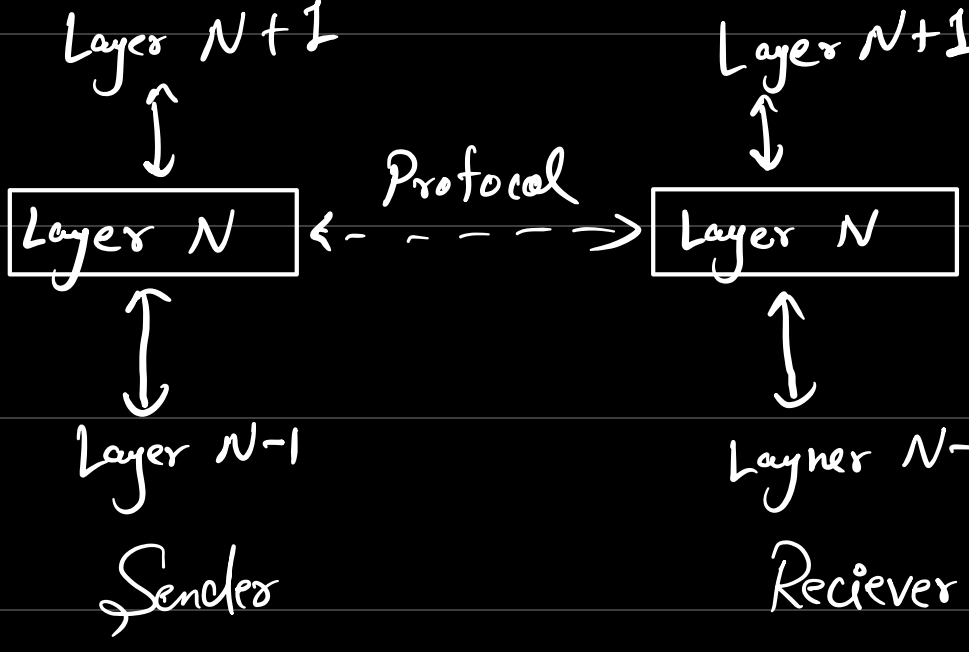






Hardware + software (Network oriented Layer)

- **Relationship b/w Services and Protocol IN OSI**



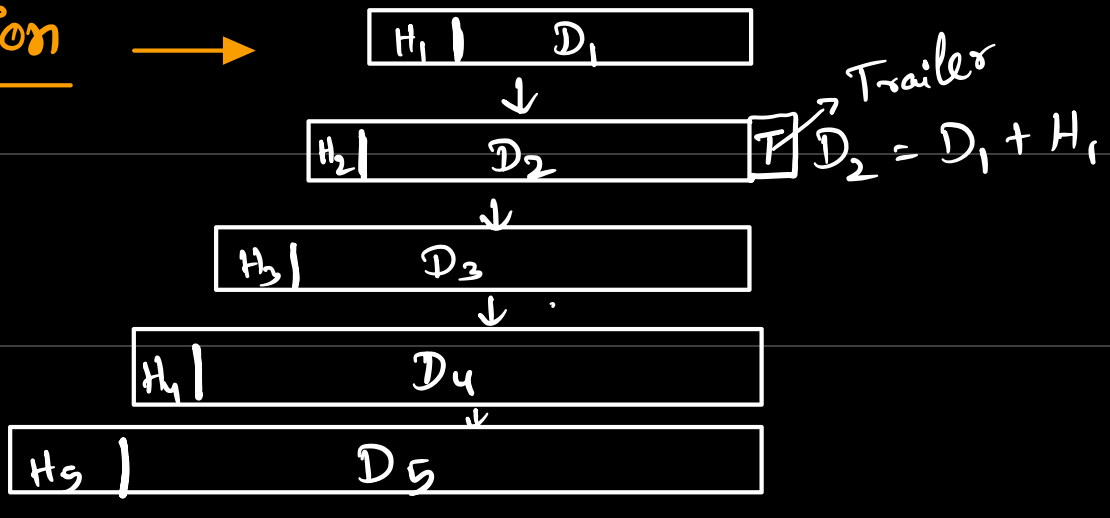
- **Interface** → It defines the information and services that a layer must provide for the layer above it.

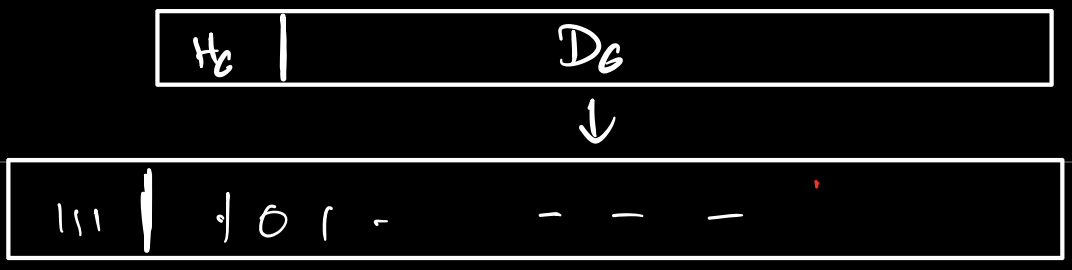
- **PDU** → Protocol Data Unit
  ↳ It is a combination of control informatio and user data.

OSI Layer	PDU
① Physical Layer	Bit
② Data Link Layer	Frame
③ Network Layer	Packet
④ Transport	TPDU
⑤ SL	SPDU
⑥ Presention	PPDU
⑦ Application	APDU

- **Note** → TPDU can be categorised in segaments → TCP Protocal and datagram → UDP Protocal.

- **Encapsulation** →





Decapsulation will be done by intended recipient.

- **Physical Layer** → It defines electrical, mechanical functional & procedural characteristics of interfaces and medium
  - It defines the transmission mode i.e simplex duplex & half duplex. ↓ simplex/ duplex

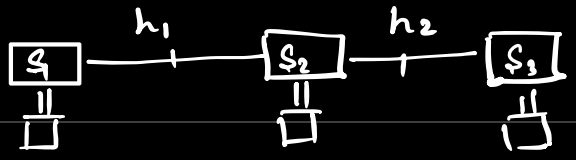
Ex. LANs are full duplex.

  - It defines link configuration (p2p or multipoint)
  - It defines topology "
  - It is a pure hardware layer.
  - **Responsibility** → 1. Bit by bit transmission
    2. Bit representation i.e it defines the encoding scheme utilized. (Signal encoding)
    ↳ Manchester / D. Manchester
    3. Data rate
  - **Services** → Provided from one layer to another
    4. Sync of bits
    5. Line configuration (Link)

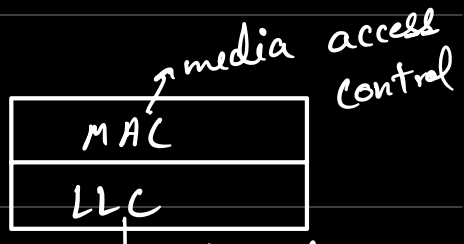
6. Physical Topology

7. Transmission Mode.

- **Data Link Layer** → It moves frames from one hop to another.



Responsibilities → ① Framing
② Physical addressing
③ Flow control
④ Error control
⑤ Access Control



- **Network Layer** → It defines the delivery of individual packets from source host to the destination host.
  - Responsibilities → ① Logical addressing
    ② Routing

- **Transport Layer** → It defines process to process delivery.
  - Responsibilities → ① Service point addressing (Port)

② Segmentation and reassembly.

③ Connection Control

Connection oriented services
① Establish
② Send data
③ Remove Link
④ Error Control
⑤ Flow control

Connectionless services
↳ If you have data, send it.

- Session Layer → Responsibilities ⇒
  ① Dialog Control
  ② Synchronization

NOTE → In a connectionless service the session layer can be deactivated since it has no role there.

- Presentation Layer → data oriented Layer → It purely deals with data and hence also known as data oriented Layer.
  - Responsibilities →
    - Responsible for interoperatability

① Translation
② Compression
③ Encryption

b/w devices.

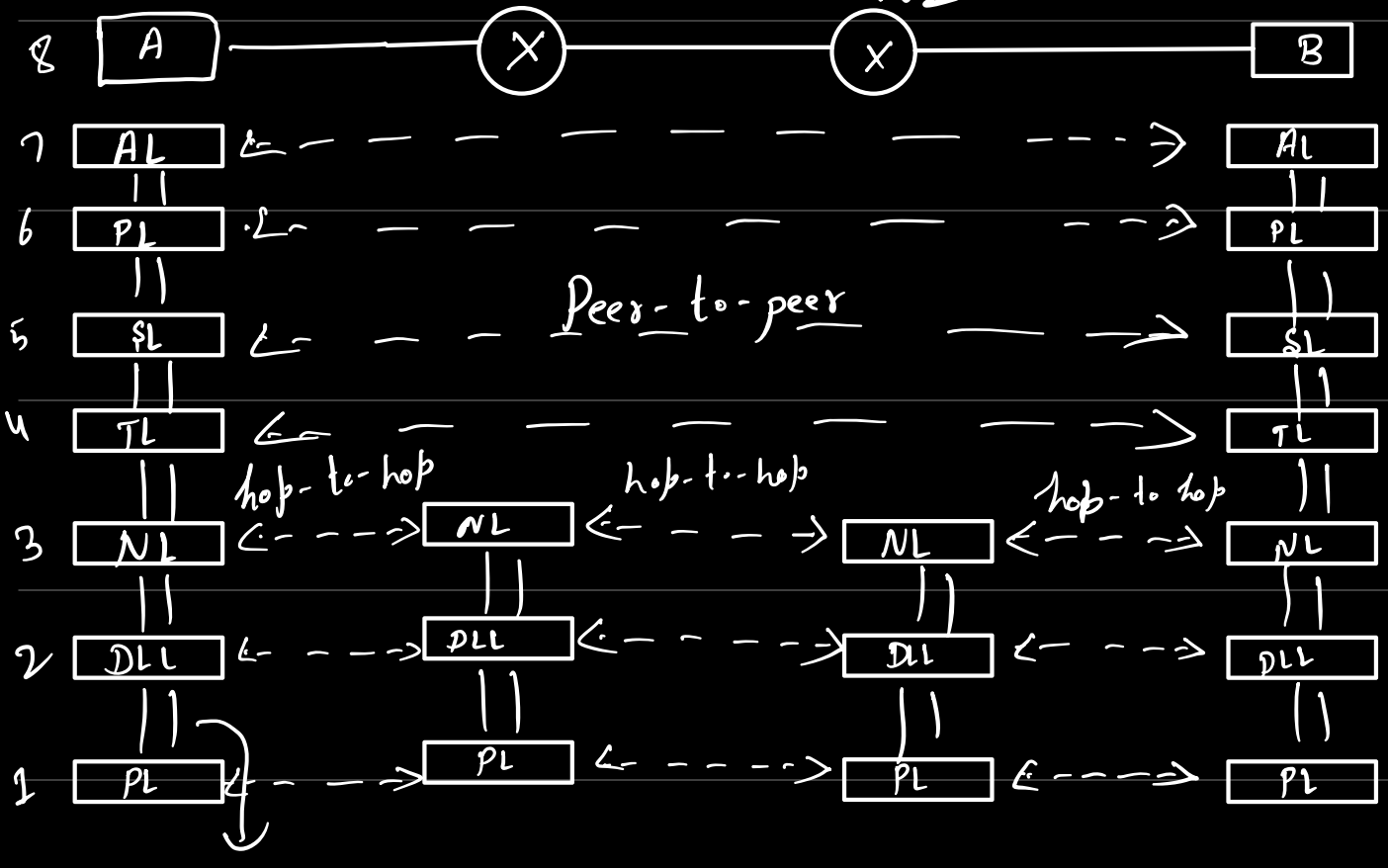
- **Application Layer** → • **Responsibilites**
  ① Maintains harmony to protocols by providing services to users.
  ② The most basic guideline to the layer is that the user interface line must be perfect.

- **Main Services** → ③ Network virtual terminal

- **Advantages of Layering System** → ① It uses divide & conquer principle and makes maintainance simple.
② It uses object-oriented principles like abstraction and encapsulation.

- **Disadvantages** → ① Interdependency among different layers.
② Duplication of certain functionalities.

ex. error control
flow control.



• 3-hops Two station

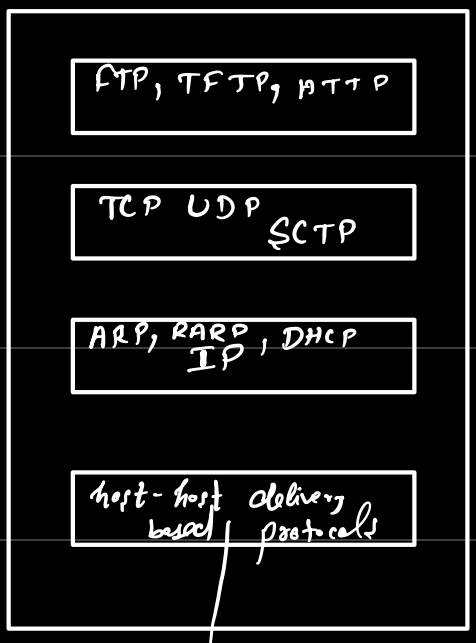
• Peer-to-peer → Peers are A & B here
(A: sender, B: receiver)

• In hop-to-hop → every station has to look through network layer.

• TCP/IP Model

Transmission control protocol

Internet protocol



• Self paced Assignment -> Write short notes on ① ISO/OSI model & ② TCP/IP ③ Different type of network devices

• Physical Layer

• Transmission Impairment →

① Attenuation → It is the loss of energy during transmission due to resistence in the medium

• Decibel → It measures the relative strength of two signals or one signal at two different points.

-ve value → attenuated

+ve value → amplified

$dB = 10 \log_{10} \frac{P_2}{P_1}$ — Powers at point 1 & 2

$$dB = 20 \log_{10} \frac{V_2}{V_1}$$

Ex. Assume that power at P_2 is halved as compared to power at point P1 calculate Attenuation.

Given, Power at point P1 is P
" " " P2 is P/2

$$= 10 \log_{10} \left(\frac{1}{2} \right)$$

$$= -3.01 \text{ Decibel}$$

Q It is seen that the loss in a cable is measured in dB/km. Assume that the signal at the beginning of the cable is -0.3 dB/km and the power at the beginning of cable is 2 mW. Calculate power at 5 kM.

Given $dB = -0.3 \times 5$ dB

$$10 \log_{10} \frac{P_2}{P_1} = -1.5$$

$$\log_{10} \frac{P_2}{2} = -0.15$$

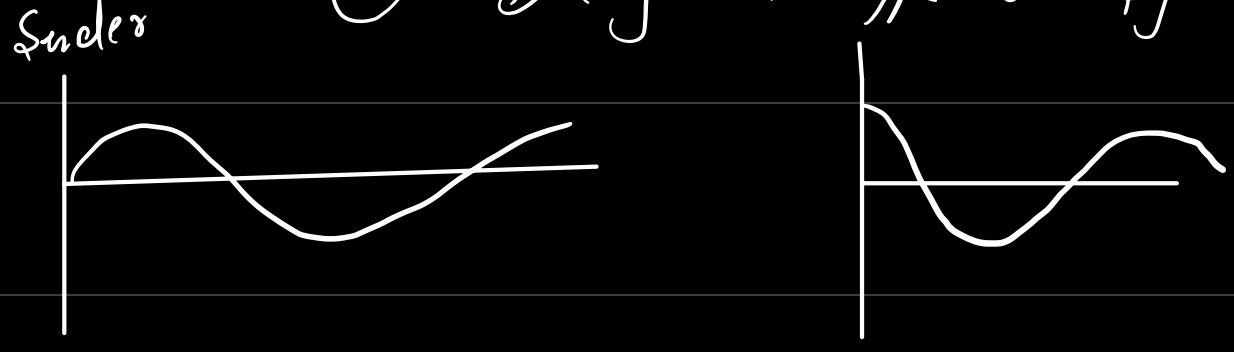
$$\frac{P_2}{2} = 10^{-0.15}$$

$$P_2 = \frac{2}{10^{0.15}} \text{ mW}$$

$$= 1.41 \text{ mW}$$

2) Distortion → It happens because of the following 3 reasons →

① Different speed of signals
② Delay in the channel
③ Delay in different signal



3) Noise → It may be thermal, induced in terms of crosstalk or an impulse that can corrupt the signals

- SNR - Signal to noise Ratio

SNR = avg. signal power / avg. noise power

It is used to calculate theoretical bit rate limit. A high SNR implies less corruption by noise.

$$SNR_{dB} = 10 \log_{10} SNR$$

It may change overtime.

Eg° Assume power of signal as 10 mW & power of noise as 1 μW. Calculate SNR & SNR_{dB}. What is the value of SNR for a noiseless channel.

$$\frac{10 \times 10^{-3}}{1 \times 10^{-6}} = 10000$$

$$SNR_{dB} = 40.$$

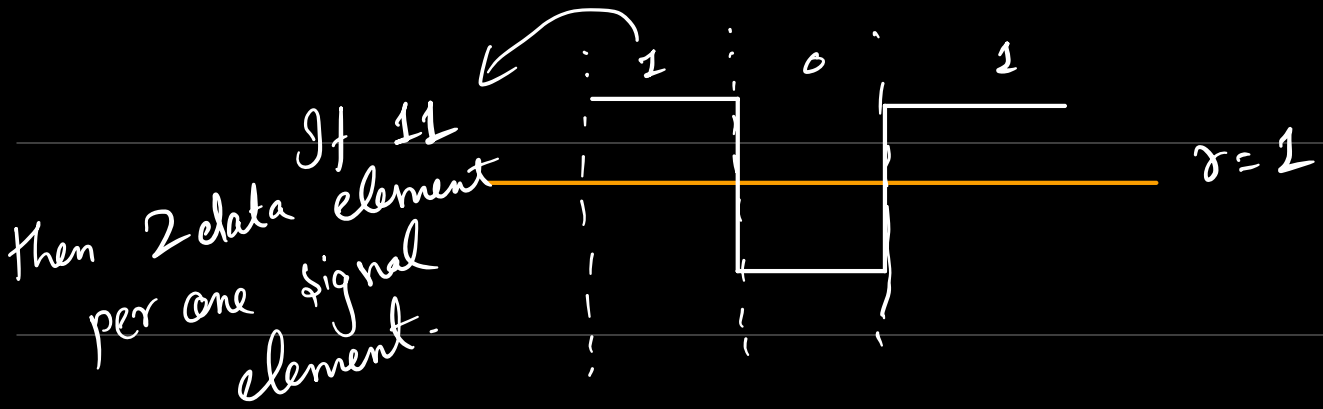
- **Data Rate** → It is defined as number of data elements sent in one second.
  - ↳ bit rate (bps)

- **Signal Rate** → It is defined as number of signal elements sent in one

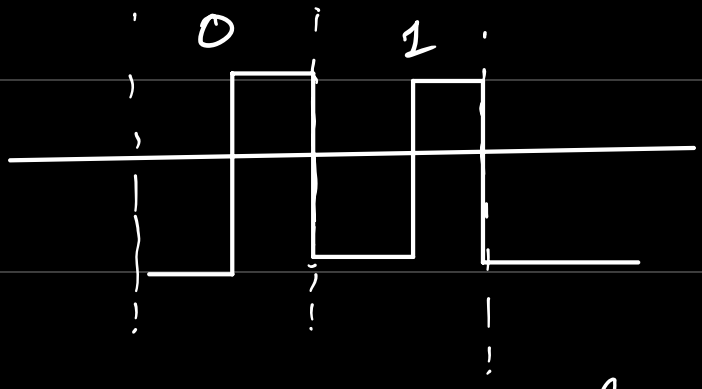
second. It is also known as pulse rate / modulation rate.

$$S = C \times N \times \frac{1}{r}$$

- S → signal rate
- C → constant
- N → Data rate
- r → number of data elements carried by each signal element.



- One data element per one signal element.



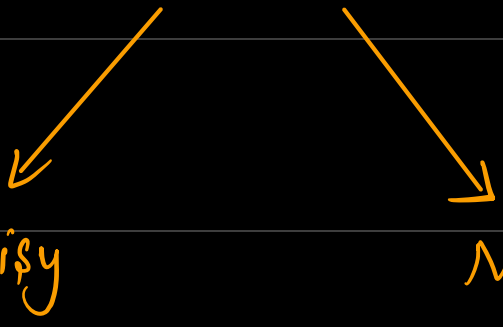
↓

one data element per two signal element.

- The goal in data communication is to increase data rate. (Speed of transmission will increase)

To decrease the signal rate. due to which bandwidth requirement decreases.

- Channels



- For Noisy channels, Shanon capacity is proposed which provides the theoretical highest data rate for the channel.

$$\text{Capacity} = \text{Bandwidth} * \log_2(1 + \text{SNR}) \text{ bps}$$

- NOTE → ① This formula provides the characteristics of the channel
② Since there is no signal level indication implies no matter how many levels are we cannot achieve data rate higher than capacity of Channel.

Noiseless Channel.

- Bit rate = $2 \times BW \times \log_2 L$ → signal Level.
- Nyquist rate defines the theoretical max^m bit rate.

- **NOTE** → Increasing the levels of signal decreases reliability of the system.

- **Performance Parameters**

① **Bandwidth** →

② **Throughput** → No. of packets getting transferred in unit time.

③ **Delay** →

Delay = propagation + Transmission + Queing + Processing

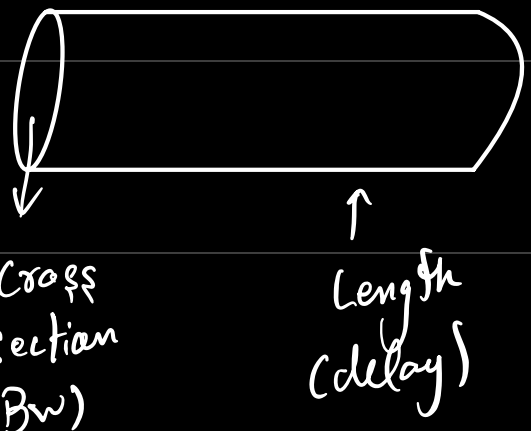
propagation delay: d/v

Transmission: $\frac{\text{size of packet}}{\text{bandwidth}}$

Queing: It is the time required to hold the message before it can be processed

④ **Jitter** → Transmission of different packet which encounter different delay. It is expressed in unit of time.

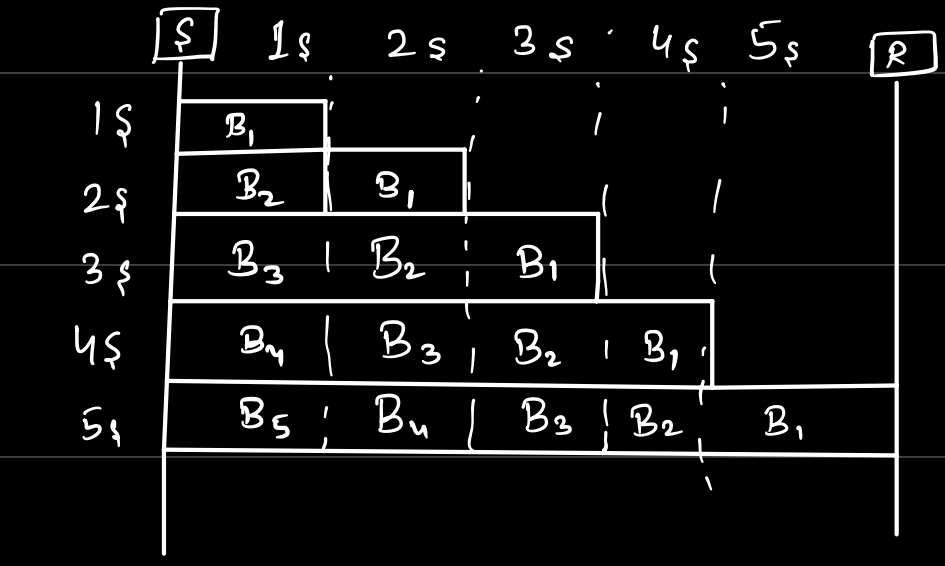
- **Bandwidth delay Product** → It specifies the number of bits that can fill the link.



$V = \text{delay} \times B.W$

- **Case - I** → $BW = 1$ bps

$Delay = 5$ s



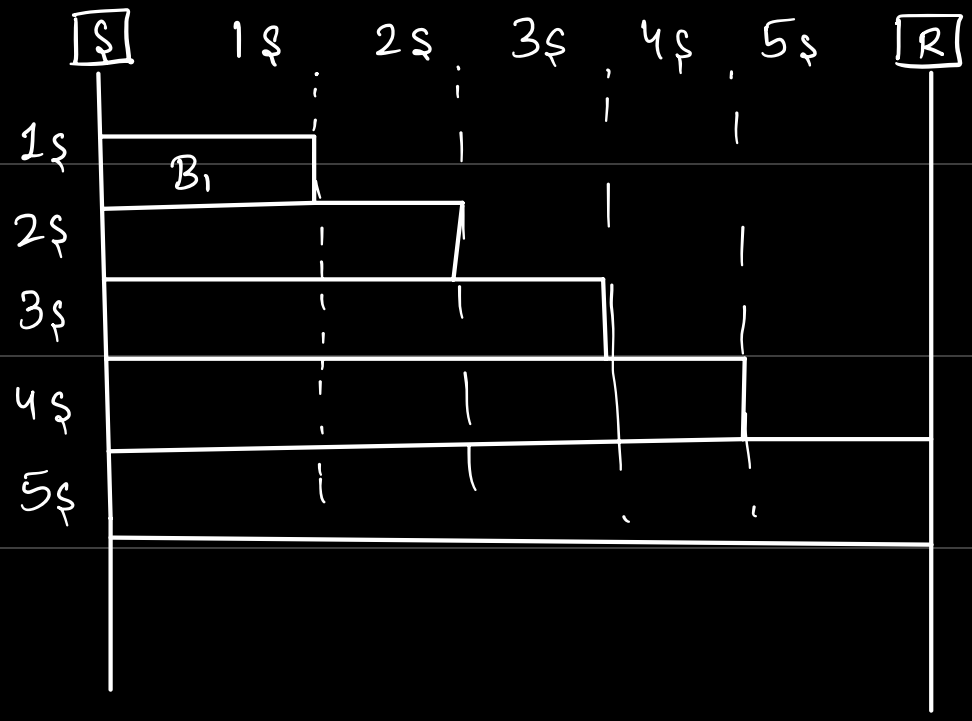
Case 2 : $B.W = 4$ bps

$Delay = 5$ seconds

4×5

$= 20$ bits

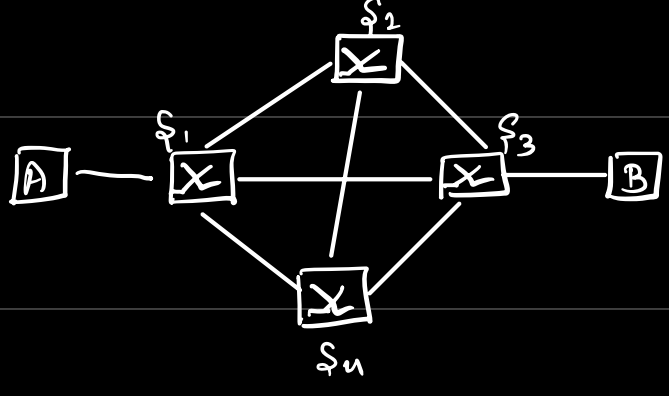
B

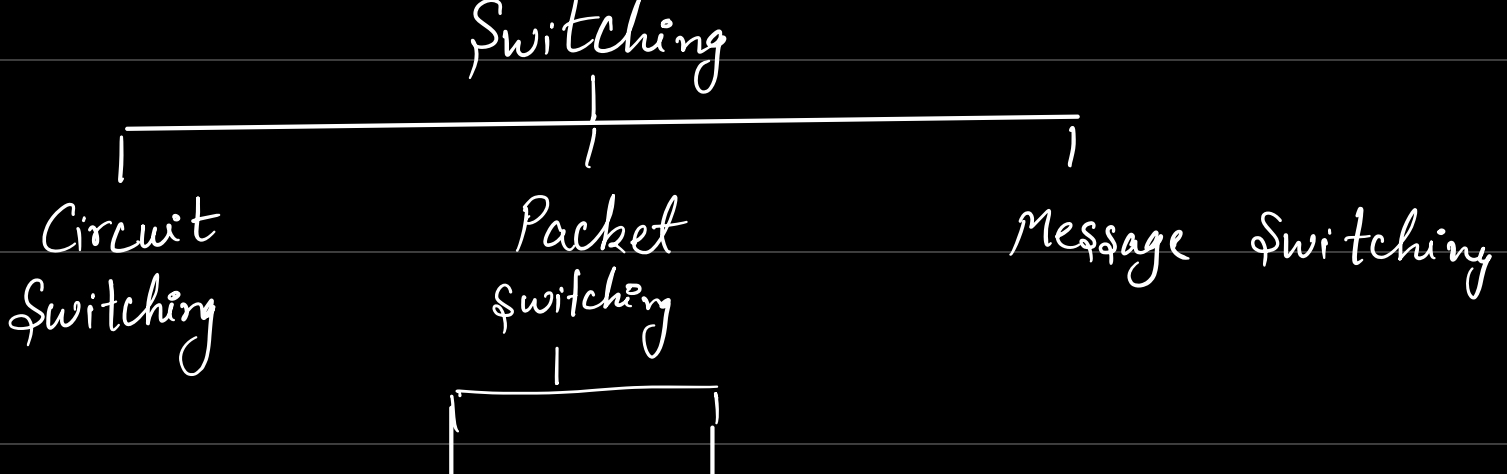


- **Significance** → Ideally the sender should send a burst of data of size twice the bandwidth x delay product.
  (2x BW x Delay)

→

- **Switching** →





Datagram network (IP)

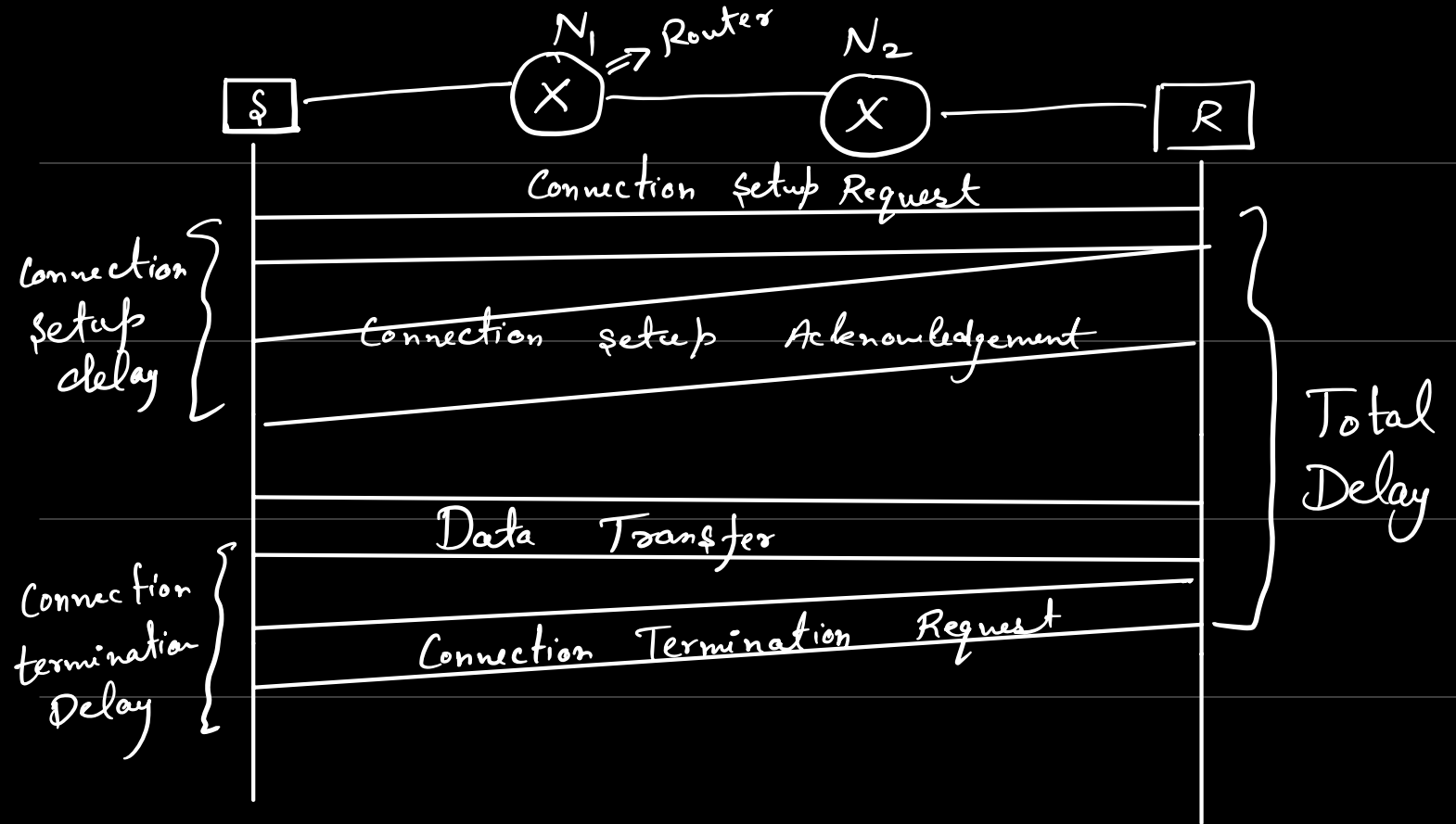
VCI Virtual Circuit N/w (TCP)

Circuit Switch Network :→ There are three faces in circuit switch network =>

① Connection setup ✓

② Data transfer face ✓

③ Connection tear down ✓



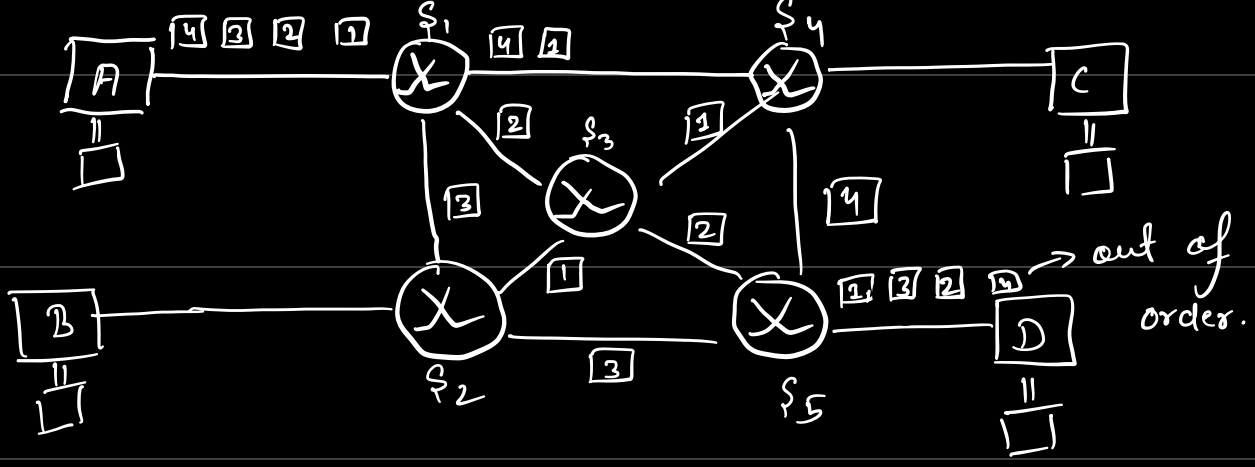
- **Performance of Circuit Switched Network.** →

① **Efficiency** → Since there is less utilisation of channel. Efficiency is Lower.

② Delay is Less

- Application → Public telephone systems

- Data Gram Networks →

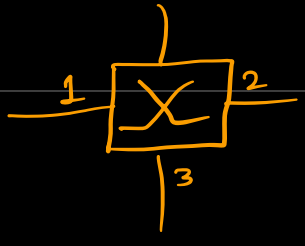


- Disadvantage is out of order packets.

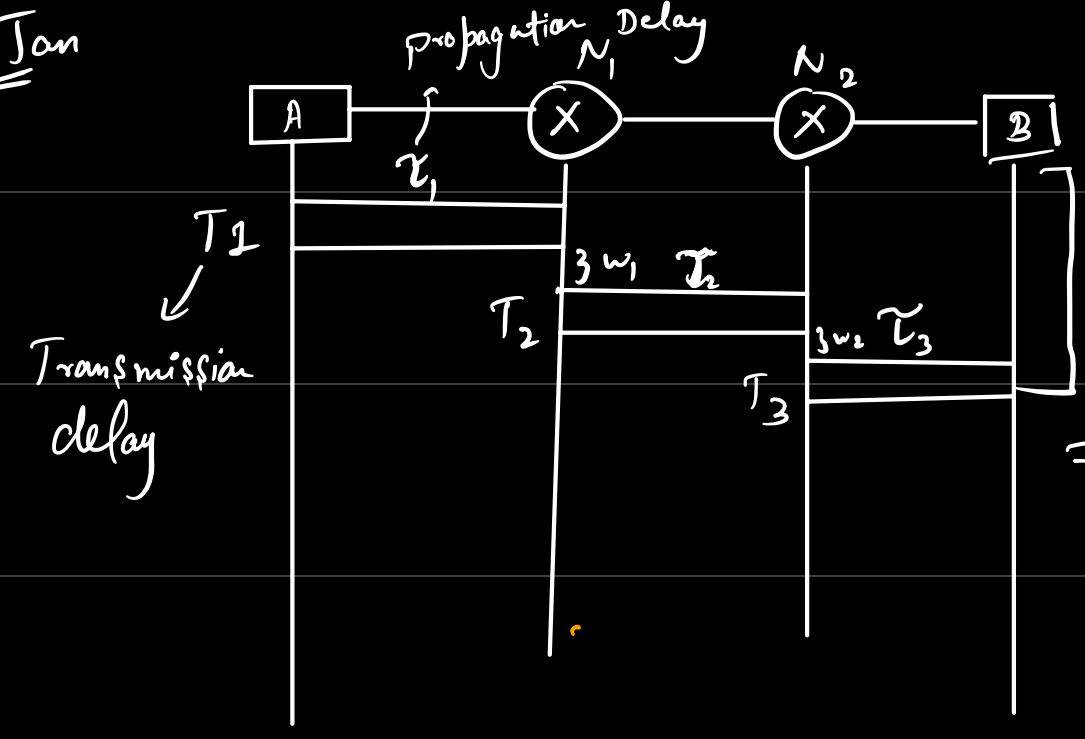
→ Switch

Destination Address	o/p Port
376	4
272	3

→ Cam Table



21st Jan



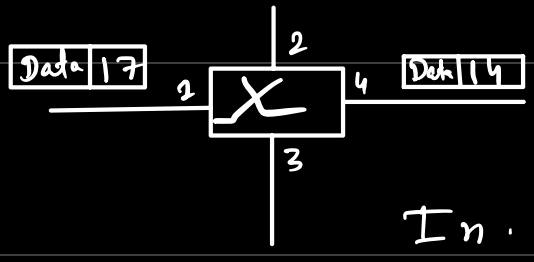
- Performance → ① Efficiency is better than circuit switching
  ② Delay is greater than circuit switching

- Virtual Circuit Network → • It utilizes the characteristics of both circuit switching and data gram network.
  • It has two types of addressing
  ① Local addressing → attained through the use of virtual circuit identifiers
  ② Global → Unique in the scope of network

- VCI → Used for data transfer and is considered as an identifier in the scope of the switch. It is used by a frame b/w two switches.

These are three phases of switching using virtual circuit network →

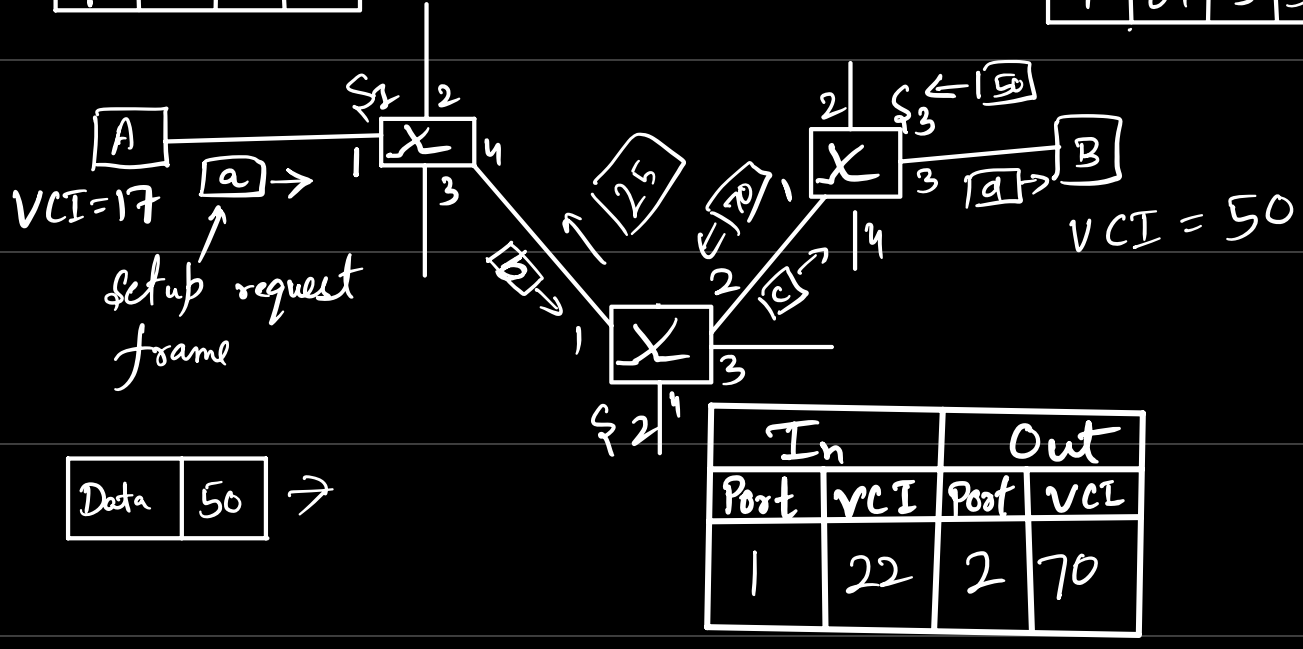
1. Set up phase
2. Data transfer phase
3. Tear down phase



In		Out	
Port	VCI	Port	VCI
1	17	4	14

In		Out	
Port	VCI	Port	VCI
1	17	4	25

In		Out	
Port	VCI	Port	VCI
1	64	3	50



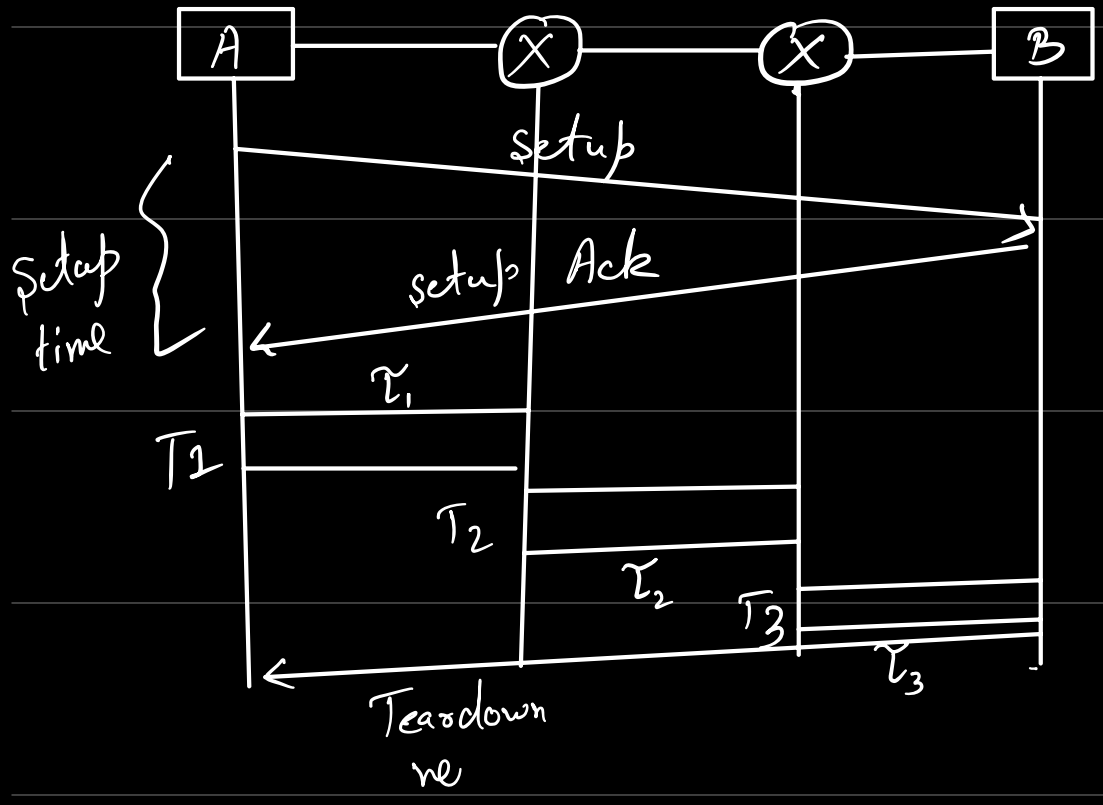
Data	50

→

In		Out	
Port	VCI	Port	VCI
1	22	2	70

- **Performance** → ① Resource reservation is flexible
  ② Resourse allocation is on-demand.
  ③ All packets belonging to same source or destination follows same path.

Hence efficiency is better than circuit switching and datagram network.



Total delay
$= 3T + 3\tau +$ setup time + teardown time

- **Applications** → ① Circuit switching is used in telephone network
  ② Data gram is utilized in Internet
  ③ VCI has an application in switched WAN.

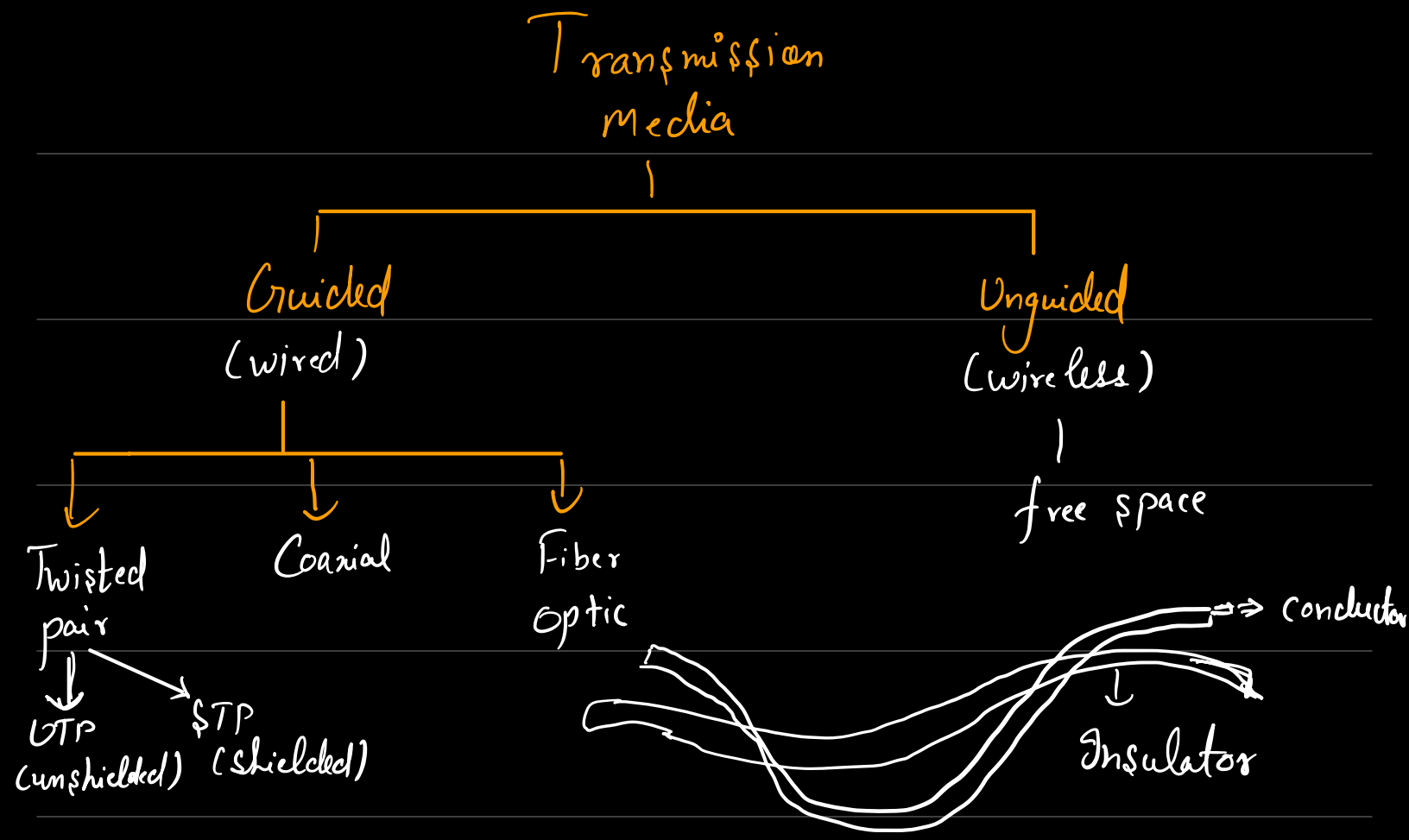
- **Msg Switching** → ① It is utilized in store and forward network.

②

Diff. b/w Circuit and Packet Switching

Item	Circuit Switching	Packet Switching
① Call setup	Required	Not required
② Dedicated physical Path	Yes	No
③ Packet follow same route	Yes	No
④ Packets arrive in Order	Yes	No
⑤ Is a switch crash fatal	Yes	No
⑥ Bandwidth Available	Fixed	Dynamic
⑦ Time of possible congestion	At setup time	On every packet

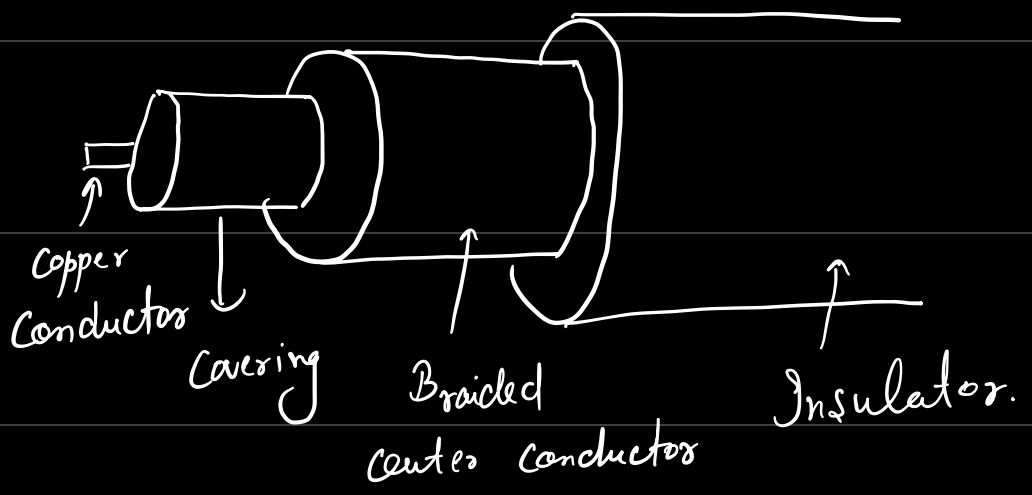
⑧ Potentially wasted bandwidth	Yes	No
⑨ Store and forward transmission	No	Yes
⑩ Transparency	Yes	No
⑪ Charging	per unit time	per unit packet



- Application of Twisted pair Cables =>

1. It is generally utilized in telephone lines

- Coaxial Cable → • It has applications in telephone network, cable TVs etc.

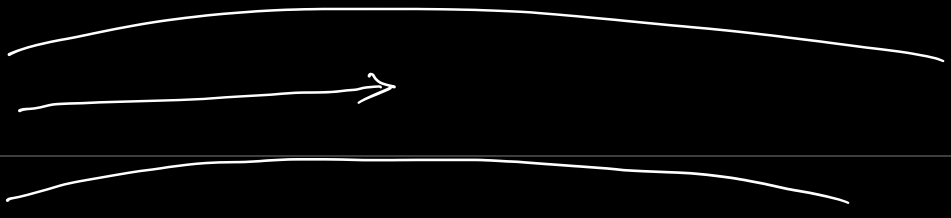


- Fibre Optics Cable → There are three important component in fibre optics cable. →
  1. Light source
  2. Transmission medium
  3. detector.
- The light source with value 0 indicate absence of light.
- Transmission medium is ultrathin glass fibre
- Detector generates an electric pulse

whenever light falls on it.

Propagation Mode

- The single mode propagation uses step index fibre and is a highly focused source of light



- Application ⇒ • It is generally utilized in backbone network. Cost is a major factor in it (BNC connectors are used).

- Advantages of fibre Optics → ① It is light weight.
  ② Has greater immunity to tapping
  ③ Has resistance to corrosive material
  ④ has immunity to EM spectrum

⑤ Supports less signal attenuation
⑥ Supports higher bandwidths

- Disadv. → ① Installation & maintainance is costly
② It supports unidirectional light propagation
③ Overall cost is extremely high.

- Unguided Media → ① Radio transmission uses multicast communication in Radios & TVs
② Microwave uses unicast

③ Infrared uses short ranged communication requiring the line of sight condition.

- Write short notes on Transmission media.

- **Cabling** → ① 10 base ② 2 ×100 ③
  10 base 5 ×100
  100 base T → twisted pairs
  100 base F → fibre optics
  10 broad 36 → ×100.

① indicates bandwidth in Mbps
② " technology i.e base band or broad band
Baseband transmit a single data signal at a time.
Broadband " multiple data signal simultaneously at the same time
③ " distance of communication without any signal loss. (×100 m)

- **Encoding Techniques** →
  - **Manchester Encoding**
    - Zero indicates transition from high to low in middle of interval
    - One indicates transition from low to high

- It provides better signal synchronization
- It IEEE 802.3 ethernet

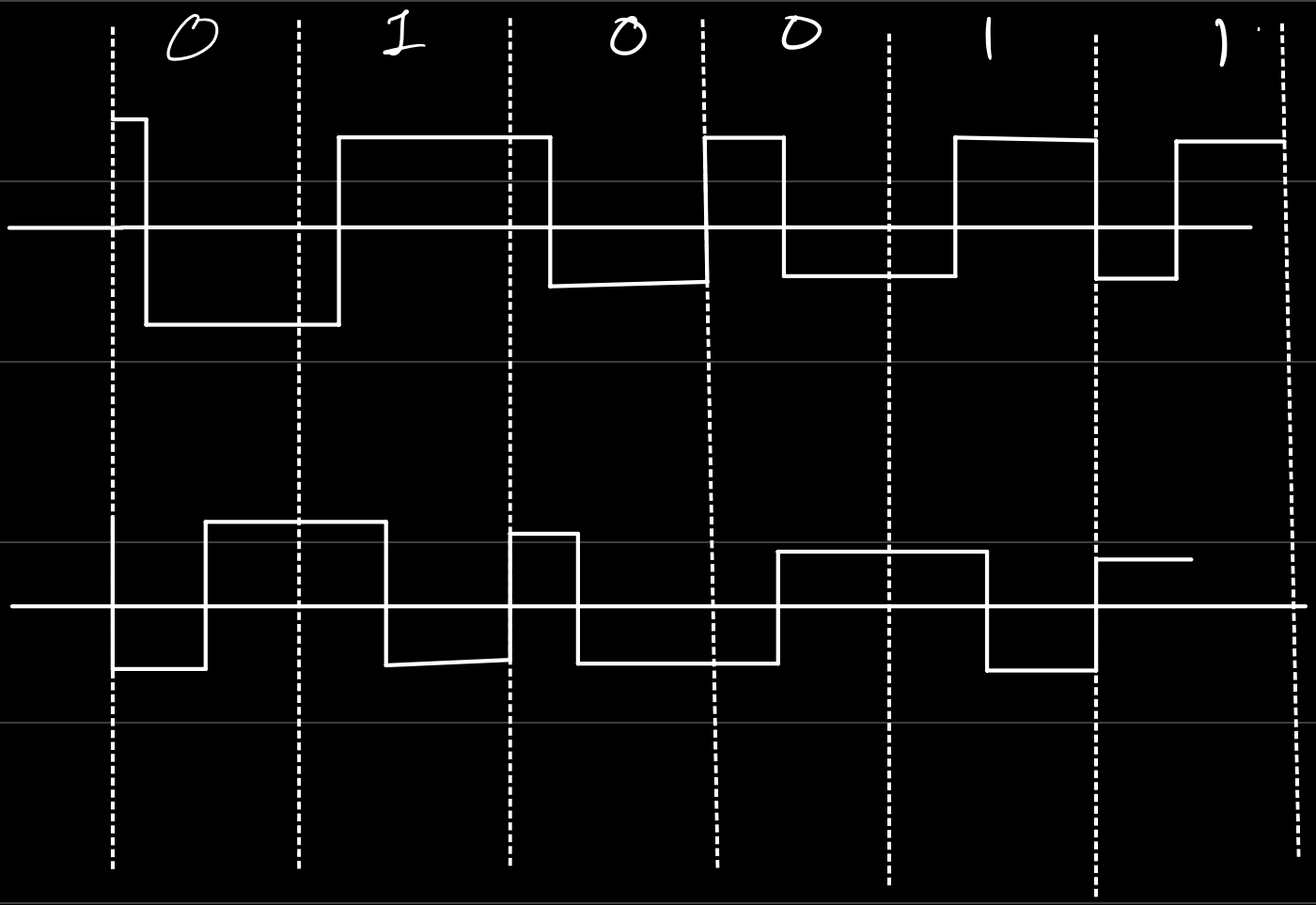
Application → RFID, NFC, IR protocols

- It has an advantage of no signal dropping issue.

- Differential Manchester Encoding → . The transition is always in the middle of interval.
  - 0 indicates transition at beginning of interval
  - 1 indicates no transition
  - Presence and absence of transition indicates the value.
  - For every bit there is a transition gaurunteed

- It has disadv. of utilizing more bandwidth as signal rate is twice of NRZ
- Application → IEEE 802.5 twisted pair cable It is known as token ring LAN

1 → ⊓ 0 → ⊔

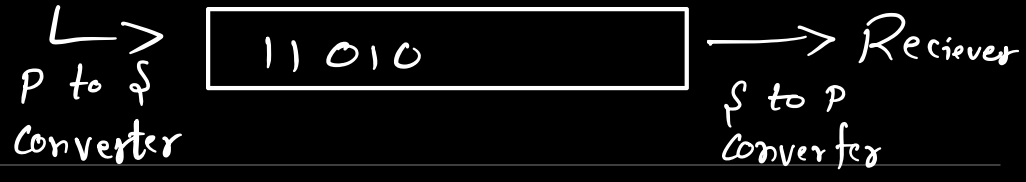


Transmission Modes

- Serial
  - Asynchronous
  - Synchronous
  - Isochronous
- Parallel

- **Parallel Tx.** → If $n = 8$ bits are there implies $n = 8$ wires will be required to transmit them.

- **Serial Tx.** → 01011



- One adv. of serial over parallel is that it reduces the cost of transmission by n.
  - ↳ physical transmission media.

- 1. In **Asynchronous Tx. mode** timing is unimportant instead info is recieved and translated by agreed upon pattern
  2. Timing is enforced using start and stop bit

- Start bit is one bit pattern
- End bit is one or more bits at the end of each byte.
- GAP is also used.

3. Asynchronous Tx. is well suited for low speed application

- 1. The speed of Synchronous Tx. is faster than that of Asynchronous
2. All the bits are sent together wherein the responsibility of receiver is to segregate the bit.

The gap is implemented using seq. of 0's & 1's

Gap may be diff. in two set of streams.

3. It is well suited for high speed appln.

- Isochronus Tx. → ① Entire stream of bits must be in sync.
  ② It garuntees data arrival at fix rate such as case of Audio and video.