

UNIT - 1

Introduction to computer Networks

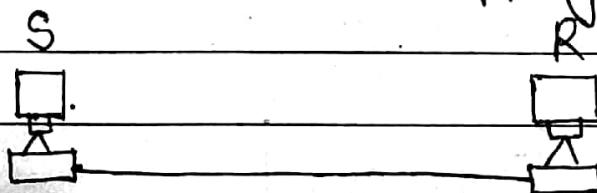
⇒ Line Configuration / Link configuration →

Line configuration define the communication between two or more devices/nodes. It refers to the way two or more communication devices attached to a link. It is also referred to as connection.

There are two types configuration.
These are given below:-

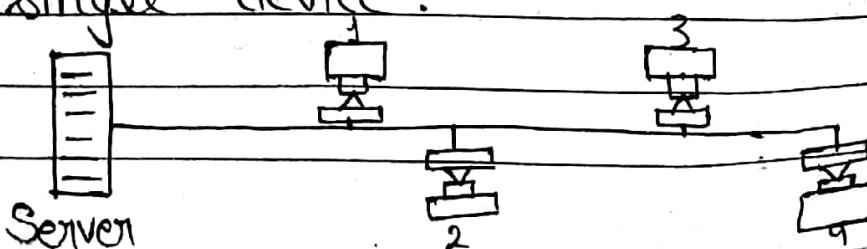
1.) Point to Point Configuration →

One to one mapping of devices.



2.) Multipoint configuration,

There are many devices connected with single device.



⇒ Topology →

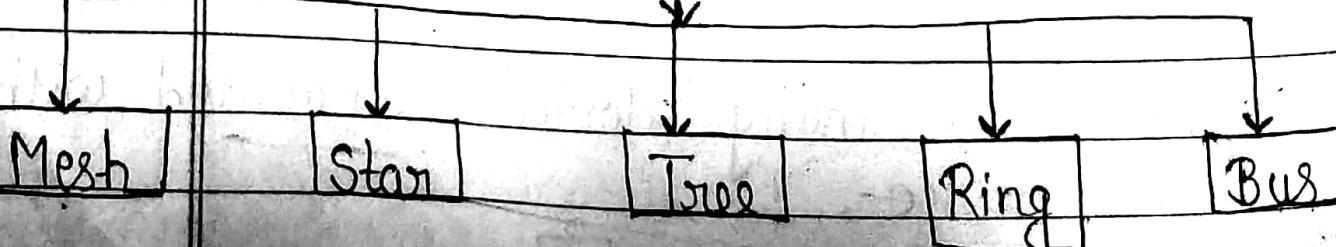
It is refer to the way a network is loadout either physical or logical.

- Two or more line configuration define the topology.
- The collection of point to point or multipoint is known as topology.
- Two or more devices conference to line configuration.

The topology of a network is the geometric representation of the relationship of all the link and linking devices (nodes) to each other.

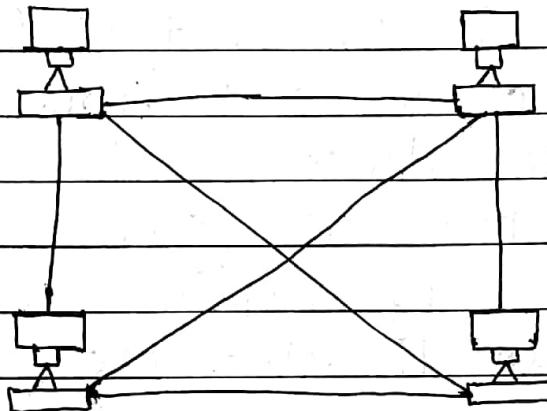
⇒ Types of topology →

Topology



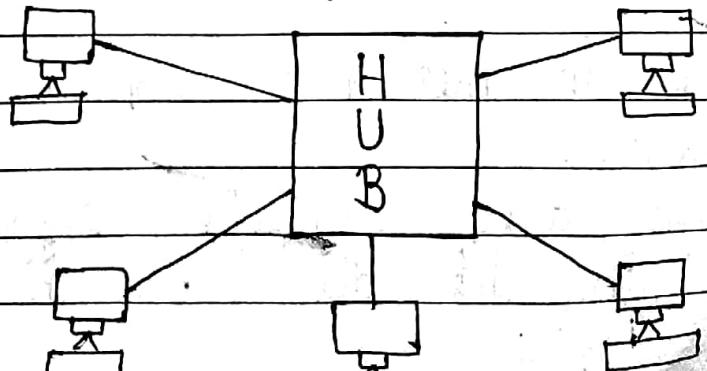
1) Mesh topology → It is a dedicated point to point line configuration b/w each nodes. It is so costly.

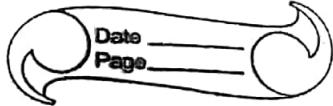
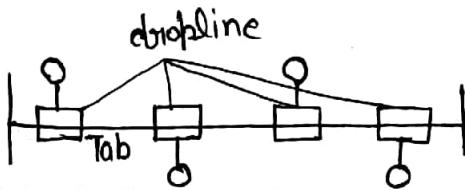
$$\text{No. of connection} = n(n-1)/2.$$



$$\begin{aligned}
 \text{No. of connection for this} &= n(n-1)/2 \\
 &= 4(4-1)/2 \\
 &= 4 \times 3 / 2 \\
 &= 12/2 \\
 &= \underline{\underline{6}}
 \end{aligned}$$

2) Star topology → It contains the HUB. Every node is connected with HUB. It is less costly from mesh topology. It is wired.





3) Bus topology → It is simplest and cheapest topology. At a moment only one person receive and send data. It is one directional.

Bus topology is an example of multipoint configuration. One long cable act as a backbone to link all the devices in the network.

The nodes are connected to the bus cable by dropline and tab.

A single traveled along the backbone. Some of its energy transformed into heat therefore it become weaker to weaker as it travel further and further.

Advantage →

- Easy to installation.
- It is less expensive than star and mesh topology.

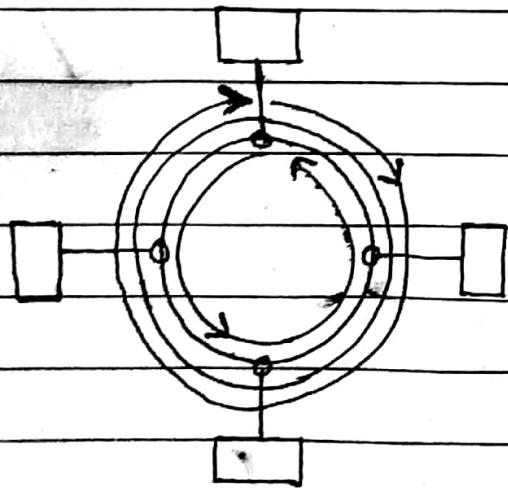
Disadvantage →

- A break in bus cable stop all transmission.
- A damage area reflects single breaks in the directions of

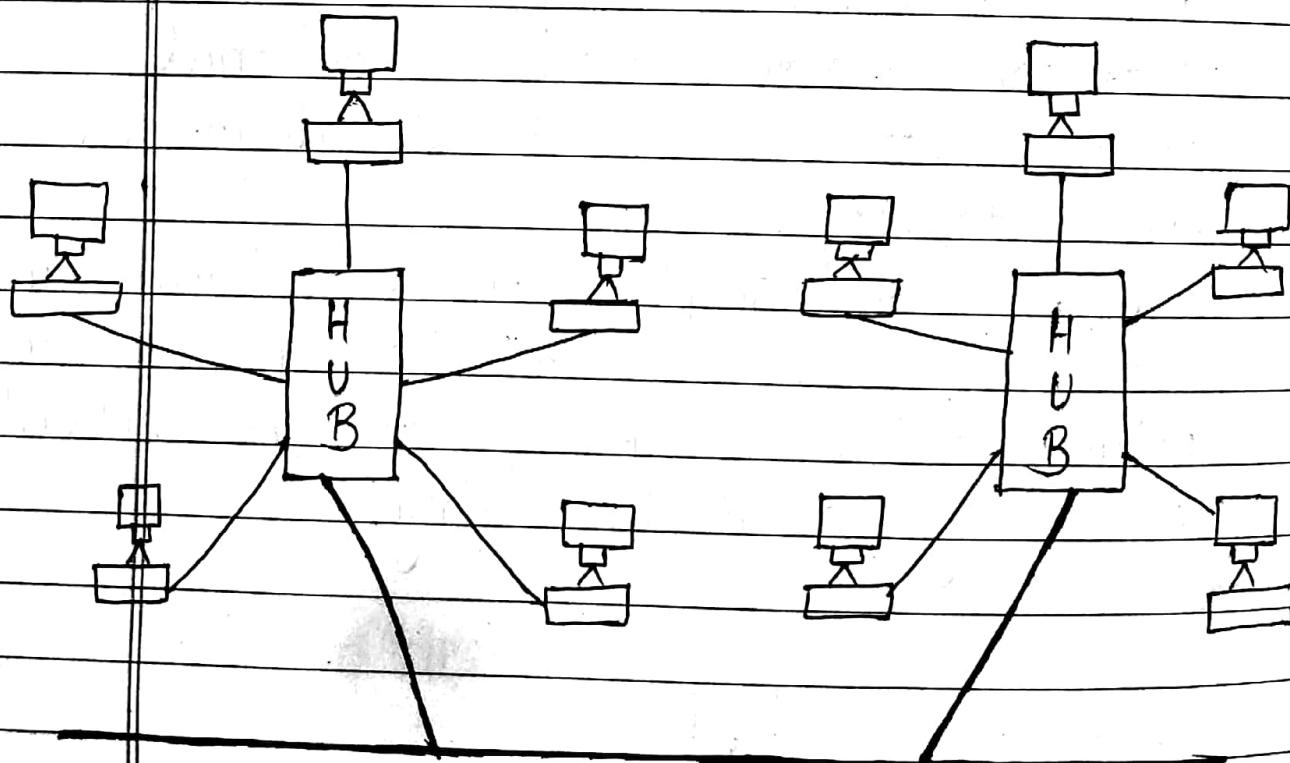
origine, creating noise in both direction.

4.) Ring topology → Ring topology has dedicated point to point connection with only the two devices on either side of it. Signal is passing along the ring in one direction from device to device. Until it reach its destination. Each device in the ring incorporated a repeater. It is easy to install and reconfigure. Unit directional traffic can be a disadvantage of ring topology.

In simple ring, a break in the ring can be disable the entire network. This weakness can be solved by using a double ring.



5) Tree topology → In computer networks, a tree topology is also known as a star bus topology. It incorporates elements both a bus topology and a star topology. Below is an example network diagram of a tree topology, in which the central nodes of two star network are connected to one another.

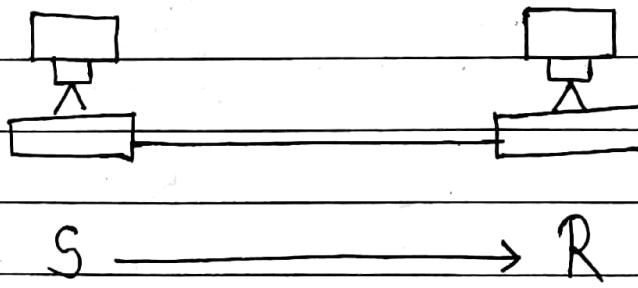


⇒ Mode of transmission →

The transmission mode defines the direction of signal flow between two connected devices. There are three modes of transmission which are given below:

- 1.) Simplex
- 2.) Half Duplex
- 3.) Full Duplex

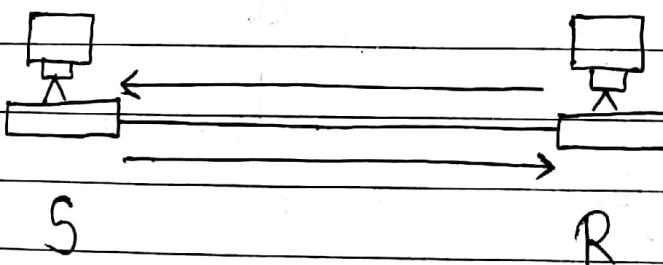
1.) Simplex mode → The communication is unidirectional (one direction at a time), or one-way.



Example → keyboard and monitor, cable TV, etc.
In this type of transmission mode sender can only send data. This is the worst performing mode of transmission. The direction of communication is unidirectional. In this mode receiver can only receive the data, it can not reply to the sender.

2.) Half Duplex mode → In this type of mode of transmission the communication between sender or receiver is two directional, but when one receive than it send after receiving means one at a time. In this sender can send and receive data, but one a time. The performance of it is better than simplex.

for example → Walkie - talkies.
(One time sending complete than next sending starting.)

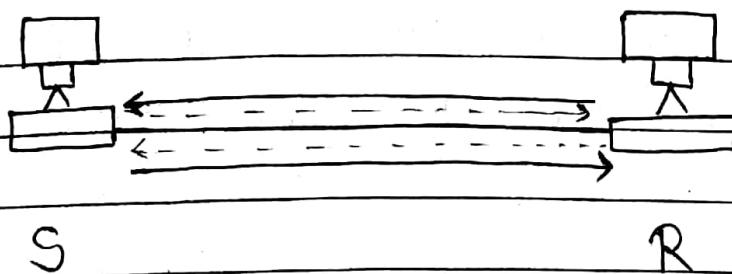


3.) Full Duplex mode → In the full duplex mode the communication is bi-directional or two-way, and data is sending and receiving simultaneously. by both devices.

In this sender can send and receive data simultaneously. This is the best performing mode of transmission.

The sender and receiver can both transmit and receive at the same time.

for example → Telephone , mobilephone .



⇒ Computer Network →

A network is a set of devices and nodes (computer) connected by communication link.

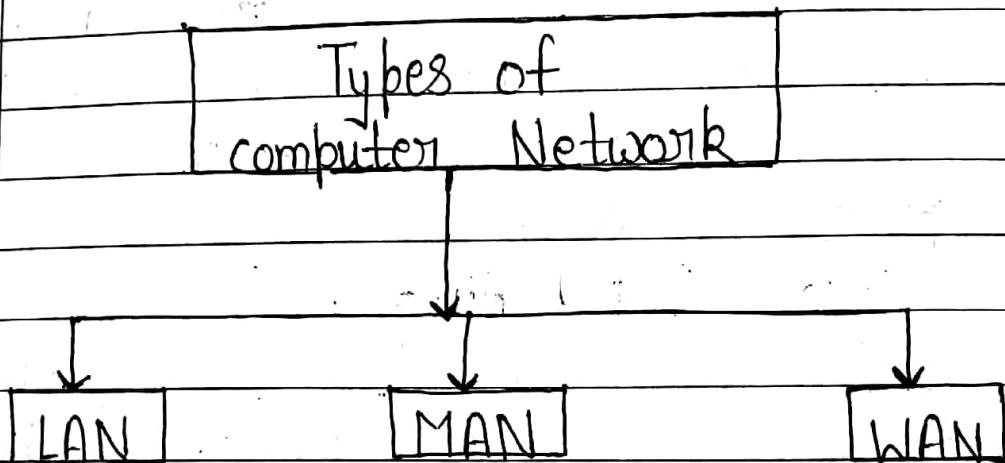
A node can be computer, printer or any other devices capable of sending and receiving data whereas computer network is set of autonomous computer interconnected together through communication medium to facilitate communication between them. for example → Internet.

The category of network can be categorized by its size , scale distance it cover , physical architecture , technology etc.

→ A computer network is a group of computers connected with each other through a transmission medium such as cable , wire etc. In this guide , we will discuss about a computer network .

⇒ Types of computer Network

There are mainly three types of computer network. These are given below :-

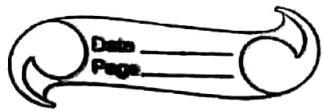


- 1.) Local Area Network (LAN)
- 2.) Metropolitan Area Network (MAN)
- 3.) Wide Area Network (WAN).

1.) Local Area Network (LAN) →

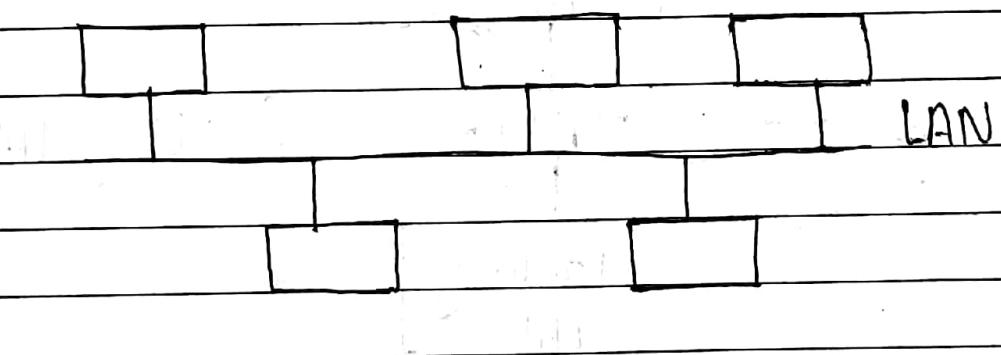
LAN stands Local Area Network. It means a network that connects a group of computers in a small geographical area. The ownership of network in LAN is private. The design and maintenance is easy in LAN.

The speed is high in it. The short propagation delay in the LAN. It is more tolerant. It is



less congestion. It allows single pair of devices to communicate. It is used for college, school, Hospital and any organisation etc. Simply we can say that the networking in any organisation is called LAN. In this twisted pair cable is used. The length of this is in some meters and speed in some KB's.

Star + Bus + Ring = LAN



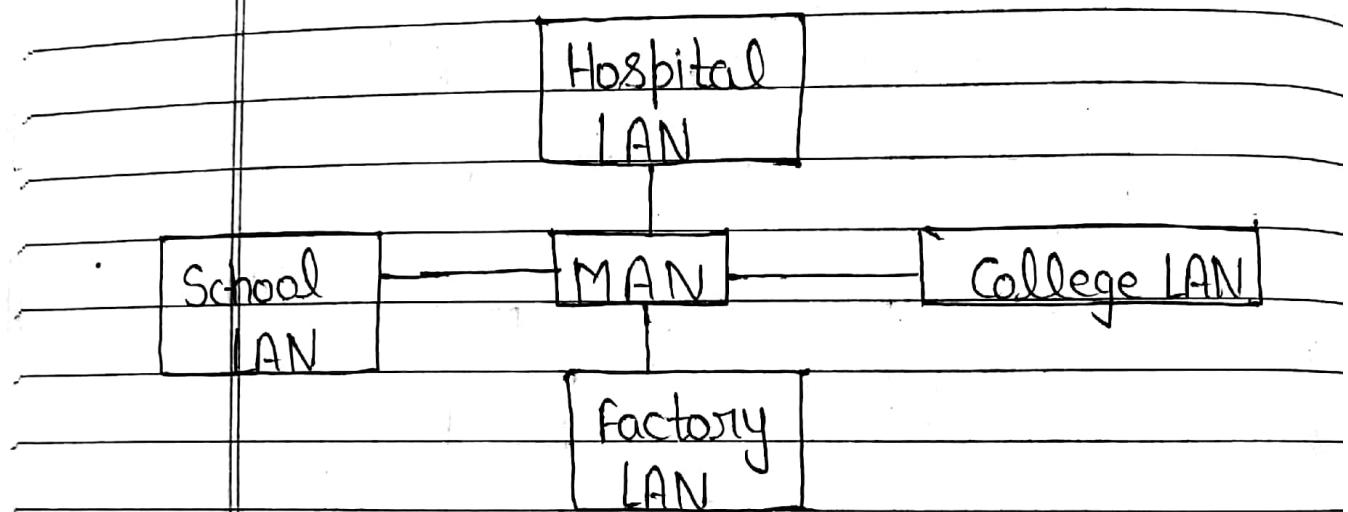
2.) Metropolitan Area Network (MAN) →

MAN stands metropolitan area network. This meaning is it covers relatively large region such as cities, towns etc. The ownership of this network is private or public. The design and maintenance of MAN is difficult. Propagation delay is moderate in MAN.

The speed is Moderate in MAN. It is less tolerant. It is more congestion. It allows the multiple computers

can simultaneously interact. It is used for the small towns and city etc. Simply we can say that the networking in city to city is called MAN. The length of this is in some km's and speed is in some MB's. The coaxial cable is used in it.

$$1\text{ LAN} + 1\text{ LAN} = 1\text{ MAN}$$



3.) WAN (Wide Area Network) →

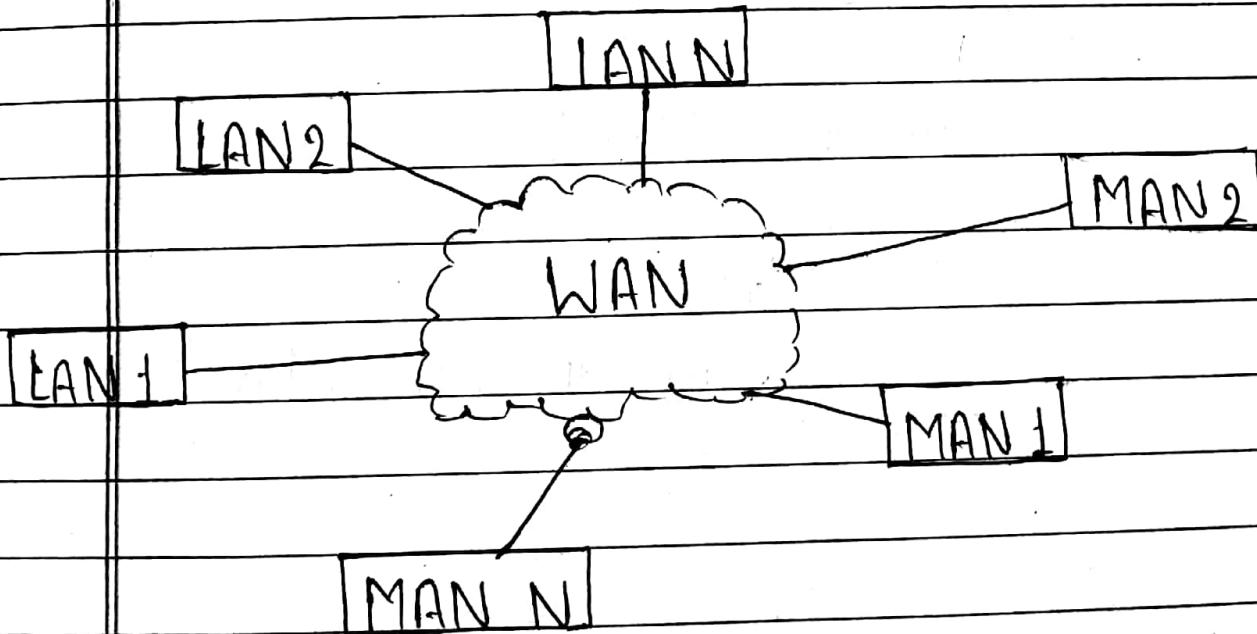
WAN stands for wide area network. Its meaning is it spans large locality and connects countries together, example internet. The ownership of network in WAN is private or public. The design and maintenance of WAN is difficult.

The propagation delay is long in WAN. The speed is low of WAN.

It has less tolerance. It is more

congestion. It allows a huge group of computers communicate at the same time. It is used for country/continent. Simply we can say that the networking in country to country is called WAN. The length of it is 30km to 10,000 km. and the speed is some GB. The optical fiber is used in WAN.

$$\text{MAN 1} + \text{MAN 2} + \text{MAN 3} = \text{WAN}$$



V.M.G.M.
→

ISO [International standard organisation]

Developed OSI in 1947 to solved the problem when two different bodies are try to communicate.

Means two diff. computer of diff. bits can not send and receive the data.

1947



Reference Model



OSI Model

(open system Interconnection)

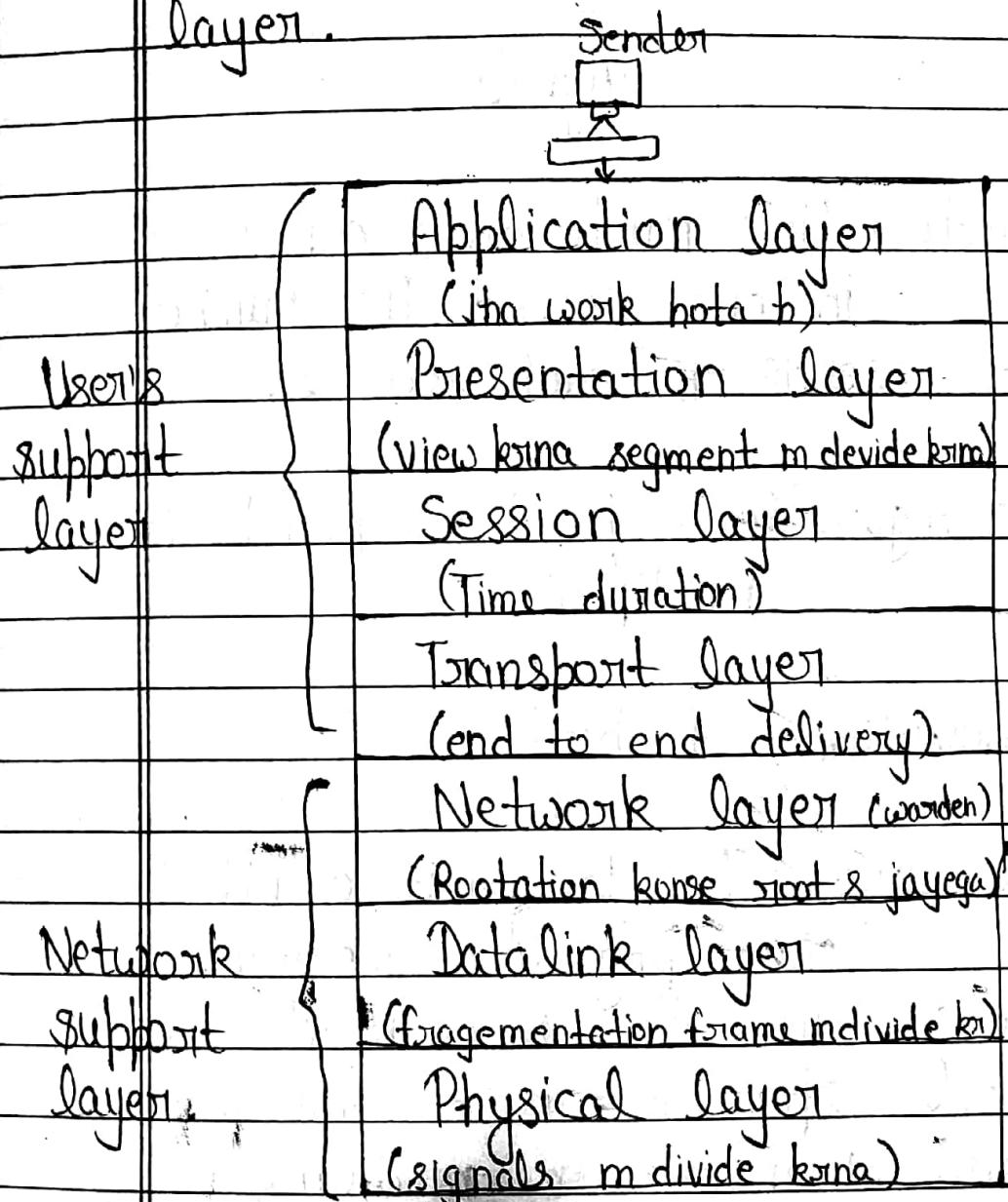
V.M.G.M.

OSI Model

OSI stands open system Interconnection. This model is developed in 1947 to solve the communication problem of different bodies (computers). It work on layer architecture.

It known as 7 layer architecture referential model. It is contain seven layers. Every layer provide the service to lower layer from itself. If the sender is in the

end then it provide services to lower layer and if receiver is in end then it provide service to upper layer.



⇒ Functions of layers →

- 1) Physical layer → It defines the bit rate. means how much data in how much bit is taken by wire.

i) Representation of bits \rightarrow (encoding)

$$0 \& 1 \longrightarrow \text{signals}$$

ii) Data rate \rightarrow How much data can be send in one second. The number of bits sends in each seconds.

iii) Line configuration \rightarrow point to point or multipoint

iv) Synchronisation of bits.

Physical layer \rightarrow To transmit a bit stream over physical medium.

\rightarrow It deals with the mechanical and electrical specification of the interface of and transmission medium.

From DLL

To DLL

L2 Data

L2 Data

Physical
layer

1010101

1010101

encoding
in signals

Transmission medium

• \Rightarrow Responsibility of Physical layer \rightarrow

1) Representation of bits \rightarrow

In physical layer data consist of a stream of a bit (sequence of 0 and 1) without any interbitmation to be transmitted , bits must be coded into signals - electrical or optical.

2) Data rate \rightarrow The no. of bits send each second.

3) Synchronization of bits \rightarrow Send tabhi hoga jab receiver kرنو ko tayor hoga .

4) Line configuration \rightarrow Line to Line , multipoint.

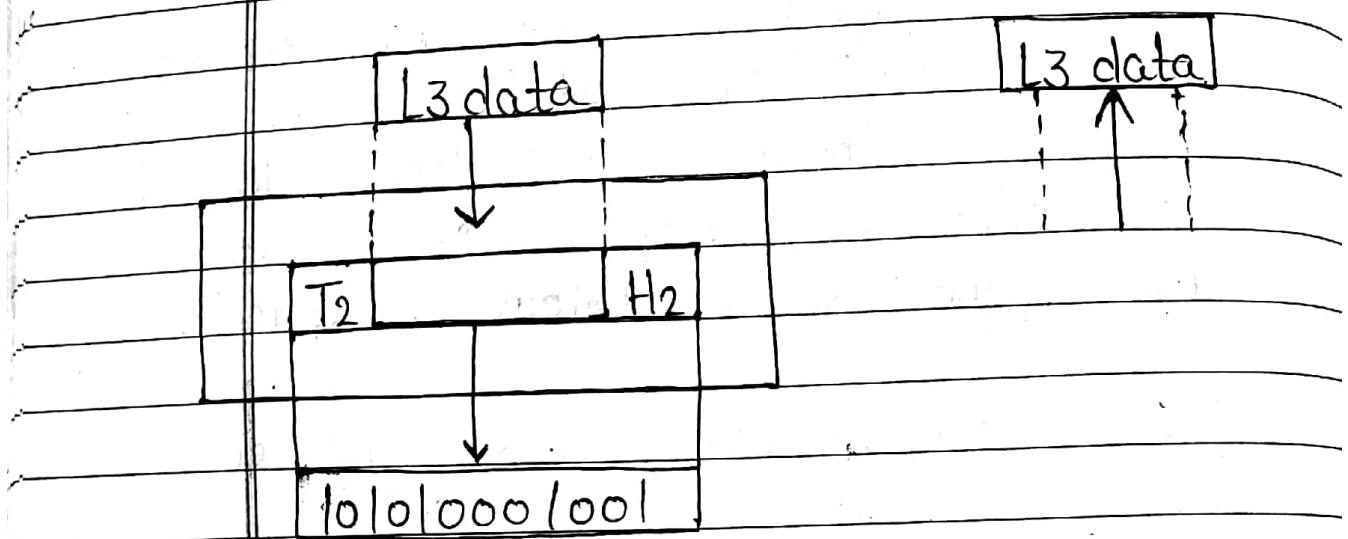
5) Physical topology \rightarrow Which topology are used in networking such as -
Bus , mesh , star . Transmission mode \leftarrow Simplex
Half Duplex
Full Duplex

2) Data Link Layer \rightarrow

A raw transmission facilities to reliable link and node it is responsible for node to node delivery . It also make the physical layer appear error

free to upper layer that is network layer.

From NW Layer



To Physical layer

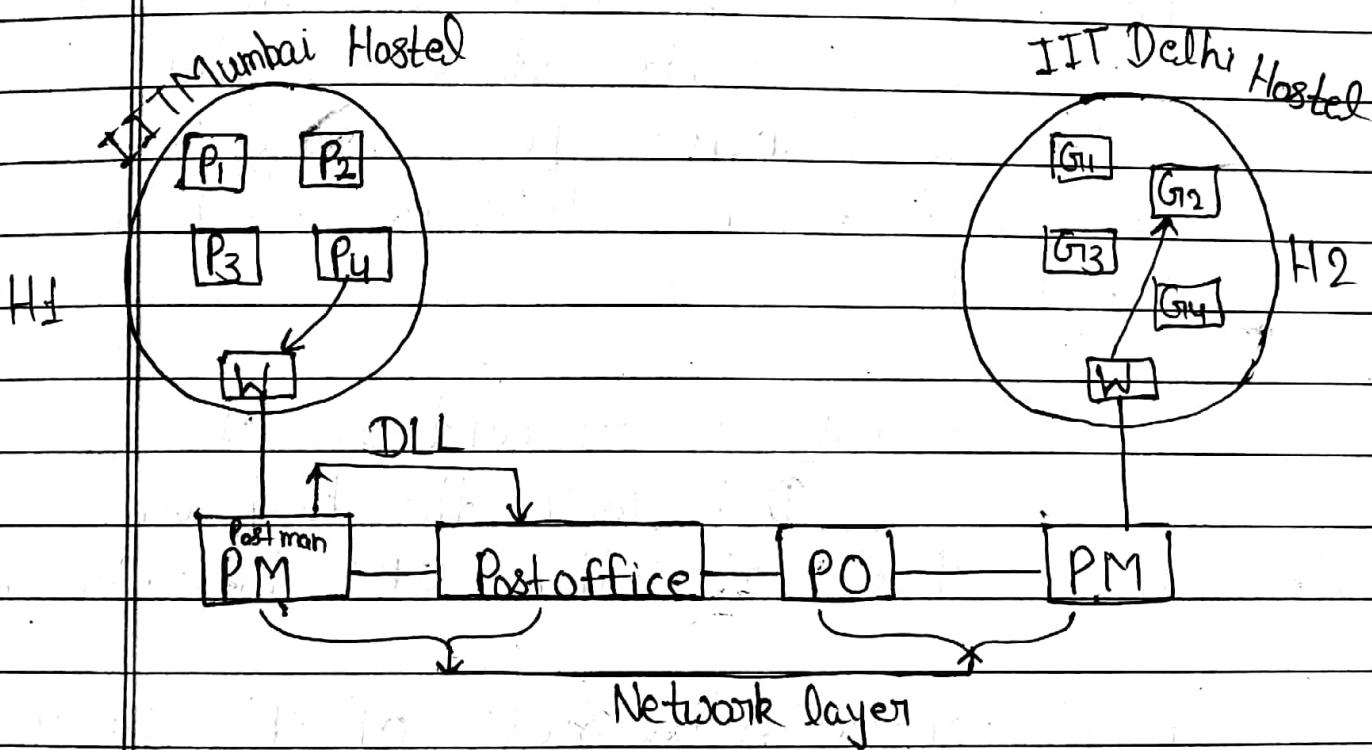
⇒ Responsibilities of Data link layer

1.) Framing → It divide the stream of bit received from network layer (L3) into manageable data unit call from.

2.) Physical addressing → If frame are disturbed on the network data link layer adds header to the frame to define the physical address often sender and receiver address of the frame.

- 3.) Flow control →
- 4.) Error control
- 5.) Access control.

Locally add. kرنے ki responsibility means host to host delivery DLL kरतا h.



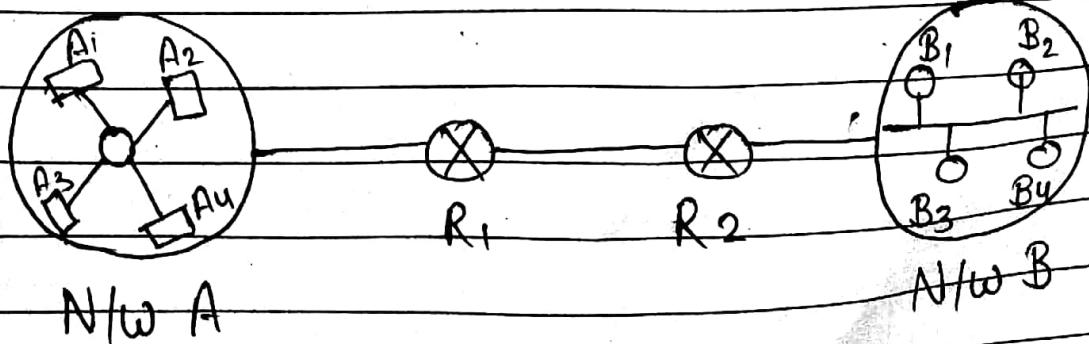
Students → Process

Hostel → Computer

Warden → Transport Layer

Postman → N/w layer

Postoffice → Router

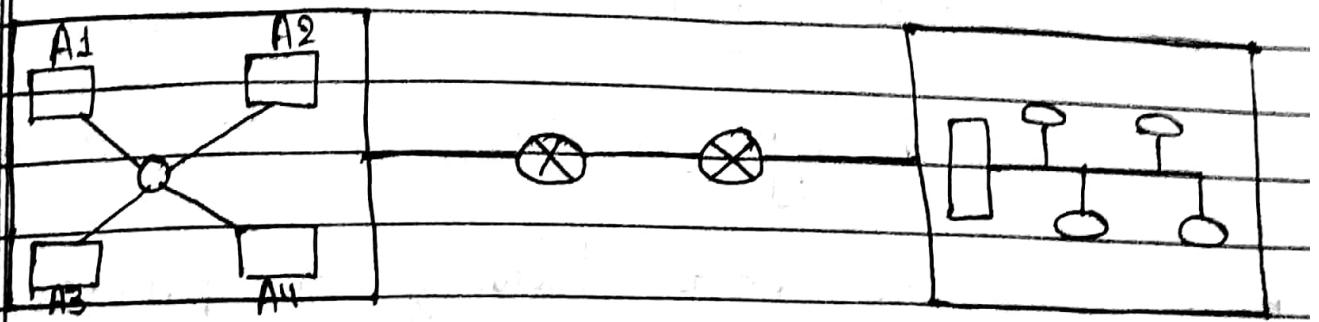


- 1.) Node to node delivery Or host to host delivery.
- 2.) Flow control.
- 3.) Error control.
- 4.) Framing.

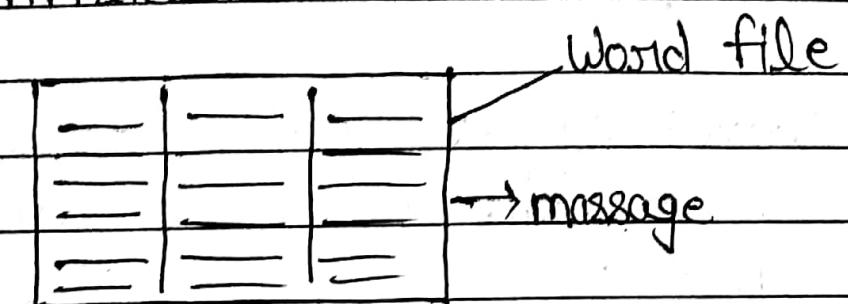
Flow control → It controls the data-rate. It means the data is transfer per second in ^{per second}. It control the data rate to host to host.

Error control → Error control in DLL with the help of these three algorithm CRC, LRC, VRC.

Access control → Protocols of this layer determine which of the device has control over the link at any given time when two or more devices are connected to the same link.



Application (P & S)



Presentation layer

→ Segmentation

Network layer

→ Packets

DLL → Framing

Network layer →

Responsibility of network layer →

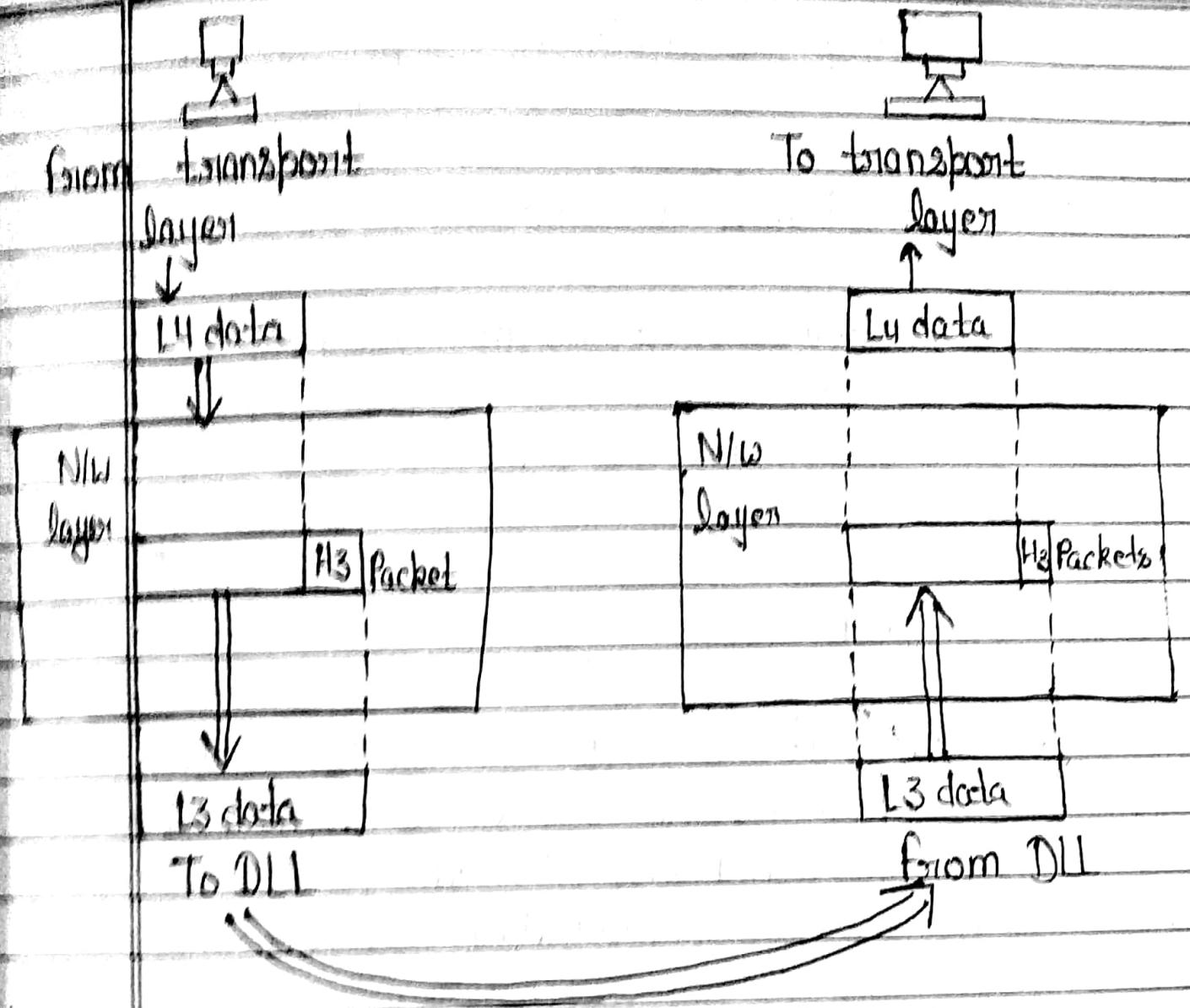
1.) Host to host delivery of packets.
It means source to destination delivery of the packets / message across multiple network.

2.) logical addressing (virtual address)
IP address is the combination of Netid or host no.
It handles the problem globally.

Routers works on N/w layer.

Bridges work on DLL layer.

3.) Routing → which path is shortest and errorfree in which data is send to receiver.



→ Transport Layer →

Responsibility of Transport Layer →

End to end delivery of the entire message. (Process to Process delivery).

whereas network layers deserve end to end delivery of individual msg.

1) Service point addressing → port no. btane ka kaam.

2) Segmentation and Reassembly →

Reassembly to segmentation.

3) Flow control

4) Error control.

⇒ Session Layer →

It is the network dialog controller. It establishes, maintains and synchronized the interaction between communication devices.

Responsibility of session layer →

1) Dialog controller → (mode of control)

Session layer allows to system to enter into a dialog. It allows the communication between two processes to take place either Half duplex, full duplex and simplex

2.) Synchronization → The session layer allows a process to add checkpoints (synchronization) into a stream of data.

Example: A computer give command to printer to print 200 pages so each pages have checkpoint after 10 pages when printer has printed the page if some reasons it connection cut then it restart print to next 10 pages. means (50) restart (51).

⇒ Presentation Layer →

It is concerned with the syntax and semantics (each section of bits) of the information exchanged b/w two devices or system.

Responsibility of Presentation Layer,

1.) Translation → (Convert the data format)

The processes in two systems are usually exchange information in the form of character strings, numbers.... The information should be changed to bit stream before being transmitted because different computer are using

different encoding system.

- 2.) Encryption → (data conversion) Secure kinda
- 3.) Compression → (minimize kinda size, zip file).

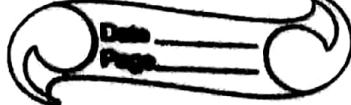
⇒ Application layer →

It enables the user whether human or software to access the network. It provides user interfaces and support for services such as email, remote file access, share dbms etc.

Data transmission manner →

Connectionless → Unorder (Order change)

Connection oriented -



⇒ TCP/IP Protocols Suits →

Transmission Control protocol / Internet protocol.

APPLICATION	APPLICATION						
PRESENTATION	SMTP	FTP	TENET	DNS	SNMP	NPS RPC	KFTP
SESSION							

Transport layer

TCP

UDP

Network layer

ICMP

IGMP

IP

ARP

RARP

DLL

Protocol

defined by
the underlying

Physical layer

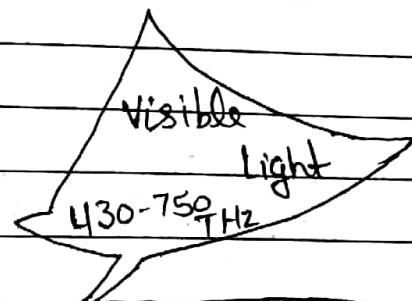
Network

- TCP/IP standard form of transmission control protocol / Internet protocol.
- It is used for internet was developed prior to OSI model. Therefore, layer of TCP/IP protocol don't match with OSI model.
- It has 5 layers
 - 1) Physical
 - 2) Data link layer
 - 3) Network
 - 4.) Transport
 - 5.) Application layer.
- The first four layer provides physical standard N/W interface , internet , networking and transport function that corresponding to the DLL .

~~Jm gm~~ Transmission Media

Physical Layer → (cable)

→ Transmission Media →



Power voice	Radio communication (Radio, microwaves, satellite)	Infrared light	Ultraviolet light	X, gamma cosmic rays
3 MHz	300 GHz			

Transmission media can be divided into two parts. These are given below:

- Guided
- Unguided



- Guided Media → Which are those that provides a conduit from one device to another.

~~Example~~

Twisted pair cable, coaxial cable, optical fiber.

(isko twisted isliye karte h jisse baton ki koi noise affect na de)

Repeater is used for ~~actually strength where attenuation is done~~ ~~is done~~ ~~is done~~

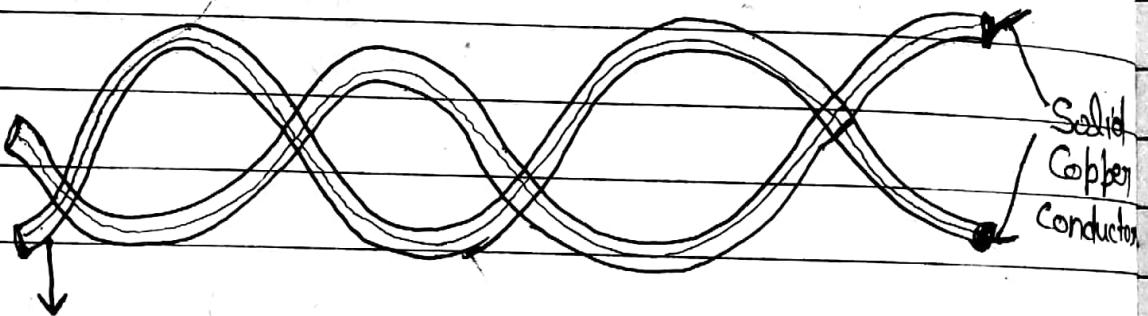
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⇒ Twisted pair cable →

Twisted Pair

100 Hz

5 MHz



Outer
Insulator

Twisted pair consist of two conductor each surrounded by an and insulating material. It is two types :-

- 1.) UTP [Unshielded twisted pair]
- 2.) STP [Shielded twisted pair]

It is plastic coded

~~Base band is used for analog and Broad band~~
for the digital signals.

Cables -

- Twisted pair cable - 10 Base T, 100 Base T
- Coaxial cable $\leftarrow^{10 \text{ Base 2}, 100 \text{ Base 2}}_{10 \text{ Base 5}, 100 \text{ Base 5}}$
- fiber optics - 100 Base fx

→ Twisted pair cable → It has cheap cost.

10 Base T → 100 mt.

↓
10 mbps.

→ Coaxial cable →

10 Base 2 → 200 mtrs.

↓

10 mbps

It is basically used for LAN also
Ethernet LAN.

10 Base 5 → 500 mtrs.

↓

10 mbps.

→ Fiber optics →

100 Base fx → 1.9 ≈ 2 km.

↓

100 mbps.

Modem is device to convert the analog to digital and digital to analog signal.

⇒ Twisted pair cable →

It is the simplest transmission medium. It is consist of following:
It is in twisted phase. It is the outerphase insulator for saving outer electromagnetic waves.

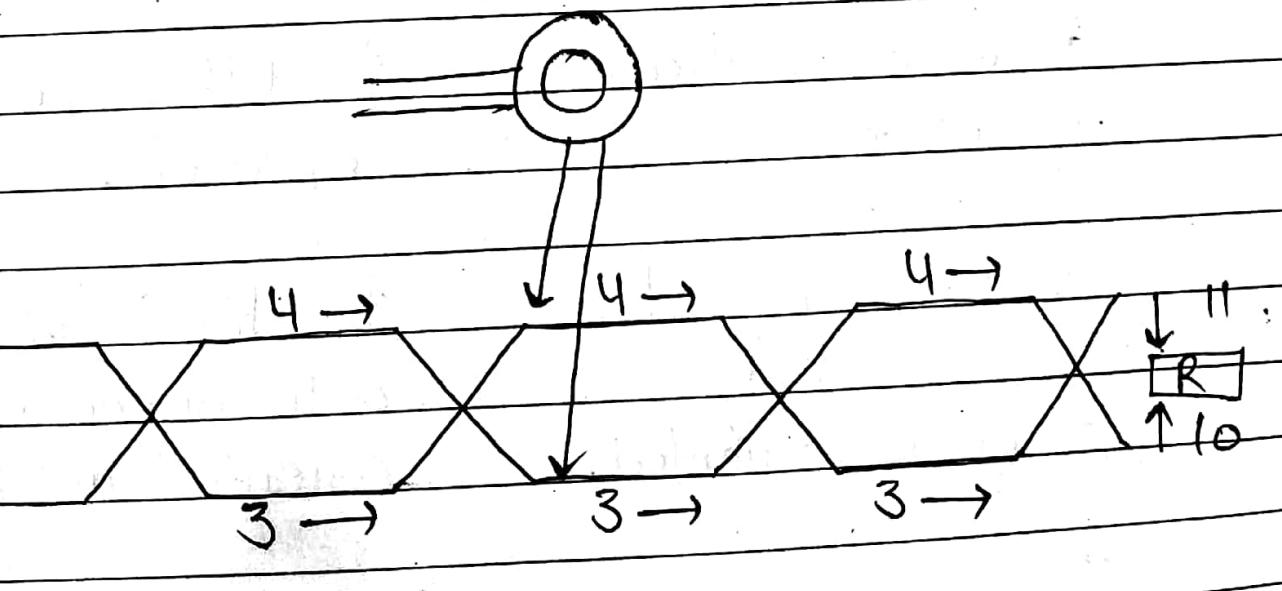
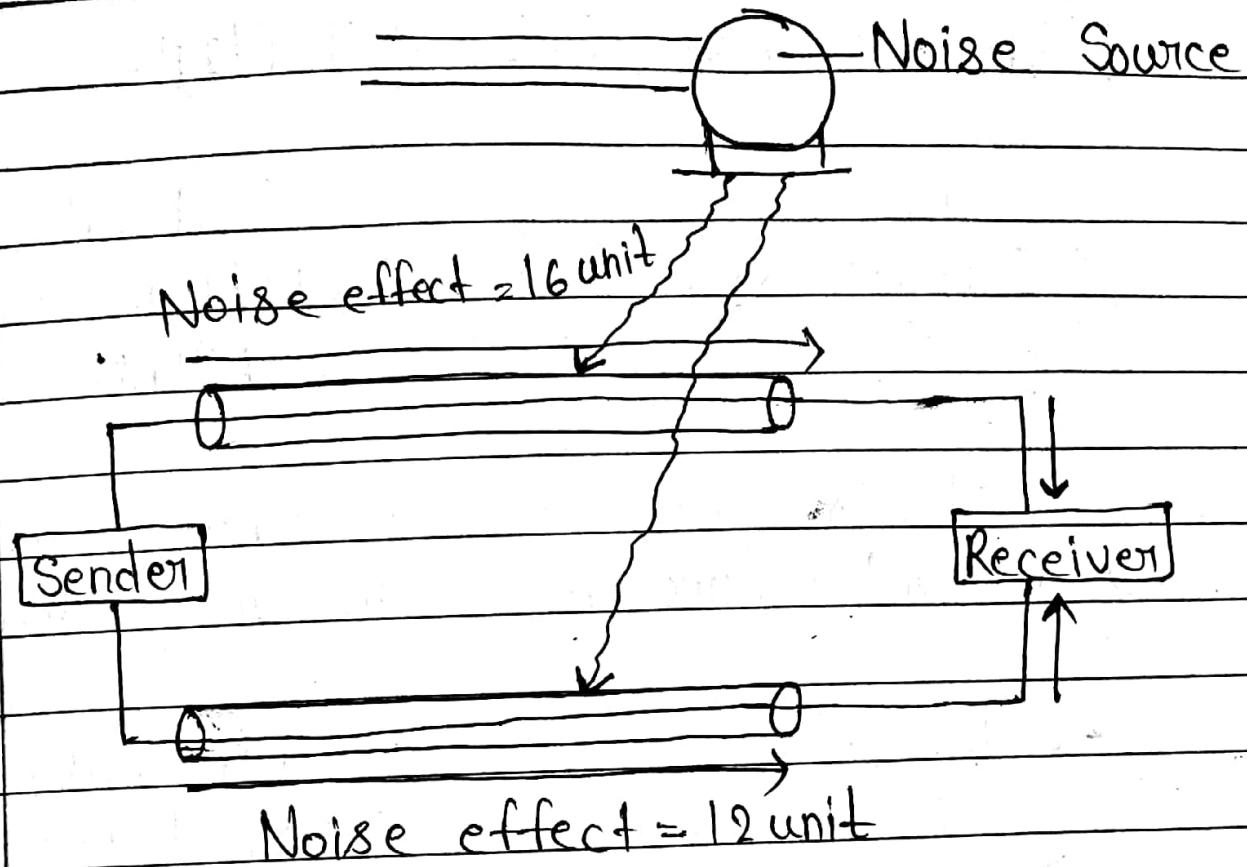
It transmitted both analog and digital signal. The twisted pair may be shielded, metal and unshielded.

A twisted pair consist of two copper wire about 1 mm. thick.

→ These two wires are individually content in a plastic insulation and are twisted together in a helical form.

→ Purpose of twisting the wire is to reduce the electrical interference from the similar pair in the surroundings. The performance of the wire improves with the increase in the no. of twist per fold.

If the two wires are parallel than the



Difference blw OSI & TCP/IP -

OSI

OSI is developed
by ISO

It stands Open
system interconnection.

It uses the network
layer.

It consists 7 layer.

It follows vertical
approach.

In it transport
layer is only
connection oriented.

The OSI header is
5 bytes.

It has no protocols.

TCP/IP

TCP/IP is developed
by ARPANET)

It stands transmission
control protocol.

It uses only
internet layer.

It consists 5 layer.

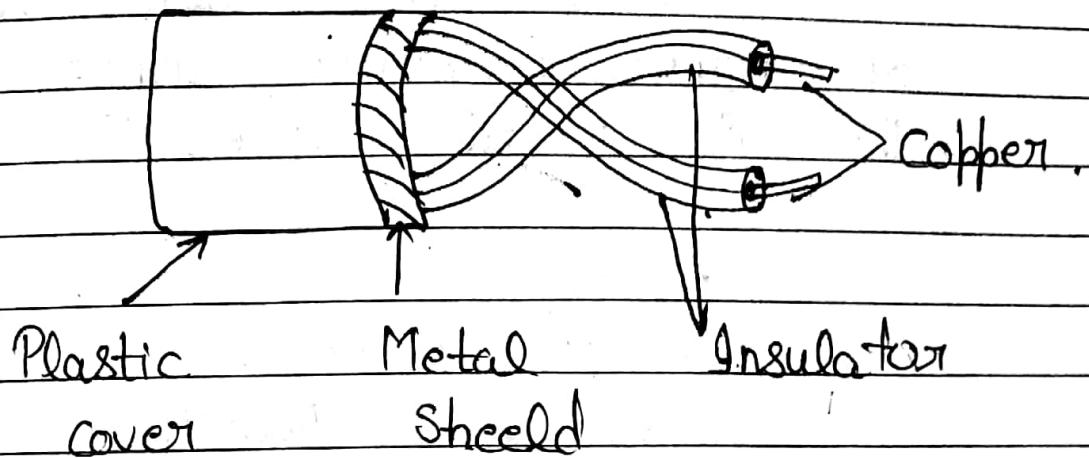
It follows horizontal
approach.

In this it is
both connection
oriented and less.

The header size
is 20 byte.

It has protocols.

Shielded Twisted pair



In the shielded twisted pair cable there is a plastic cover which is protect to wire. Here two copper conductor and the insulator is also in it. Here is a metal shield which is used to protect this by outer rays. This cable is twisted for protected outer noise and rays. It is one type of twisted pair cable.

Advantages

- It reduce chance of crosstalk.
- It offer better electrical characteristics.

Disadvantages

- It has higher cost per foot of wire
- There is no improvement in segment length.

⇒ Co-axial cable →

Co-axial cable carries signal
of higher frequency range than
the twisted pair cable.

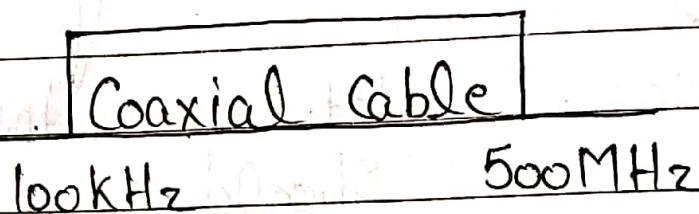
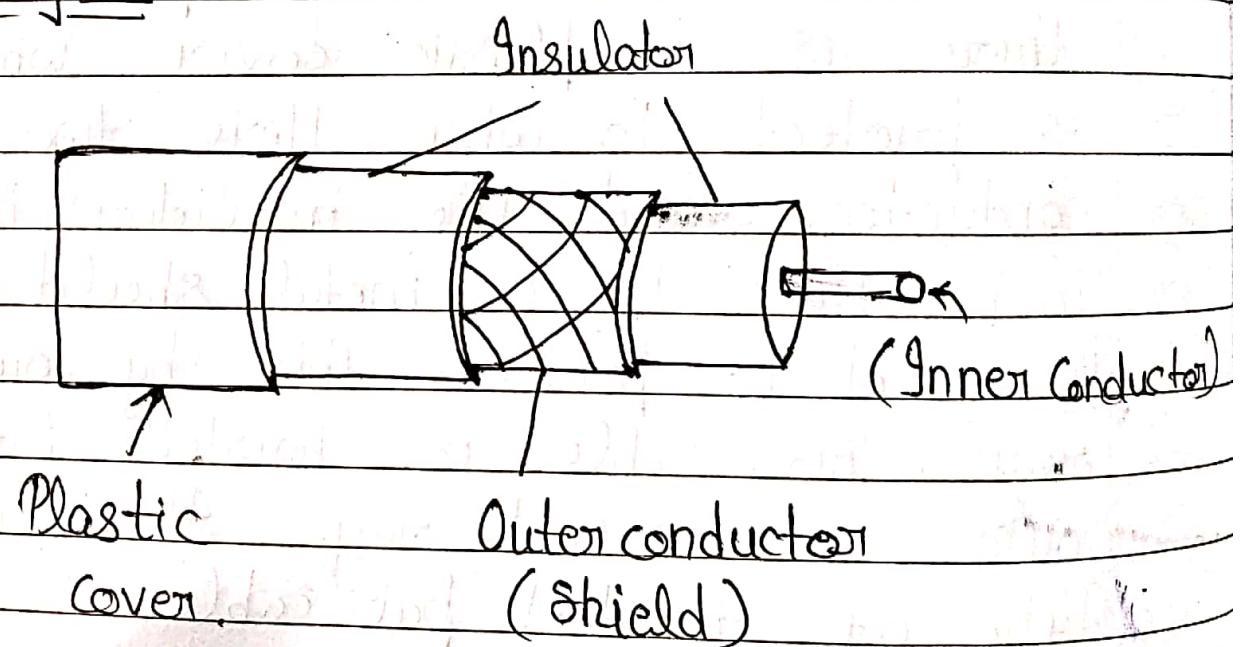
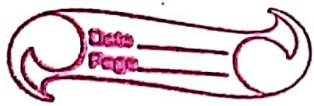


Figure →



RG 58 → Used for thin ethernet
RG 59 → Used for TV.



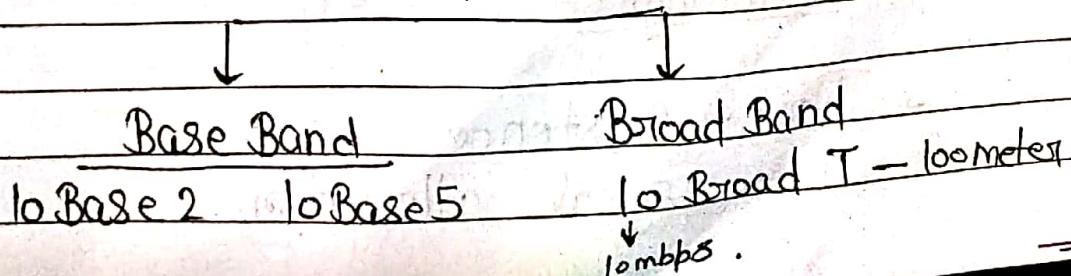
Advantages -

- It is used for both analog and digital transmission communication.
- It offers higher bandwidth as compare to twisted pair cable and can span longer distances.
- It is less expensive than optical fiber.
- It has lower error rate as compare to twisted pair.
- It is not as easy to tap as twisted pair because copper wire is contained in plastic cover.

Disadvantages -

- It is usually more expensive than twisted pair.
- Application of coaxial cable -
- Analog network, digital ; cable TV, Traditional Ethernet LAN, digital transmission and ethernet.

Coaxial Cable

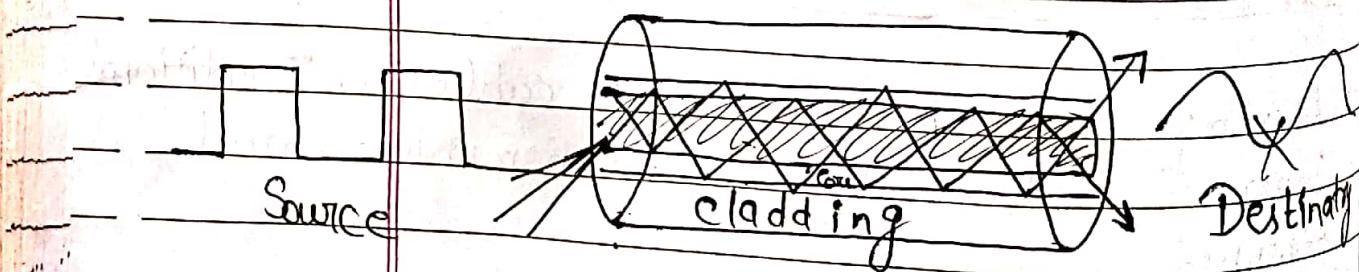
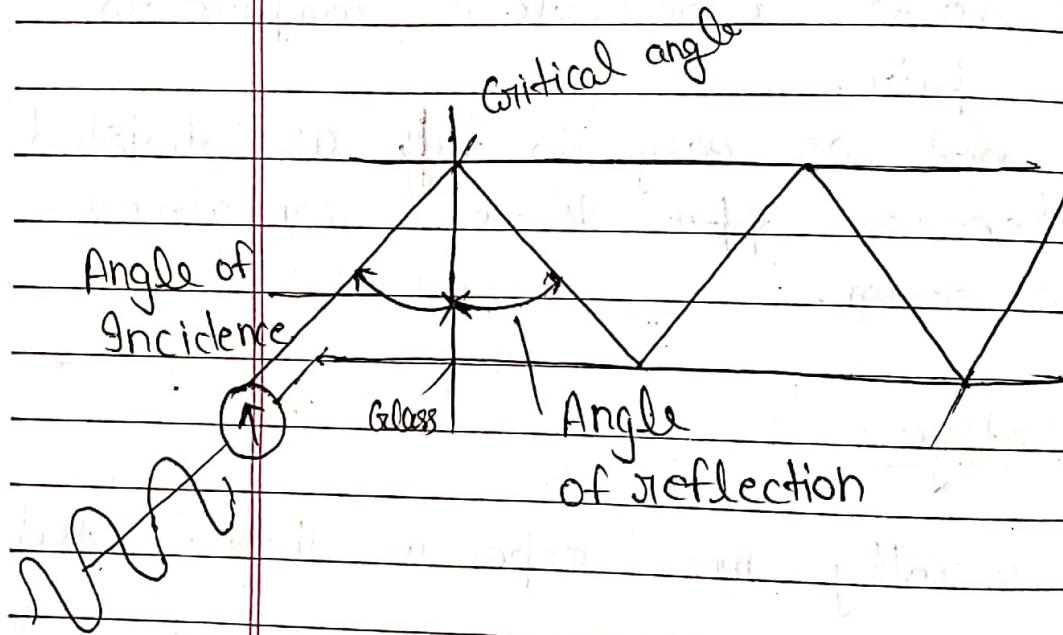


→ Optical fiber

Light = 3×10^8 m/sec ki form m. data jata h. Reflection form m. data chalta h.

optical fiber

500 MHz 500 THz



Advantages -

- Noise Resistance.
- Less signal attenuation.

→ Higher Bind width.

Drawback

- Cost is not beneficial.
- Connectivity is break then the connectivity started is very difficult.

Disadvantages

- High initial cost.
- Difficult to maintain.
- Difficult to repair.

→ Name the two types of bind width.

→ What is the main advantage of wide?

→ What is the main disadvantage of wide?

→ What is the main advantage of narrow?

→ What is the main disadvantage of narrow?

→ What is the main advantage of medium?

→ What is the main disadvantage of medium?

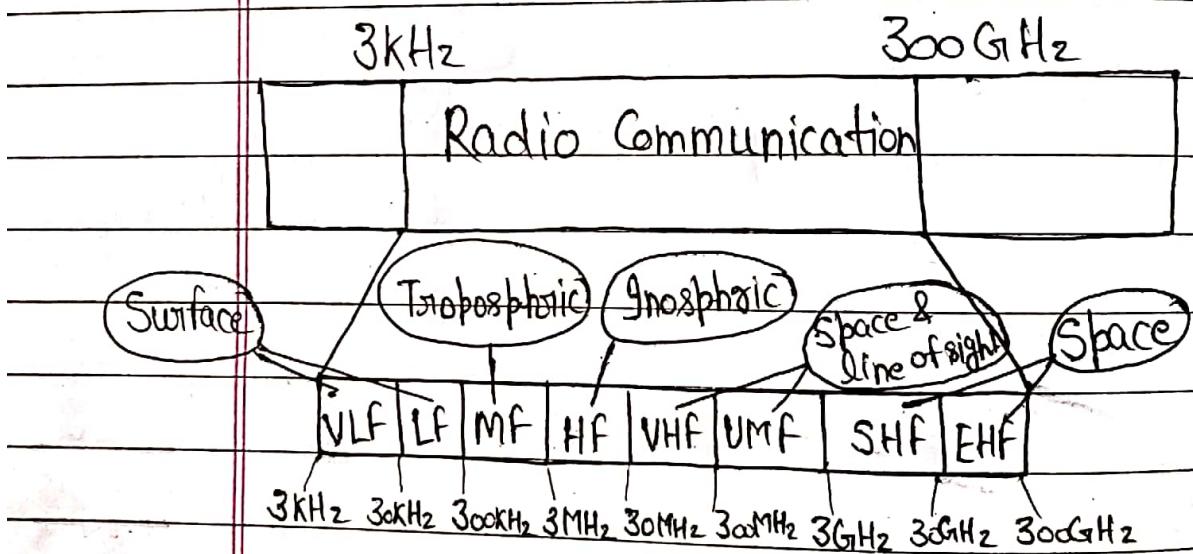
→ What is the main advantage of flexible?

→ What is the main disadvantage of flexible?

Unguided Media → (Wireless) →

The frequency range of guided media is 3 kHz to 300 GHz.

The example of it is radio's waves, microwaves and satellite waves communication etc. It is the wireless media.



Very low frequency \rightarrow VLF
Low " " LF

MILIA

Middle " MS

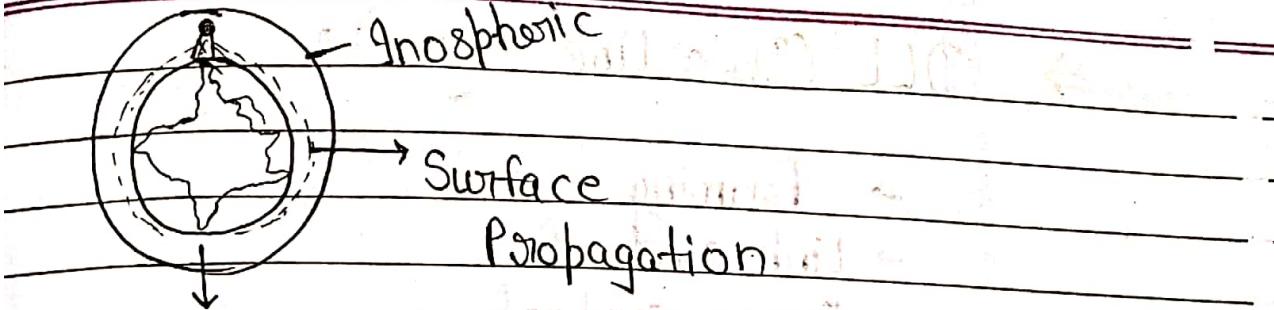
High " → HF

Very high " \rightarrow VME

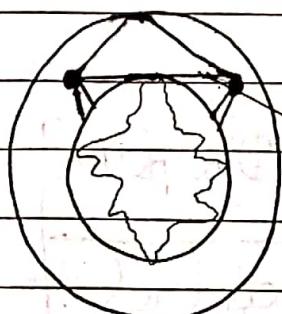
~~Ultra high~~ → UMF

Super high " → suff

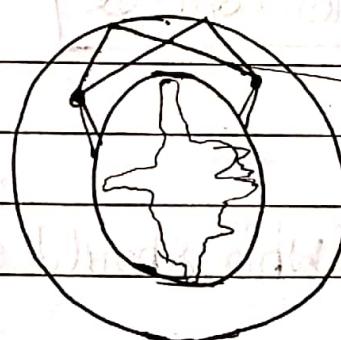
Extreme High " → SHF
Extreme High " → EHF



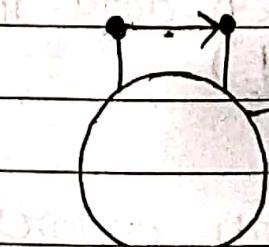
Troposphere



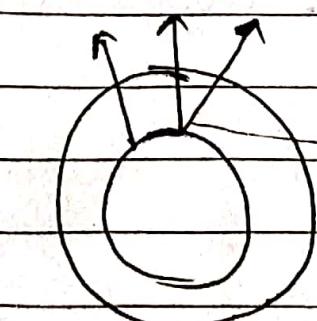
Tropospheric
Propagation



Anospheric
Propagation



Line of sight
propagation

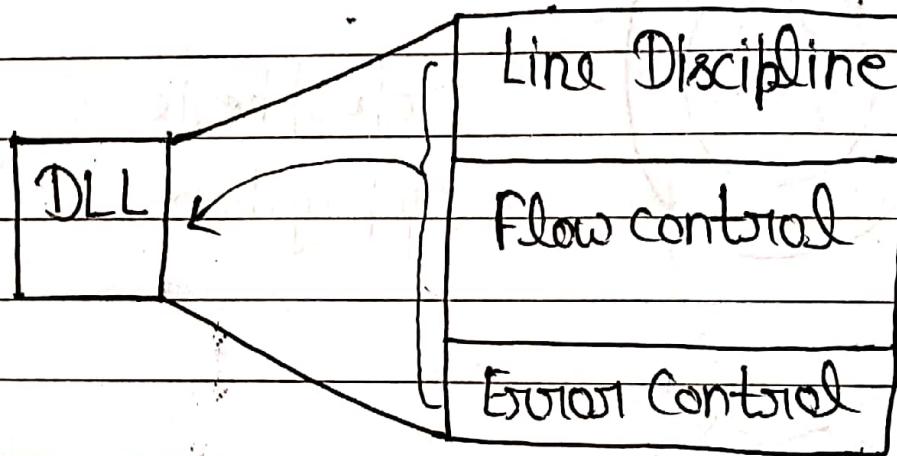


Space propagation

⇒ DLL (Data Link Layer) →

- Framing
- Link control
- Error control
- Flow control
- Access control

Link control →



Line discipline → (who should send now.)

Flow control → (How much data may be sent)

Error control → (How can errors detected & corrected.)

EOT → End of transmission



Line discipline

ENQ / Ack (enquiry / acknowledgement)

POLL / Select.



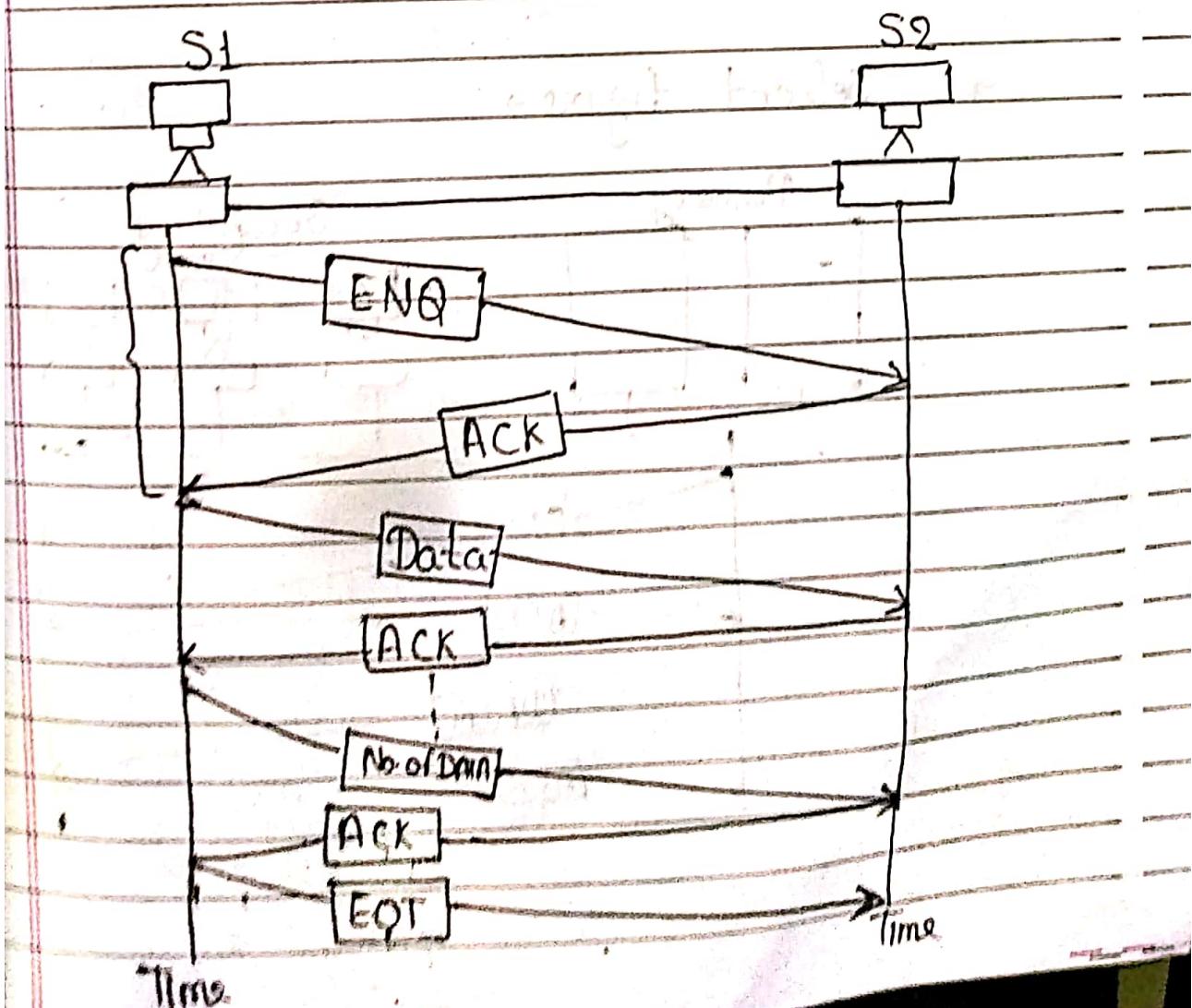
(Who should start)



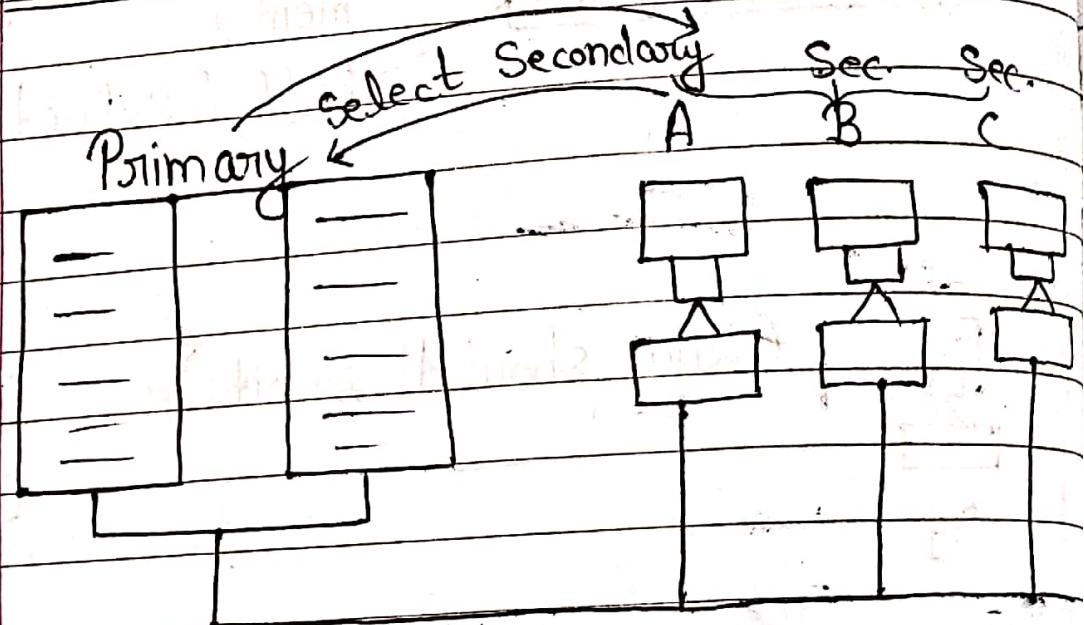
S1

S2

How can one station can be sure that the other is ready.

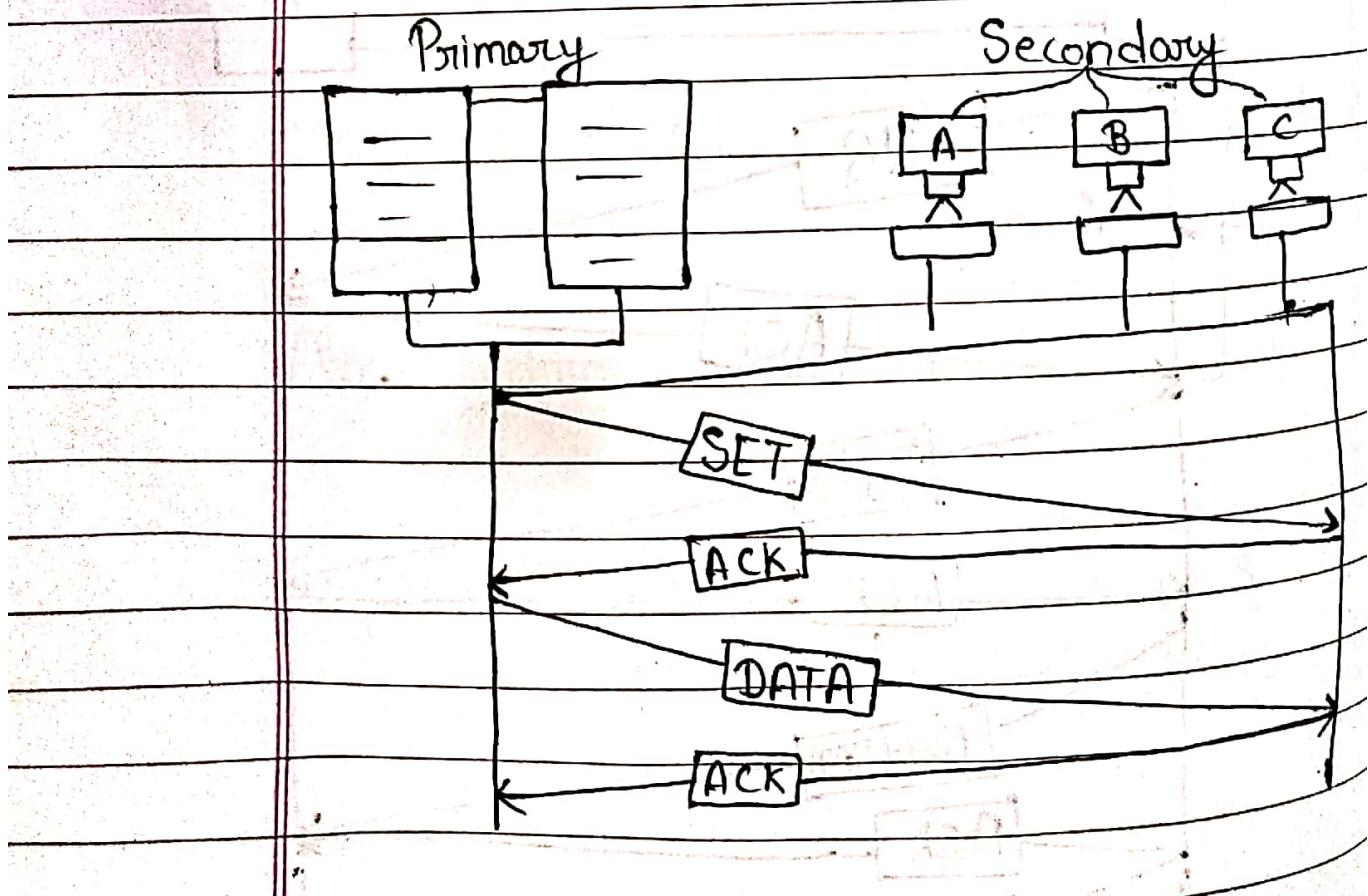


2.) Poll / Select →

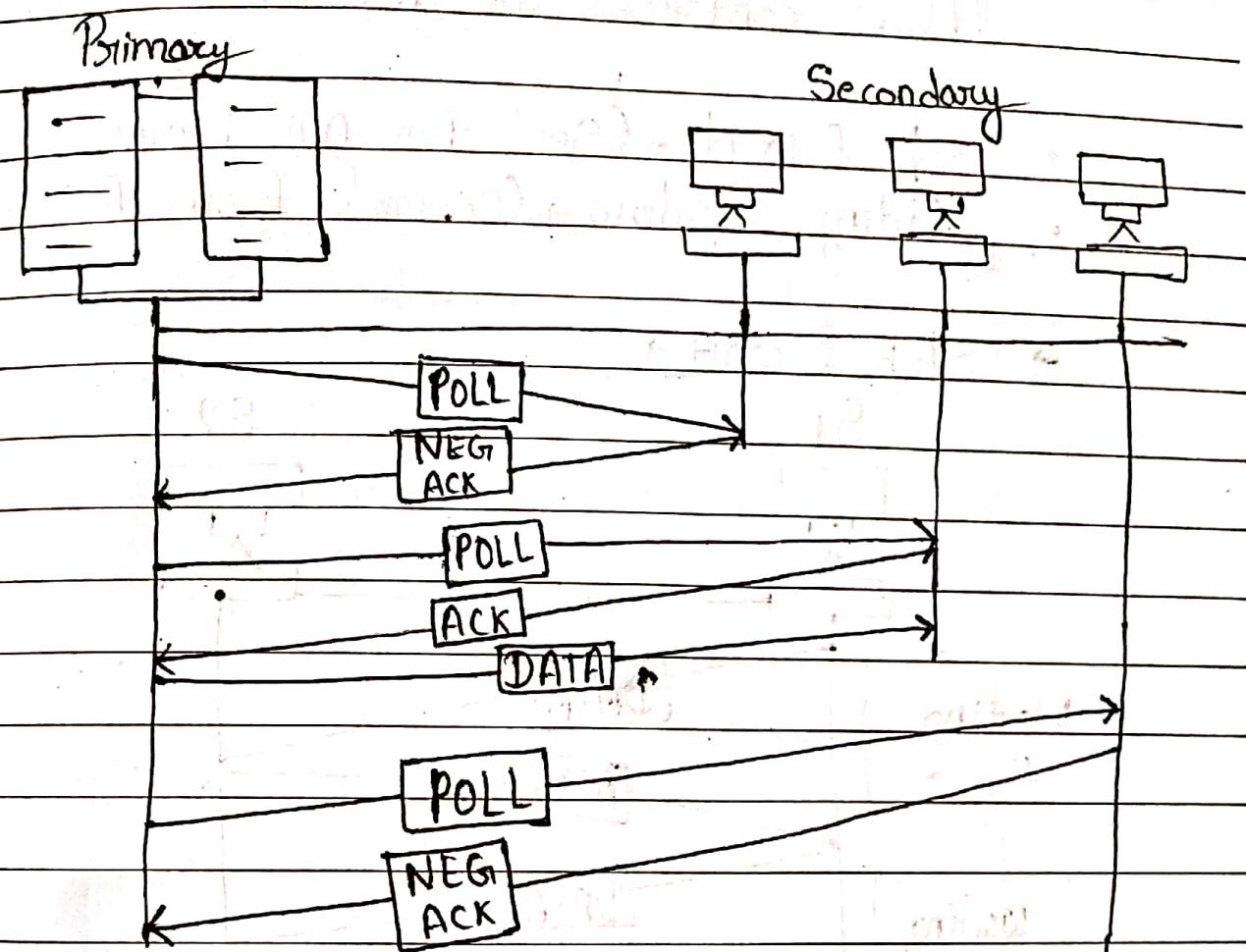


(who has right to the channel)

* Select figure →

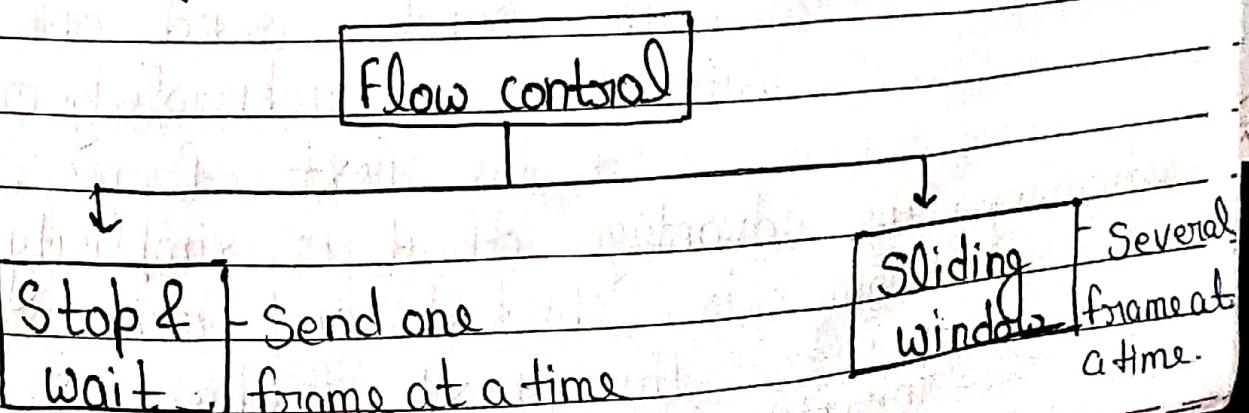


* Poll figure →



⇒ Flow control →

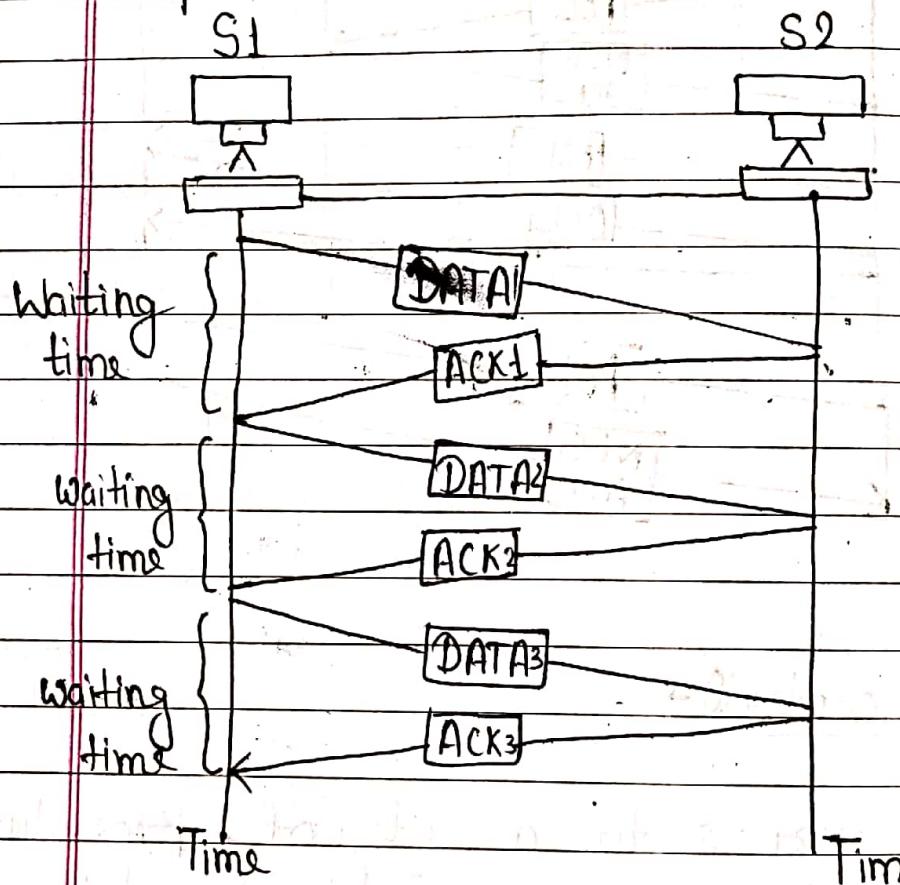
It refers to a set of procedure used to restrict the amount of data, the sender can send before waiting for acknowledgement.



There are two methodology of flow control as follows

- Stop & wait → (Sent for one frame)
- Sliding window → (Several frame for send)

→ Stop & wait →



In the stop & wait method of flow control, the sender send one frame and wait for an acknowledgement before send the next frame.

Advantage: The advantage of it is simplicity. Each frame is checked and acknowledged before the next frame is send.

Disadvantage: inefficiency is the disadvantage of it. It is also a time consuming process.

→ Sliding window → Several no. of frame send at a time.

6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Sender Window

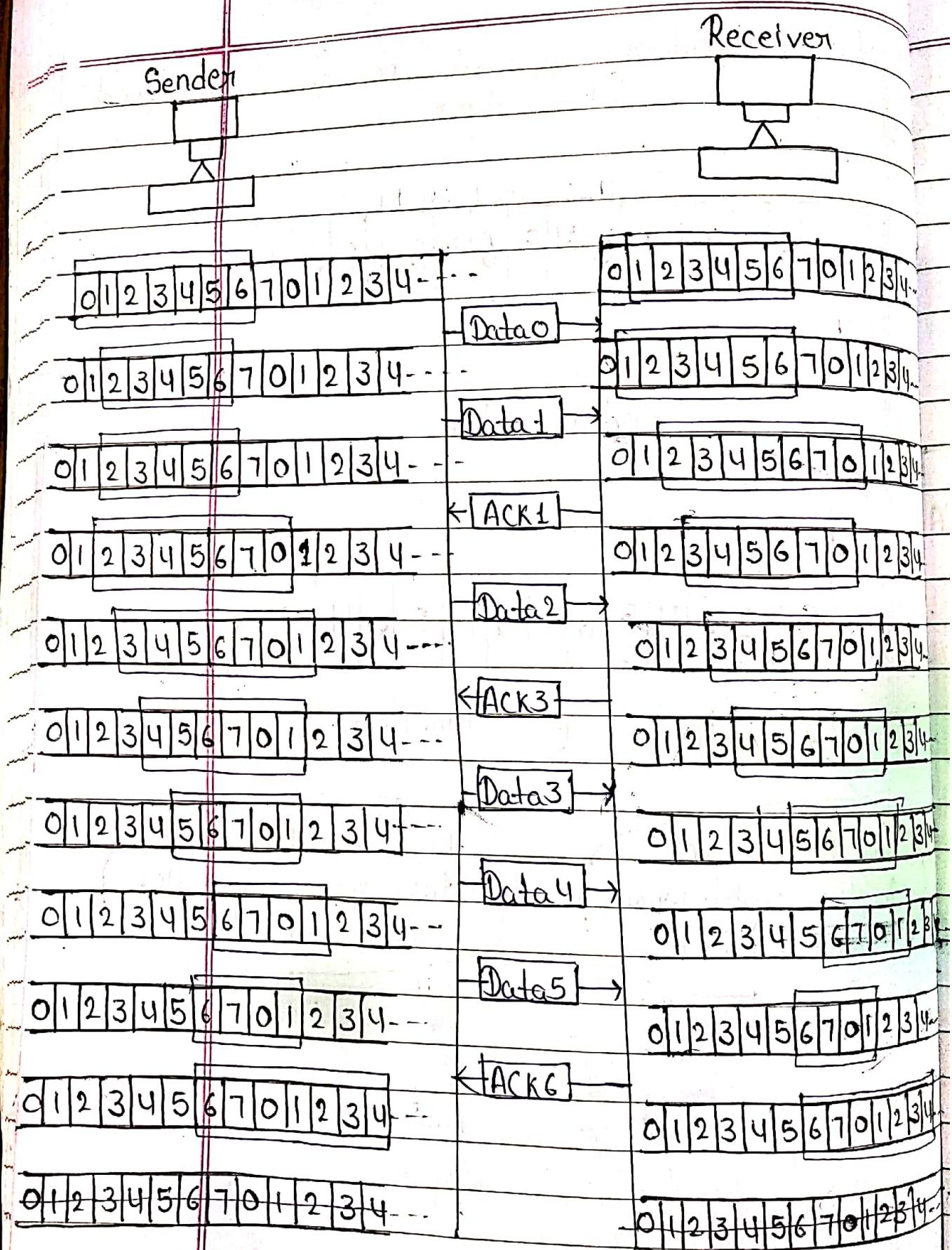
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

→ Direction

→ Direction

This wall moves to the right when frame is sent

This wall moves to the right when ACK is received



Error Control →

It refers to error detection and Retransmission. This retransmission is ARQ (Automatic Repeat request.).

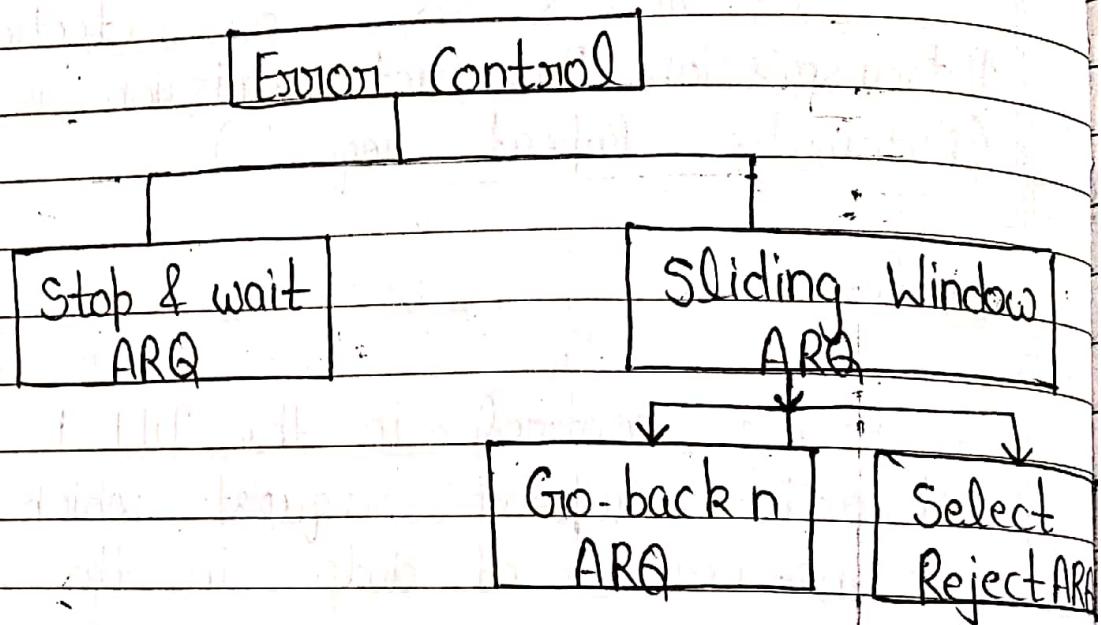
ARQ →

Error control in the DLL is based on automatic repeat request which means retransmission of data in three cases:

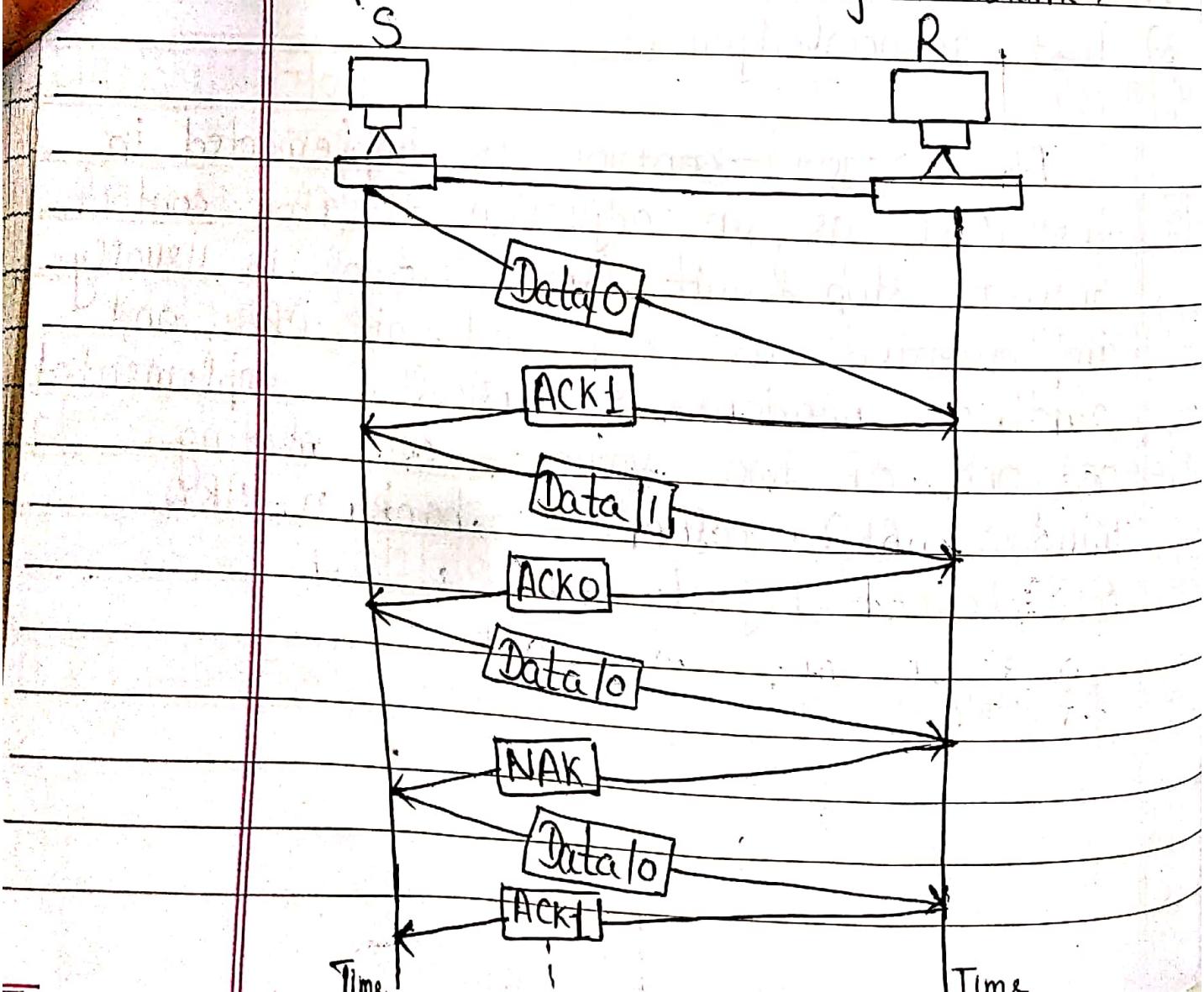
- 1.) Damaged frame
- 2.) Lost frame
- 3.) Lost acknowledgement.

ARQ error control is implemented in the DLL as an adjustment to flow control. In fact stop & wait flow control is usually implemented as stop and wait ARQ. and sliding window is basically implemented as one of two variants of sliding window ARQ called go-back n ARQ or select - Reject ARQ.

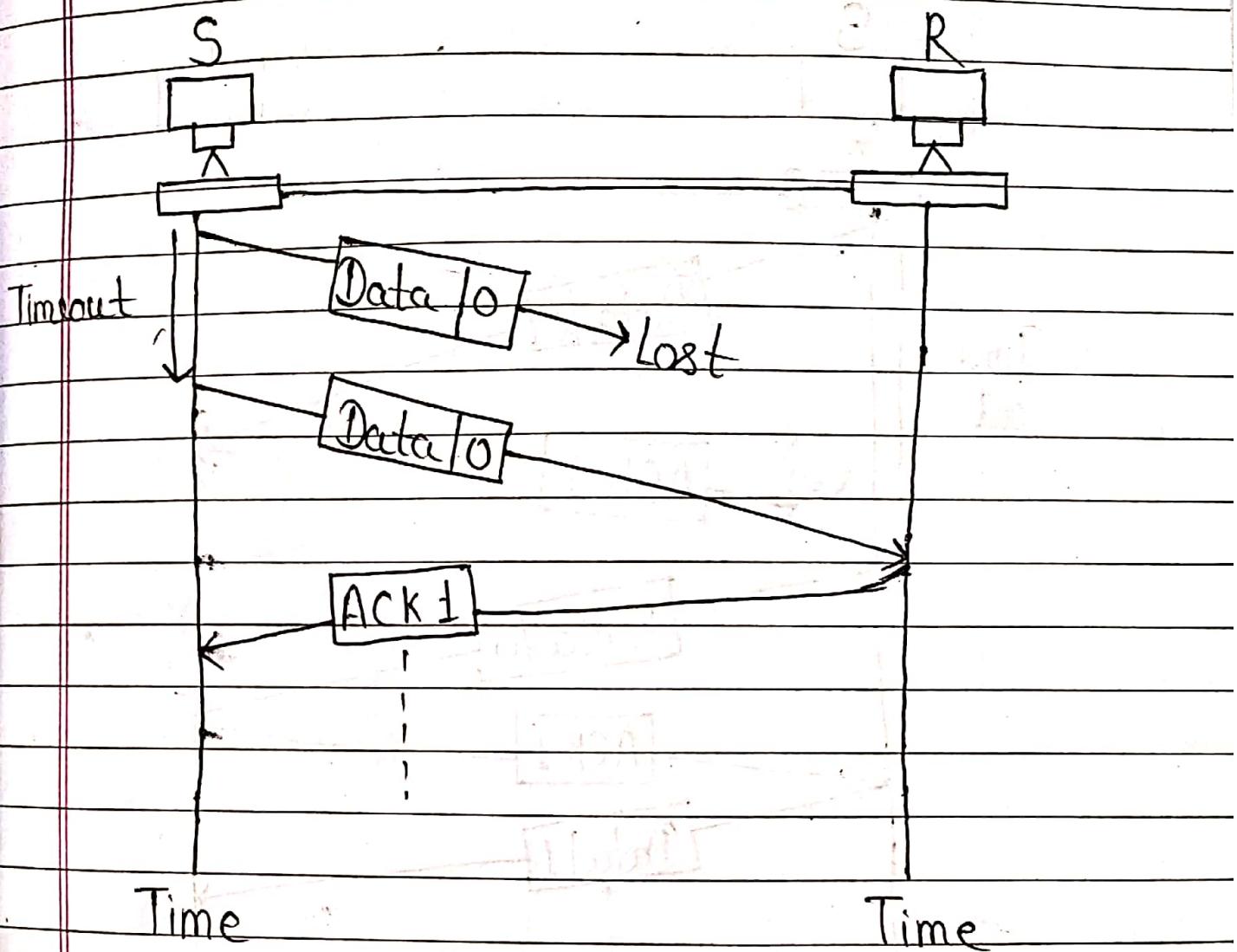
1.) Stop & wait ARQ →



a) Stop & wait ARQ , damaged frame →

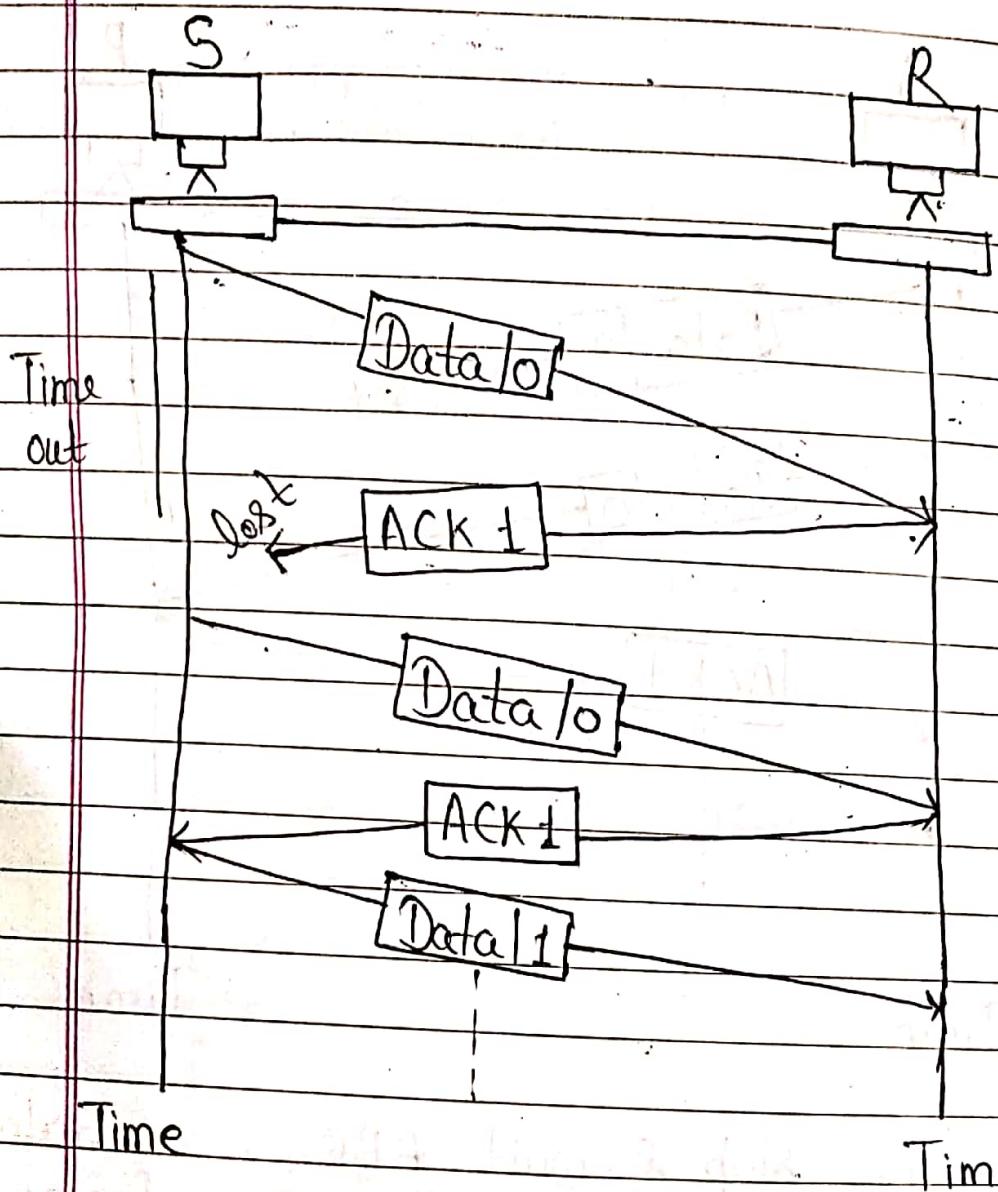


b) Stop & wait ARQ, lost data frame →



In the stop & wait ARQ, lost data frame the sender send the one frame as data 0 but it is lost and receiver does not send its ack. so in the full time duration it resend this frame and after completing sending receiver is also send this ack of this frame as ACK 1.

c.) Stop & wait ARQ, Lost Acknowledgement



In this stop & wait ARQ, lost acknowledgement sender send only one frame at a time as data 0.

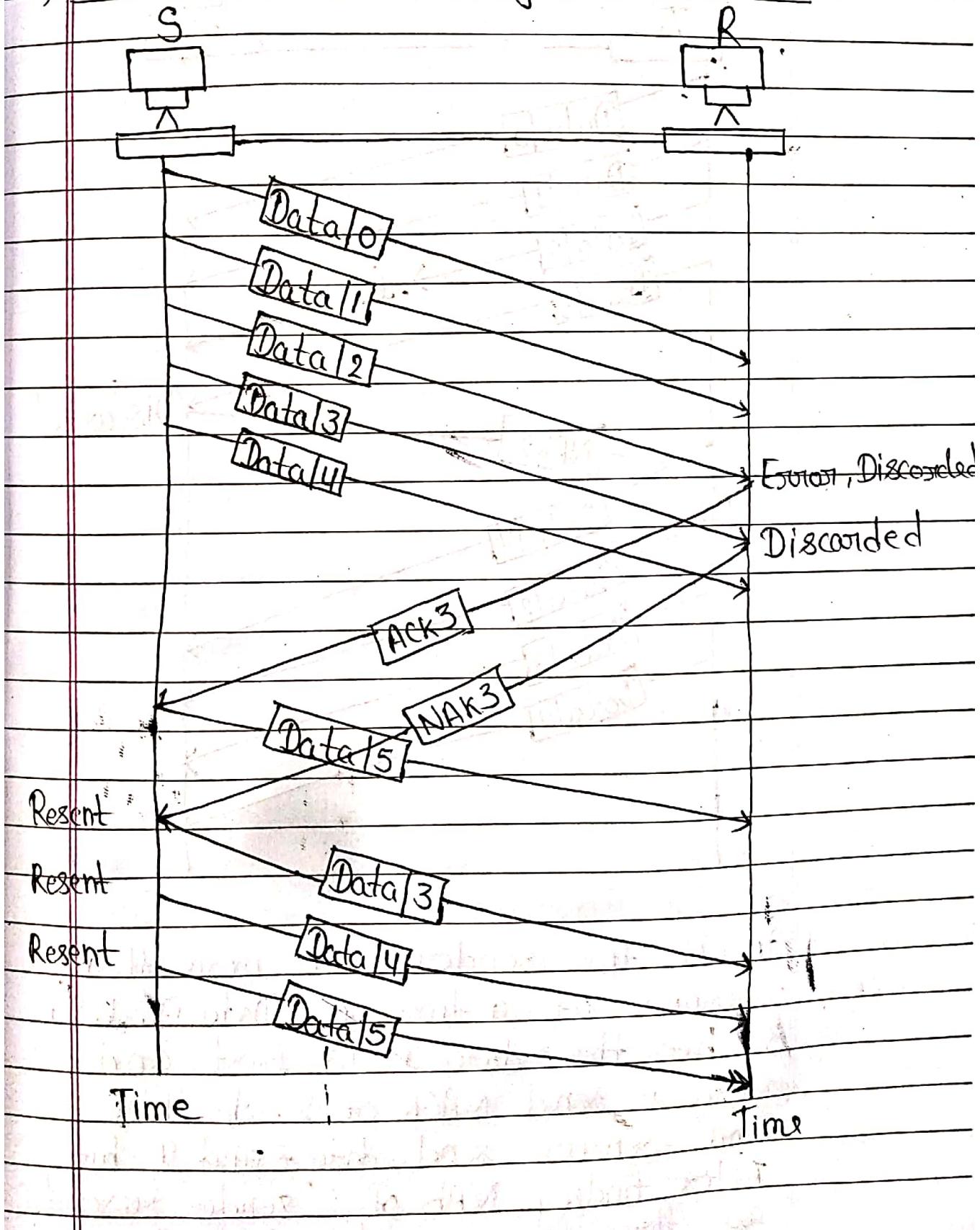
Here receiver send the ack 1 but it is lost then time duration out so sender transmits data 0 and now receiver send ack 1 so sender is send another frame as data 1.



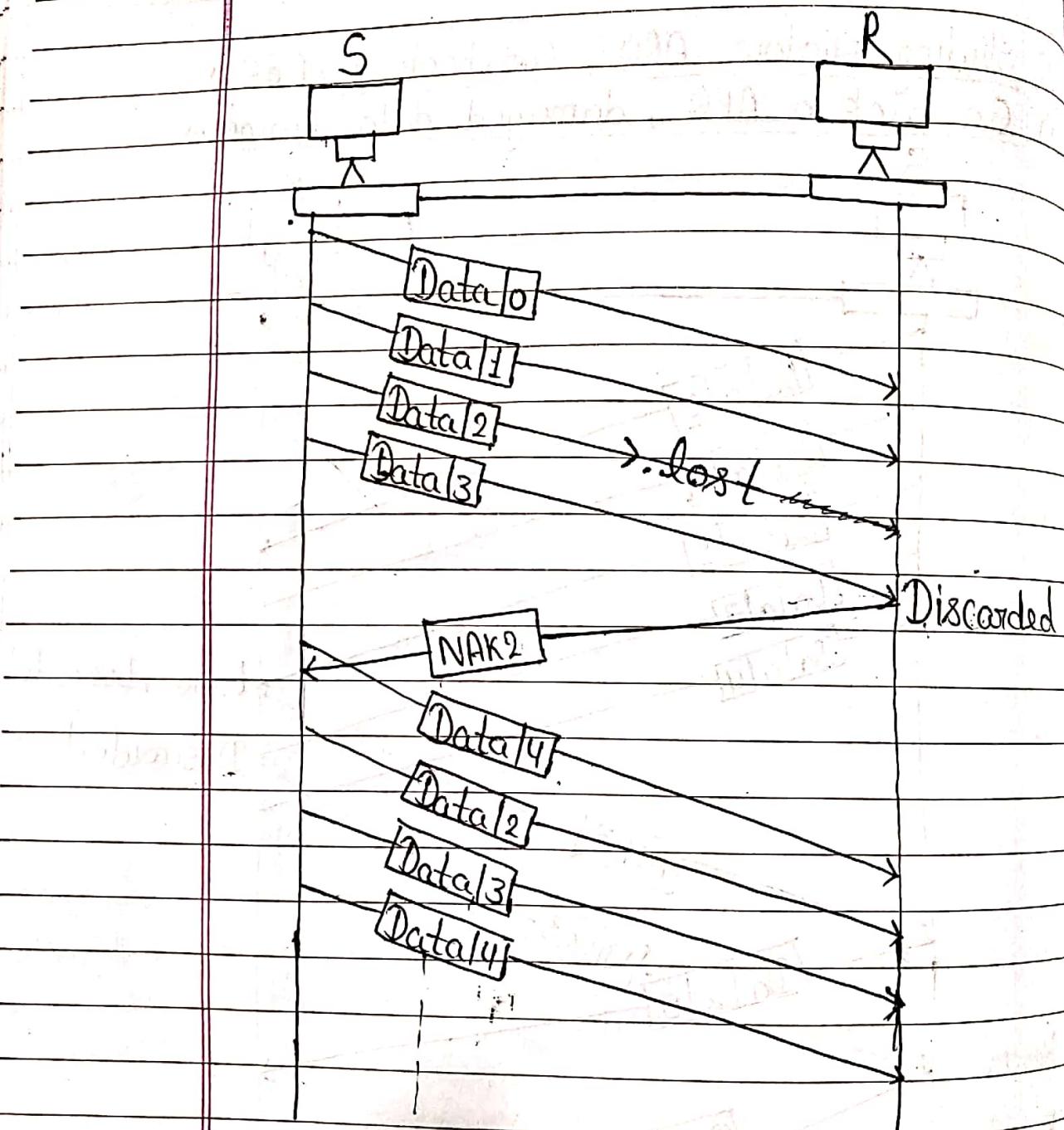
2) Sliding Window ARQ, damaged frames →

a) Sliding Window ARQ, Go-back n ARQ →

i) Go-back n ARQ, damaged data frame →

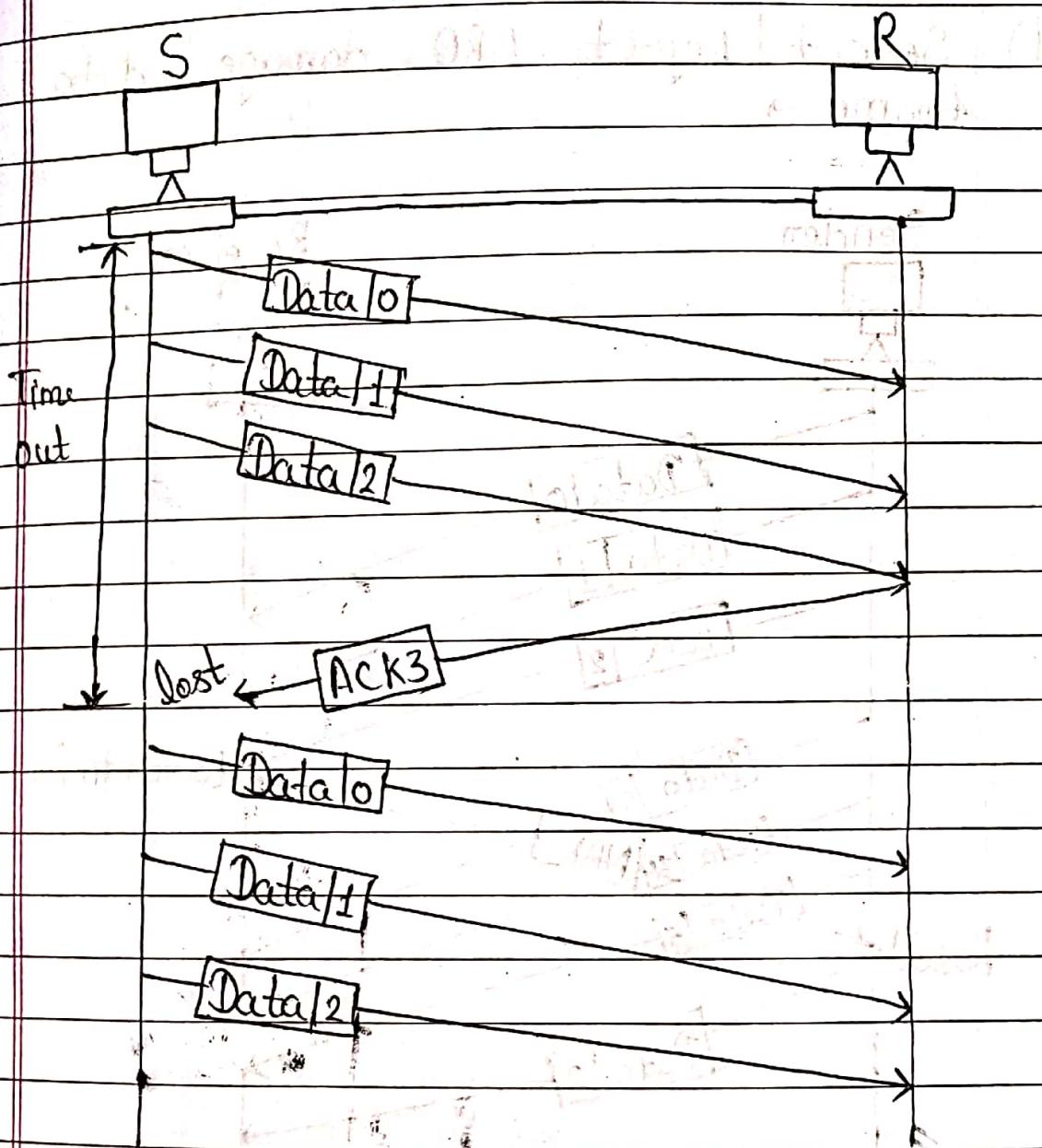


ii) Go back-n ARQ, lost data frame →



In it the sender send more than 1 frame at a time as Data 0, 1, 2, 3 but the data 2 is lost and receiver send NACK of 2. In this time sender send data 3 and 4 but after finding NAK of 2 sender resend all three frames as data 2, 3 and 4.

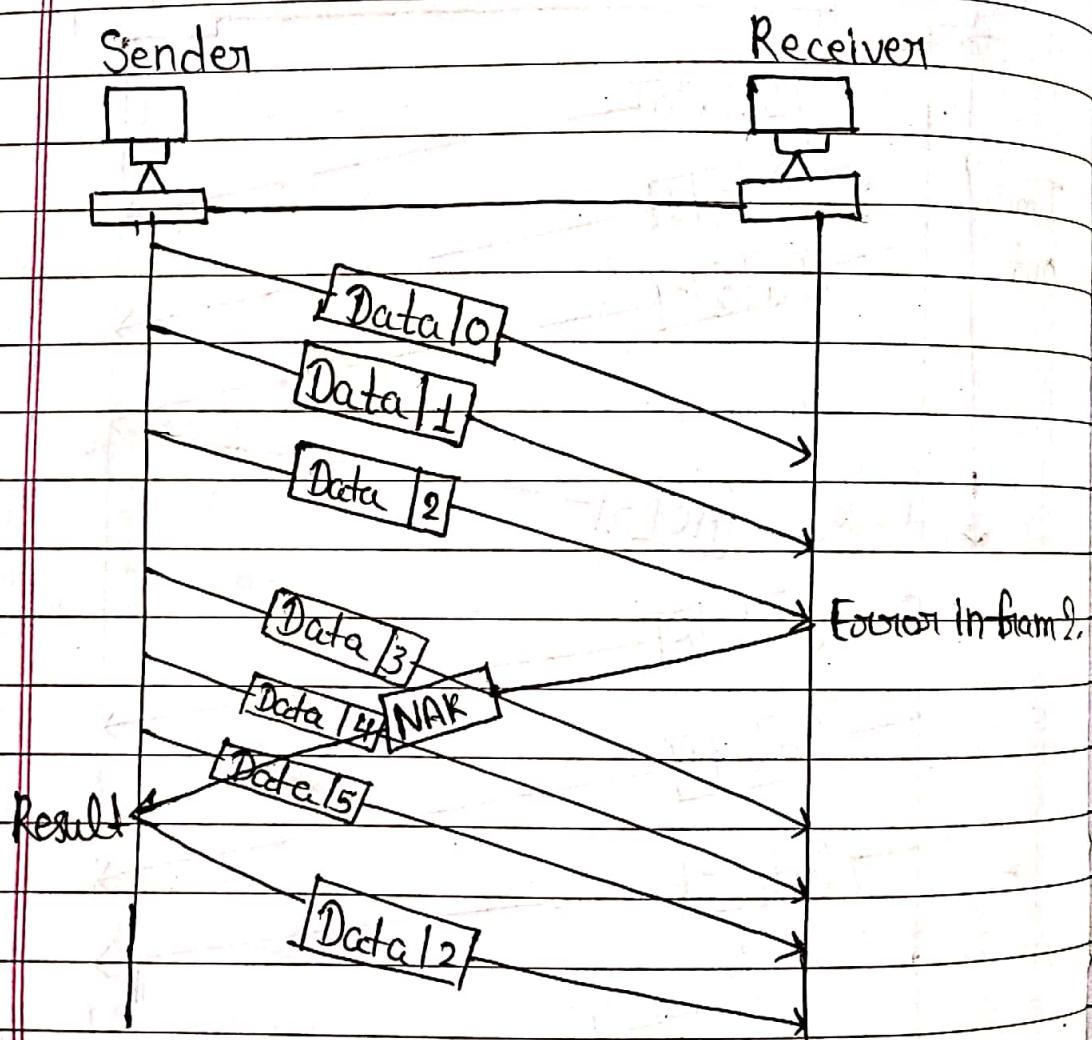
iii) Go-Back-n, Lost Acknowledgement →



In this sender send more than 1 frame just like Data 0, 1 and 2. and receiver send the ACK for data 3 but it is lost and time duration is out so sender is retransmit all these frame as Data 0, 1 and 2.

2.) Select / Reject ARQ →

1) Select / Reject ARQ, damaged data frame →

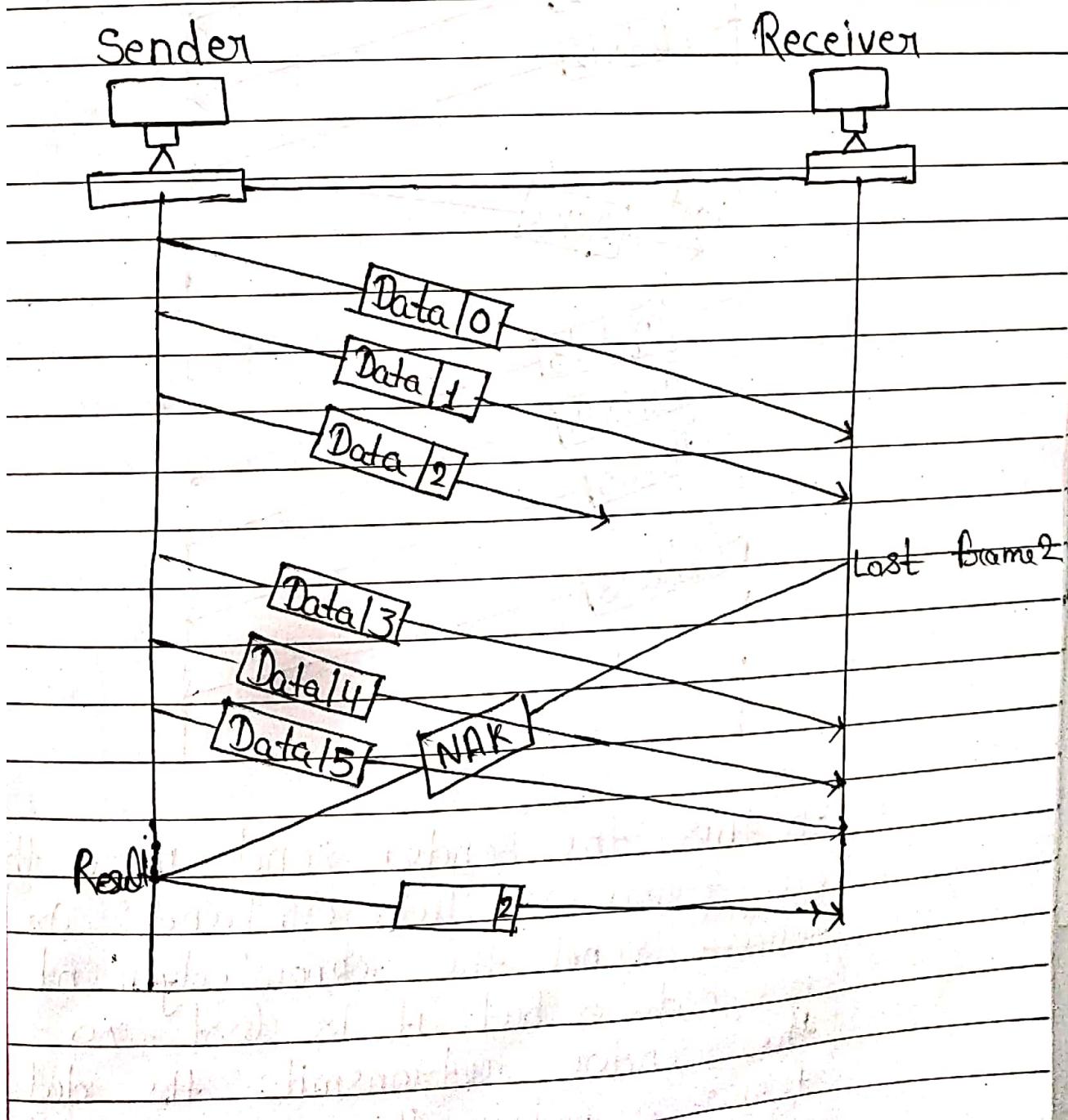


In the Select / Reject ARQ, damaged data Sender send more than 1 data ^{frames} means it send Data 0, Data 1 and data 2 for receiver. But in the frame of data 2 there finding an error so it is reject when receiving the Negative ackno

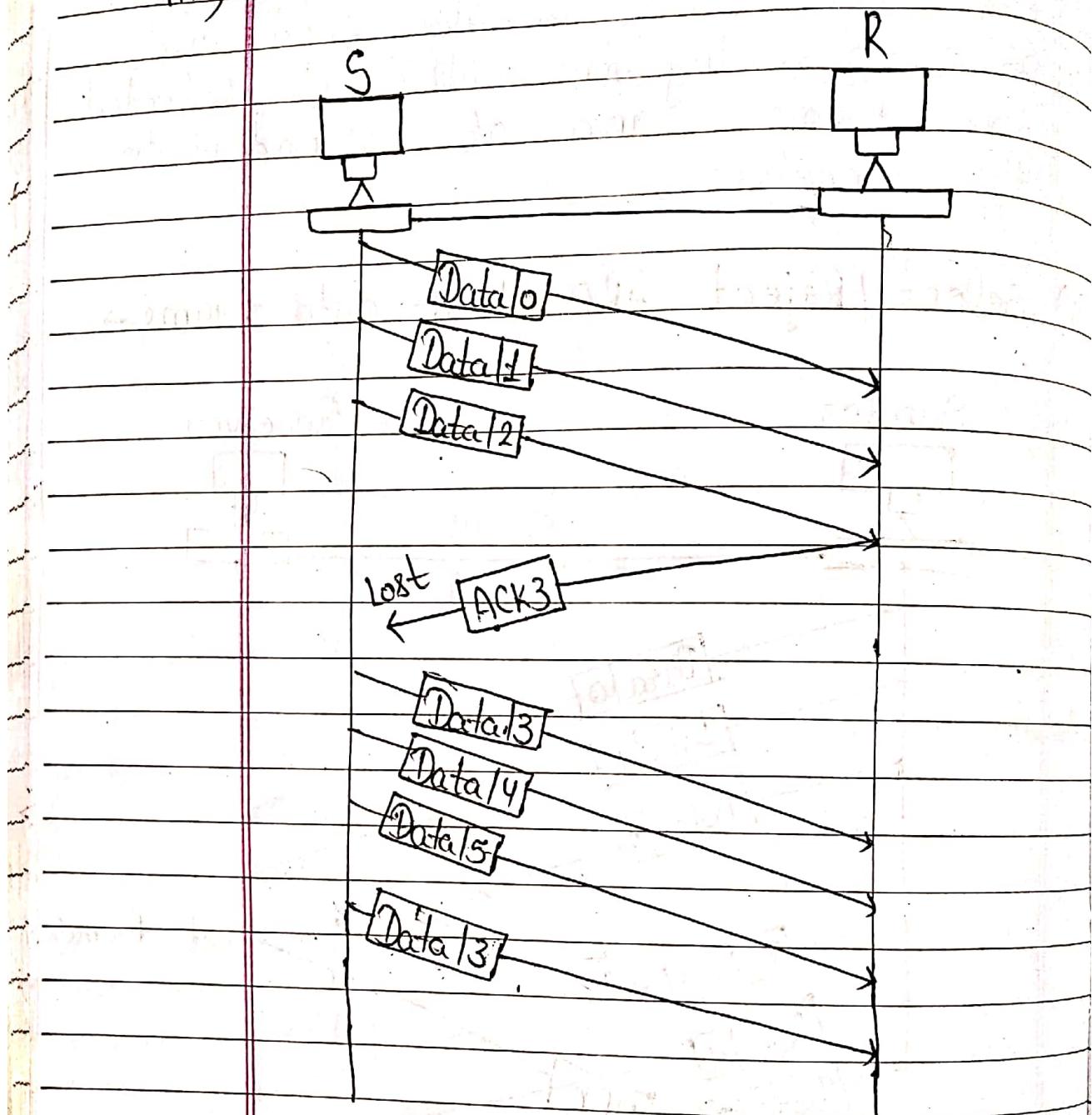


Acknowledgement of frame 9 than in this time data 3, 4, 5 is also send and after receiving the NAK it selected the frame 2 and also resend it to the receiver.

Select/Reject ARQ, lost data frame →



iii) Select/Reject ARQ, lost Acknowledgment

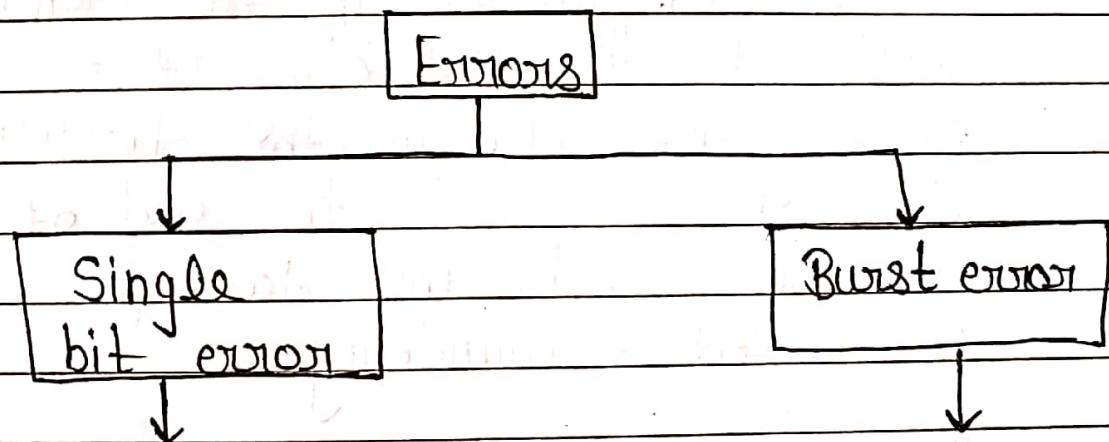


In this the sender send more than one frame as Data 0, 1 and 2 or receiver send the acknowledgement for data 3 but it is lost so the sender retransmited the data frame 3 but in this time sender send the Do two data frame as 4,5 and also data frame 3.

Error Detection & Correction

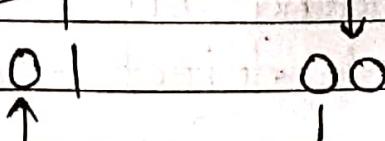
It is the responsibility of DLL.
Data can be corrupted during transmission
for reliable communication error
must be detected and corrected
at DLL.

Types of Errors →



In single bit error
only one bit in
data unit has
changed.

Example



In burst error
more than one /
two or more bits
in the data unit
have changed.

Example



⇒ Detection →

To find out the error where exactly is arises whether a single bit error or burst error.

We have to send extra bit to findout the exact data is called the redundant bit.

for error detection to send the extra information in the transmission, insist of the reflecting the entire the stream the shorter bit of to the end of each data unit. this technique is called redundancy.

" Error detection uses the concept of redundancy , which means adding extra bit for detecting error at the destination .

Addition of redundant bit is the methodology to detect the error .

Accept

Reject

Checking function

Accept

Reject

Checking function

1010000010101010

Generating
function

Receiver

Data & Redundancy
check

1011101

10100000101010101011101

Sender

Redundant bit Or Redundancy check

Detection Methods

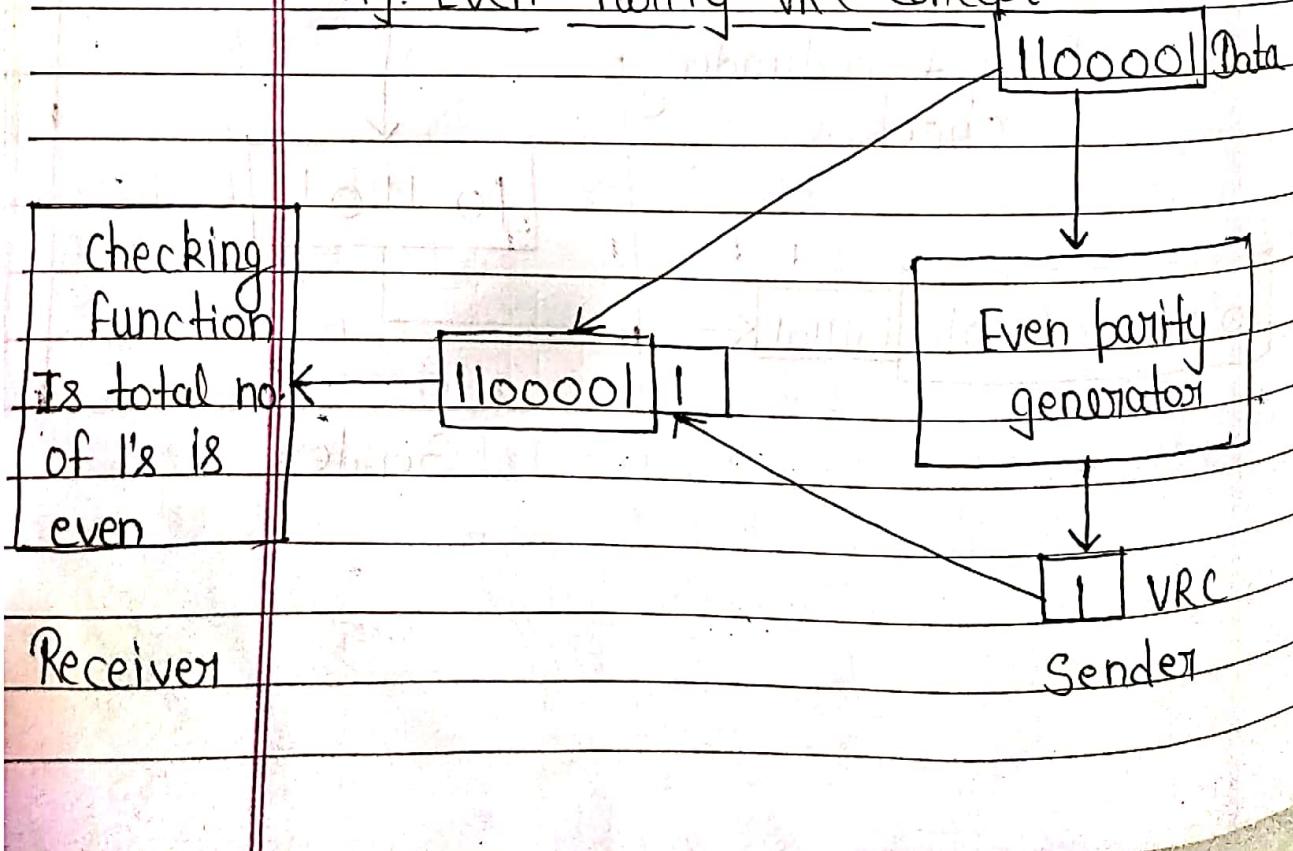
VRC LRC CRC Check sum

1) VRC [Vertical Redundancy check] →

In VRC a parity bit is added to every data unit so that the total number of 1's becomes even. This is also called the even parity error detection method.

Individually check the digit.

fig! Even Parity VRC concept



agar bit (0,1) m jo even h uski opposite bit add
karte h jaise 1110111 m 1 even 6 time so add 0 here.

Date _____
Page _____

Example

← 1110111 1101111 1110010 1101100 1100100
W O G I D

← 1110111 0 1101111 0 1110010 0 1101100 0 1100100 1
111/111 0 1101111 0 1110/10 0 1101100 0 1100100 1

This type error is reduce by next methodology.

2) LRC [Logitudinal Redundency check] →

Original data

← 11100111 11011101 00111001 10101001 10101010
↓ ↓ ↓ ↓ ↓
→ 11100111
→ 11011101
→ 00111001
→ 10101001
→ 10101010

if one is odd then add 1 for even and
if both are even then add 0 for odd.
whole digit have single even bit that is 1.

jo egn given hogi uski maximum power m means

f 4 h then 4 times add 0. ya ~~last value~~ ~~last value~~ hogi given
 $x^4 + x^3 + 1$ or 11001. last ki 4 digit b long remainder

3.) CRC [Cyclic Redundancy Check] -

It is totally based on the binary division method.

~~examples~~

$$\begin{array}{r} \text{1010101010} \\ \text{m} \\ \hline 11001 \mid 1010101010 \quad 0000 \\ 11001 \downarrow \quad | \quad | \quad | \quad | \\ 011000 \\ 11001 \downarrow \quad \downarrow \quad \downarrow \\ 000011010 \\ 11001 \downarrow \quad \downarrow \\ 00011000 \\ 11001 \downarrow \\ 0000000 \end{array}$$

$$\begin{array}{r} \text{10101010100010} \\ \text{m+1} \\ \hline 11001 \mid 10101010100010 \\ 11001 \downarrow \quad | \quad | \quad | \quad | \quad | \\ 011000 \\ 11001 \downarrow \quad \downarrow \quad \downarrow \\ 000011010 \\ 11001 \downarrow \quad \downarrow \\ 00011001 \\ 11001 \downarrow \\ 0000000 \end{array}$$

$$x^4 + x^3 + 1$$

It should not be divisible by x .
Also not be $(x+1)$