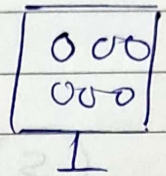
2 hour class - 2 attendance.

8 Jan

Computer Network

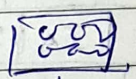
Processes in system can communicate by IPC



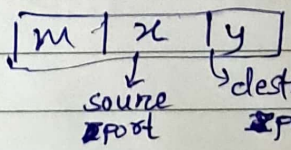
systems we need computer network
ommunication protocols (rules)

CN

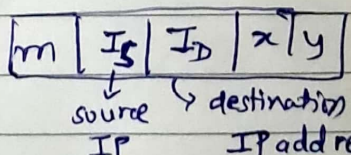
COMPUTER NETWORK

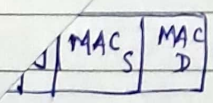


Layer
presentation Layer
session Layer
ransport Layer



Network →





Data Link Layer.

ress :-

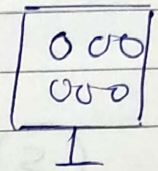
Physical. → Takes care of medium or channel through which information passes.

2 hour class - 2 attendance.

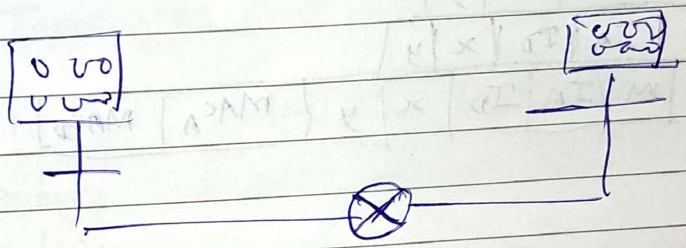
8 Jan

Computer Network

Processes in system can communicate by IPC



For different systems we need computer network and communication protocols (rules)



Essential

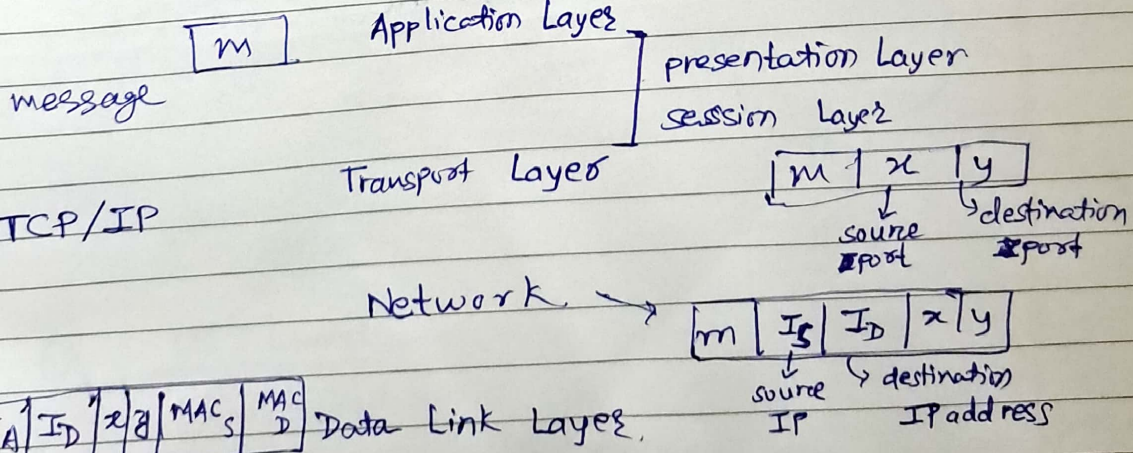
i) EC

ii) FC

optional

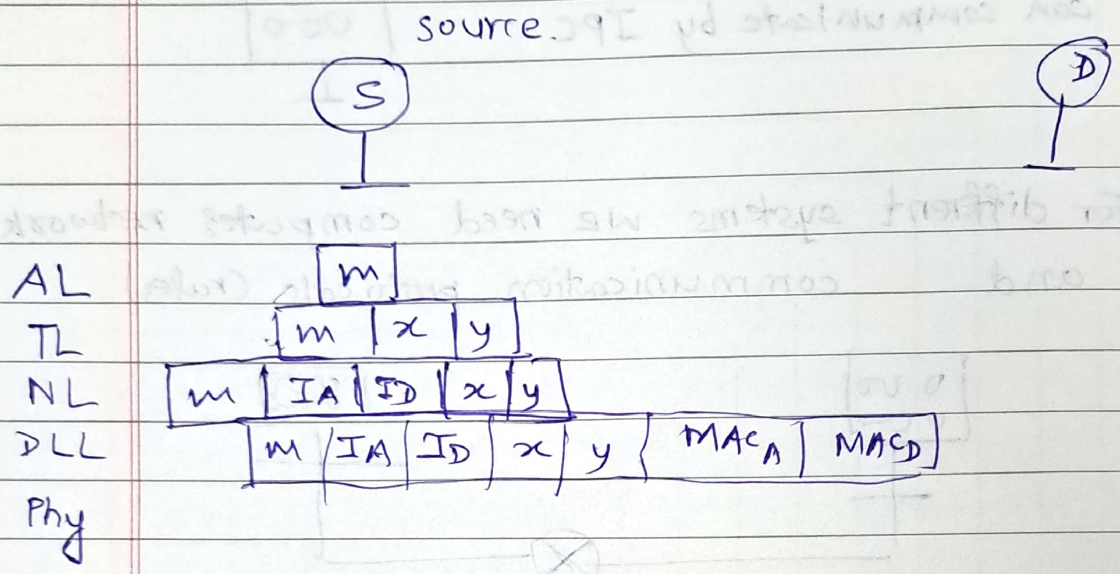
(i) Routing

OST Layer



Physical. → Takes care of medium or channel through which information passes.

IP + port number = Socket Number



DNS

If u give url, DNS gives you IP address.

↓

Domain name server

ARP If you give IP, you get MAC address

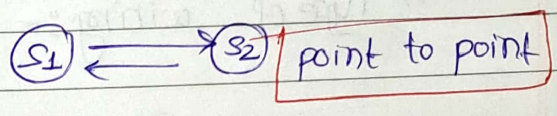
IP ⟶ MAC

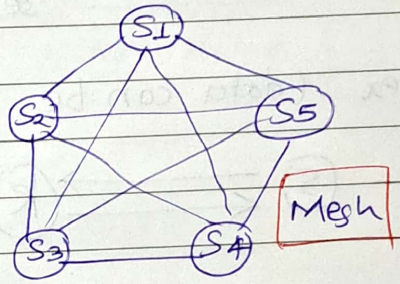
Types of Networks

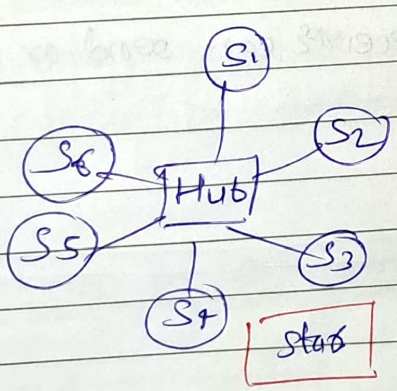
1) PAN (personal)
2) LAN (local)
3) MAN (Metropolitan)
4) WAN (wide)

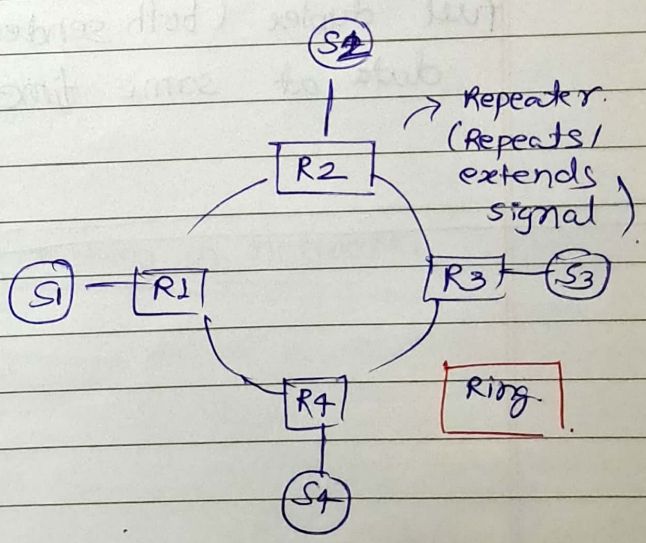
Network Topologies

1) Point to Point
2) Mesh topology.
3) Star topology
4) Ring topology.

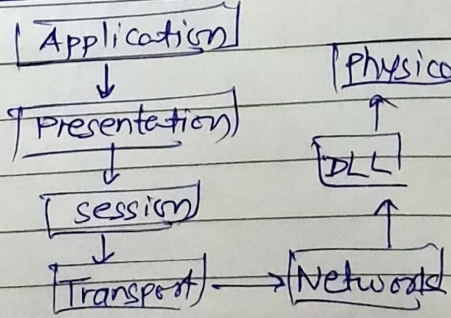








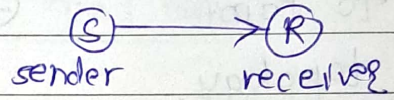
OST Layers



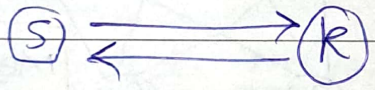
* Physical Layer:-
- Channel (Ethernet
Fibre optics, wiring)

Physical Layer :-

1) Channel (Ethernet wiring, Fibre options)
2) Encoding & decoding.
3) Multiplexing and demultiplexing.
4) Data rate (bits per second)
5) Band width.
6) Network topologies.
7) Type of wiring :- simplex.



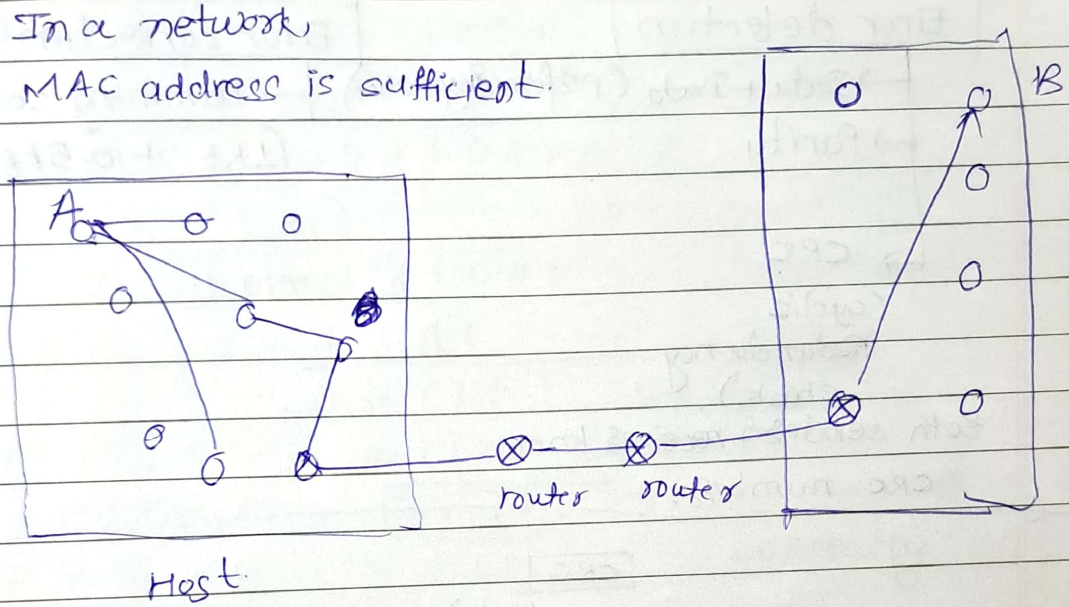
half duplex. (data can be send but one at a time)



full duplex (both sender & receiver can send or receive data at same time.)

Data link layer

In a network,
MAC address is sufficient.



* No routing required (Hub-to-Hub) in same network/host
* Routing required when connecting different networks.

Problems in Data sending/receiving in networks:-

1) Access control.
2) Flow control
3) Error control.

Error Handling

- **Error detection**
  - → Data + Data (perform operation)
  - → Parity
  - → CRC (cyclic Redundancy check).

  Both sender & receiver know CRC numbers.
- **Error correction.**
  - → Hamming code (1kb + 0.5kb)

CRC
1101 (say)
(4 bits)

S — message.

1011011 | 000
(4−1) bits

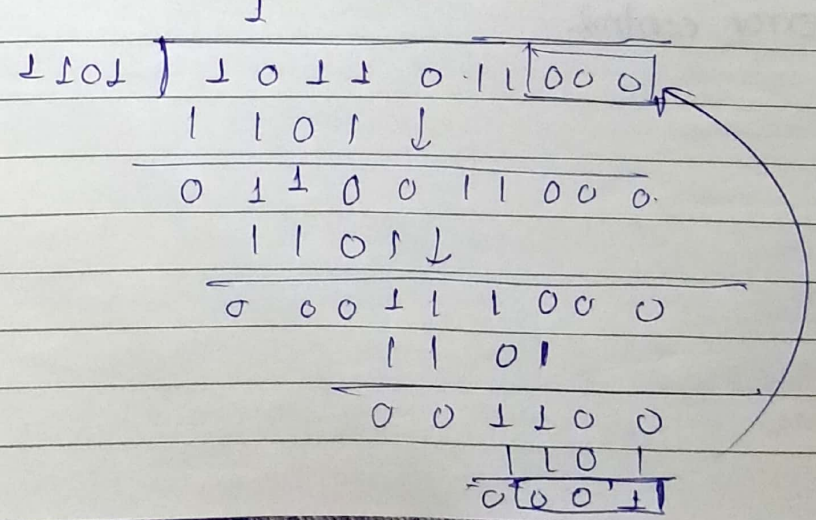
R

1011011 | 001
↓
remainder

Why 3 bits?

ans:- perform ~~division operation~~ ~~subtraction~~ mix.
→ XOR operation. → inequality

1,1 → 0
0,0
1,0 → 1
0,1 → 1



replace for receiver

002 ⇒ 2

Receiver

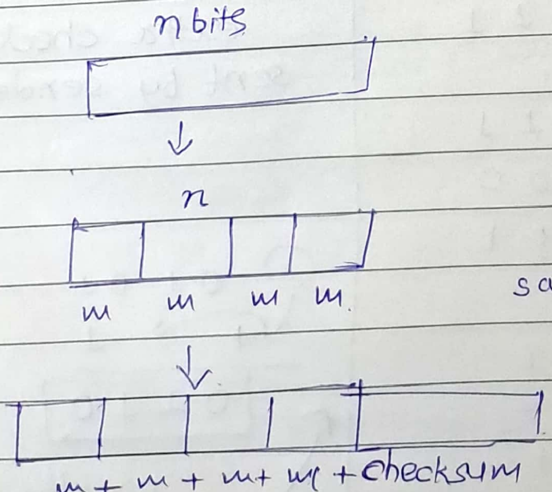
```
            1 1
1101 ) 1 0 1 1 0 1 1 0 0 1
       1 1 0 1
       0 1 1 0 0 1 1 0 0 1
         1 1 0 1
         0 0 0 1 1 1 0 0 1
               1 1 0 1
               0 0 1 1 0 1
                   1 1 0 1
                   [0 0 0 0]
```

[0000] message received correctly.

Error detection

↳ checksum

divide n bits into equal sized parts. (say m-sized parts.



addition must be zero on receiver side.

Problem :-

Adding

m + m + m + ... checksum

say (8bit) (8bit) (8bit)

Finally the answer of sum, may be 9 bit or more (i.e. (n+1) bits received.

ex:-

20 bits

7	11	12	0	6
4	4	4	4	4

7 → 0111
11 → 1011
12 → 1100
0 → 0000
6 → 0110

] first add 2 numbers then, if carry come, then wrap up carry.

1 1 1 → carry

+ operation

```
   0 1 1 1
+  1 0 1 1
-----------
 1 0 0 1 0
```

resultant.

final carry, add this in resultant

```
   0 0 1 0
+        1
-----------
   0 0 1 1
```

```
   0 0 1 1
+  1 1 0 0
-----------
   1 1 1 1
```

```
   1 1 1 1
+  0 0 0 0
-----------
   1 1 1 1
```

```
   1 1 1 1
+  0 1 1 0
-----------
 1 0 1 0 1
```

9 is the extra checksum sent by sender

```
 (1) 0 1 0 1
+        1
-----------
   0 1 1 0
```

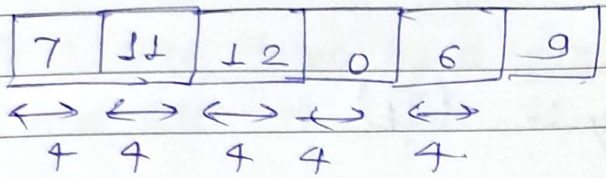
Finally take 1's complement

1 0 0 1 ⇒ 9

answer

message received.

message sent.



Receiver

a.) compute sum

b.) Take complement

c.) If answer is 0000, then message is correctly received.

a) $7 + 11 + 12 + 0 + 6 \Rightarrow 0110$

$+ 9 \Rightarrow + 1001$

1111

b) 1111

complement :- $\boxed{0000}$

c) $\boxed{0000}$, message correctly received

Different types of delay :- (Geek for Geeks)

1) Transmission delay :- (T_t)

The time taken to put packets from host to outgoing link

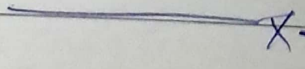
Transmission delay (T_t) = $\frac{\text{Length (in powers of 2)}}{\text{Band width (in decimals)}}$

Q] L = 1000 bits , BW = 1 kbps
= 1000 bps.

Transmission delay = $\frac{1000}{1000}$ = 1 sec.

Q] L = 1 kb
= 1024 bits , BW = 1 kbps.

ans:- Transmission delay = $\frac{1024}{1000}$ = 1.024 second.



Propagation delay :- T_p.

It is time taken by a single bit to reach from one end of link to other end of link

$$T_p = \frac{\text{distance}}{\text{velocity}}$$

Queuing delay :- T_q

After receiving the packet, it will not be processed immediately, it has to wait in queue / buffer.
So, amount of time it waits in queue before being processed is queing delay

We dont have any formula for it,
Hence, ignore it.

Processing delay :-

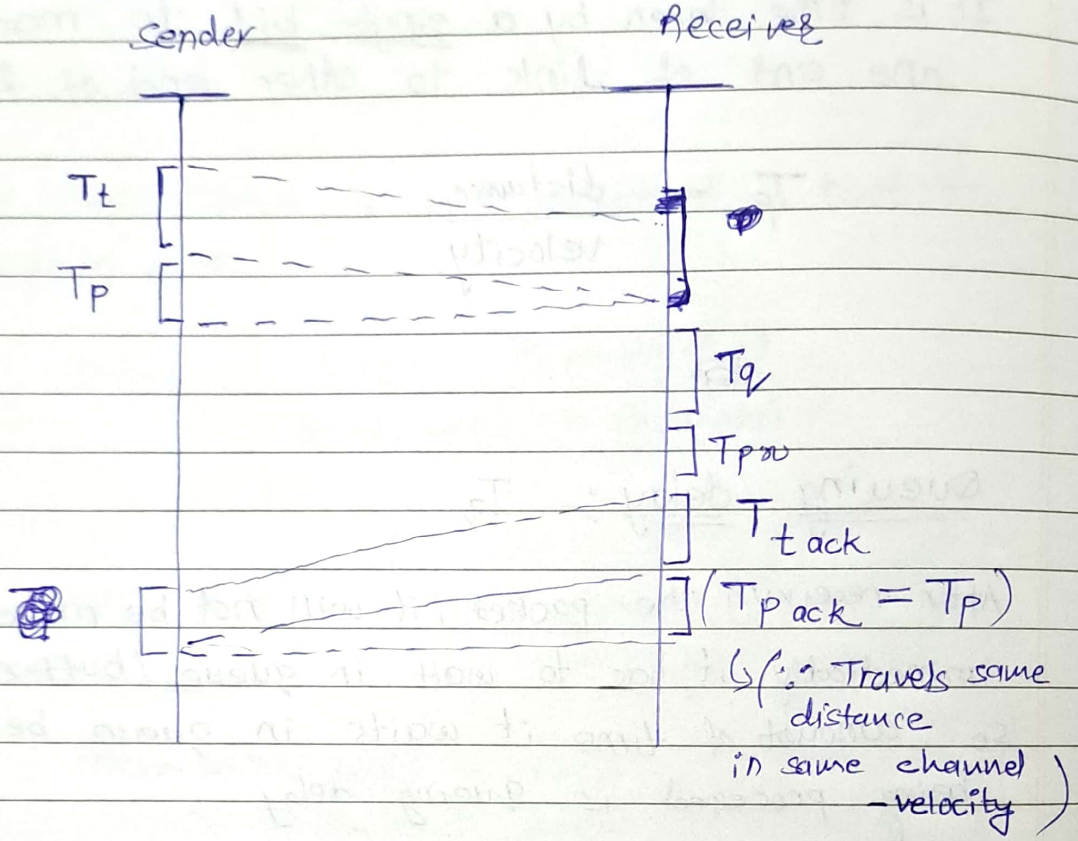
T_{pro}. • Time for checksum calculations.

Total

$$T_{total} = T_t + T_p + T_q + T_{pro}$$

Flow control method

Stop and wait mechanism



- Receiver should send an acknowledgement packet telling that 'main message' is received.
- Acknowledgement is small message, Hence ignore its queuing & processing time

Total time ⇒ $T_t + T_p + T_q + T_{pro} + T_{tack} + T_p$

usually T_q, T_{pro}, T_{tack}, are small times.

$$\text{Total time} = T_t + 2T_p$$

$$\text{efficiency} = \eta = \frac{\text{Useful time}}{\text{Total time}} = \frac{T_t}{T_t + 2T_p}$$

$$\therefore \eta = \frac{T_t}{T_t + 2T_p} = \frac{1}{1 + 2\left(\frac{T_p}{T_t}\right)} = \boxed{\frac{1}{1 + 2*a}}$$

Throughput (or) Bandwidth utilisation.

$$= \frac{L}{T_t + 2T_p}$$

$$= \frac{\frac{L}{BW} \times BW}{T_t + 2T_p} = \eta * BW$$

Note:- $2T_p$ is also called RTT (Round trip time).

a] $T_t = 2ms$, $T_p = 1ms$.

ans:- $\therefore RTT = 2T_p = 2ms$

$$\eta = \frac{T_t}{T_t + 2T_p} = \frac{1}{1 + 2(1)} = \frac{1}{3} = 33.33\% \text{ efficient}$$

b] If we want $\eta \geq 0.5$ (more than 50%), what is T_t & T_p ?

ans:-

$$\frac{T_t}{T_t + 2T_p} \geq \frac{1}{2}$$

$T_t \geq 2 T_p$

$\frac{L}{BW} \geq 2 * T_p$

$\therefore \boxed{L \geq 2 * T_p * BW}$ for $\eta > 50\%$.

———— x ————.

Q] BW = 4 Mbps
= 4×10^6 bps , $T_p = 1$ ms. , $\eta \geq 0.5$, L = ?

ans:- $L \geq 2 * T_p * BW$

$\geq 2 * 1$ ms $* 4 \times 10^6$ bps.

$\geq 8 \times 10^3$ bits

$\geq 10^3$ bytes. (or) 8×10^{-3} Mb

———— x ————.

Factor influencing η

$$\eta = \frac{1}{1+2a} = \frac{1}{1+ 2 * \frac{T_p}{T_t}}$$

$T_p \rightarrow \frac{d}{v}$

$T_t \rightarrow \frac{L}{BW}$

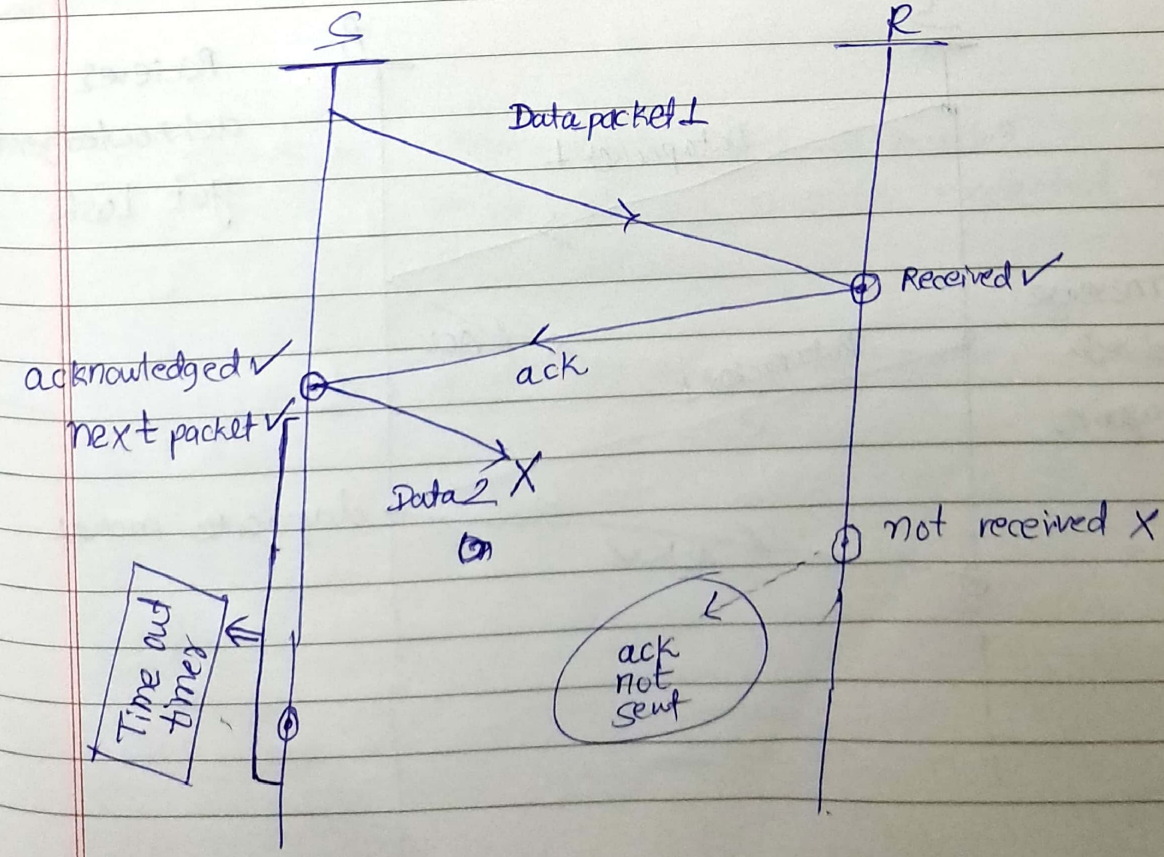
$$\eta = \frac{1}{1+ 2 * \frac{d}{v} * \frac{BW}{L}}$$

$\frac{BW}{L}$ → usually fixed for a network

$\eta \propto \frac{L}{d}$

$L \rightarrow$ length of packet

$d \rightarrow$ distance

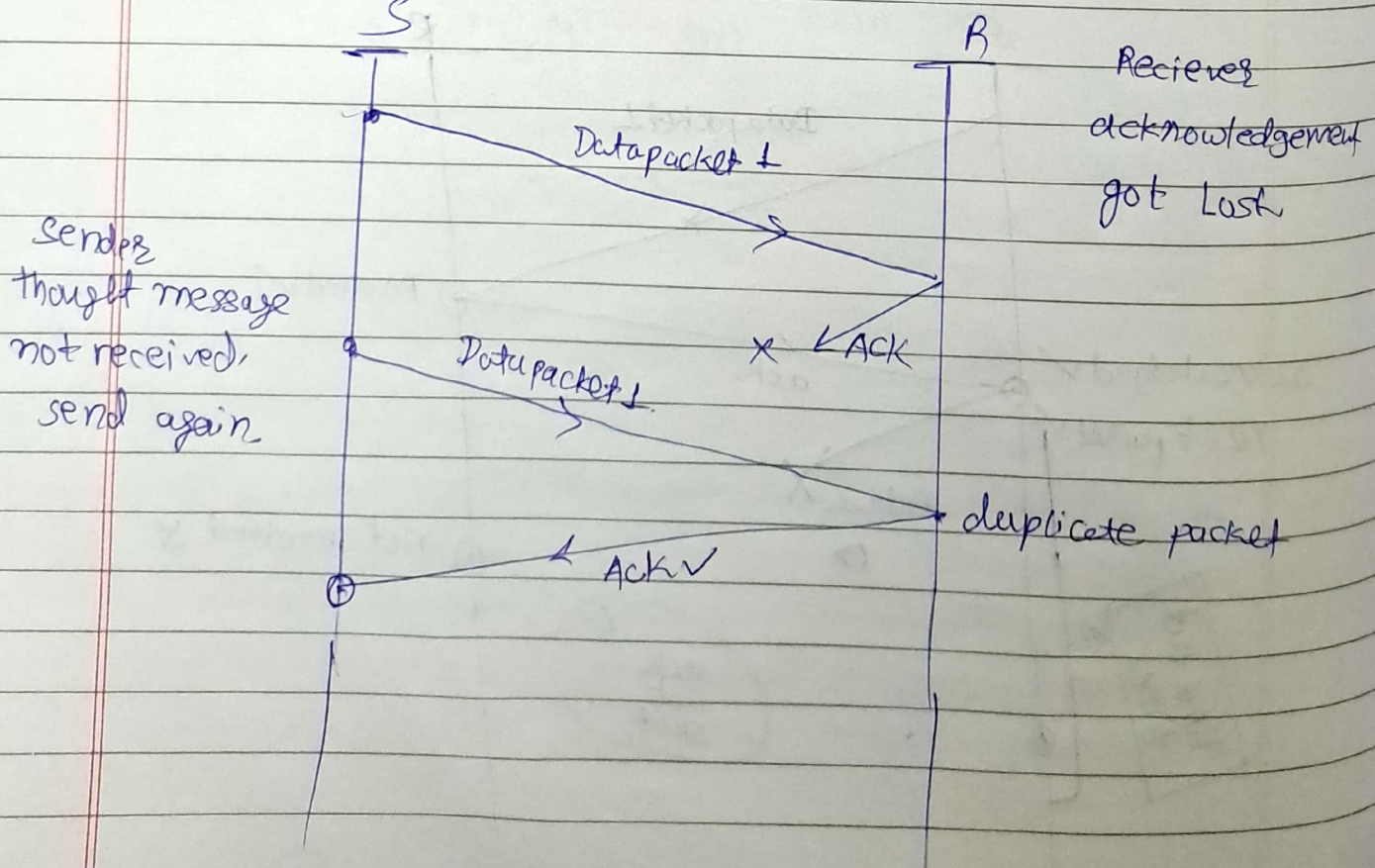


If(ack is received within timeout_time){
sender will send next message};

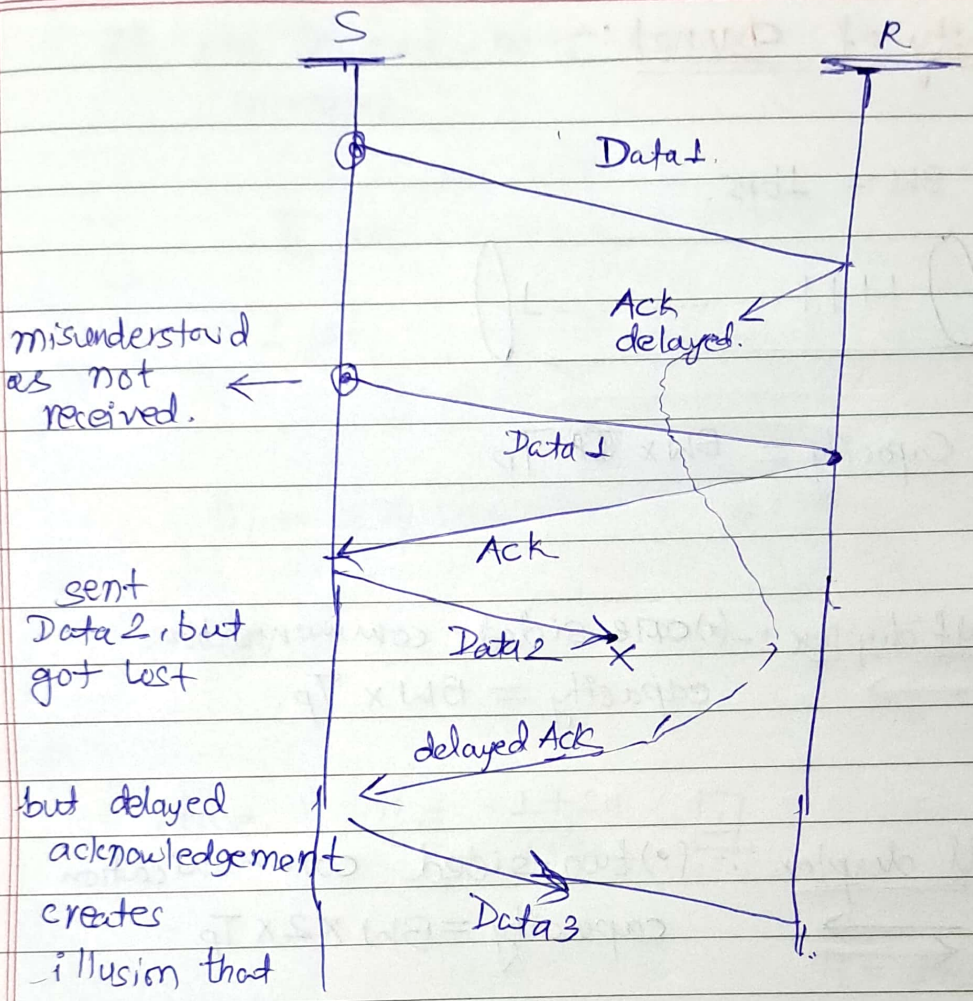
else { sender will send same message again};

Stop & wait + Time out time = Stop & wait Automatic Repeat Request.

Problem 2) Whether receiver receives duplicate message, acknowledgement should be sent.



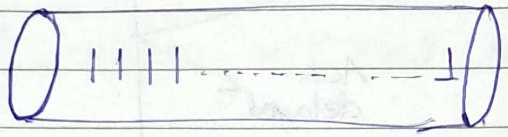
Problem 3) Delayed Acknowledgement.



Solution :- Add Acknowledgement number
= sequence of number expected next.

Capacity of channel :-

BW = 1bps.



Capacity = BW x T_p

Half duplex :- (•) one sided communication

→ capacity = BW x T_p.

Full duplex :- (•) two-sided communication

⇄ capacity = BW x 2 x T_p

Q] How to increase efficiency ?

$$\eta = \frac{1}{1 + 2 * \frac{T_p}{T_t}} = \frac{1}{1 + \frac{2 * T_p * BW}{L}}$$

a) we cannot change length in a network

b) → we don't want to change bandwidth

ie 1Gbps → 1kbps, η will increase

Hence, we may change, no. of packets send.

$$\eta = \frac{1}{1 + 2a} \rightarrow \frac{\text{no. of packets sent}}{\text{Time for sending 1 packet.}}$$

If we increase, no. of packets, the time also increases.

T_t sec $\longrightarrow$ 1 packet

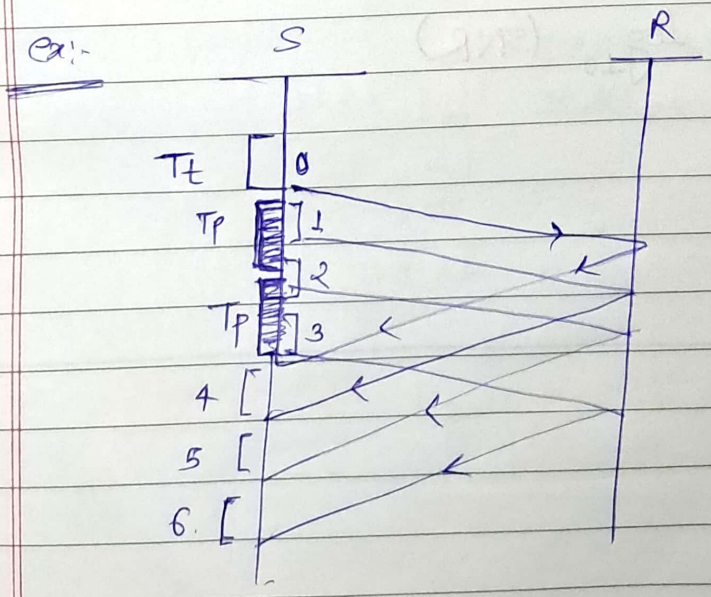
1 sec $\longrightarrow$ $\left(\frac{1}{T_t}\right)$ packet

$(T_t + 2T_p)$ sec $\longrightarrow$ $\left(\frac{T_t + 2T_p}{T_t}\right)$ packet

ie $(1+2a)$ packet

Hence, $\eta = \frac{1+2a}{1+2a} = \boxed{1}$

Ex:-



$T_t = 1ms$

$T_p = 1.5ms$

sending 1 message & receiving its acknowledgement

$\Rightarrow T_t + 2T_p$

$\Rightarrow 1ms + 2(1.5)$

$\Rightarrow 4ms.$

6 messages sent. and 4 received

(or)

4 messages sent 4 received.

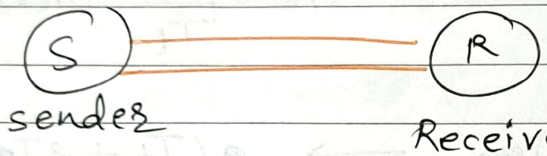
We use Multiplexing for this purpose.

$\eta = \frac{4ms}{4ms} = 1$

Tutorial 2

Analog vs digital Data

- Analog → continuous
- digital → non-continuous



Signal to Noise Ratio :- (SNR)

$$SNR = \frac{\text{avg. signal power}}{\text{avg. noise power.}}$$

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

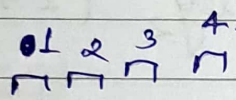
dB = decibels

For Noiseless channels

This formula developed by Nyquist gives maximum bit rate

maximum bitrate = 2 * Bandwidth * $\log_2 L$

L → Levels of sending data.



or 4 levels ⇒ 00, 01, 10, 11

↳ 2 bits can be used to represent 4 numbers.

↳ no. of bits in message

Q] Consider a noiseless channel.
BW = 3000 Hz and there are 4 signal Levels.
Find maximum bit rate

ans:-

BW = 3000 Hz = 3000 bps.

max. bitrate = 2 * 3000 bps * $\log_2 4$

= 2 * 3000 bps * 2

= 12,000 bps.

= 12 kbps

Note:- It is impossible to have noiseless channel.

$\log 3162 = 3.500$ $\log 2 = 0.301$

For Noisy channels :-

Shannon developed formula :-

$$\text{max. bit rate} = \text{Bandwidth} * \log_2 (1 + \text{SNR})$$

8] Consider a noisy channel with bandwidth as 3000 bits per second (bps). With SNR = 3162 Find max. bit rate.?

ans :-

$$\text{max bit rate} = 3000 * \log_2 (3162 + 1)$$

$$= 3000 * \log_2 (3163)$$

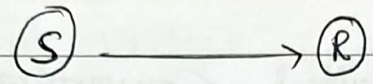
$$= 3000 * \frac{\log_{10}(3163)}{\log_{10}(2)}$$

$$= 3000 * 11.62$$

$$= 34800 \text{ bps}$$

$$= \boxed{34.8 \text{ Kbps}}$$

X



Latency :- Total time taken for sender to send data & Receiver to receive data completely.

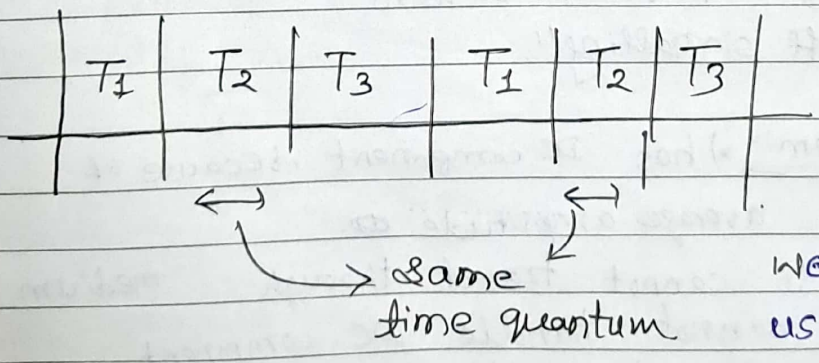
Multiplexing :-

1] FDM (Frequency division multiplexing).

freq range	300 Hz – 500 Hz
freq range	500 Hz – 800 Hz
freq range.	1 kHz – 2 kHz

Signals of different frequency will not interfere.

2] Time division multiplexing.



Same time quantum

We can execute using Round Robin.

3] Wavelength division multiplexing.

* use gfg

Digital to Digital Conversion :-

- Line coding:
  - helps the receiver to get original bits.
  - Line coding transforms set of bits into digital signal.
  - to prevent overlapping of pulses & distortions

Sender

digital data ⇒ digital signal ~~~> digital signal ⇒ digital data

3 types of line coding :-

1) • Unipolar
   - only 1 polarity is used, ie. bit 1 - positive voltage (ON), bit-0 - no voltage (off)

"Unipolar - Non-return-to-zero"
"on-off signalling"

Problem :- i) has DC component, because of non-zero average amplitude.
So cannot travel through medium which cannot handle DC component
ii) synchronisation problem

Techniques ⇒ RZ ⇒ Return to zero.
→ NRZ ⇒ Not Return to zero.

2) **Polar** :- Two voltage Levels.
to minimise DC component problem

Technique → Polar NRZ.

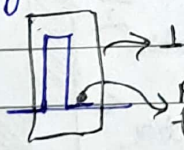
3) **Bipolar Encoding** :- Three voltage levels [+ve, zero, -ve]

Properties of Encoding :-

i) Bandwidth used is reduced.
ii) Power is efficiently used.
iii) Probability of error is reduced.
iv) Error detection and correction capabilities.

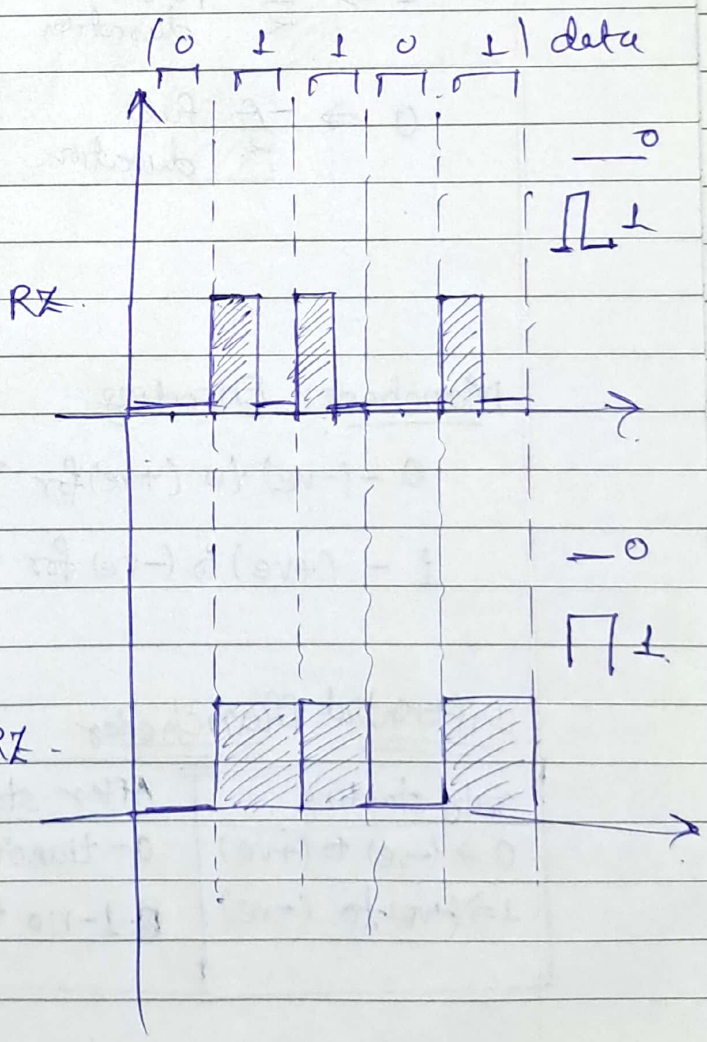
Unipolar RZ

0 - off pulse.
1 - on pulse for $T_b/2$
followed by Return to zero.



Unipolar NRZ

1 - pulse for full duration
0 - off pulse.



Polar

- RZ.

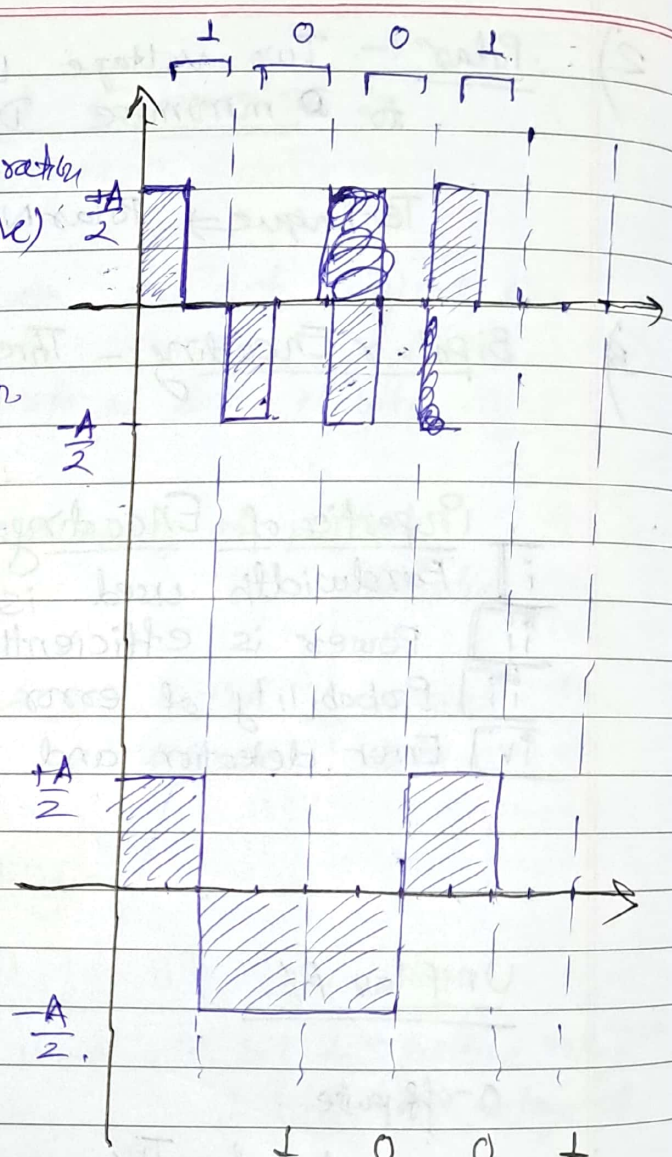
  $0 \Rightarrow \frac{-A}{2}$ half duration (negative)

  $1 \Rightarrow \frac{+A}{2}$ half duration

- NRZ

  $1 \Rightarrow \frac{+A}{2}$ full duration

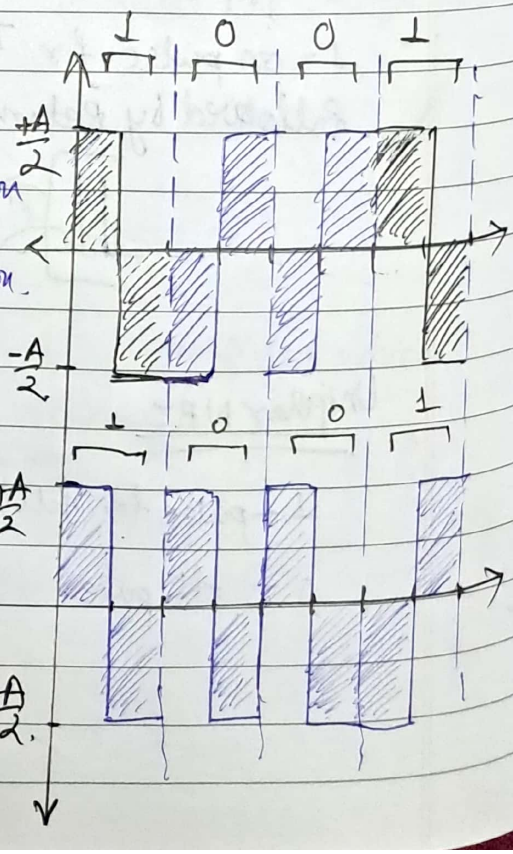
  $0 \Rightarrow \frac{-A}{2}$ full duration



Manchester Encoding

0 - (-ve) to (+ve) for $t_{b/2}$ duration

1 - (+ve) to (-ve) for $t_{b/2}$ duration.

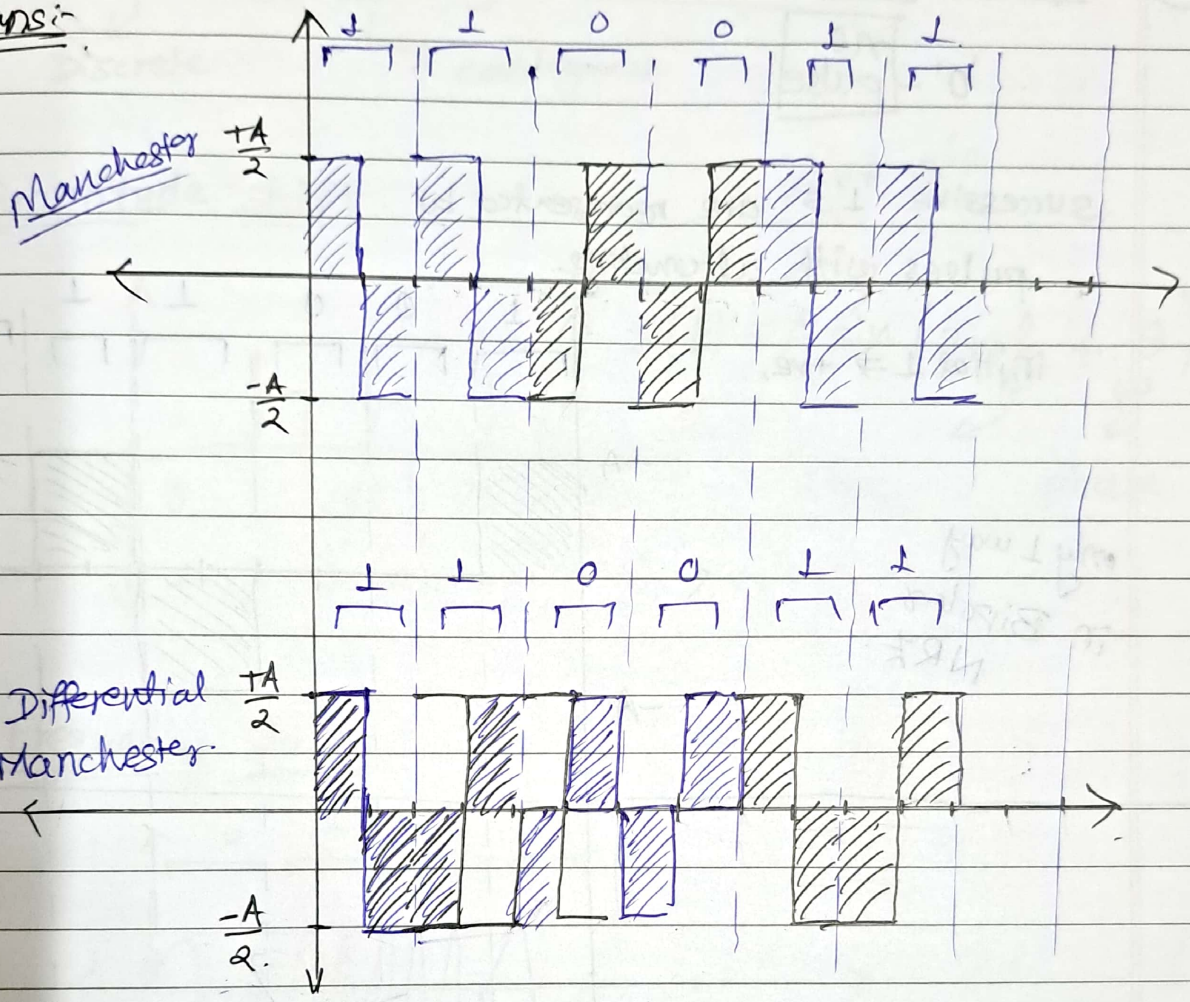


Differential Manchester

Only starting	After starting
0 ⇒ (-ve) to (+ve)	0 - transition
1 ⇒ (+ve) to (-ve)	1 - no transition

Q] Convert 1 1 0 0 1 1 into manchester.

ans:-



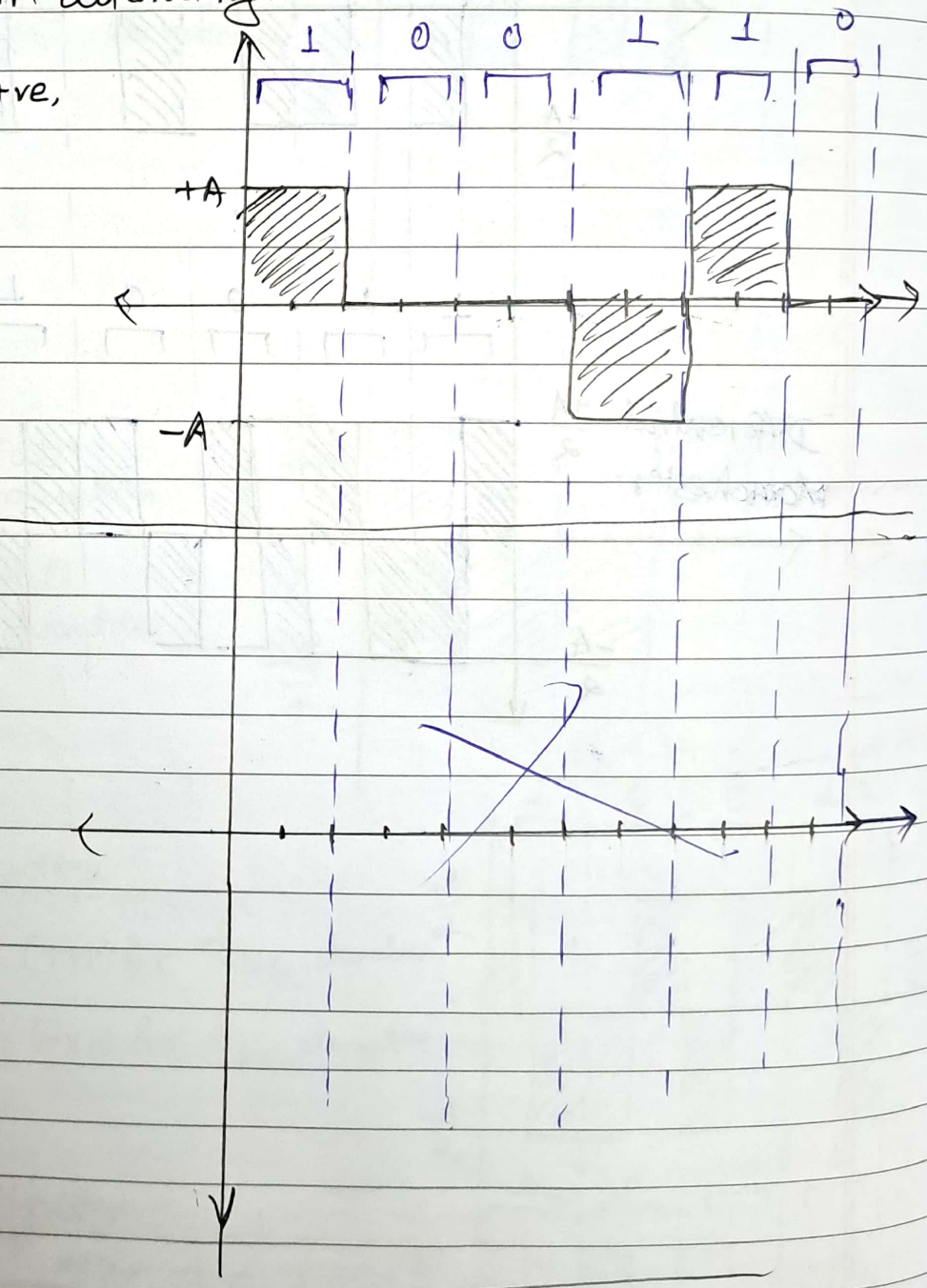

classmate
Date
Page

(3) Bipolar NRZ (does not have types)

'0' – no pulse.

successive '1's are represented by pulses with alternating.

initial 1 ⇒ +ve,



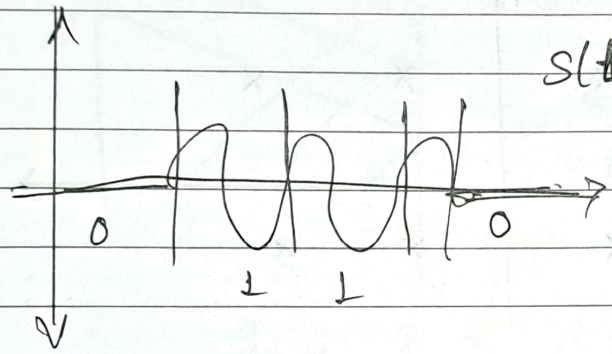
only 1 way in Bipolar NRZ.

Digital to Analog Conversion

Digital → Discrete

Analog → contiguous.

1) Amplitude shift



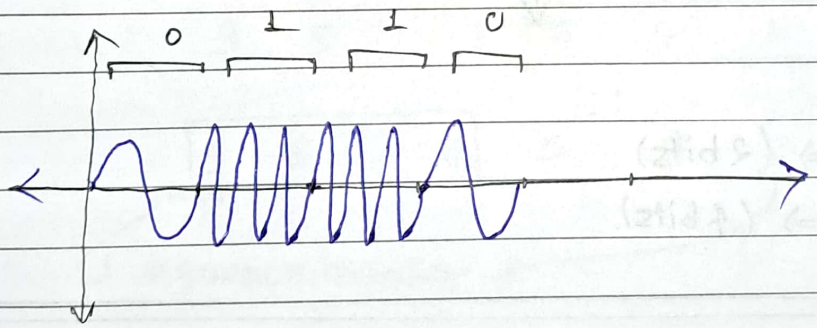
$$s(t) = A \sin(2\omega f + \theta)$$

Amplitude

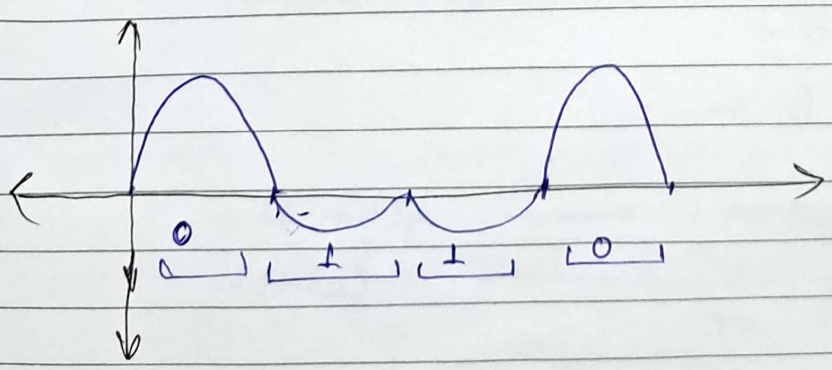
freq

phase.

2) Frequency shift



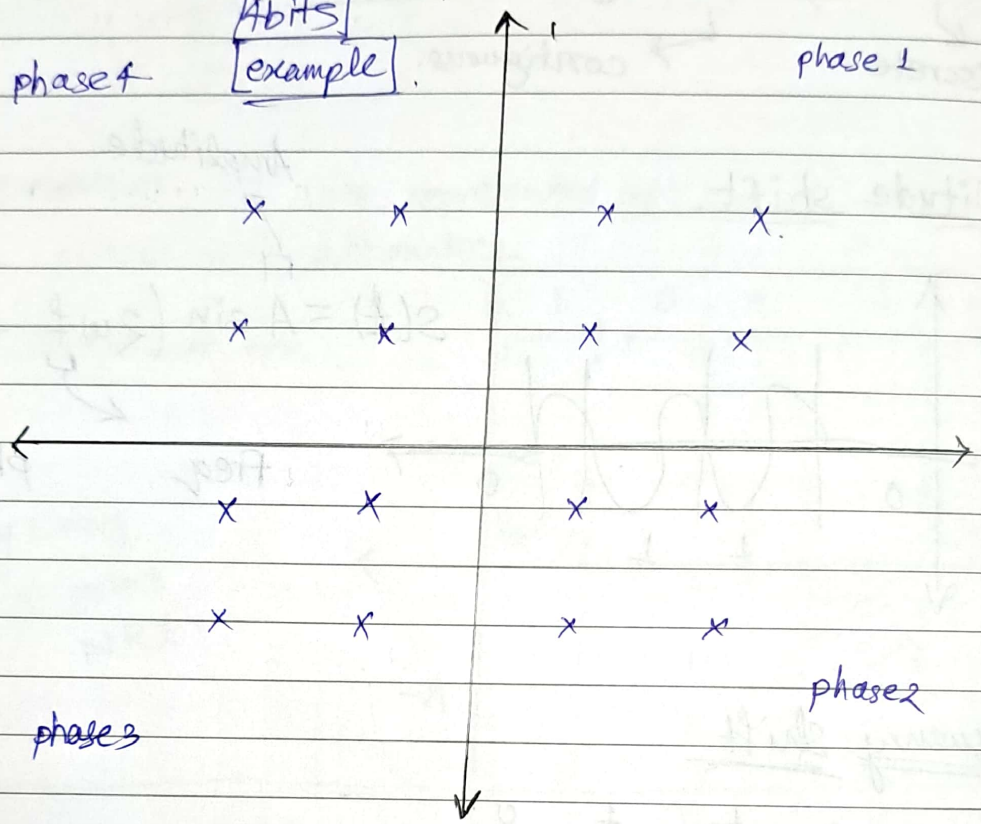
3) Phase Shift



4) QAM (Quadrature Amplitude Modulation)

4bits

example.



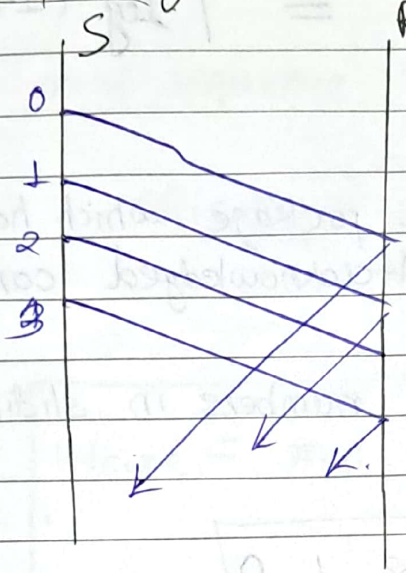
4-QAM ⇒ (2 bits)

16-QAM ⇒ (4 bits).

Tutorial End.

Lecture start

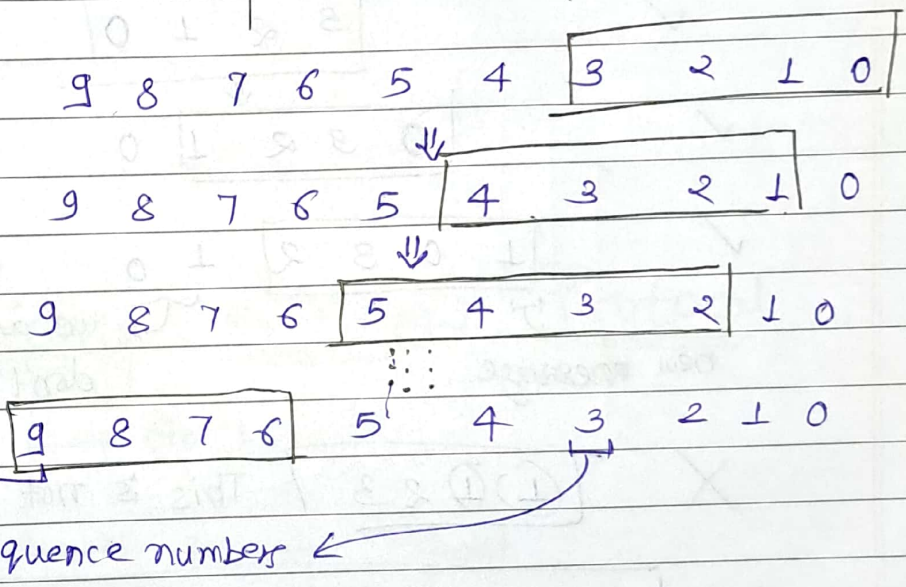
Multiplexing



We are sending messages; without caring of receiving acknowledgement.

We decide the size of window & slide as ack are received.

(4 size window)



Say Each message takes $T_t + 2T_p$ time.

Will represent as $\Rightarrow \left(\frac{T_t}{T_t} + \frac{2T_p}{T_t}\right) \times T_t$

$\Rightarrow (1 + 2a) \times T_t$.

$T_t + 2T_p \longrightarrow 1$ package.

$(1+2a) \longrightarrow \frac{1}{T_t}$ package

$N \longrightarrow \frac{N}{(1+2a)T_t}$ packages.

No. of min. unique sequence numbers required $= \lceil \log(1+2a) \rceil$

The sequence number of a package which has been transmitted, received & acknowledged can be reused.

concept:- All sequence numbers in sliding window must be unique

✓ 3 2 1 0

✓ 0 3 2 1 0

✓ 1 0 3 2 1 0

new message. ↳ we assume they don't exist in world.

✗ (1)(1) 2 3 This is not acceptable.

$$W_{size} = 1 + 2a = 1 + 2\left(\frac{T_p}{T_p}\right)$$

[Q] $T_t = 1ms$, $T_p = 49.5\ ms$.

$$W_S = 1 + \frac{2 \times 49.5}{1} = 100$$

$= T_p$

$= 100$

Seq. no $\Rightarrow$ 100, No. of bits $\Rightarrow \lceil \log_2[100] \rceil = 7$.

Q] If no of bits = 6, What is efficiency?

ans:- no. of sequence nos ⇒ 64

$$\text{efficiency} \Rightarrow \frac{64}{1+2a \approx 100} \Rightarrow \boxed{64\%}$$

$$\boxed{W_{size} = \min\left(1+2a, 2^N\right)}$$

Sliding Window Protocal.

- Go back N
- selective Repeat.

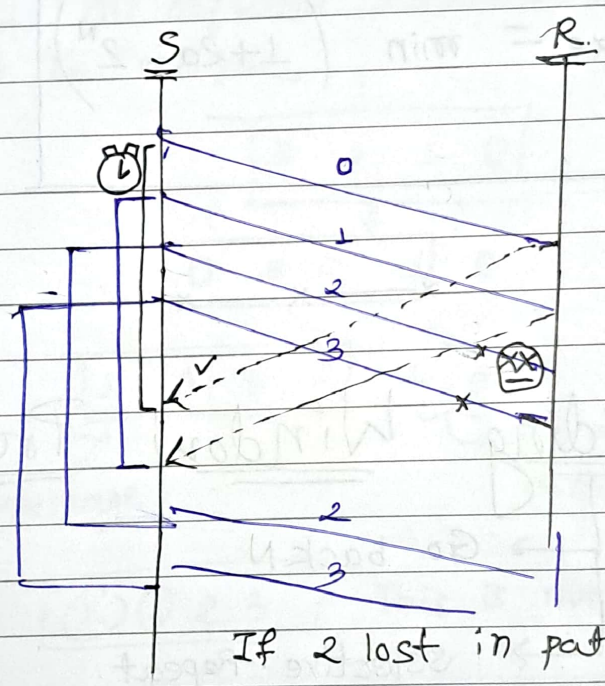
Go-back-N (GB-N)

1) Sender Window size is $N > 1$.
2) Receiver Window size is 1.

Receiver accepts only 1 packet at a time.

GB-4

Every package sent has timeout timer to resent message



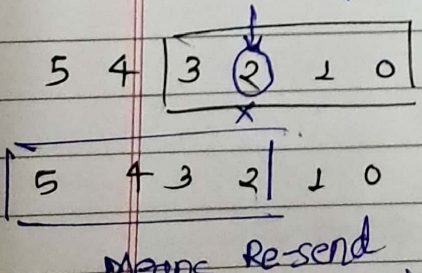
Received
0 ✓
1 ✓
?
3

} will be discarded.

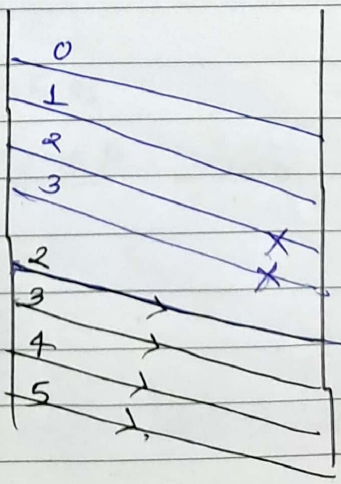
If 2 lost in path

Out of order packet is not accepted.
Hence ack not received on sender side.
Now, 2 & 3 are re-send after timeout time over

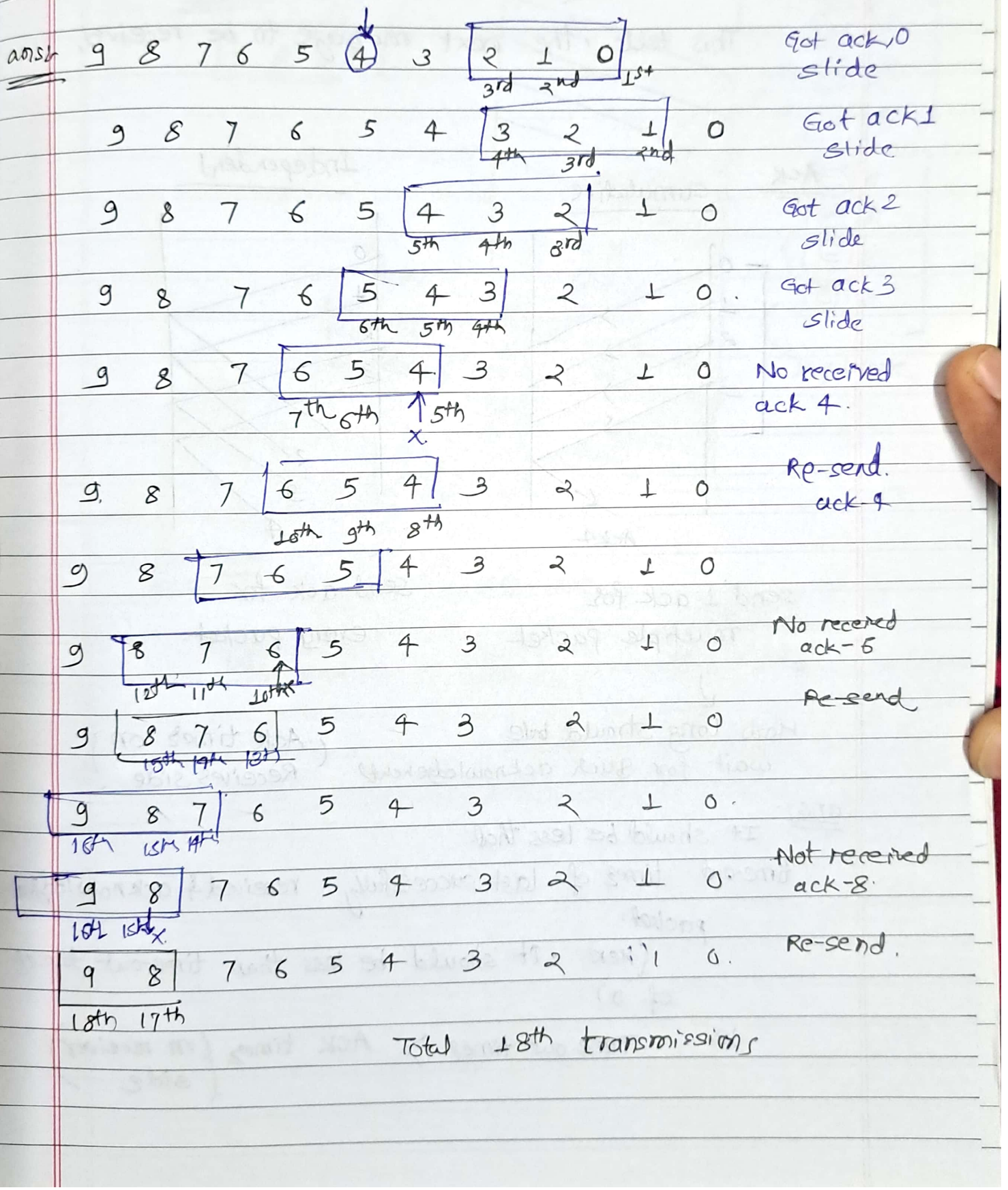
Go-back N packet strategy



Means Re-send but N-packets



Q] GB-3, Every 5th packet transmitted is lost
You are given 10 packet to send,
then how many transmission Required.



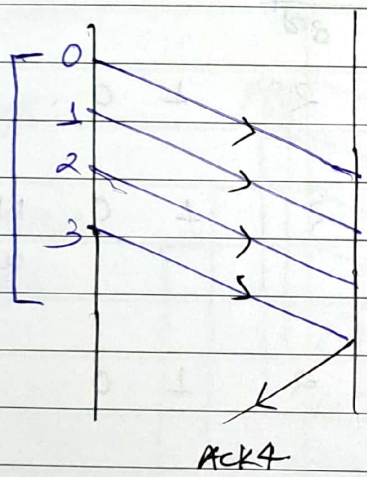
Total 18th transmissions

Note: Acknowledgement Number
is (1 + send number)

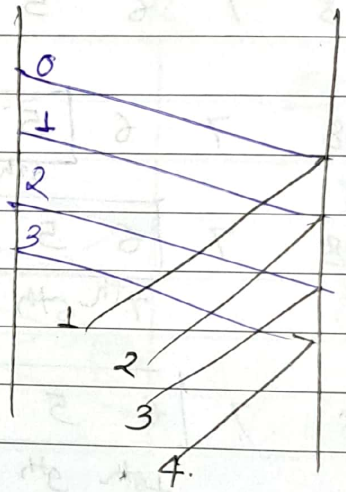
This tells the next message to be received.

Ack

Cumulative



Independent



send 1 ack for multiple packet

↓

How long should we wait for such acknowledgement? (Ack timer on receiver side)

Send ack for every packet.

ans:- It should be less than time-out times of last successfully received & acknowledged packet

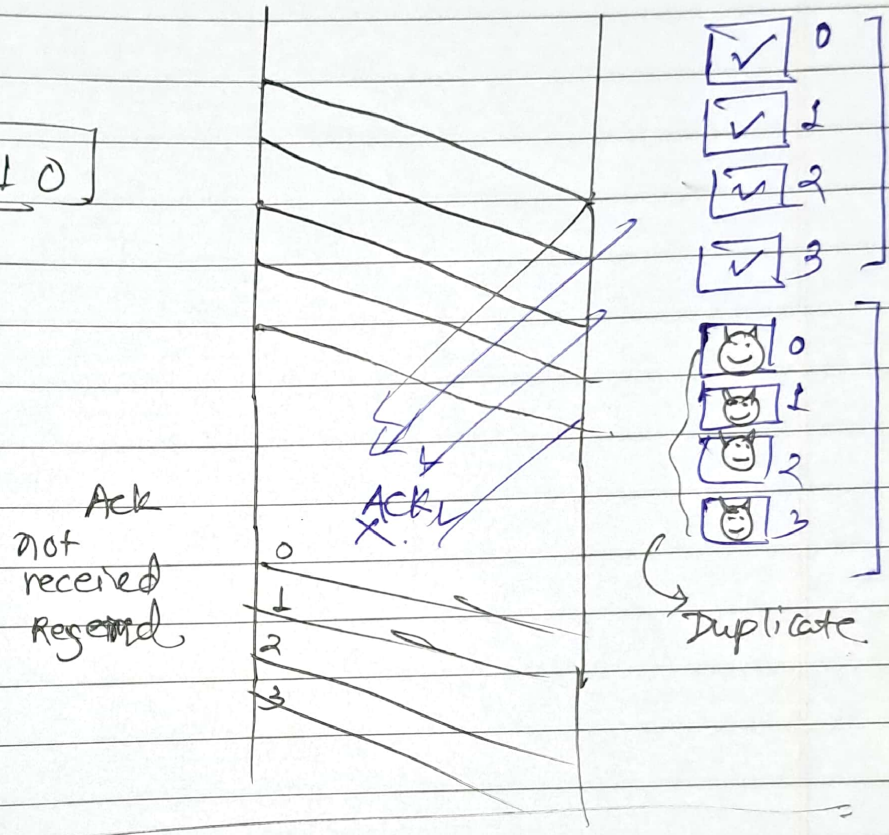
(Here, it should be less than time-out times of 0)

ie. Time out times > Ack times (on receiver side)

Issue of sequencing

GB-4

3 2 1 0



Solution

If window sizes are.

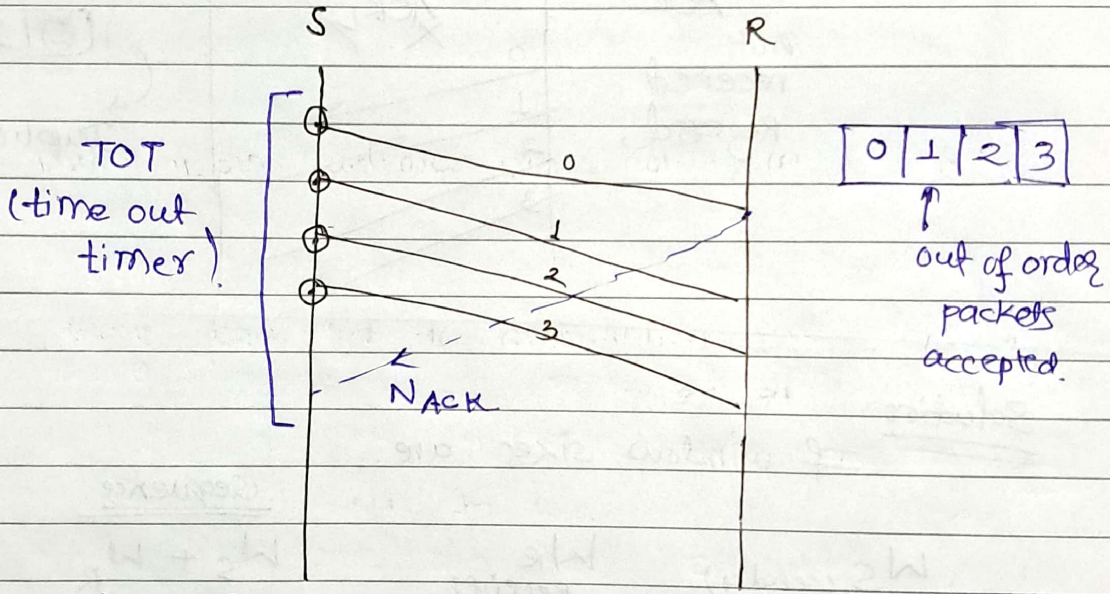
W_S (sender)	W_R receiver	sequence $W_S + W_R$
N	1	(N + 1)

Lec-8

Selective Repeat :- (SR protocol)

⊙ $W_S > 1$. (can send multiple packets before receiving acknowledgement)

⊙ $W_R = W_S$



If 0 is corrupted then receiver will send negative acknowledgement before time out only

since $W_R > 1$, so can accept out of order packet.

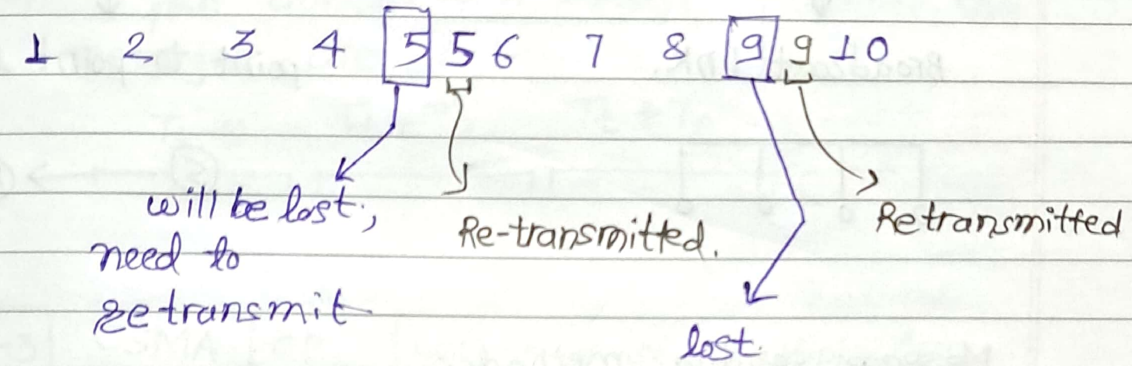
#only lost packet is selectively sent not entire packet.

$W_S \neq 3$, !

Q] $W_S = 3$, Total 10 packets, every 5th packet is lost. How many transmissions are required according to SR protocol?

Hence 12 transmissions required. (In case of Go-back N 18)

ans:



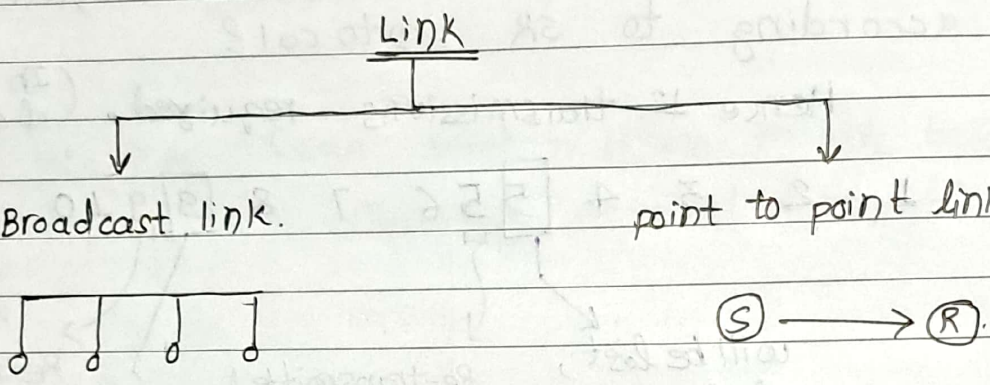
SR is similar to sliding window, because only Lost packet transferred.

In SR, acknowledgement for every package is independent.

SR supports concept of negative acknowledgement as well.

Comparision	Stop&wait	GBN	SR
Efficiency	$\frac{1}{1+2a}$	$\frac{N}{1+2a}$	$\frac{N}{1+2a}$
Buffer	1+1	N+1	N+N
Seq no.	2	N+1	2N
Retransmission	1	N	1
Bandwidth	low	high	moderate

Access control :-



Message sending methods :-

M-1 Round Robin Method.

We are giving time slots to all the host, but there can be a case when the host does not have anything to send but still time slot will be alloted & Hence time waste. ☹

- Also, message may get corrupted. If at same instance two senders send messages.

$$T_{slot} = T_t + T_p$$

Here T_t is useful work.

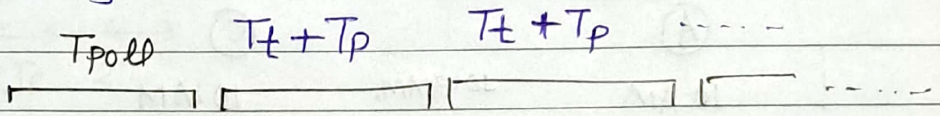
So, $$\eta = \frac{T_t}{T_t + T_p} = \frac{1}{1+a}$$

$$\therefore \boxed{a = \frac{T_p}{T_t}}$$

M-2 Polling

The one who wants to access the medium of communication, must send/raise request.

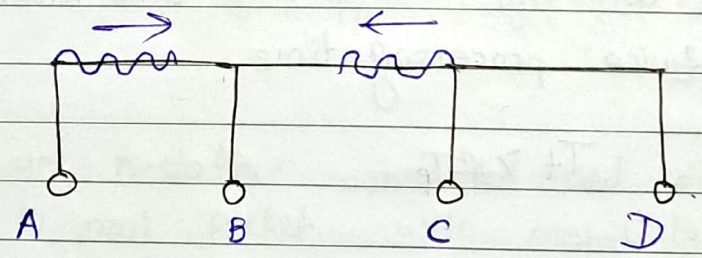
In T_{poll} duration ⇒ A request is raised, then messages are sent.



M-3 CSMA/CP [carrier sense Multiple Access collision detection]

- very popular, used in Ethernet.

No ACK Here.

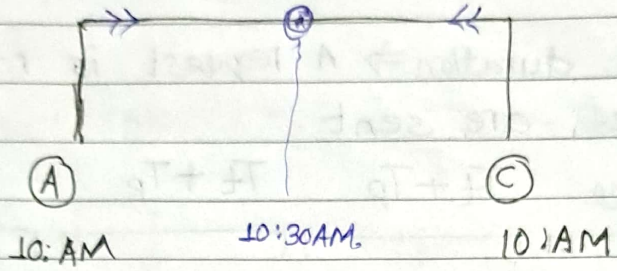


Say A & C send together when medium was empty, they both send some message on chain.

Both will see mixture of A&C message, they will think message has been sent; and since no acknowledgement they will not re-transmit messages.

How they will detect collision?

ans:-



both send message at same time, so message collides at midpoint of wire at say 10:30 AM

Hence After that say 11AM, both will receive corrupted signals

To detect collisionge. Transmission time must be greater than twice processing time

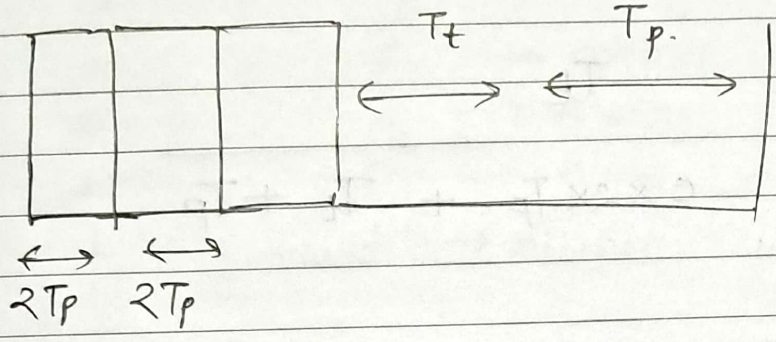
$$T_t > 2T_p$$

$$\frac{L}{B} > 2T_p$$

$$L_{min} > 2(T_p)B$$

$$\therefore \boxed{L_{min} = 2(T_p)B}$$

Efficiency of CSMA/CP = ?



$$\eta = \frac{T_t}{C * 2 \times T_p + (T_t + T_p)}$$

C ↑ no. of attempt before one successful.

$$\eta = \frac{T_t}{C \cdot 2 \cdot T_p + (T_t + T_p)}$$

Q There are n-stations connected and every station wants to send packet with probability 'p'. Probability of success is when one station transmits data.

$$P_{success} = {}^{n}C_1 \times p \times (1-p)^{n-1}$$

when $p = \frac{1}{n}$, max probability

$$P_{max} = \frac{1}{n} \times \left(1 - \frac{1}{n}\right)^{n-1} \times n$$

$$= \left(1 - \frac{1}{n}\right)^{n-1}$$

as $n \to \infty \Rightarrow \boxed{\frac{1}{e}}$

No. of times a host should try before success

$= \frac{1}{p} = e$

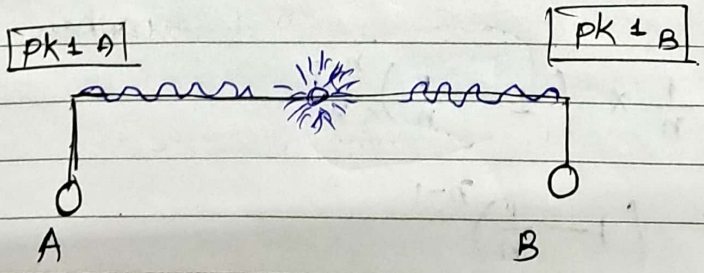
$$\eta = \frac{T_t}{e \times 2 \times T_p + T_t + T_p}$$

$$= \frac{1}{1 + 6.44 \left(T_p / T_t\right)}$$

$$= \frac{1}{1 + 6.44 \left(\frac{d}{v}\right) \times \left(\frac{B}{L}\right)}$$

Ethernet

In CSMA/CP, 2 stations A and B are continuously sensing channel for empty medium. If there is some collision, both of them will wait for some time, After which they will wake up.



collisions can happen in following range :-

$0 \rightarrow 2^{n-1}$ (0,1)

$0 \rightarrow 2^{n-1}$ (0,1).

$T_A = \boxed{\quad} * T_{slot}$ $T_B = \boxed{\quad} * T_{slot}$

A	B	
0	0	→ collision.
0	1	→ A wins.
1	0	→ B wins
1	1	→ collision

$P(A) = \frac{1}{4}$ $P(B) = \frac{1}{4}$ $P(\text{collision}) = \frac{1}{2}$.

All combinations when B range ⇒ {0, 1, 2, 3}

A	B		Winner
0	0	→	C
0	1		A
0	2		A
0	3		A
1	0		B
1	1		C
1	2		A
1	3.		A.

$P_A = \frac{5}{8}$

$P(B) = \frac{1}{8}$

$P(C) = \frac{2}{8} = \boxed{\frac{1}{4}}$.

Whoever captures channel first has higher probability of capturing channels in next attempts.

The probability of collisions is decreasing, but capture effect possibility is still there.

Aloha

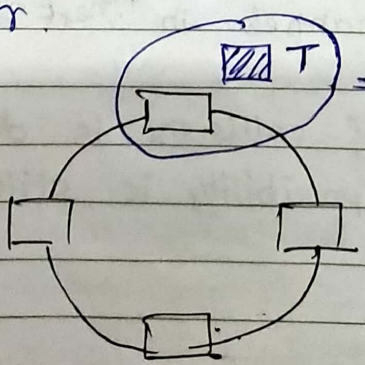
- Pure: They allow station to transmit any time.
- slotted: They divide time into slots & stations will start transmissions at particular slot.

Token passing :-

- Ring topology considered.
- A token is circulated in ring.
- Whoever host holds token is allowed to transmit in channel.

Ring Latency :- How long a bit will take to loop through Ring completely.

- It depends on Length of ring & velocity of information.



→ can send.

- Every station can hold Token for 'b' time.

Ring Latency ⇒ Transmission + Token holding

$= \left(\frac{d}{v}\right) + N * (b) / BW$

N ↙ no. of stations

b ↳ How much time a bit takes to pass unit distance.

$\therefore$ cycle time $= \frac{d}{v} + N * \underbrace{THT}_{\text{Token holding Time.}}$

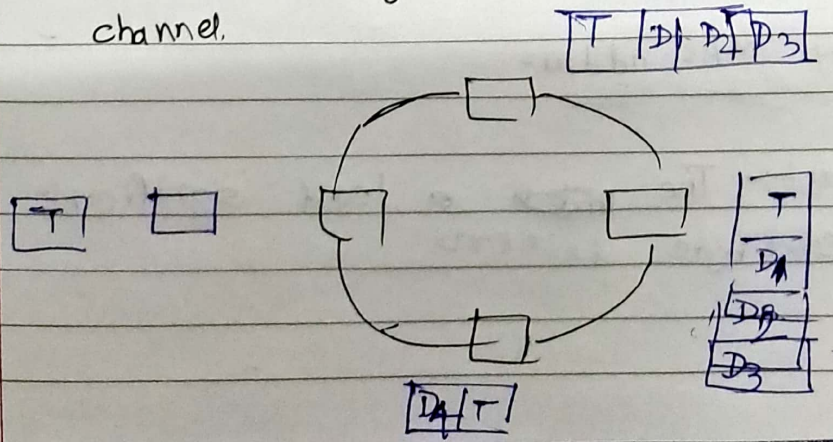
Useful time (time when transmitting data packet).
(host transmits data packet, when it has Token.)

$= N * T_t$.
↳ transmission time

$$\text{Efficiency} = \eta = \frac{N * T_t}{\frac{d}{v} + N * THT}$$

- Delayed token Re-insertion.
- Early token Re-insertion.

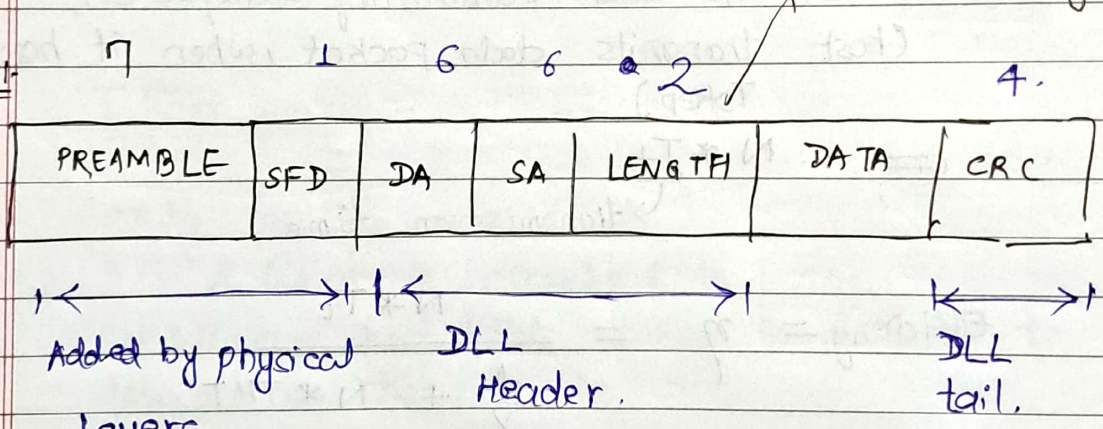
- It is responsibility of sender to remove his/her data on channel.



ETHERNET (IEEE 802.3)

- Bus topology
- connecting:- Join ethernet to computer
- For Access control :-
  - We use CSMA/CP
  - no acknowledgment

Ethernet Frame :-



new Data wakes up all stations.

SFD ⇒ 10 10 10 11. (1byte = 8bits)

DLL ⇒ physical address.

Types of MAC address

1) Unicast:- The least significant bit of first byte is zero

1A : 2B : 34 : 48 : 56

0001 10 10 | 0010 [redacted] 1011 :

2) Multi-cast :- Least significant bit of first byte is 1.

A3 : B4 : C5 : 67 : 89 : 10

1010 | 001 1 : 10110100 - - - -

X . X — X

3. Broad casting :- All bits are 1.

FF : FF : FF : FF

Always destination address is MAC address

—— X ——

CN Tutorial

High-level data link Control (HDLC)

1-1 unicasting
1-many (Multicasting)

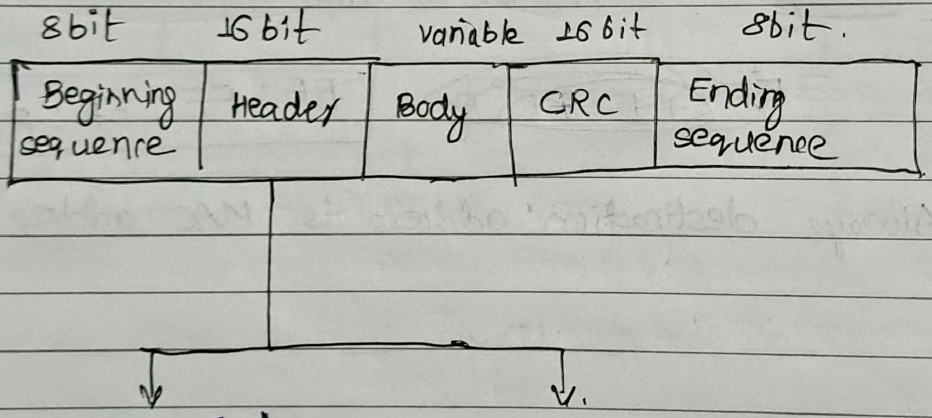
- works on data link layer (DLL)

⇒ Bit oriented.

HDLC frame format :-

Whenever beginning is 8 bit 0 1 1 1 1 1 1 0 (6 1's)

then it is in HDLC format.

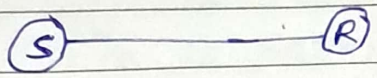


HDLC Types

1) I-frame (Information) (0)
2) S-frame (supervisory) (10)
3) U-frame (Un-numbered) (11)

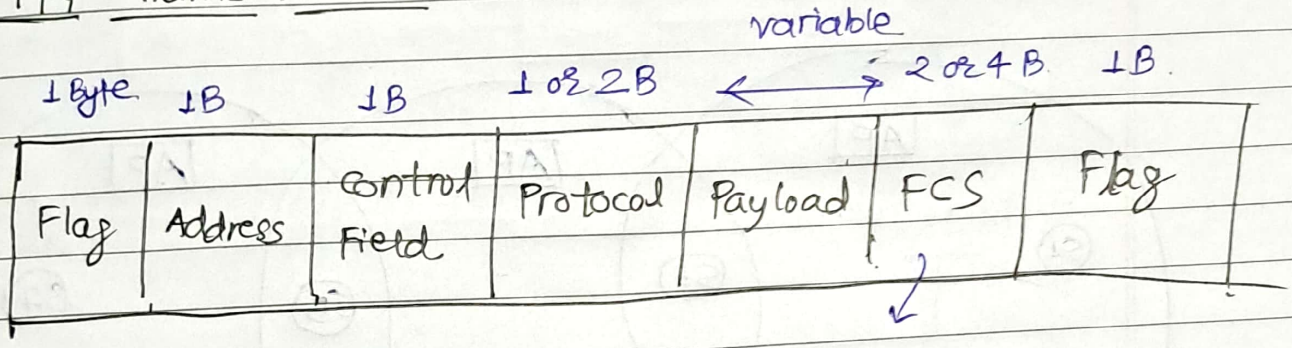
Point to point protocol (PPP) (DLL)

Byte-oriented.



unicast.

PPP frame format :-

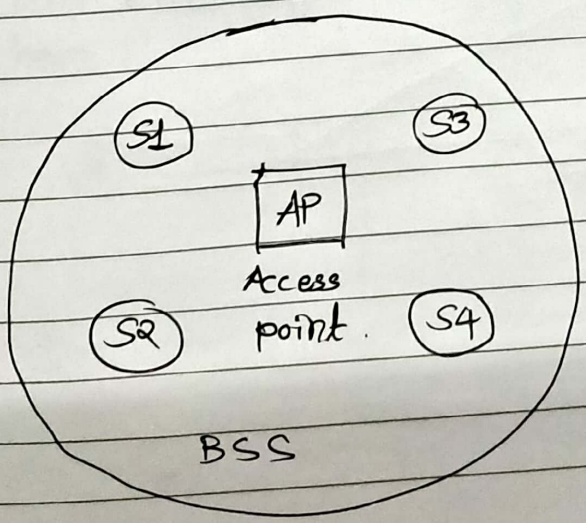


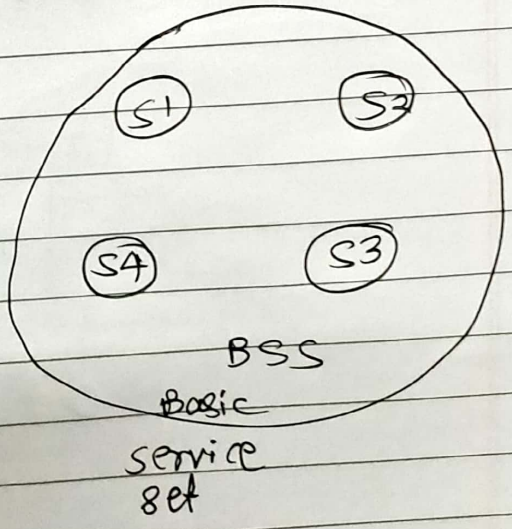
WLAN (wireless LAN)

⇒ IEEE 802.11.

⇒ use Radio waves.

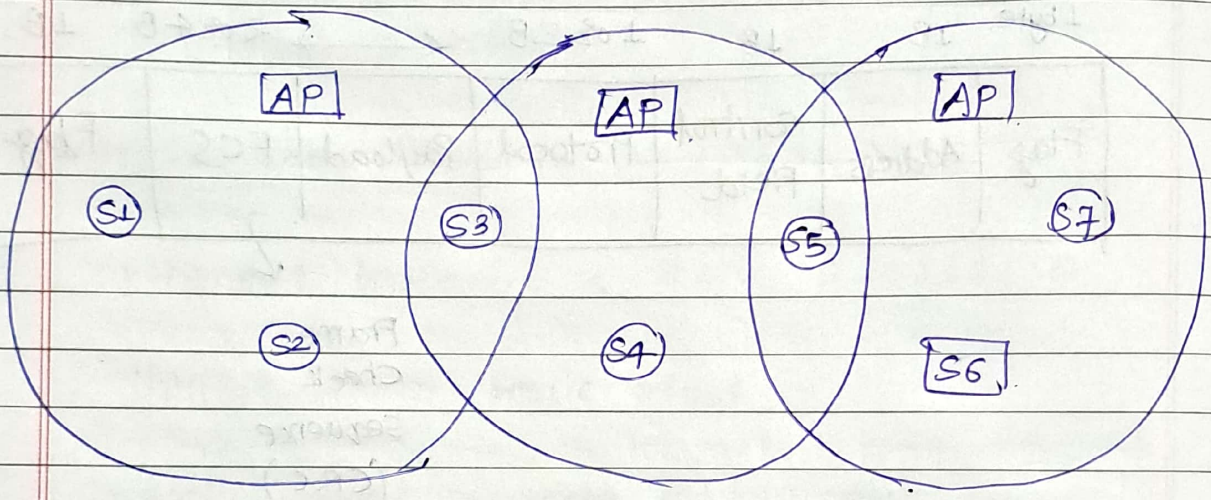
⇒ Basic service set.





Whenever u are connecting 2 or more Basic service sets, it is known as Extended service set.

Extended service set



MAC (48 bits).

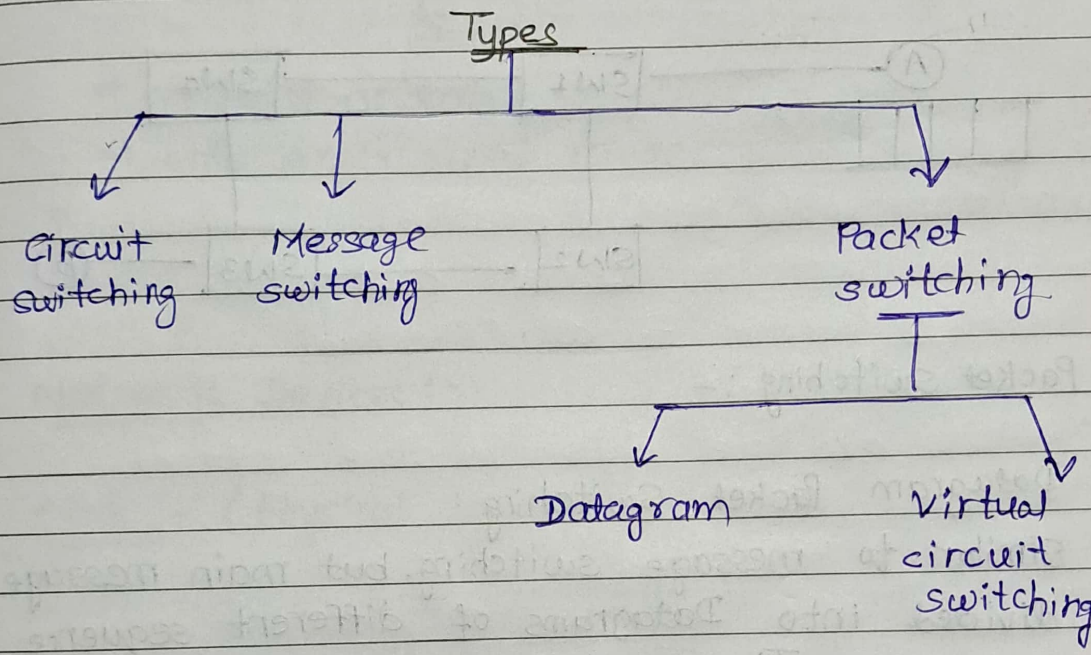
ESS.

Advantage :-

1) Extended Reach
2) Device Flexibility.
3) Easy Installation & Management.
4) Scalability
5) Easy Network Management.

Switching :-

"Mesh topology" is considered to be best, but switching is better than Mesh topology

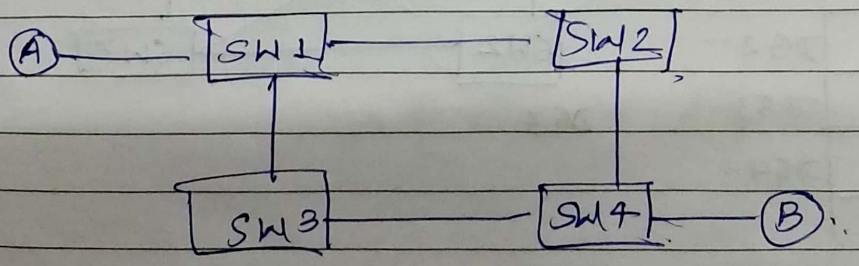


3 phases of switching :-

1) Connection Establishment
2) Data transfer
3) Connection Termination

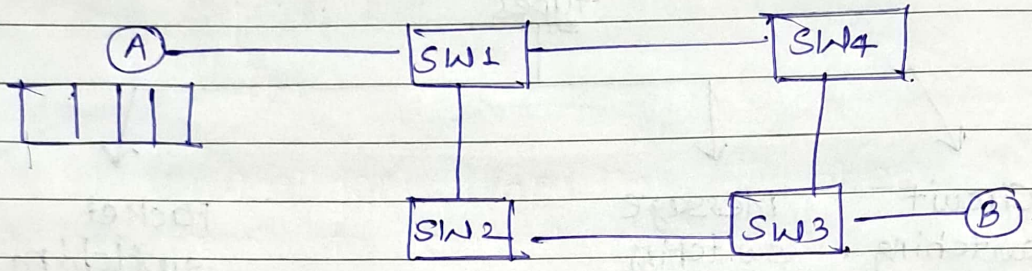
Circuit switching :-

Data will be sent simultaneously without any stoppage here.



Message Switching

Main message will be divided into small sub-message and sent.

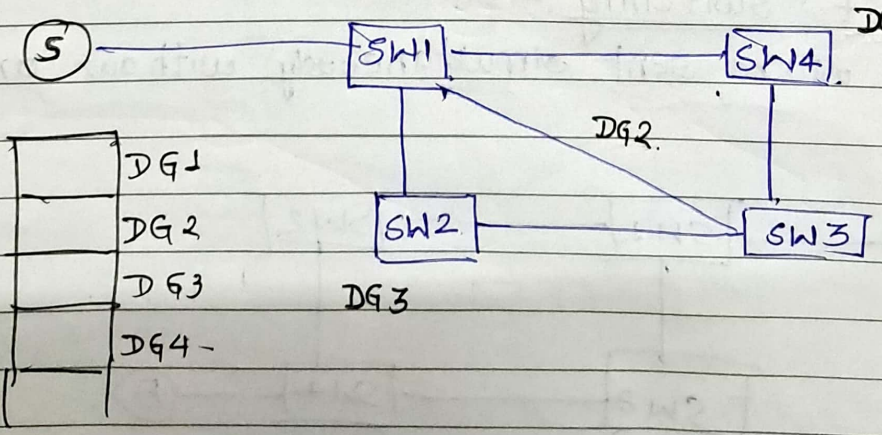


Packet switching :-

1) Datagram Packet Switching.

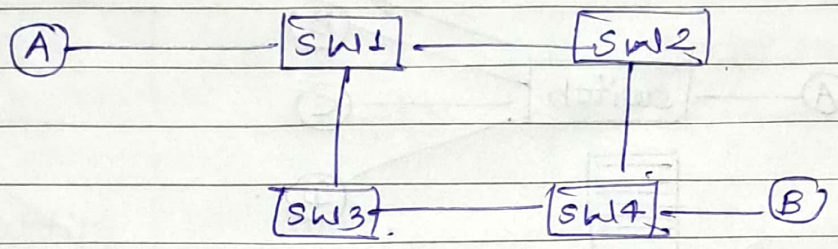
Similar to message switching, but main message divided into Datagrams of different sequence Number. These datagrams travel over different path based on network Traffic.

Hence, more data can be sent / Network Traffic less.



⇒ Out of order packet delivery.

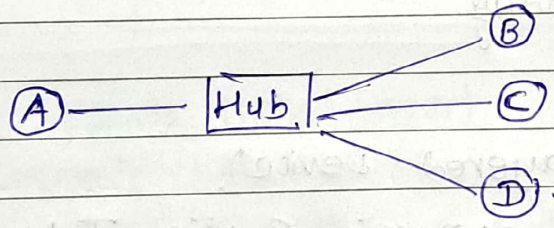
2) Virtual Circuit packet switching.



⇒ connected oriented.
⇒ only single fixed route

Network Devices :-

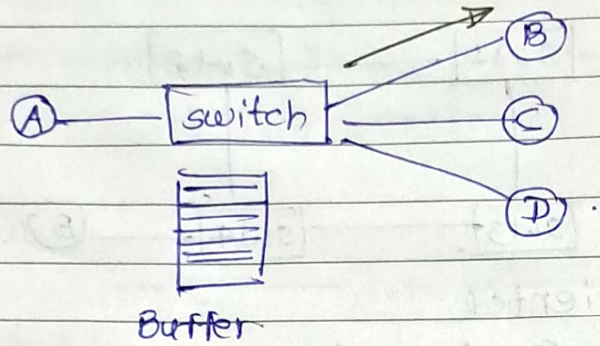
• Hub :- (Physical Layer Device)



⇒ Multi port devices.
⇒ Hub broadcasts to all devices the packets/frames.
⇒ Data forwarding Device.

Types → 1) Passive Hub.
Types → 2) Active Hub : Amplifier.

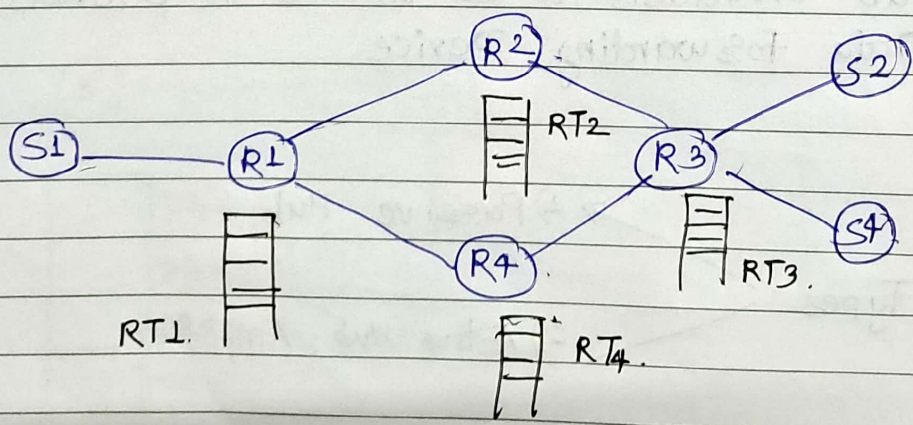
- Switch (DLL- Data Linked Layer)



• switch is intelligent than Hub, it checks IP addrss and then sends to correct destination, instead of sending to all (like Hub)

• switches also have buffer to store information
• unicast, multi-cast
• Filtering & Forwarding

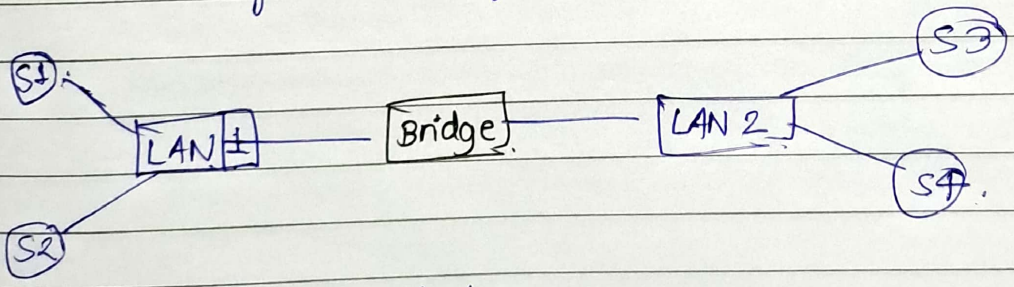
- Router (Network Layered Device)
  - Routing using dynamic Routing Table
  - Data sent in packets



Differences

Hub	switch	Router
Broadcasting	Unicasting Multi-casting	Routing.
Bits	Frames	Packets.
2 + devices	Devices to Network	Network to Network

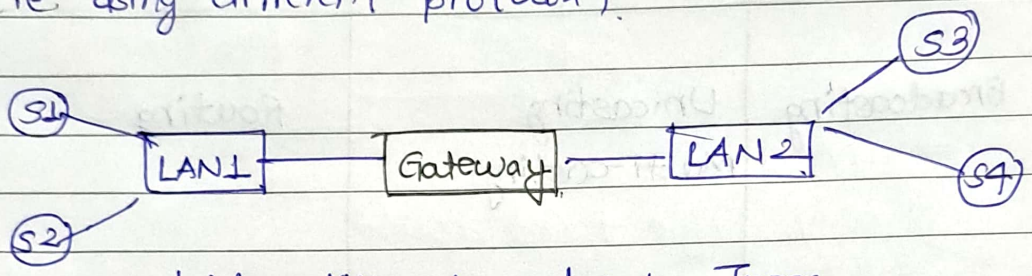
- **Bridge** (Data linked Layer).
  - connects LAN Networks.
  - Filtering & Forwarding of data frames.



Filtering - not broadcasting
- sending message to intended person.

Gateway

- similar to bridge, but can connected LANs of different network type.
(ie using different protocol).



- can bridge different network Types.

Repeater

- It repeats signal.
- Hence used as Extension.

IP Addressing

Mac address is physical Address given by Device Manufacturer.

32 bit IP Address is assigned to every host.

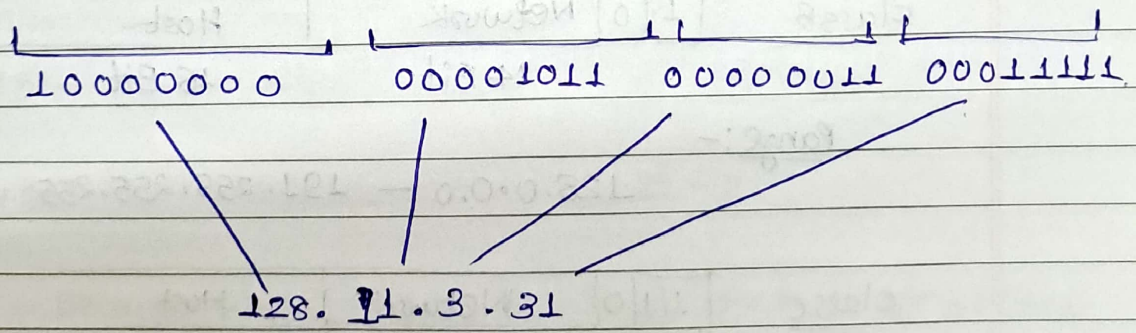
IP Address :- unique identyfying number assigned to every device connected to internet.

Classful IP Addressing :-

- 32 bit unique address having address space of 2^{32}.

Dotted Decimal Notation.

32 bit = 4byte.



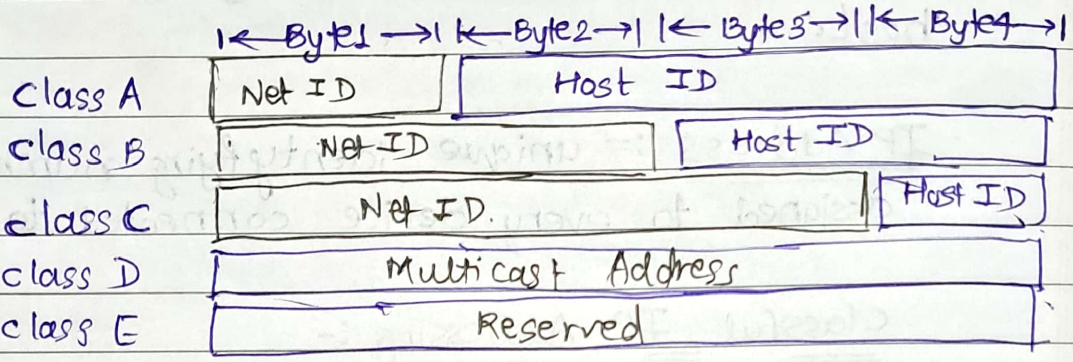
Value of any segment (Each byte) is between ie. $2^8 = 256$, i.e. 0-255.

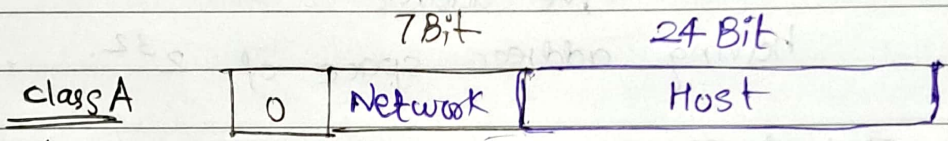
*No zeros are preceding value in any segment.
054 is wrong, 54 is correct.

Classful Addressing

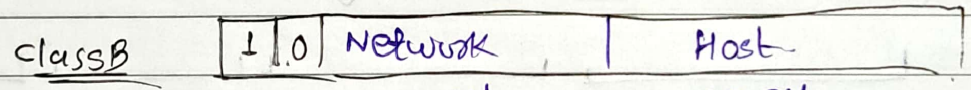
32 bit IP address is divided into 5 sub-classes

Class A, B, C, D, E



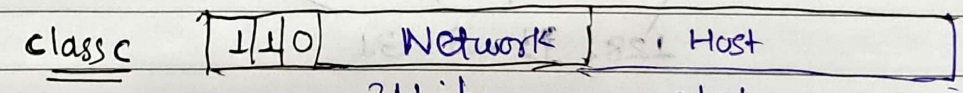


Range :- 0.0.0.0 — 127.255.255.255.

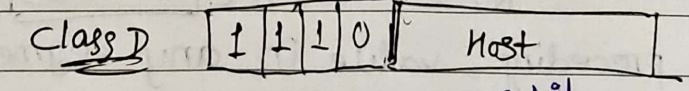


Range :-

128.0.0.0 — 191.255.255.255.



192.0.0.0 — 223.255.255.255.



224.0.0.0 — 239.255.255.255.

Class E

28 bit.

240.0.0.0 – 255.255.255.254.

Range of special IP Address.

169.254.0.0 – 169.254.0.16 :- Link local address

127.0.0.0 – 127.255.255.255 :- Loop-back address

0.0.0.0 – 0.0.0.8 :- used to communicate within current network

	IP Address.	
	Net ID	Host ID
Class A	2^7	$2^{24}-2 = 16777214$
Class B	2^{14}	$2^{16}-2$
Class C.	2^{21}	2^8-2.

Because While finding total no. of Host IP addresses, 2 IP addresses are not counted and are therefore, decreased from the total count because the first IP address of any network is network numbers and Last IP address → reserved for broadcast IP.

255.255.255.255 is Limited Broadcast Address.

Subnet Mask :-

class A :- 255.0.0.0
class B : 255.255.0.0
class C :- 255.255.255.0

Subnet mask is useful to Extract Network ID from IP address.

ex:-

255.0.0.0 ⇒ Subnet Mask
AND(&) 10.1.2.3 ⇒ IP address
10.0.0.0 ⇒ Network ID

and operation.

(Learn Public & Private IP address also)

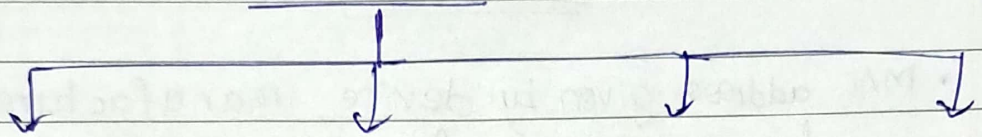
Creating Subnetworks in a Network

- 126 IP address network in class C

192.2.3.□□

Borrowing 2 bits from host portion, we can create subnetworks

192.2.3.0. → 4 subnetworks



192.23.00	192.23.01	192.23.10	192.23.11
192.23.0 → 192.23.63	192.23.64 → 192.2.3.127	192.2.3.128 → 192.2.3.191	192.2.3.192 → 192.2.3.255

Q] Create 2 subnetworks for 195.31.4.0

ans)

clearly 19.31.4.0 is class C,
Last octet is Host,
Borrow 1 bit (for 2 networks)

195.31.4.0

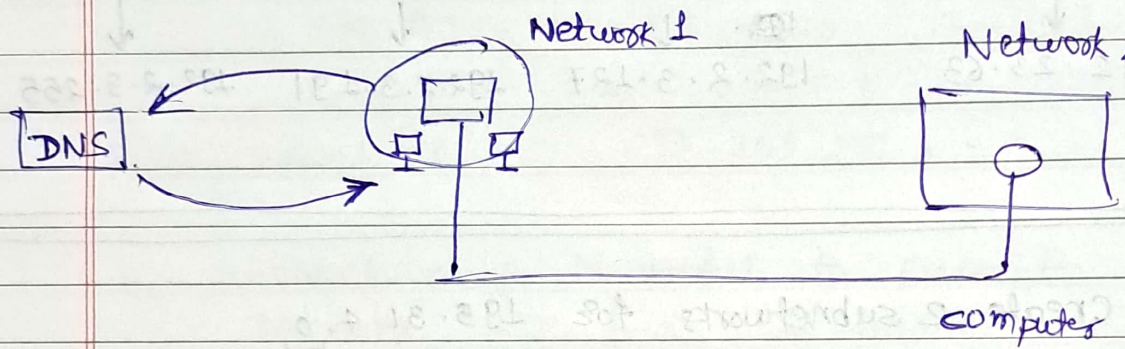
195.31.4.0	195.31.4.1
195.31.4.0 → 195.31.4.127	195.31.4.128 → 195.31.4.255

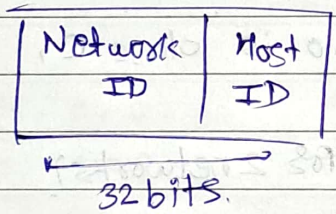
such division into subnetworks is called Fixed Length Subnetwork

Midsem (physical layer + Data link layer)

-: IP address :-

- MAC address given by device manufacturer is not sufficient for finding the device.
- Hence IP address required.



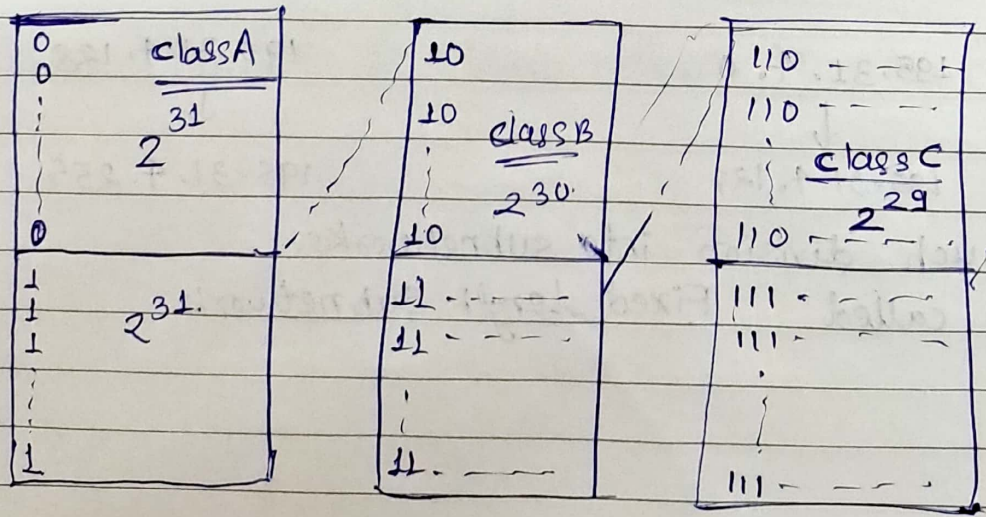


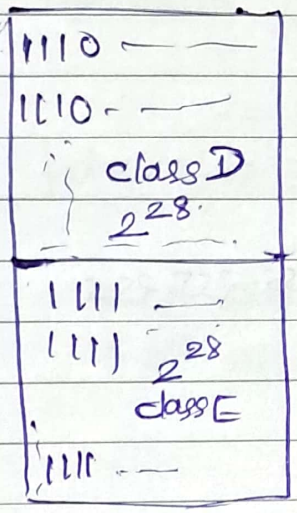
⇒ IP address.

IP address + Port No. ⟶ Socket id.

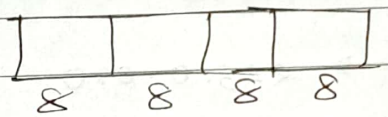
:- Classful Addressing :-

32 bits

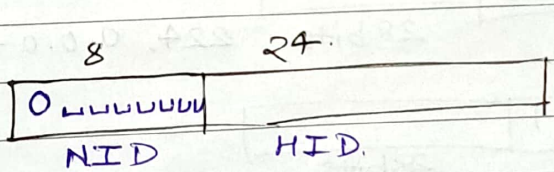




Dotted decimal Representation :-



class A :



$2^7 = 128$ networks

00000000 → 0
00000001
01111111 → 127

out of these 128 Hosts, 2 IP address respectively first (0) & Last (127) are Reserved.

Remaining 128 − 2 = 126 hosts available.

16 bits 16 bits

Class B :- | NID | HID |

Range 10------ → 128
000000 → 191
1111111

128.0.0.0 → 191.255.255.255

Class C :- | 110..... | |
24 bits 8 bits.

110------
00000 ⇒ 192.
⋮
11111 ⇒ 223

192.0.0.0 → 223.0.0.0.

Class D :- | 1110 | 28 bits 224.0.0.0 – 239.255.255.255

Class E :- | 1111 | 28 bits 240.0.0.0 – 255.255.255.255

X

Hamming code

d4	d3	d2	d1
1	0	1	0

d3	d3	d2	P3	d1	P1	P0

4 bit data.
3 bit parity → P_0, P_1, P_2

2^0 2^1 2^2.

7	6	5	4	3	2	1
1	0	1	P_3	0	P_2	P_1
			↓		↓	↓
			0		1	0

$P_1 \rightarrow d_1 + d_3$.

$P_2 \rightarrow d_1 + d_2$

$P_3 \rightarrow d_2 + d_3 + d_4$

Data:- 7 bit

Data:- 1001101.

11	10	9	8	7	6	5	4	3	2	1
1	0	0	P_4	1	1	0	P_3	1	P_2	P_1

$P_1 \rightarrow 2^0$
$P_2 \rightarrow 2^1$
$P_3 \rightarrow 2^2$
$P_4 \rightarrow 2^3$
$P_5 \rightarrow 2^4$.

- No. of P_1, P_2, P_3 -- till data Last.
- place, them at respective positions
- place data at remaining positions.

Do XOR operation & set Pi value such that we get even parity.

XOR of all data bits.

$P_1 \rightarrow$ ~~data bits~~ at 1, 3, 5, 7, 9, 11 position.
take 1, skip 1, do XOR operation.

$P_1 \rightarrow$ ~~(1) 0 (0) 1 (1) 0 (1) = 1~~

$(2^0 = 1)$

$P_2 \rightarrow$ take consecutive 2, skip 2, starting from 2.

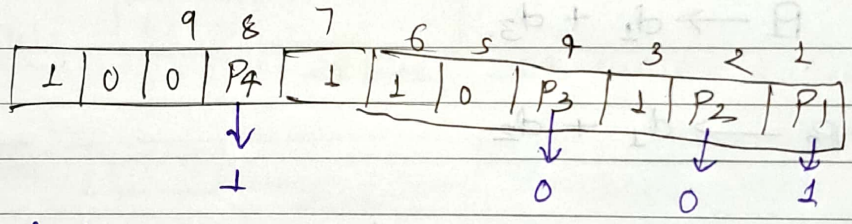
$(2^1 = 2)$ 2, 3, ~~4, 5~~, 6, 7, ~~8, 9~~, 10, 11

$P_3 \rightarrow$ take consecutive 4, skip 4, starting from 4.

$(2^2 = 4)$ 4, 5, 6, 7,

$P_4 \rightarrow$ take consecutive 8, skip 8, starting from 8.

$(2^3 = 8)$ 8, 9, 10, 11.



Data to be sent.

1 0 0 1 1 1 0 0 1 0 1.

If error occurs at 9th position :-

* Hamming code can detect 1 bit error.
P_1 changes to 1, others no change, because not depend on 9th position.
P_4 changes to 1 $P_4\ P_3\ P_2\ P_1$

1	0	0	1	⇒ 9th position.

* Disadvantage :- we need storage to store the error position.
This storage is equal to $P_1, P_2 \ldots P_n$ bit size.

- CSMA/CP, is not preferred for wireless.
- because of properties of CSMA/CP.
  (more distance, less bandwidth in wireless.

- syllabus for quiz covered.

- 6 question, attempt 5.