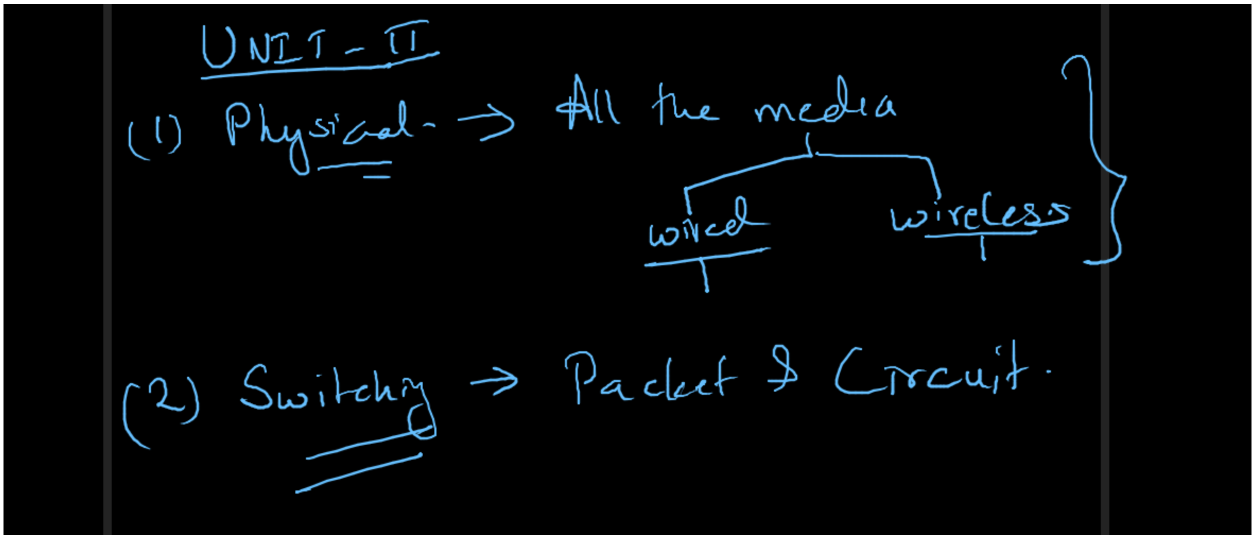
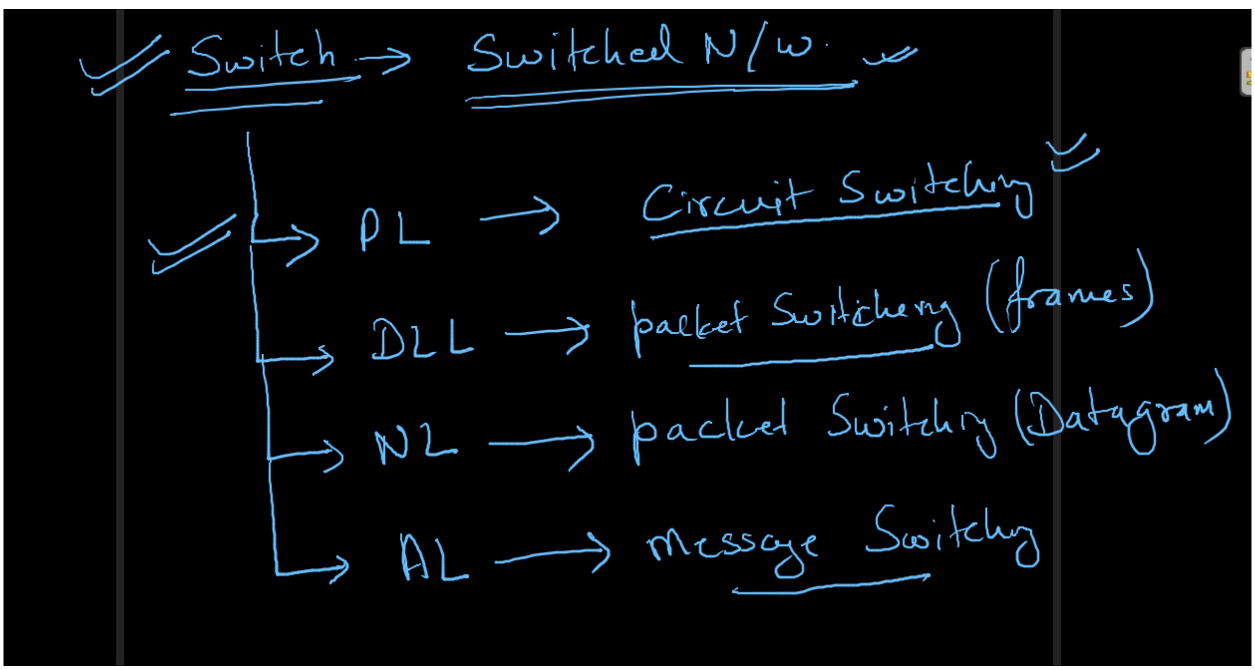
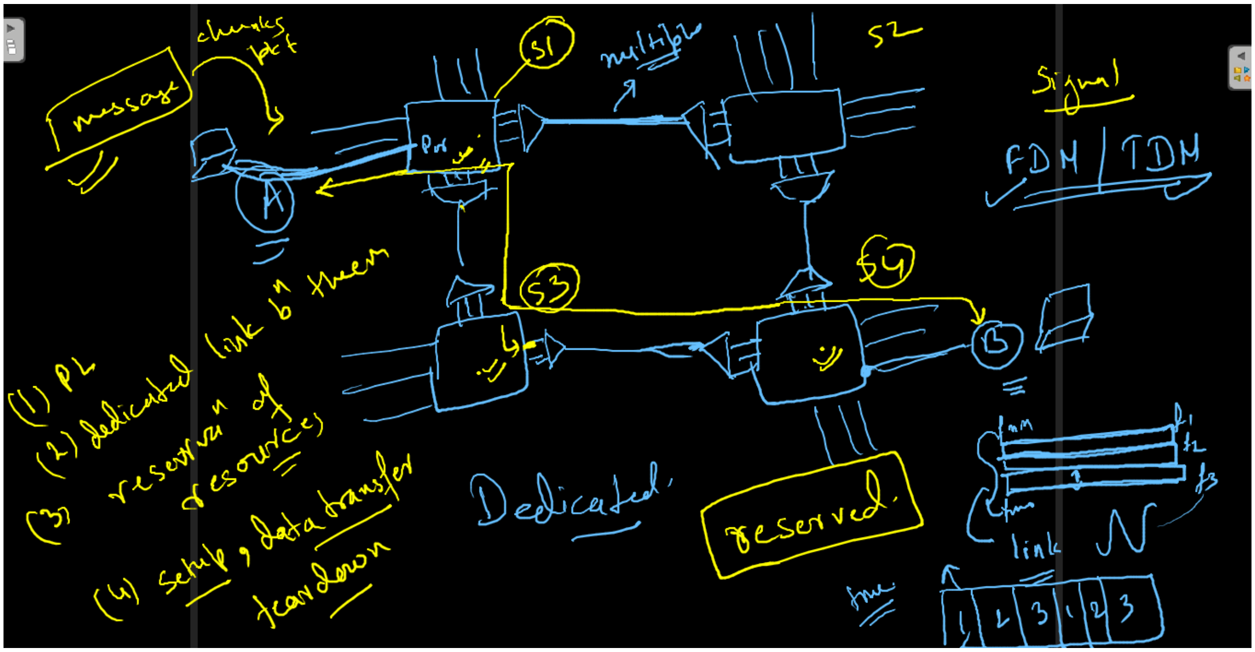
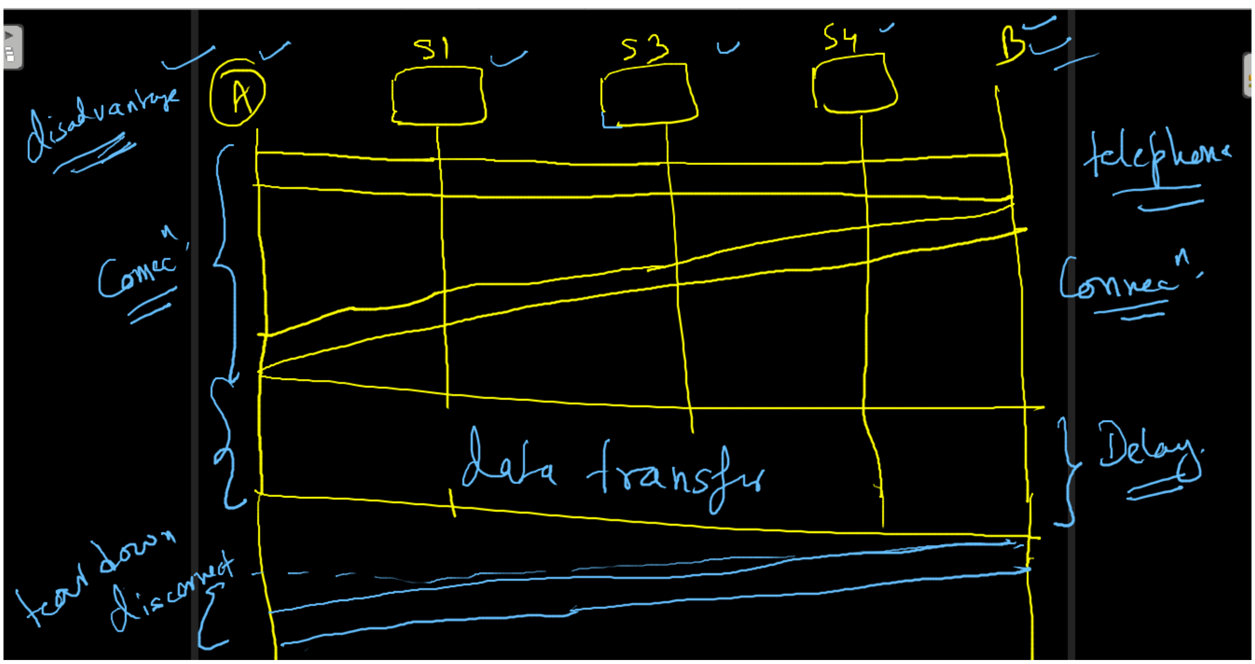
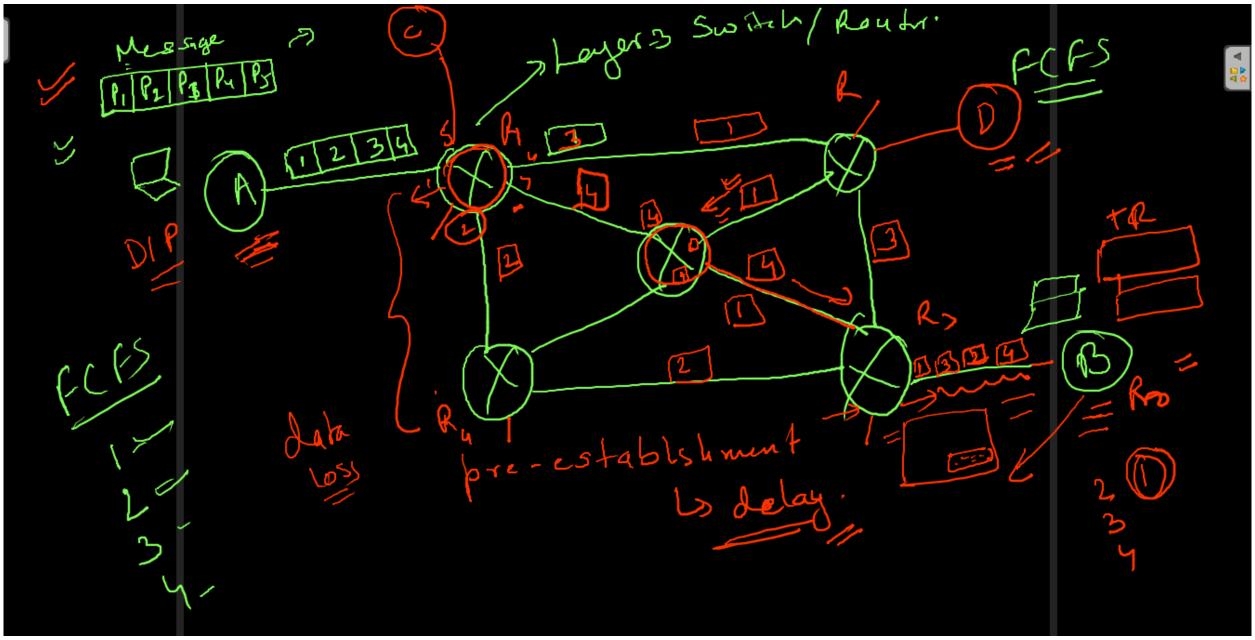
Module – II

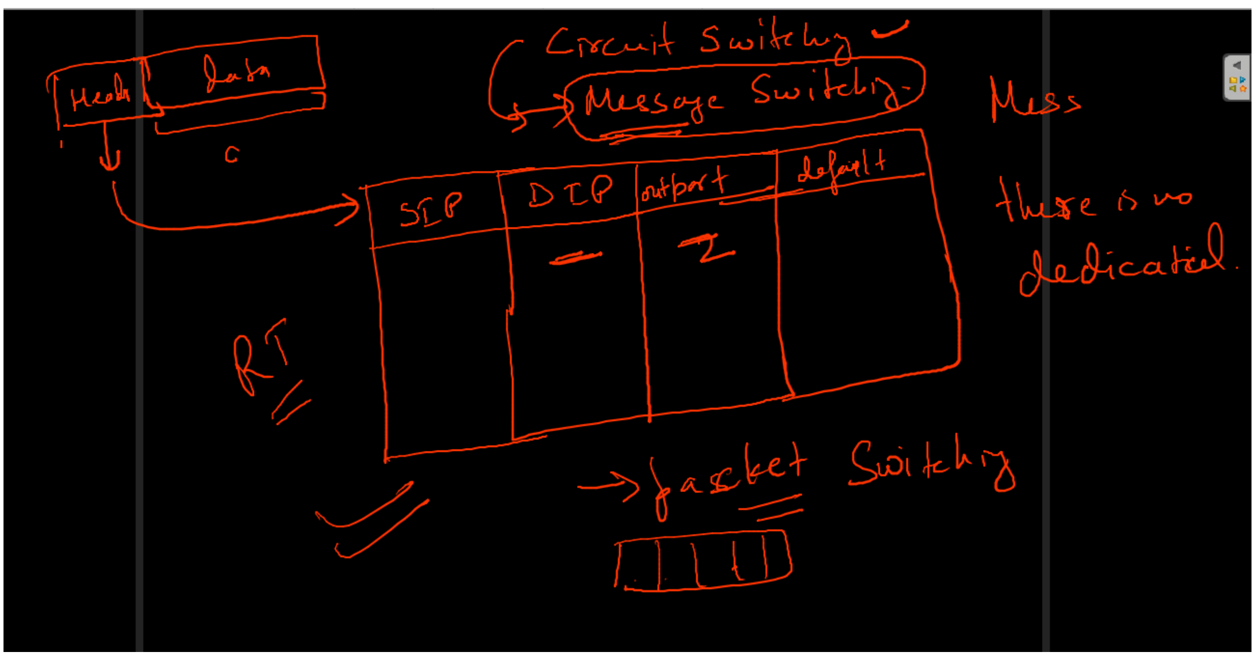

UNIT – II
(1) Physical → All the media
wired
wireless
(2) Switching → Packet & Circuit.


Switch → Switched N/w.
PL → Circuit Switching
DLL → packet Switching (frames)
NL → packet Switching (Datagram)
AL → message Switching

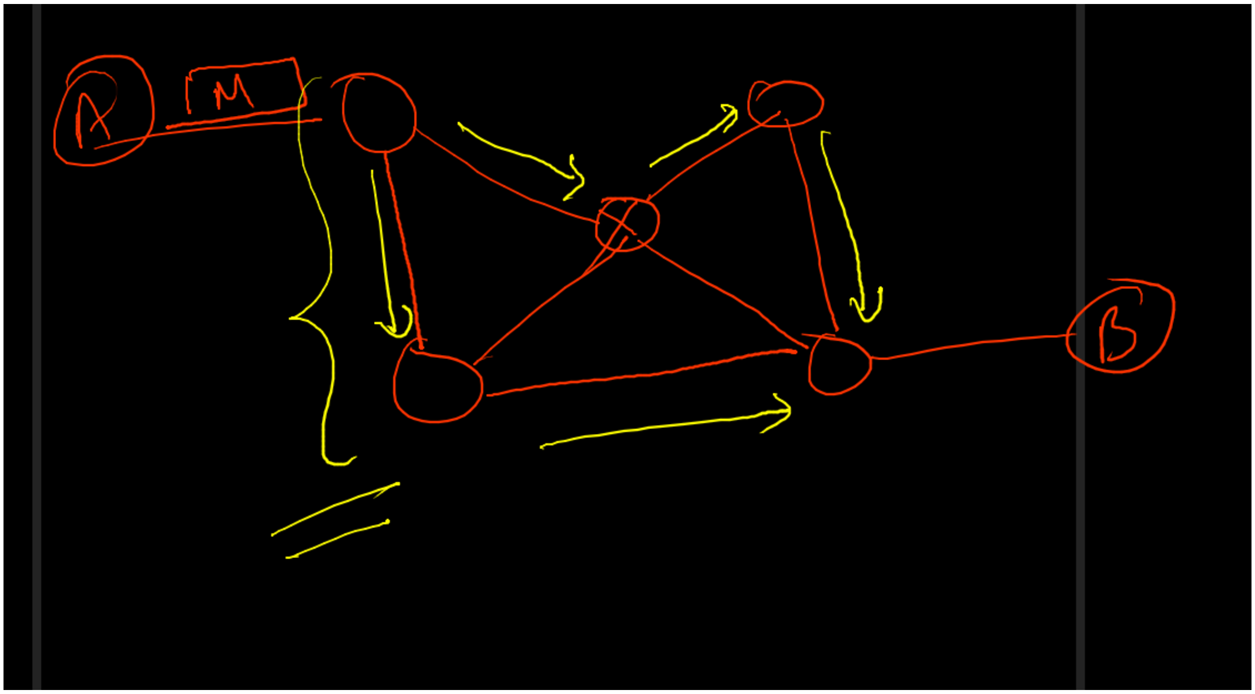

message
S1
multiple
S2
Signal
FDM / TDM
A
S3
S4
B
(1) PL
(2) dedicated link b/n them
(3) reservation of resources
(4) setup, data transfer
teardown
Dedicated.
reserved.
link
1 2 3 1 2 3

A
S1
S3
S4
B
disadvantage
telephone
data transfer
Delay.
tear down
disconnect



Message
P1 P2 P3 P4 P5
Layer3 Switch / Router
FCFS
DIP
R1
R3
R4
TR
FCFS
data loss
pre-establishment
delay

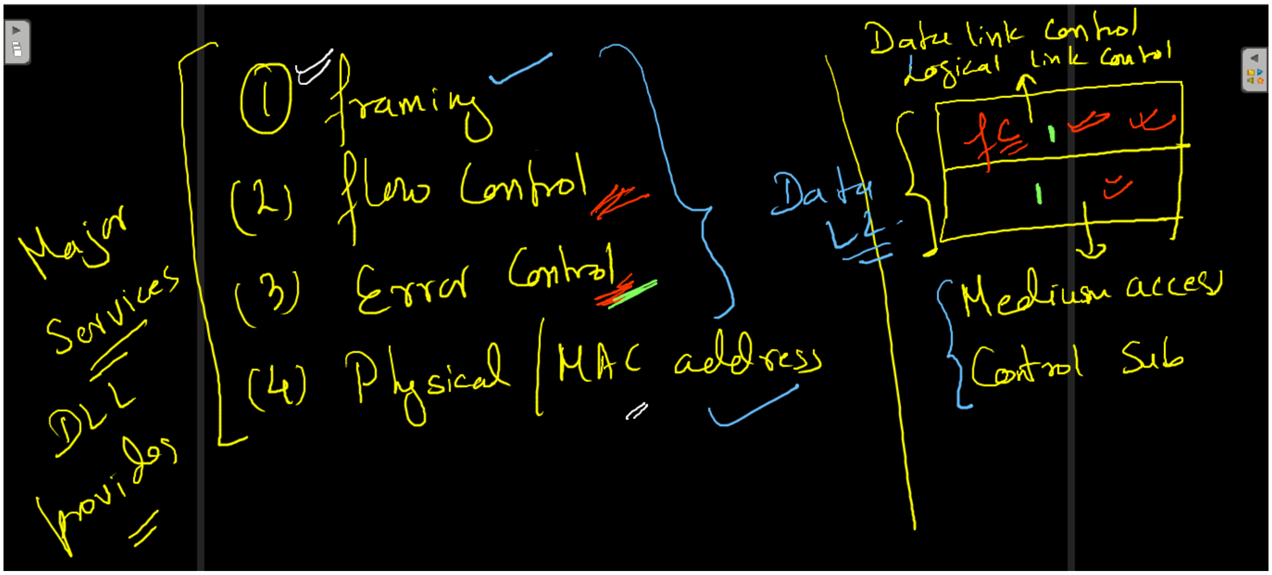


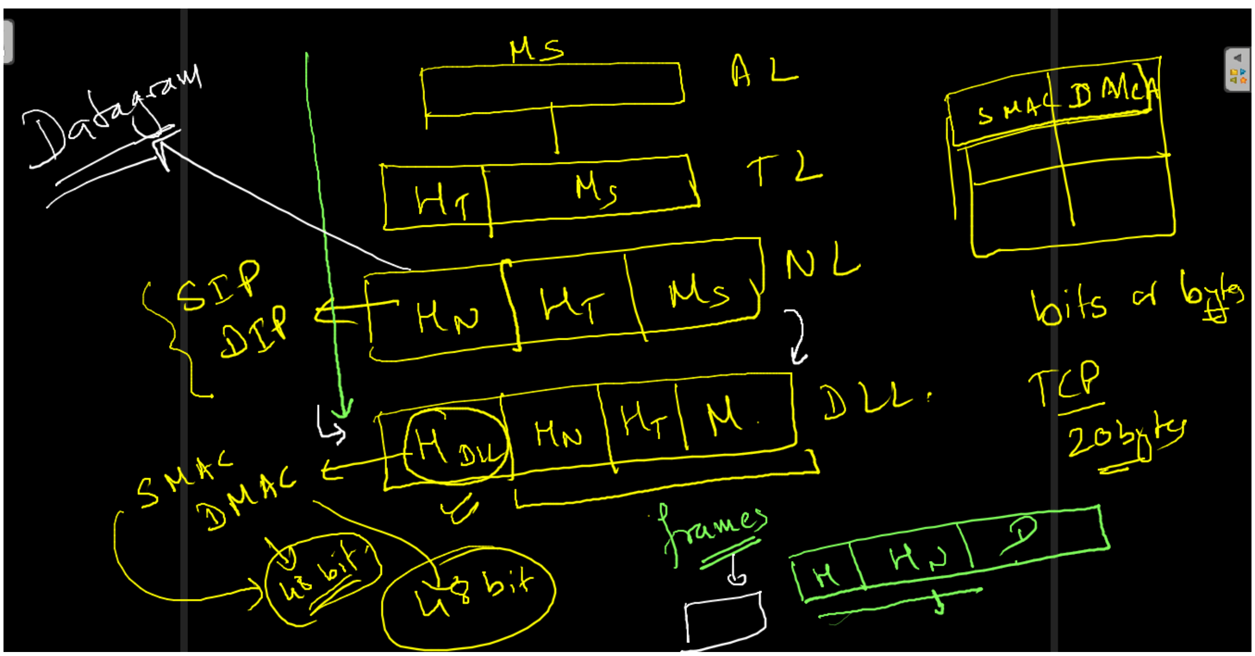
Header
data
Circuit Switching
Message Switching
Mess
there is no dedicated.
SIP
DIP
outport
default
RT
packet Switching

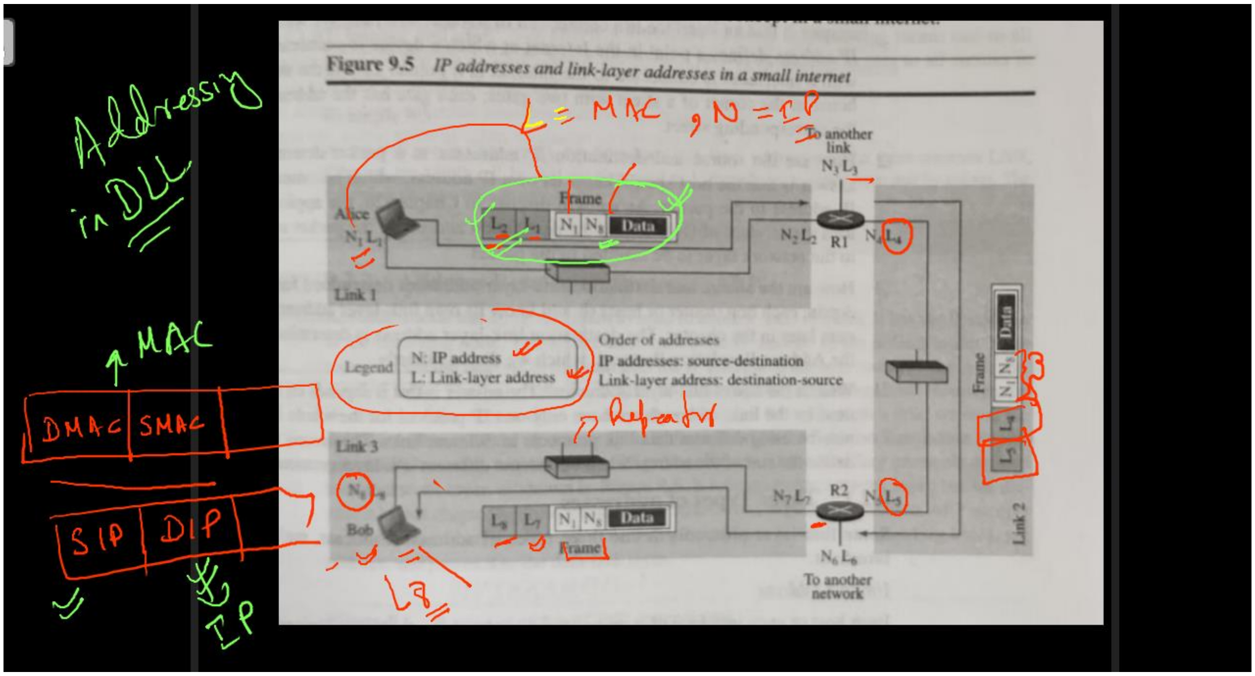


Data link layer:

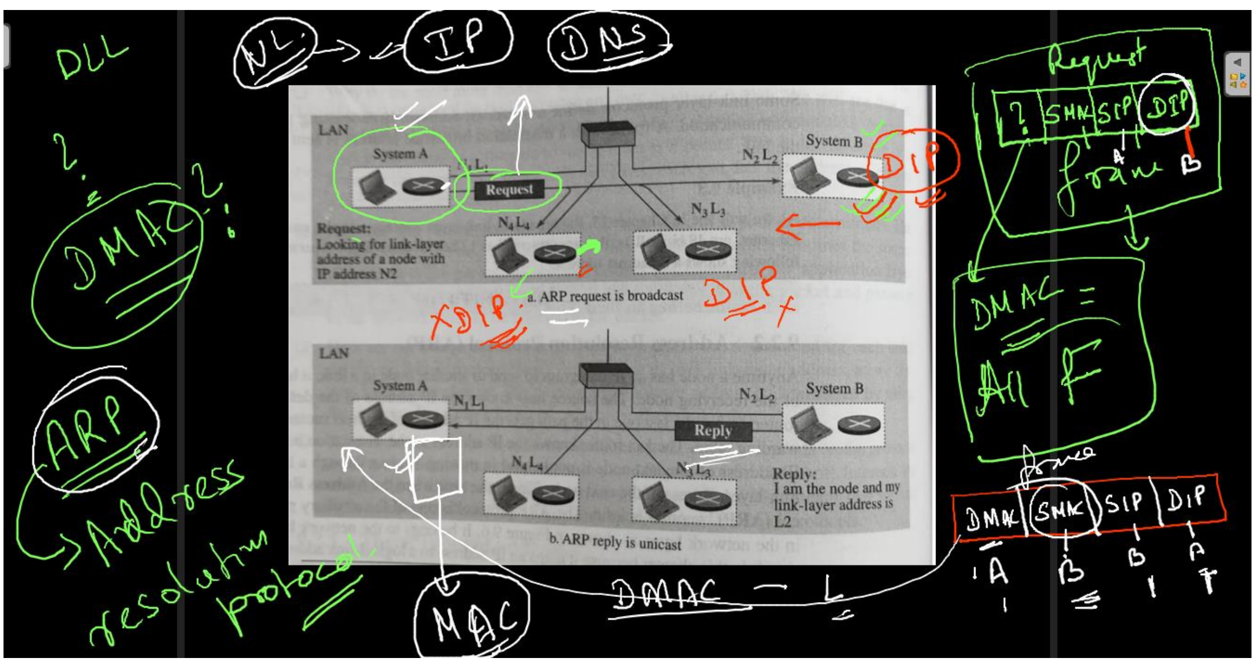
- Hop to Hop
- point to point Connec^n Connec^n
- 2^n layer from bottom
- MAC addresse (Physical add.
- 48 bit. Long hexadecimal format.
- (frame.)


Major Services DLL provides
(1) framing
(2) flow Control
(3) Error Control
(4) Physical / MAC address
Data L2
Data link Control
Logical link Control
Medium access Control Sub

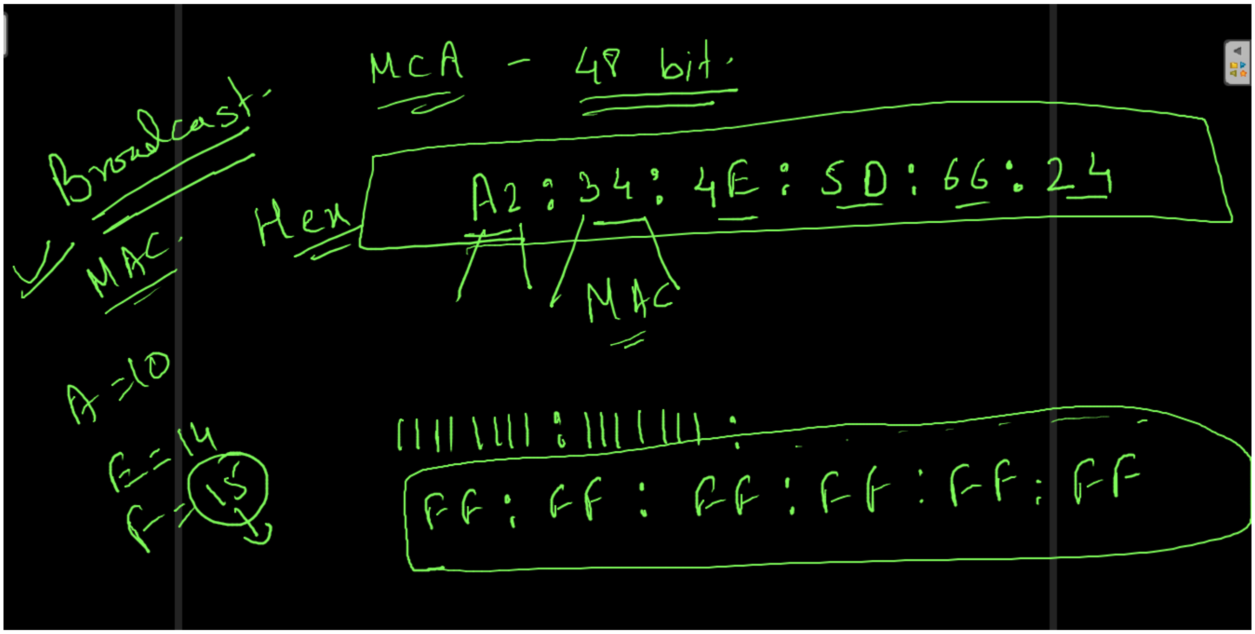

MS
AL
Datagram
HT
Ms
TL
SIP
DIP
HN
HT
Ms
NL
HDLL
HN
HT
M
DLL
SMAC
DMAC
48 bit
48 bit
frames
H
HN
D
SMAC
DMAC
bits or bytes
TCP
20bytes

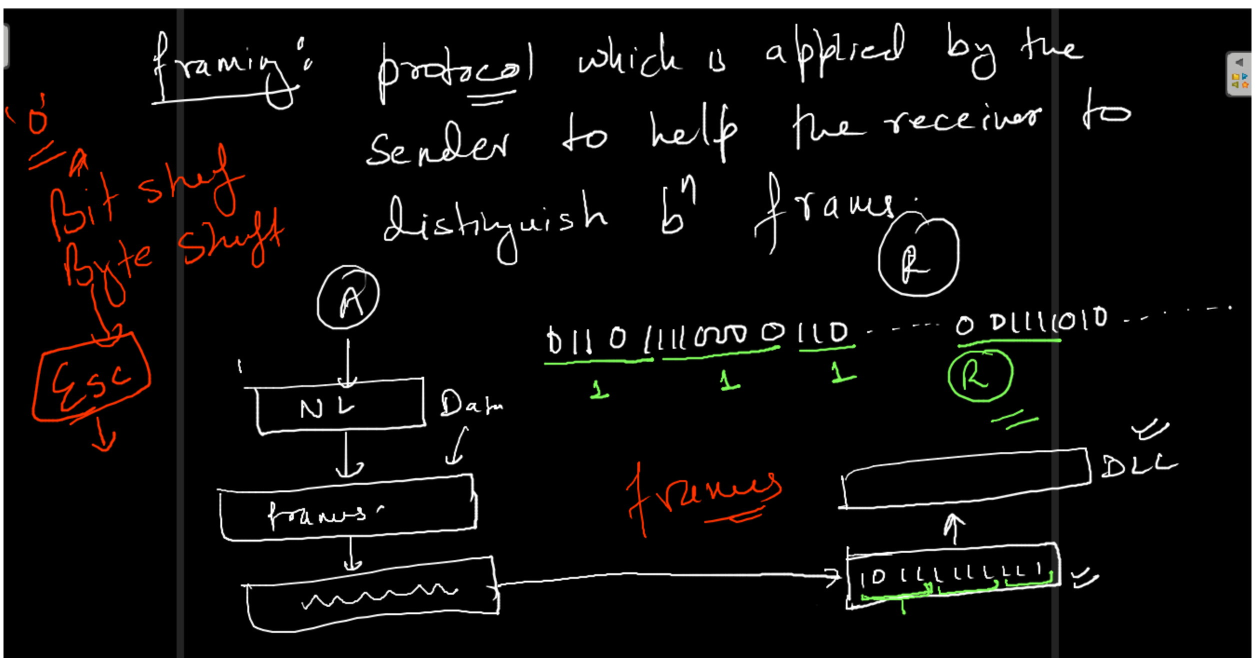


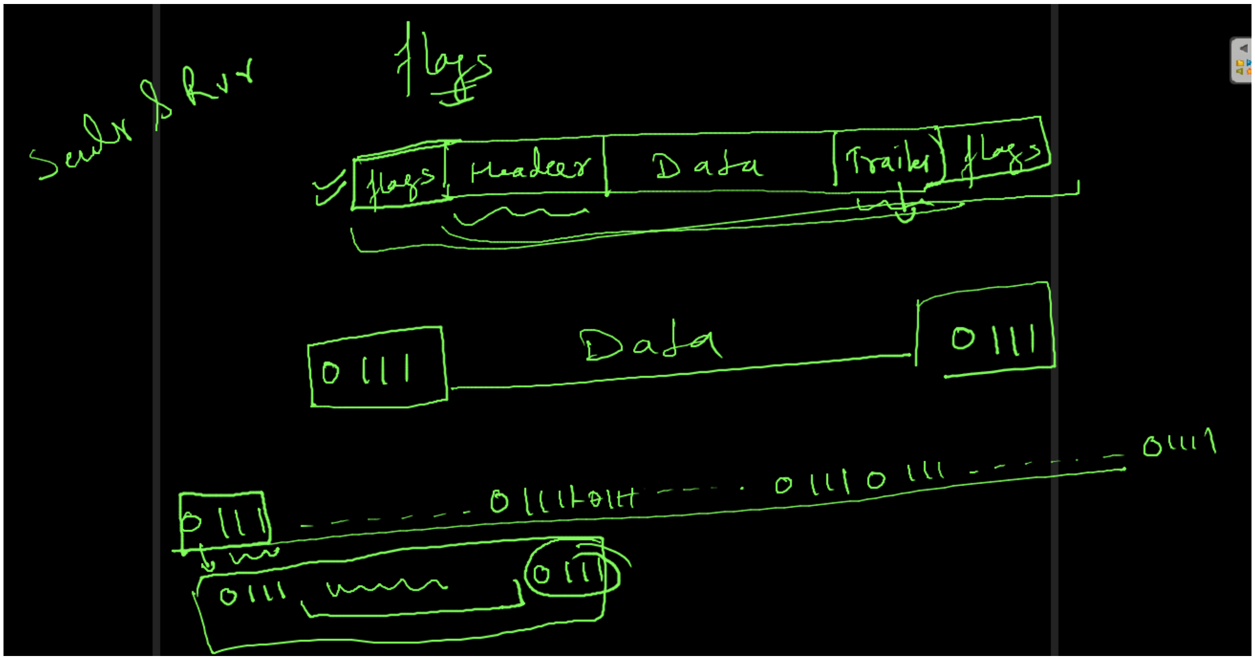
Addressing in DLL
Figure 9.5 IP addresses and link-layer addresses in a small internet
L = MAC , N = IP
To another link
Frame
Data
Alice
R1
Link 1
Legend
N: IP address
L: Link-layer address
Order of addresses
IP addresses: source-destination
Link-layer address: destination-source
MAC
DMAC SMAC
Repeater
Link 3
Bob
R2
Link 2
SIP DIP
IP
L8
To another network

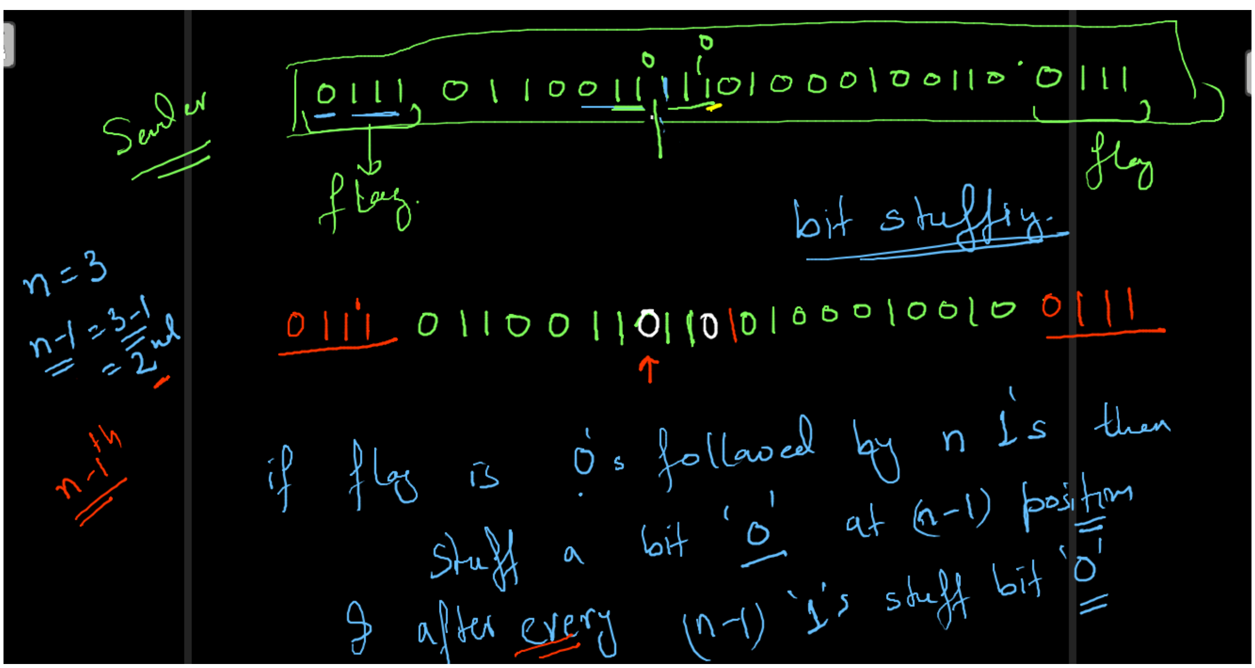


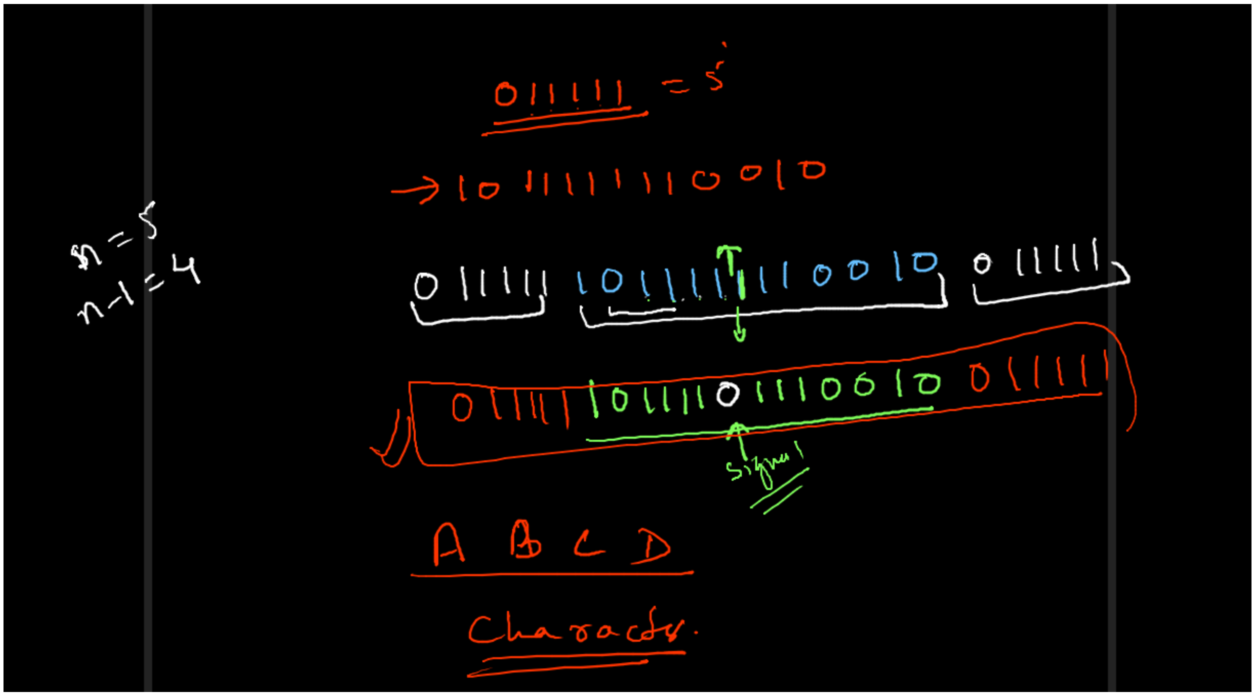
DLL
NL → IP
DNS
DMAC ?
ARP
Address resolution protocol
LAN
System A
System B
Request
Request:
Looking for link-layer address of a node with IP address N2
a. ARP request is broadcast
DIP
Request
? SMAC SIP DIP
frame
DMAC = All F
Reply
Reply:
I am the node and my link-layer address is L2
b. ARP reply is unicast
MAC
DMAC – L
DMAC SMAC SIP DIP
A B B A


MCA - 48 bit.
Broadcast.
MAC.
Hex
A2:34:4E:5D:66:24
MAC
A=10
E=14
F=15
1111 1111 : 1111 1111 :
FF:FF:FF:FF:FF:FF

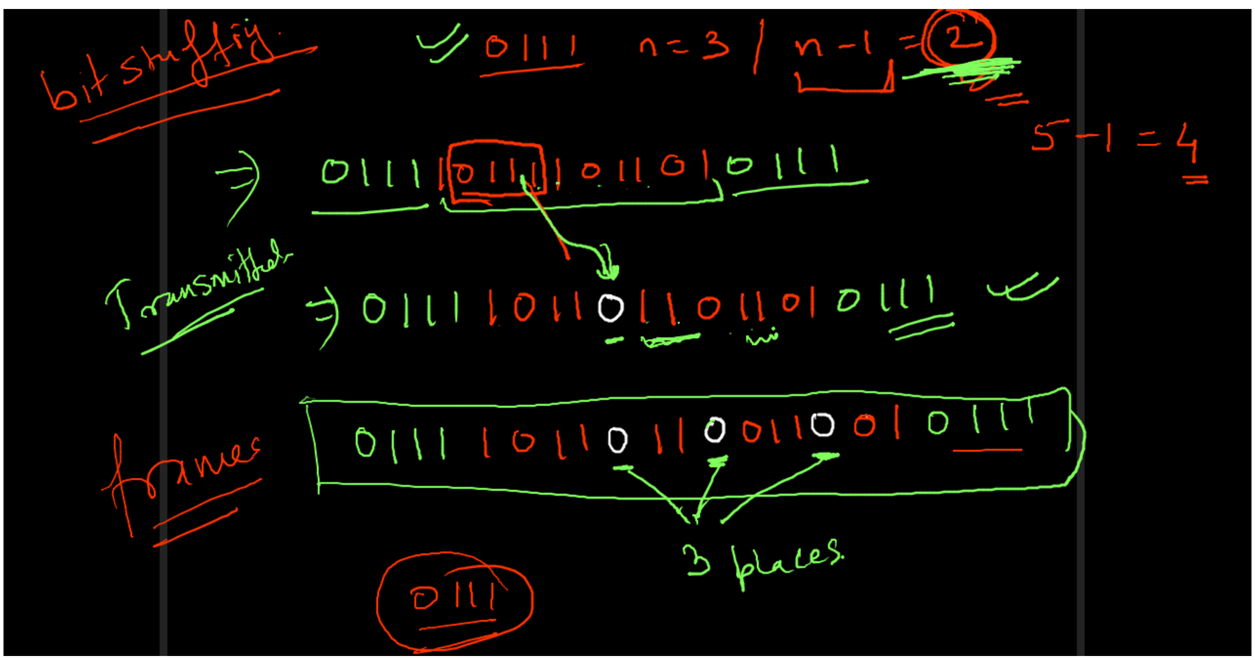

framing: protocol which is applied by the sender to help the receiver to distinguish b/n frames.
'0'
Bit stuff
Byte stuff
Esc
A
R
NL
Data
frames
0110 1111000 0110 ---- 0 0111 1010 ......
1
1
1
R
DLL
frames
10 1111111111


Sender & Rvr
flags
flags
Header
Data
Trailer
flags
0111
Data
0111
0111
0111
0111
0111

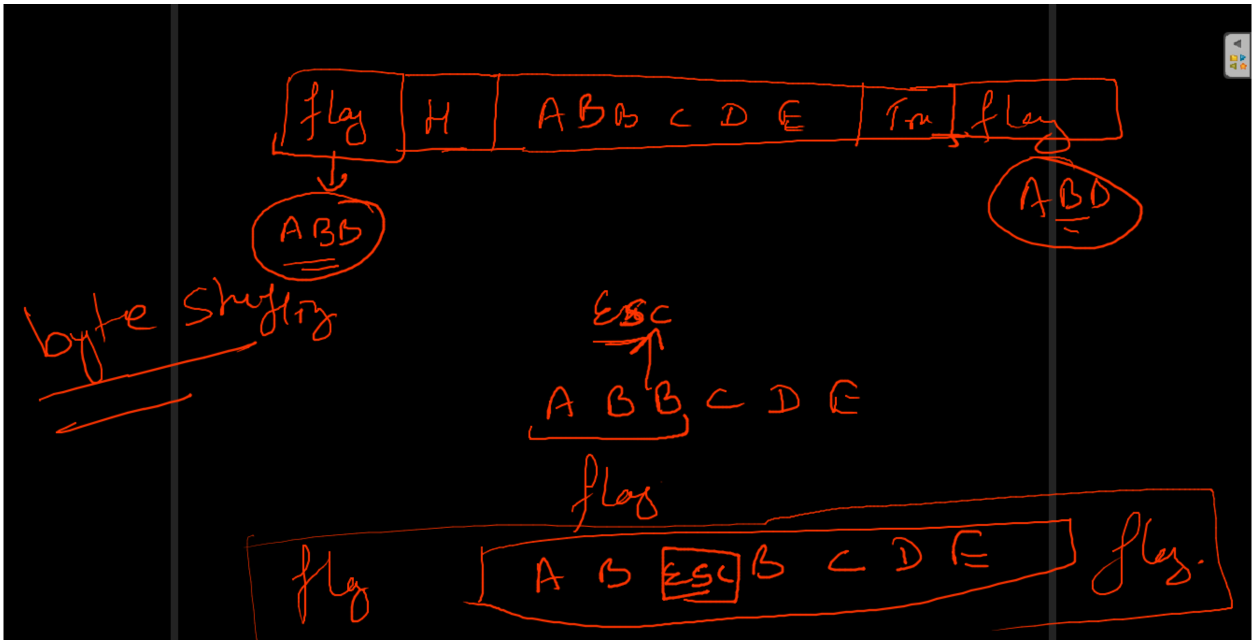

Sender
0111 0110011111010001001100 0111
flag
flag
bit stuffing.
n = 3
n-1 = 3-1 = 2nd
n-1th
0111 01100110110101000100010 0111
if flag is 0's followed by n 1's then
stuff a bit '0' at (n-1) position
& after every (n-1) 1's stuff bit '0'

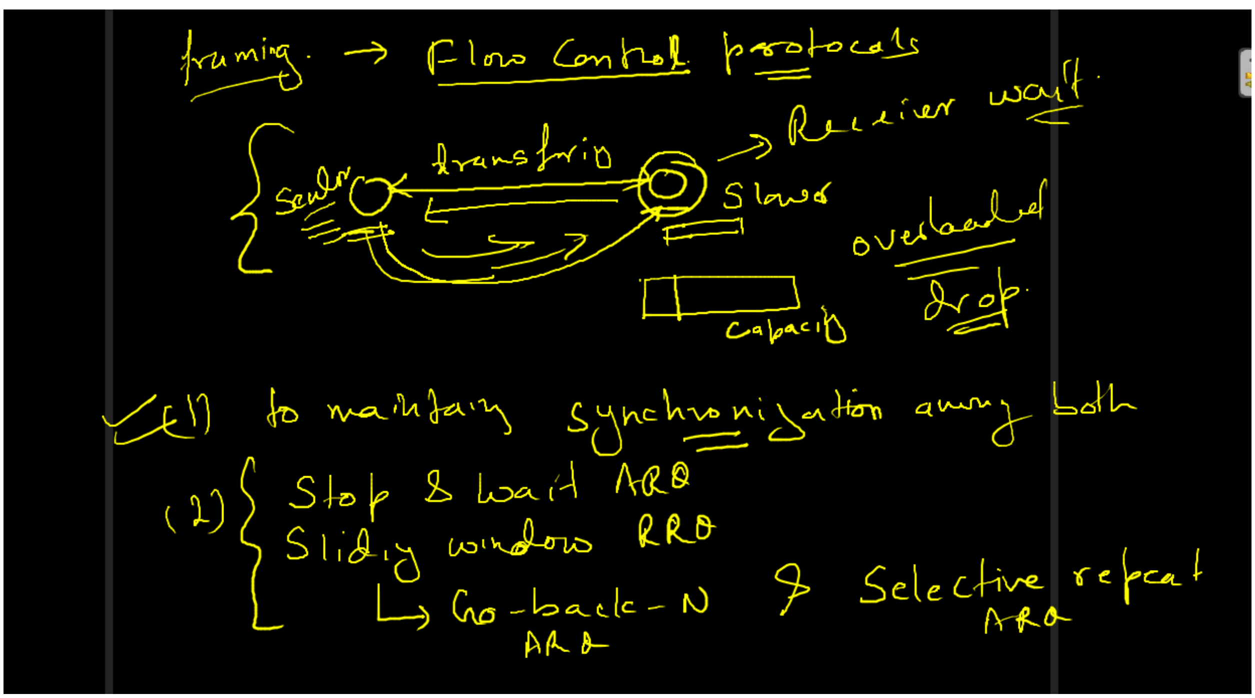


011111 = 5
→ 10111111100010
n = 5
n-1 = 4
011111 1011111 11100010 011111
011111 1011110111100010 011111
signal
A B C D
Character.



bit stuffiy.
0111 n=3 / n-1 = 2
5-1 = 4
0111 0111 0110 0111
Transmitted
0111 1011 0 11 0110 10111
frames
0111 1011 0 11 0 0110 0 10 0111
3 places
0111


flag
H
A B B C D E
Tra
flag
ABB
ABD
byte stuffing
ESC
A B B C D E
flag
flag
A B ESC B C D E
flag.


framing. → Flow Control protocols
→ Receiver wait.
transferring
Sender
Slower
overloaded
drop.
capacity
(1) to maintain synchronization among both
(2) Stop & wait ARQ
Sliding window ARQ
↳ Go-back-N ARQ & Selective repeat ARQ

(1) transfer time — t_f

(2) propogatn time — t_p

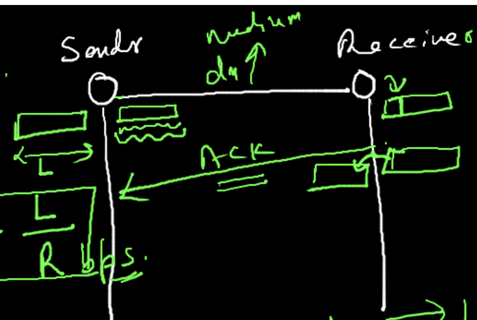
(3) Acknowledgement time

- $t_{f\,ACK}$ —
- → $t_{p\,ACK}$

(4) Channel Utilizatn

(5) Channel throughput

ISP's speed.



distance = d m

Velocity = V

$V(S) = \frac{d}{(t)}$

frequency

$$\boxed{t_f = \frac{L}{R \text{ bps}}}$$

→ length of frame

$t_{f(ACK)} = \frac{L}{R}$ (0)

transfer time $(t_f) = \frac{L}{R}$ → Speed of Sendr (bps)

$t_{p(ACK)} = \frac{d}{V}$

propogatn delay $(t_p) = \frac{d}{V}$

$t_{proc}(ACK) = (0)$

$$\text{Total time} = (t_f + t_p) + [\underbrace{t_{pro}}_{\downarrow 0} + t_{ACK} + \underbrace{t_{p_{ACK}}}_{\downarrow 0}]$$

$$= t_f + t_p + t_p$$

$$\boxed{\text{Total time} = t_f + 2t_p}$$

Channel Utilization

Sender

$$\underline{CU} = \frac{\text{transmission time of single frame}}{\text{total time.}}$$

Efficiency

$$\boxed{\eta = \frac{t_f}{t_f + 2t_p}}$$

assuming $t_{ACK} \rightarrow t_{pro} \rightarrow \underline{0}$

$$\frac{t_f / t_f}{\frac{t_f + 2t_p}{t_f}}$$

$$\frac{1}{1 + 2\frac{t_p}{t_f}} \quad \frac{t_p}{t_f} \rightarrow B$$

$$\boxed{\frac{1}{1 + 2B}}$$

a

k

Channel throughput

$$CT = \frac{\text{No. of bits in a single frame}}{\text{Total time}}$$

$$= \frac{L}{t_f + 2t_p} = \frac{\frac{L}{R} \times R}{t_f + 2t_p} \quad \left(\frac{L}{R} \rightarrow t_f\right)$$

$$= \left(\frac{t_f}{t_f + 2t_p}\right) \times R = \boxed{\eta * R}$$

Q. Suppose a sender is sending a frame of size 1000-bits & the bandwidth is 1 Mbps. If the propagation delay is 10 ms, then what will be the Channel utilization? (if $t_{ACK} \to 0$ & $t_{proc} \to 0$)

Sol. $\frac{t_f}{t_f + 2t_p}$ $\quad L = 1000$ bits / $R = 1$ Mbps (10^6 bps)

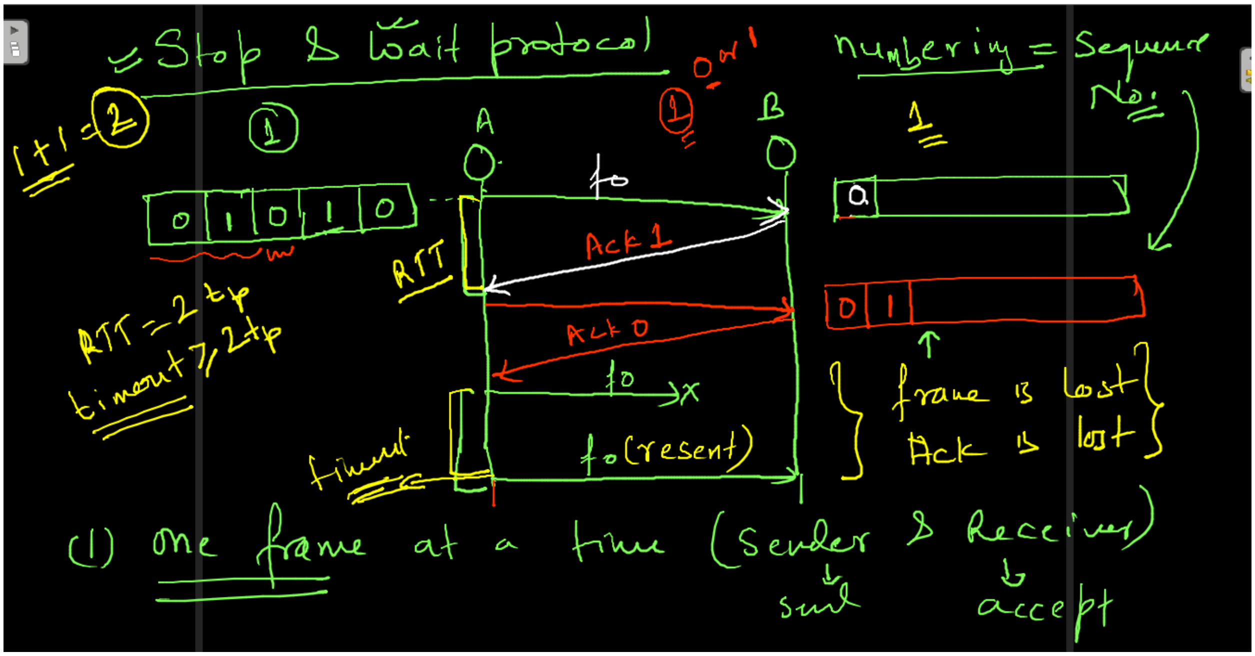
$t_p = 10$ ms $\quad t_f = L/R = \frac{1000}{10^6} = 10^{-3}$ sec $= 1$ ms

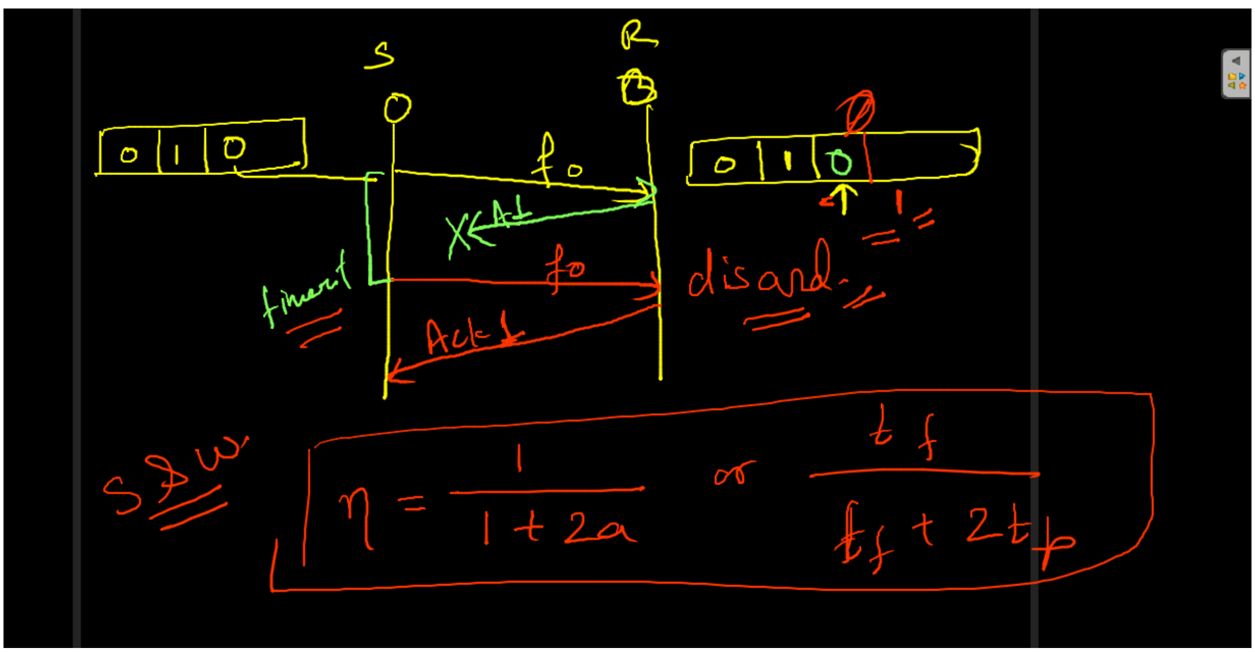
t_f.

1 bps = ?, Mbps, Kbps, Gbps

$$\frac{1}{1 + 2(10)} = \frac{1}{1+20} = \frac{1}{21} \times 100$$

$$\boxed{\eta = 4.9\%}$$


Stop & Wait protocol
numbering = Sequence No.
1+1 = 2
1
A
B
0 1 0 1 0
f0
Ack 1
RTT
RTT = 2tp
timeout ≥ 2tp
Ack 0
f0
timeout
f0 (resent)
0
0 1
frame is lost
Ack is lost
(1) One frame at a time (Sender & Receiver)
send
accept


S
R
0 1 0
f0
Ack 1
timeout
f0
Ack 1
0 1 0
discard
S&W
η = 1 / (1 + 2a) or tf / (tf + 2tp)

SSW ARQ

very slow

(1) S & R both has the capacity of accepting & sending '1' frame at a time

(2) if Any frame or Ack is lost Sender retransmit after timeout occurs

(3) Sequence No = 2 (1+1)

(4) if Receiver receives duplicate frames it simply discards.

(5) Channel effi effeci

Sliding window = window size = buffer size

w.r.t. the no. of frame that can be sent or received at a time

- Go-Back-N → SWS > RWS (1)
- Selective Repeat → SWS == RWS.

$2^3 = 8$

0 1 2 3 4 5 6 7 '2 bits'

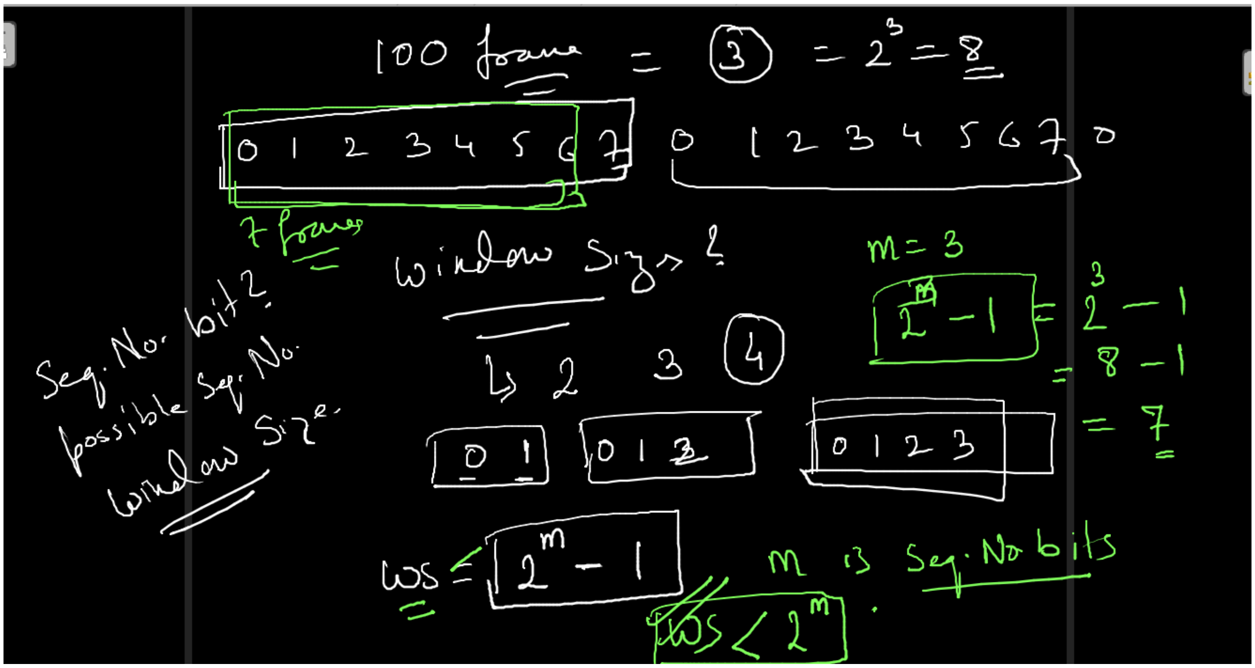
SQ No. bit - '2'

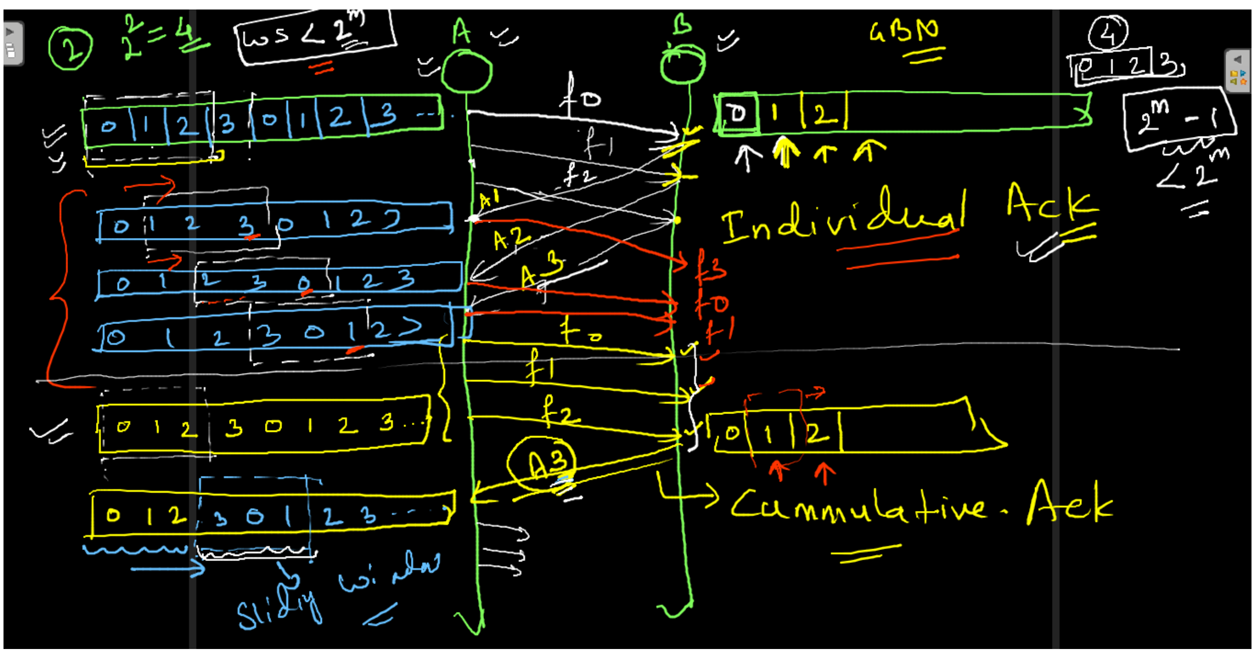
possible seq. No. 8

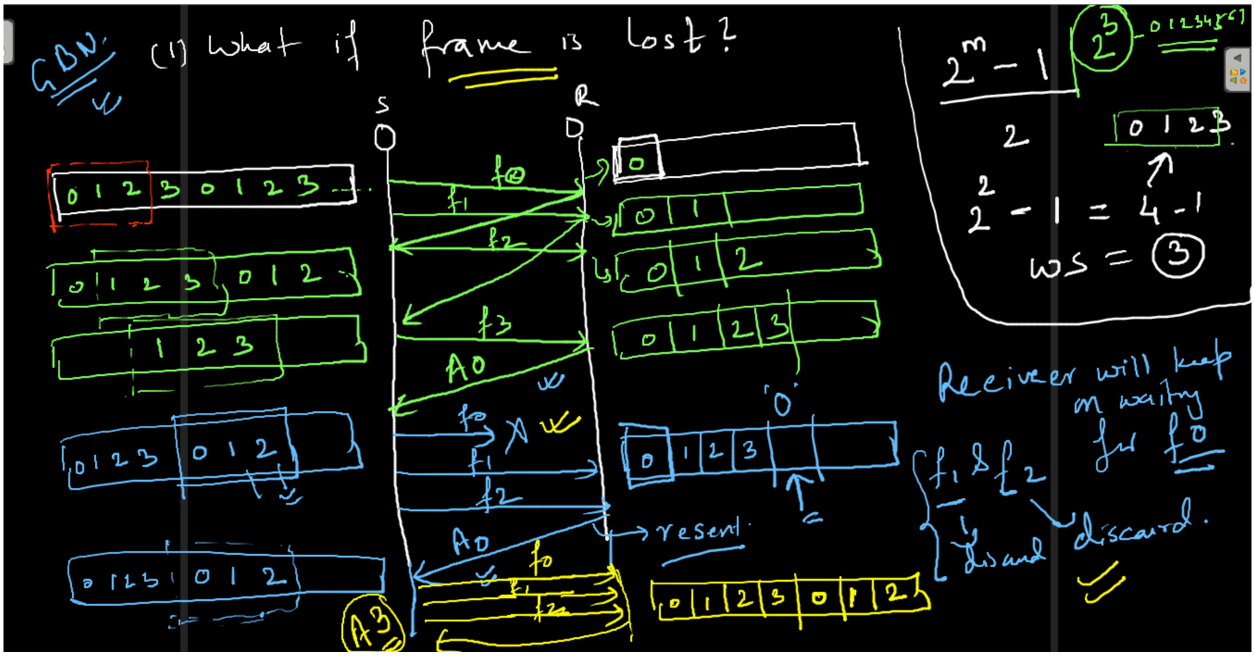
$2^2 = 4$

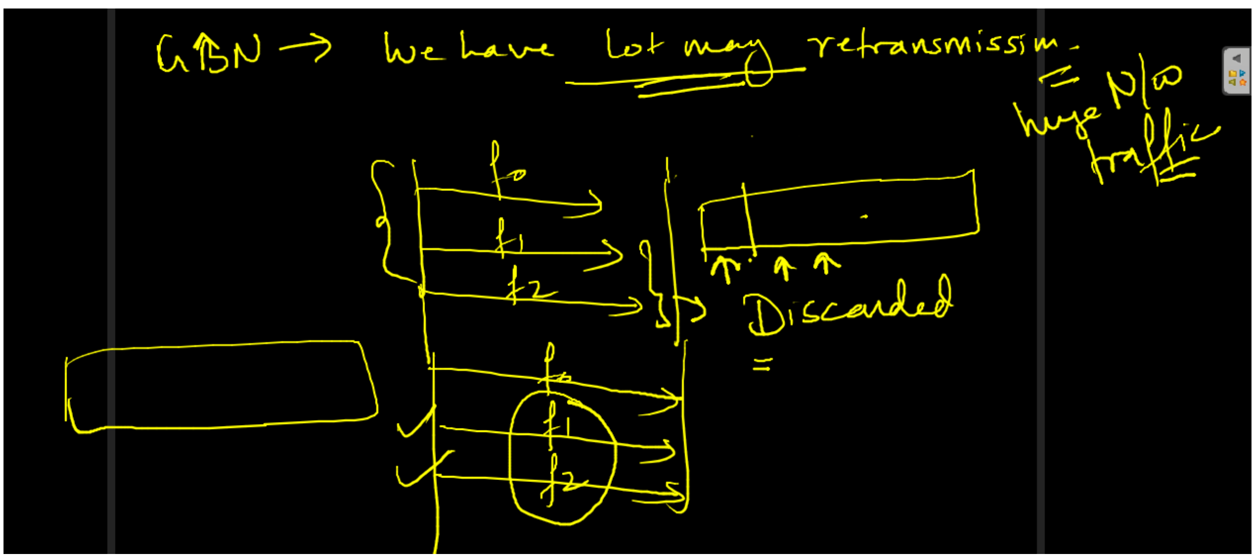
= 0 1 2 3 → seq no.

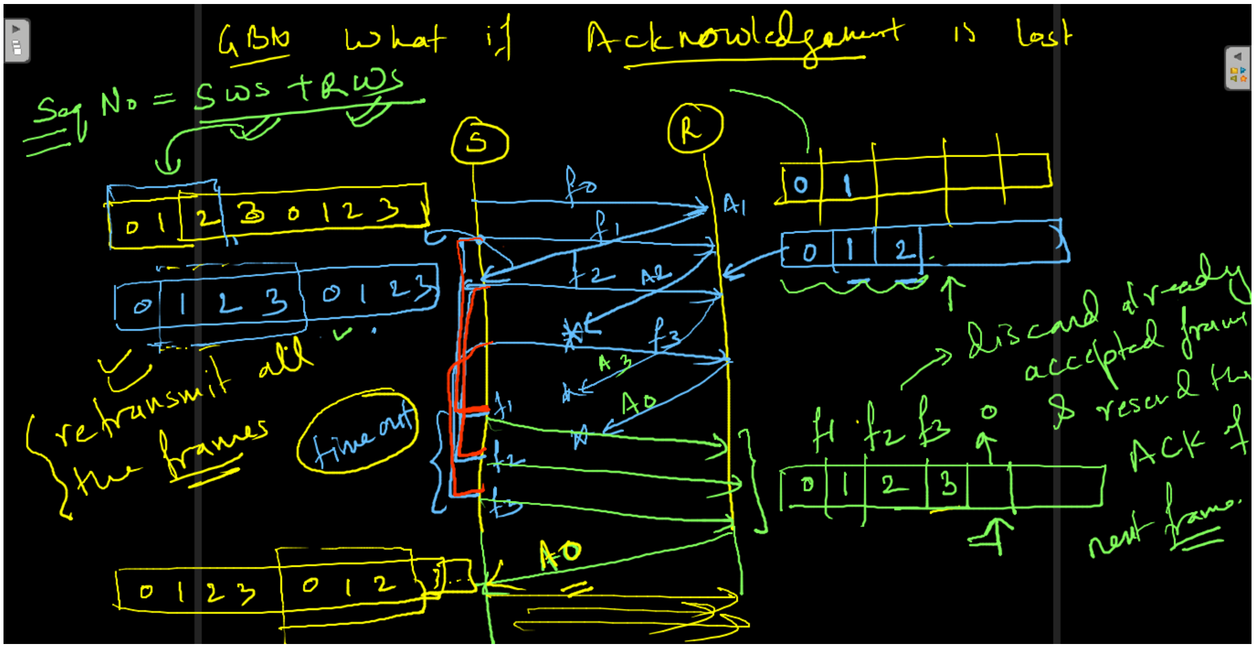
'2 bit'

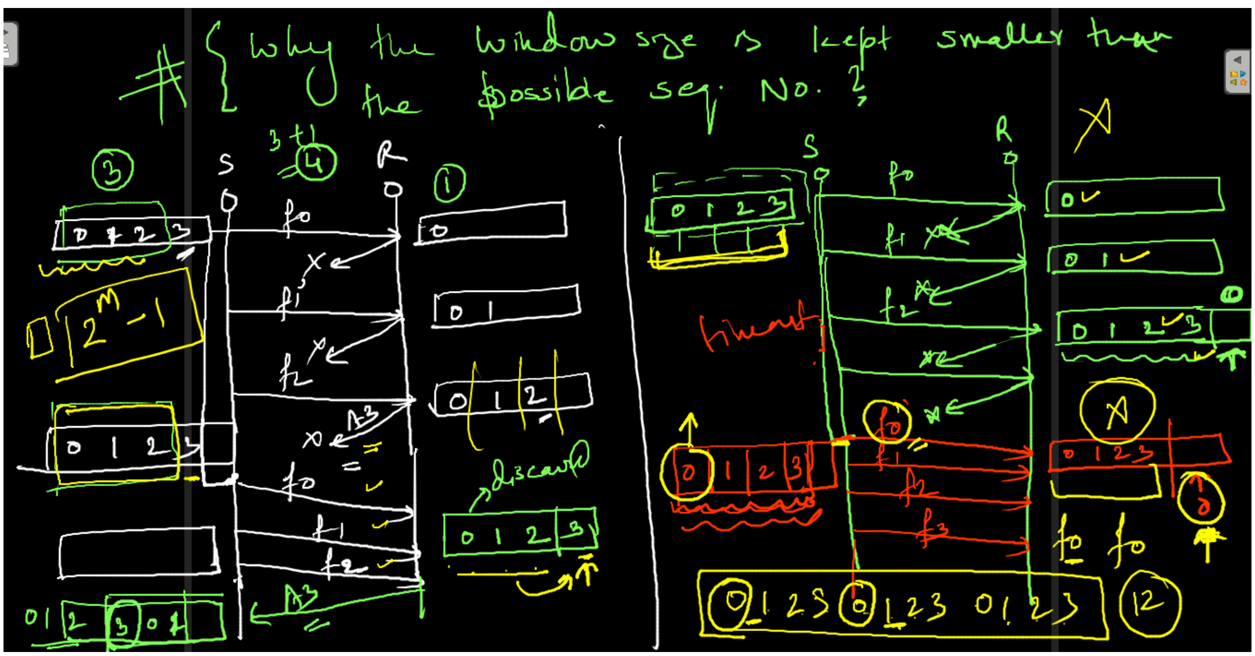

100 frame = 3 = 2^3 = 8
7 frames
window Size?
m = 3
Seq. No. bit?
possible Seq. No.
Window Size.
2 3 4
2^m − 1 = 2^3 − 1
= 8 − 1
= 7
WS = 2^m − 1
m is Seq. No bits
WS < 2^m


2
2^2 = 4
WS < 2^m
A
B
GBN
4
2^m − 1
< 2^m
f0
f1
f2
A1
A2
A3
f3
f0
f1
Individual Ack
Cummulative. Ack
Sliding window


GBN
(1) What if frame is lost?
S
R
0 1 2 3 0 1 2 3
f0
f1
f2
f3
A0
resent
A3
0 1 2 3 0 1 2
Receiver will keep on waiting for f0
f1 & f2
discard
$2^m - 1$
2^3
0 1 2 3
$2^2 - 1 = 4 - 1$
ws = 3


GBN → We have lot many retransmission
huge N/w traffic
f0
f1
f2
Discarded


GBN what if Acknowledgement is lost
Seq No = SWS + RWS
S
R
retransmit all the frames
time out
discard already accepted frames & resend the ACK of next frame.


{ why the window size is kept smaller than the possible seq. No. ?
S
R
2^M - 1
discard
timeout

Selective Repeat:

↳ Go Back N ⇒ lot many retransmissions
leads to
huge n/w traffic

Send
↓
retransmit.
{frame loss
Ack loss}

f0 → ×
← Ack R →
f1
f2 → discard.
f3

---

8 $8/2 = 4$

the WS of Sender & Receiver $2^2 = 4$
Same.

0 1 2 3 | 4 5 6 7 WS RWS

0 1 | 2 3

$\boxed{4 == 4}$ what will be the WS

SR {Sender as well as receiver} 1/2

2^{m-1} ⇒ half of total sequence no.

$\boxed{2^m - 1}$ = WS

0 1 2 3 4 5 6 | 7

① In SR ⇒ Same SWS & RWS

In GBN ⇒ SWS greater than RWS
↓
'1' only.

② window size is taken half of the total SQ No. in SR $\boxed{2^{n-1}}$

In GBN WS is taken one less than the total sequence No. = $\boxed{2^n - 1}$

$$\eta = \boxed{2^{n-1} * \frac{1}{1+2a}}$$ SR

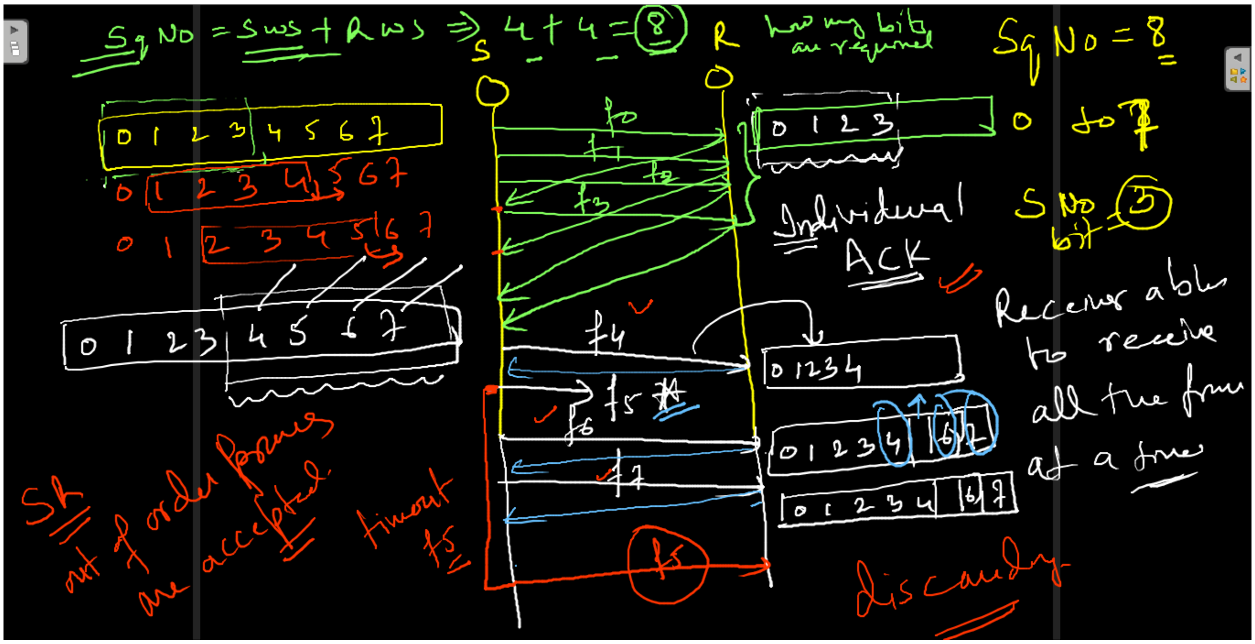
WS

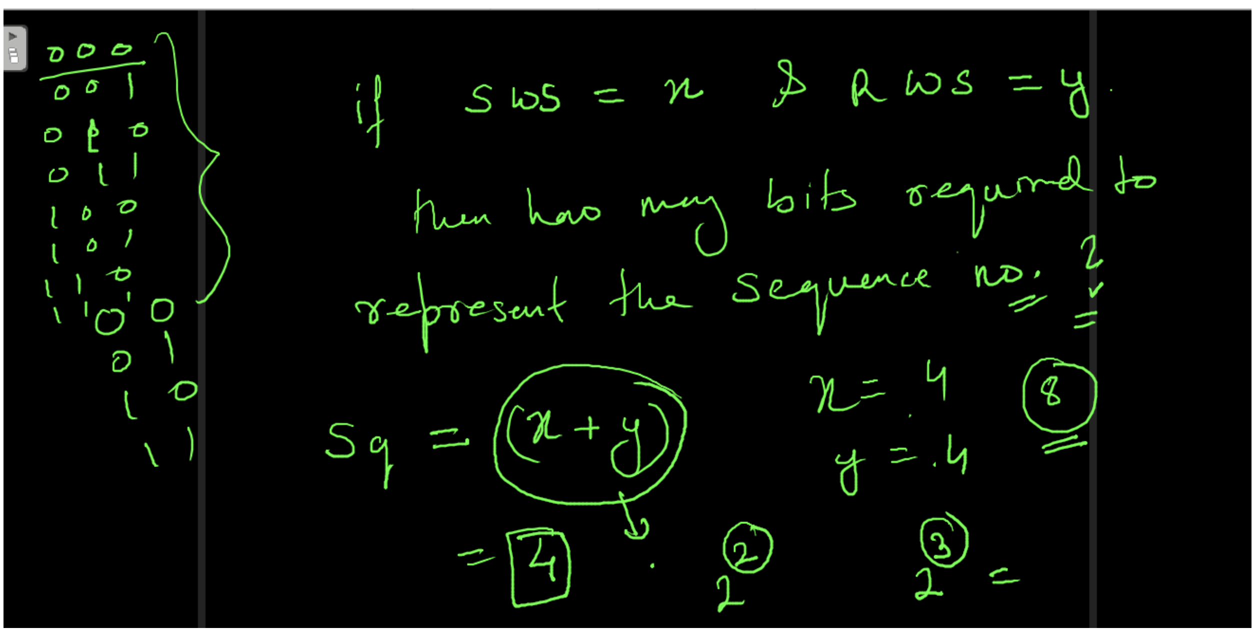
$$\eta = \boxed{(2^n - 1) * \frac{1}{1+2a}}$$ GBN

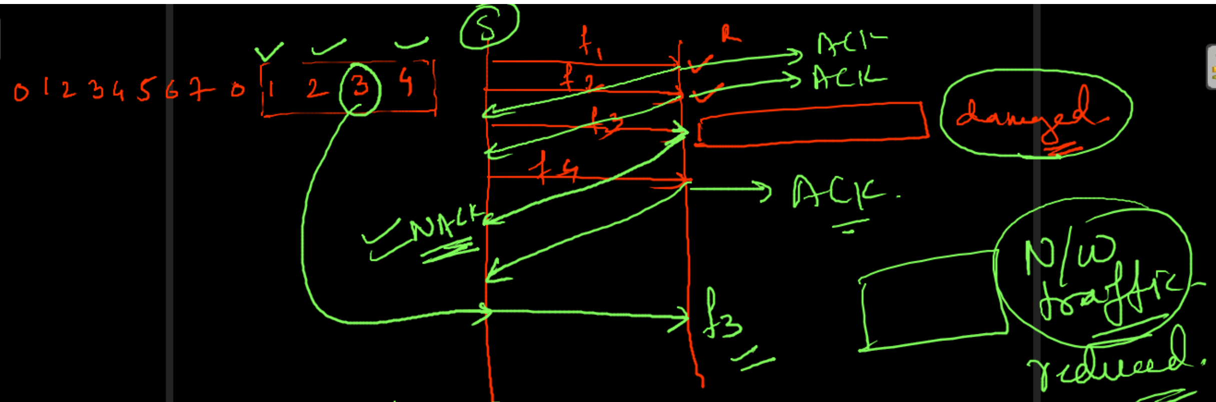
Single frame

WS

$$\boxed{\eta = 1 * \frac{1}{1+2a}}$$ S Wait


Sq No = SWS + RWS ⇒ 4 + 4 = 8
S
R
how mny bits are required
Sq No = 8
0 to 7
S No bit 3
0 1 2 3 4 5 6 7
f0
f1
f2
f3
f4
f5
f6
f7
Individual ACK
Receiver able to receive all the frame at a time
0 1 2 3 4
SR
out of order frames are accepted.
timeout f5
discarding


000
001
010
011
100
101
110
111
if SWS = x & RWS = y.
then how mny bits required to represent the sequence no. ?
Sq = (x + y)
= 4
x = 4
y = 4
8
2^2
2^3 =



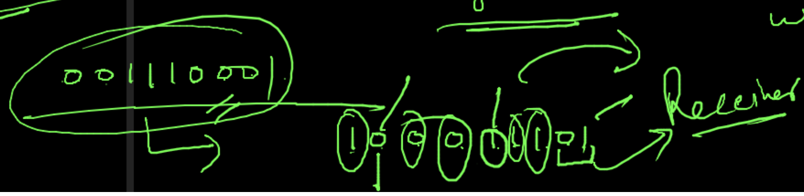
{ frame damaged / lost, Ack lost } → Sender is only retransmitting the needed frame

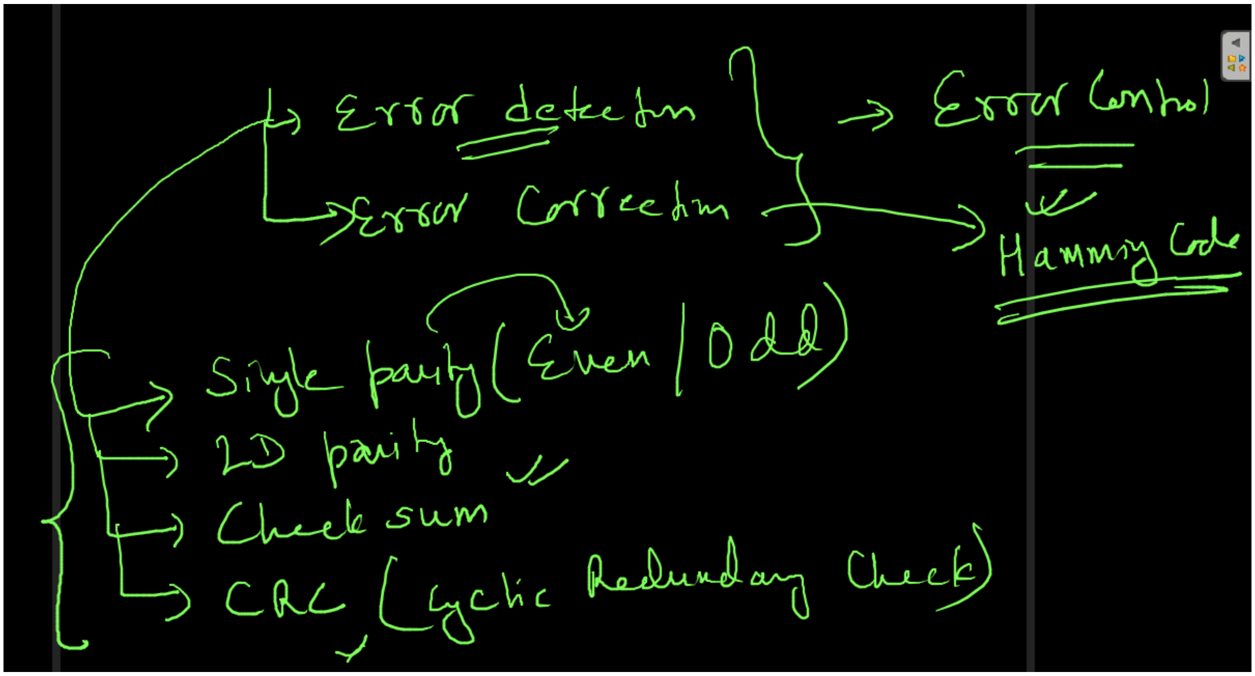
Error Control : DLL

→ { why? sustain the original data sent by the sender.

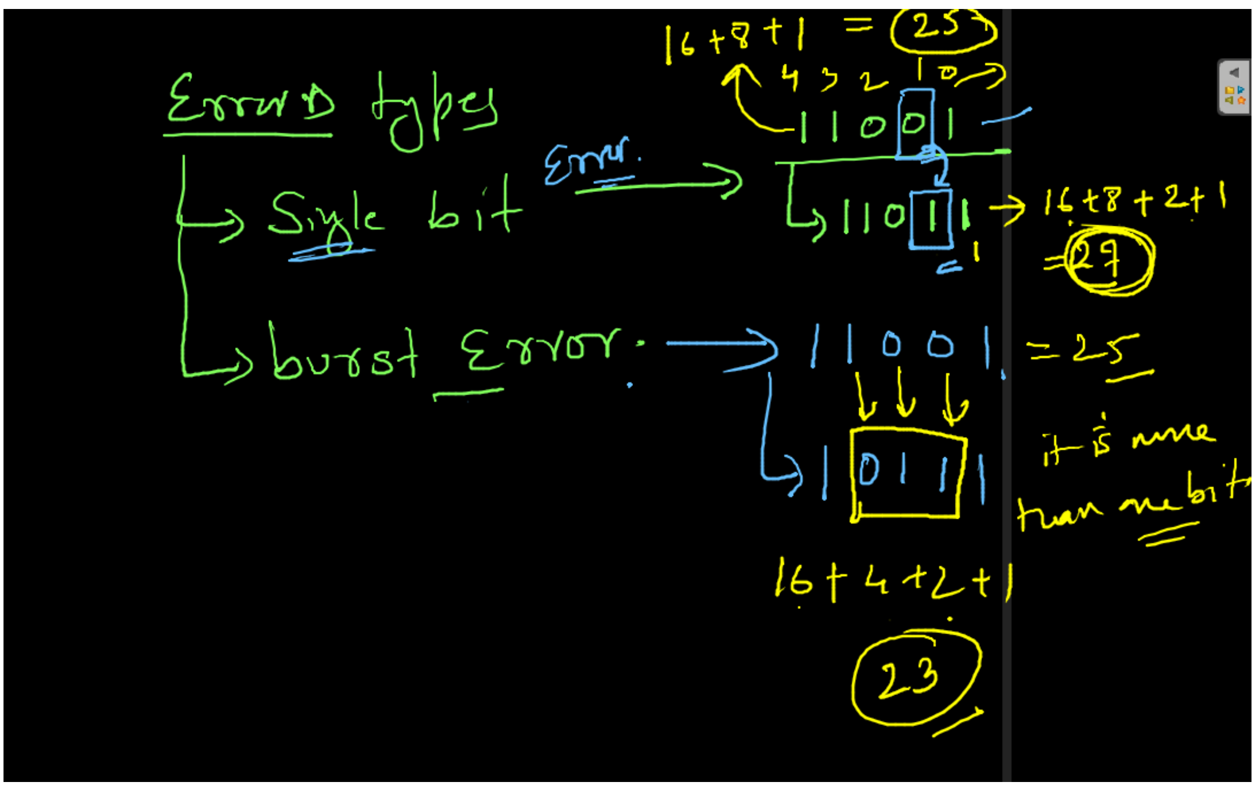
R O ⟷ O S

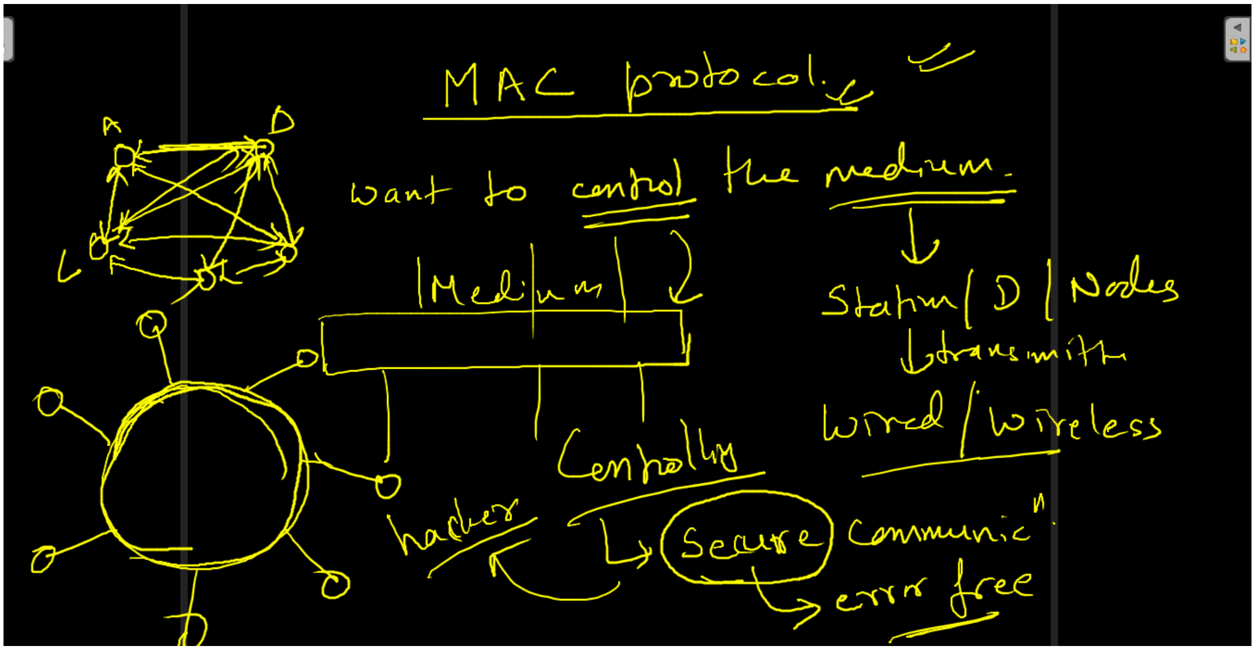
→ long medium. wireless / wired } noise motor → chances of change in data

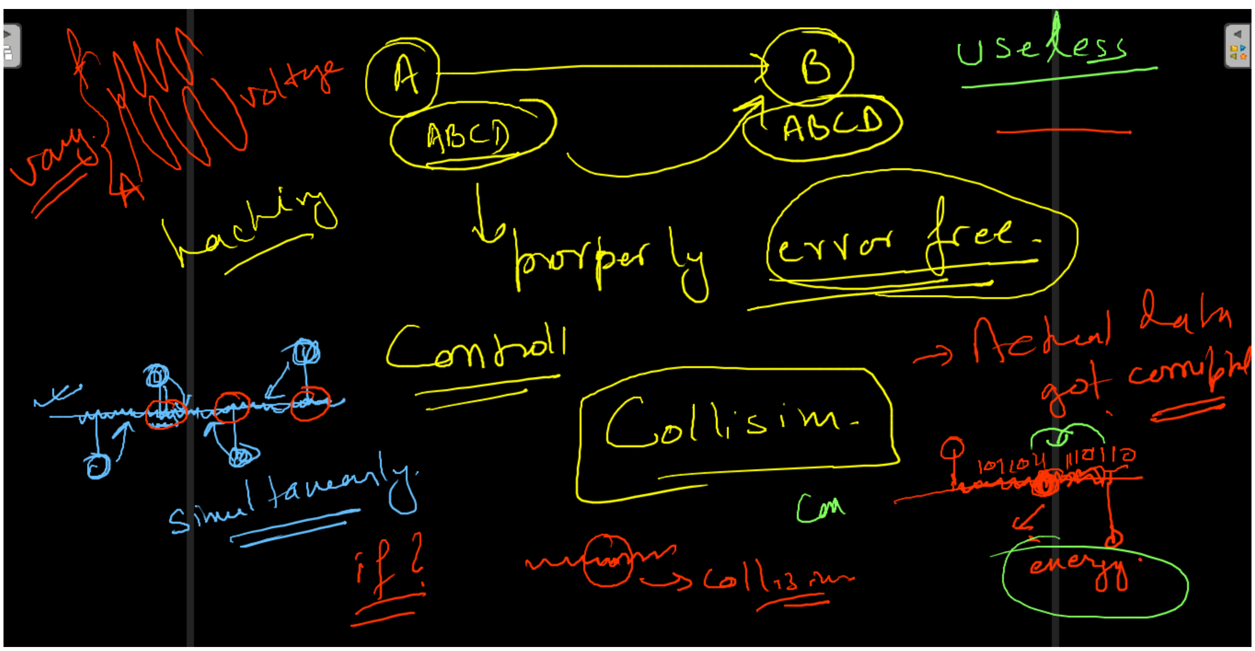


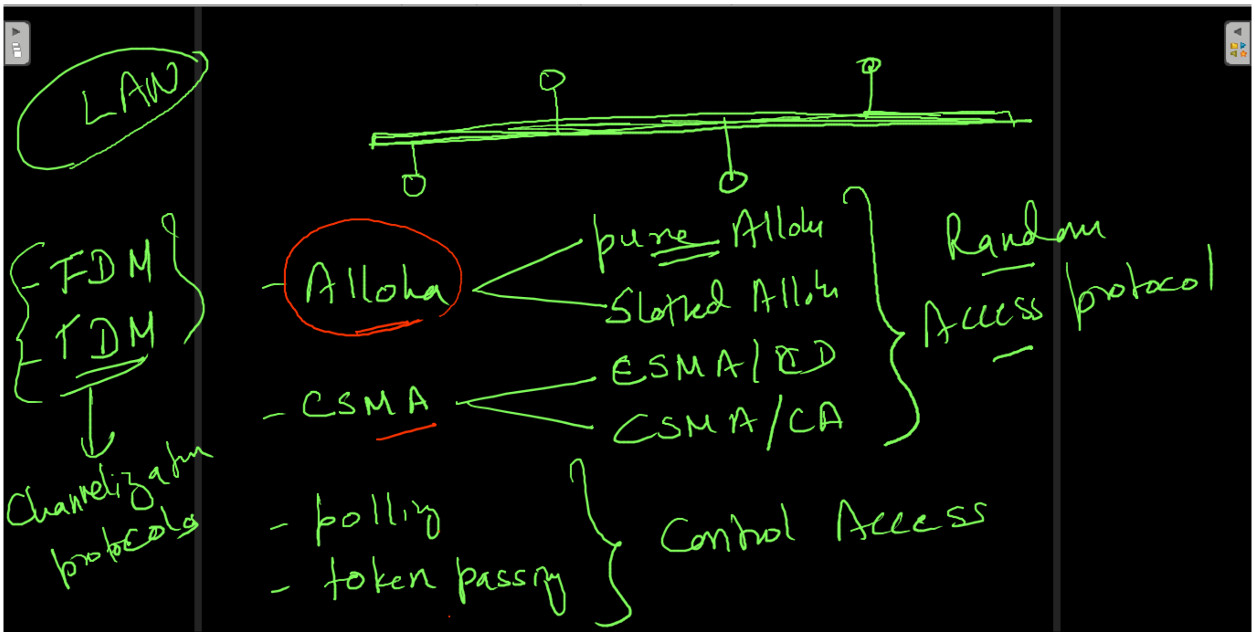


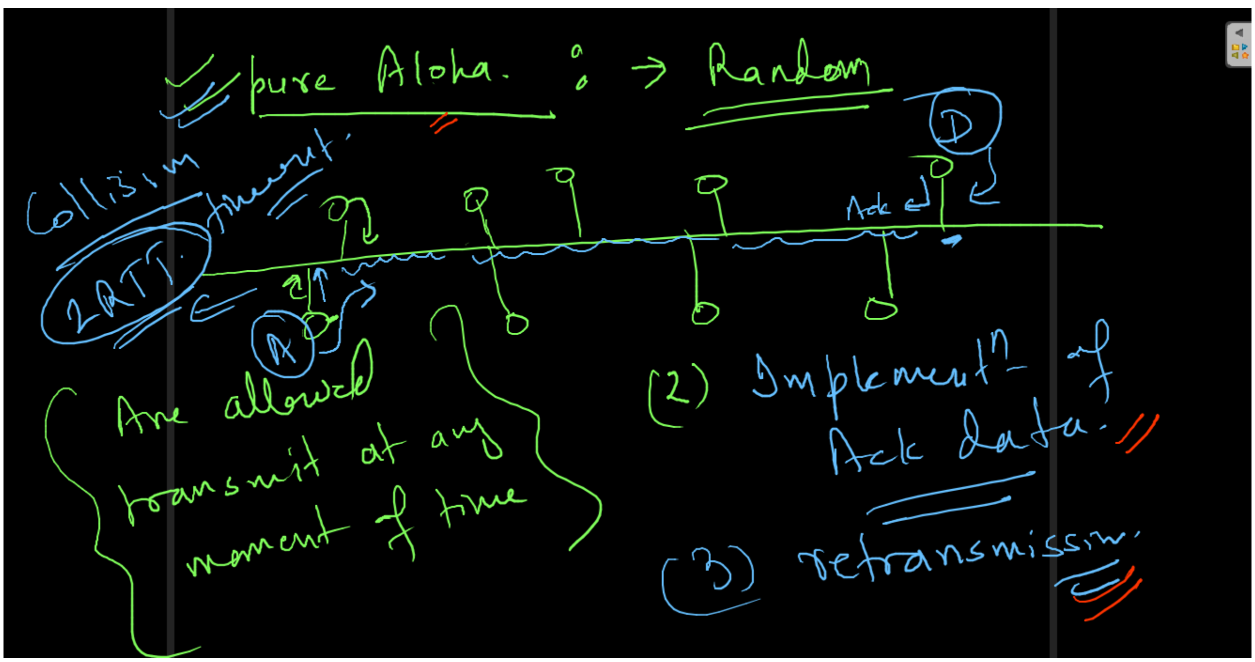
Do study the tutorial topics assigned

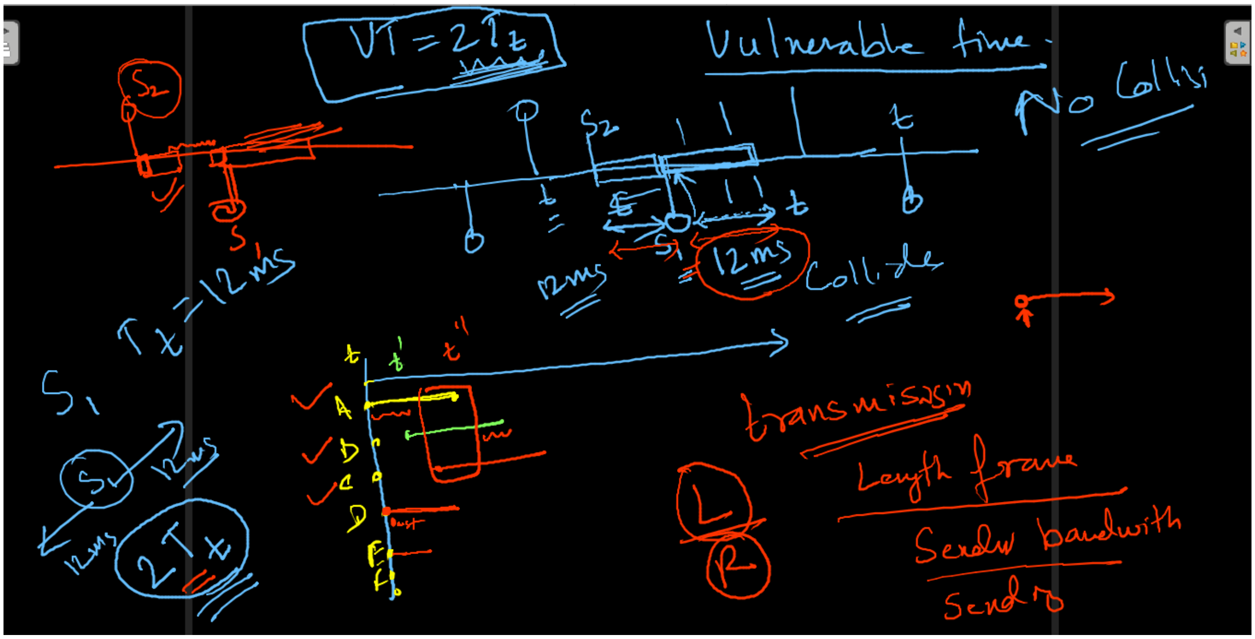


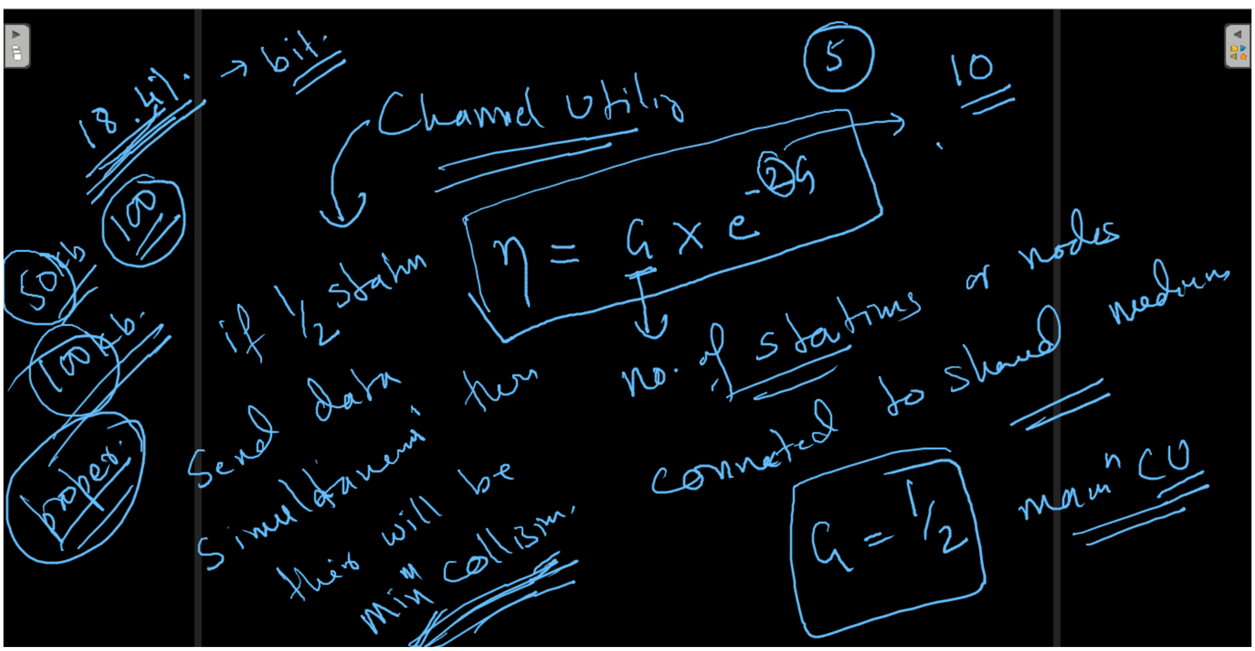

MAC protocol.
want to control the medium.
Medium
Station / D / Nodes
transmitted
wired / wireless
Controlling
hacker
Secure
communic^n
error free

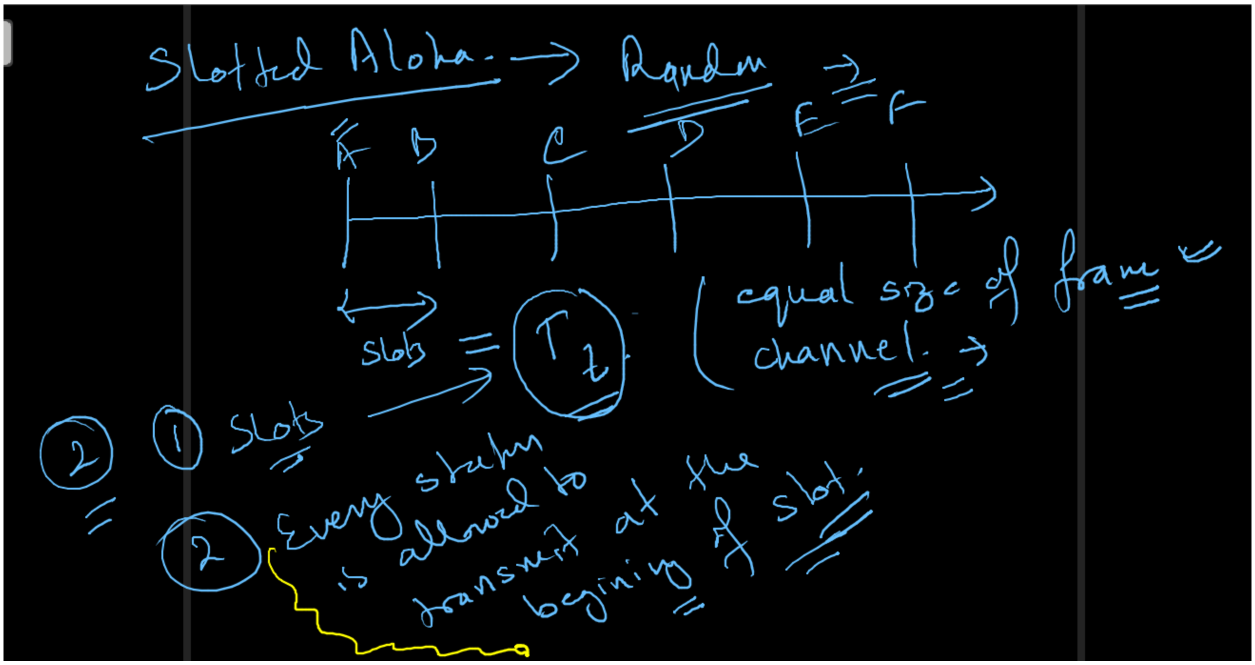

A
B
ABCD
ABCD
useless
vary
voltage
hacking
properly
error free.
Controll
Actual data got corrupted
Collision.
Simultaneously.
if?
collision
Con
energy.

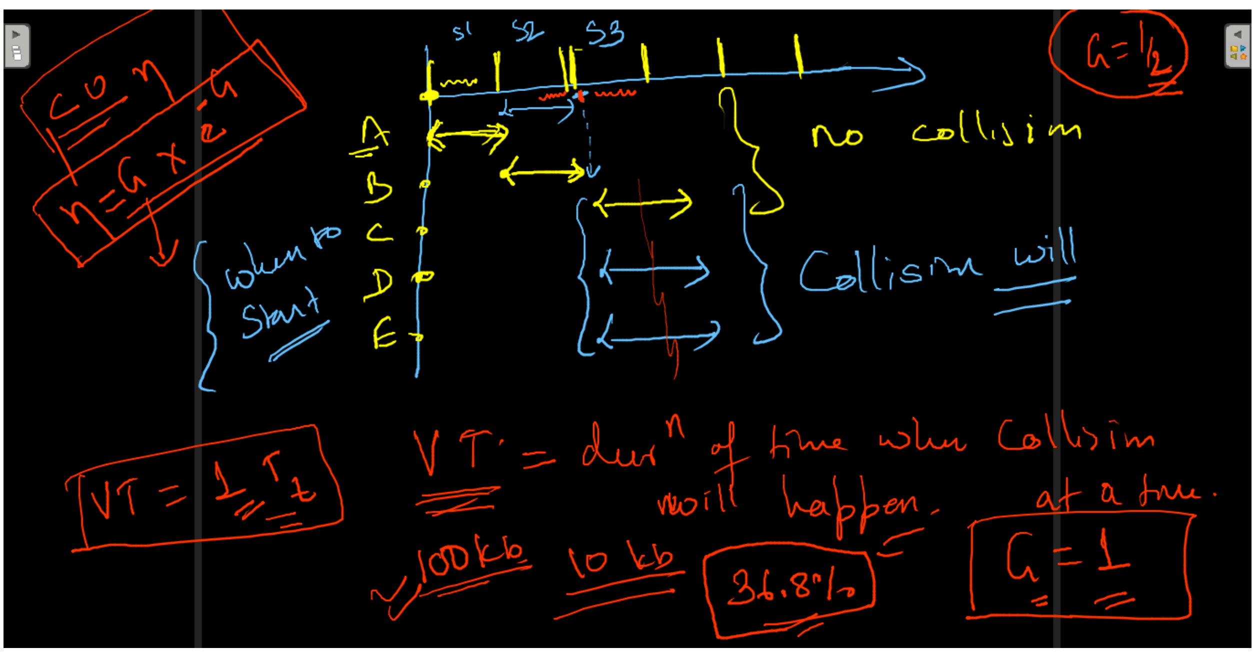

LAN
FDM
TDM
Channelization protocols
Alloha
pure Alloha
Slotted Alloha
CSMA
CSMA/CD
CSMA/CA
Random Access protocol
polling
token passing
Control Access

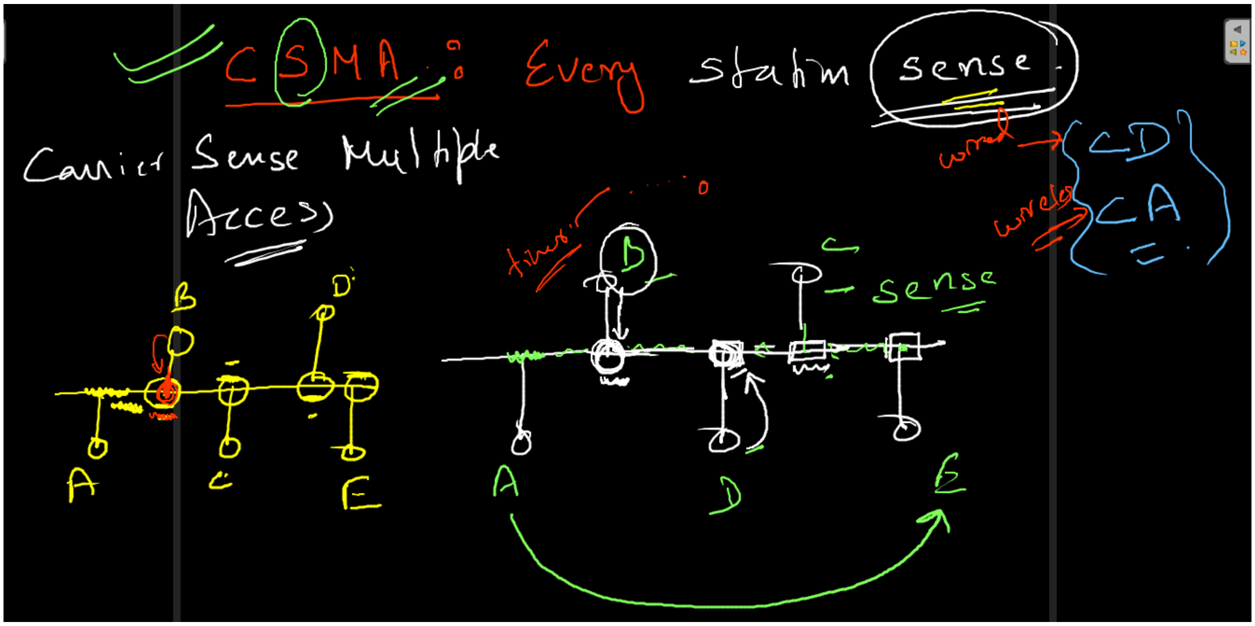

pure Aloha. : → Random
Collision
timeout.
2RTT.
D
Ack
A
Are allowed transmit at any moment of time
(2) Implementn of Ack data.
(3) retransmission.

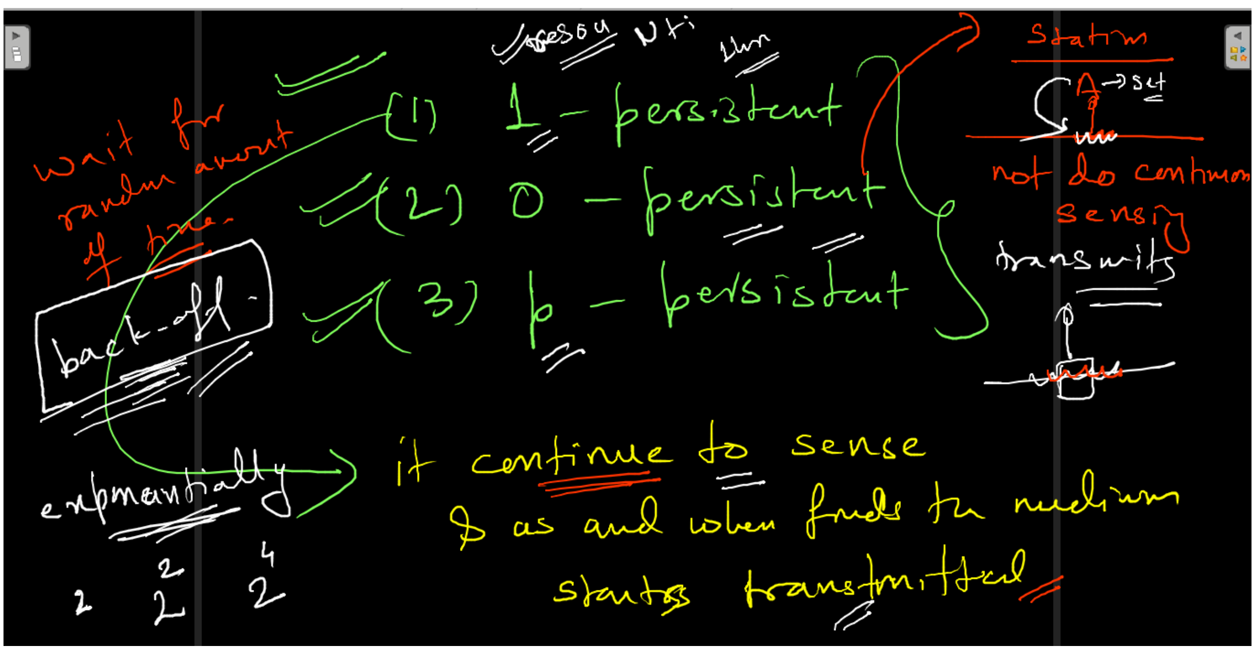

VT = 2Tt
Vulnerable time
No Collisi
S2
S1
Tt = 12ms
12ms
12ms
Collide
t t' t''
A
D
C
D
E
F
2Tt
transmission
Length frame
Sender bandwith
Sending
L
R

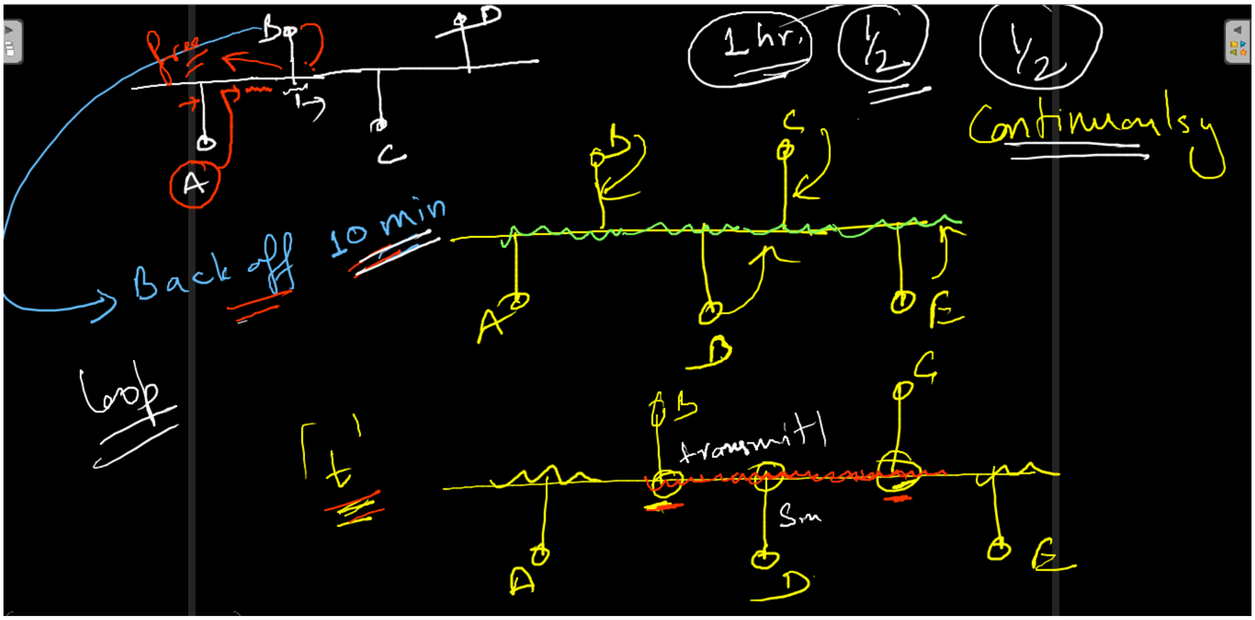

18.4% → bit
Channel Utiliz
5
10
η = G x e^-2G
50kb
100
100kb.
proper.
if 1/2 station
Send data
Simultaneous then
this will be
min collision.
no. of stations or nodes
connected to shared medium
G = 1/2
max^n CU

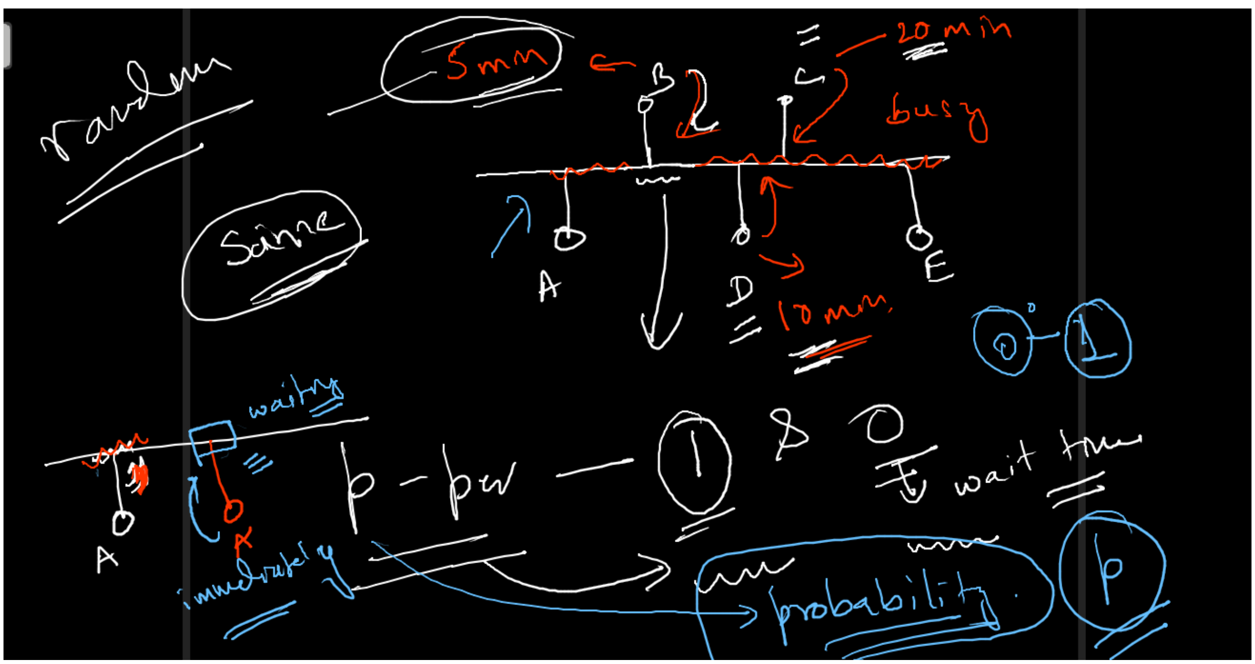

Slotted Aloha. → Random
A B C D E F
slots = T_t
(equal size of frame
channel.
2
1 Slots
2 Every station is allowed to transmit at the begining of slot.

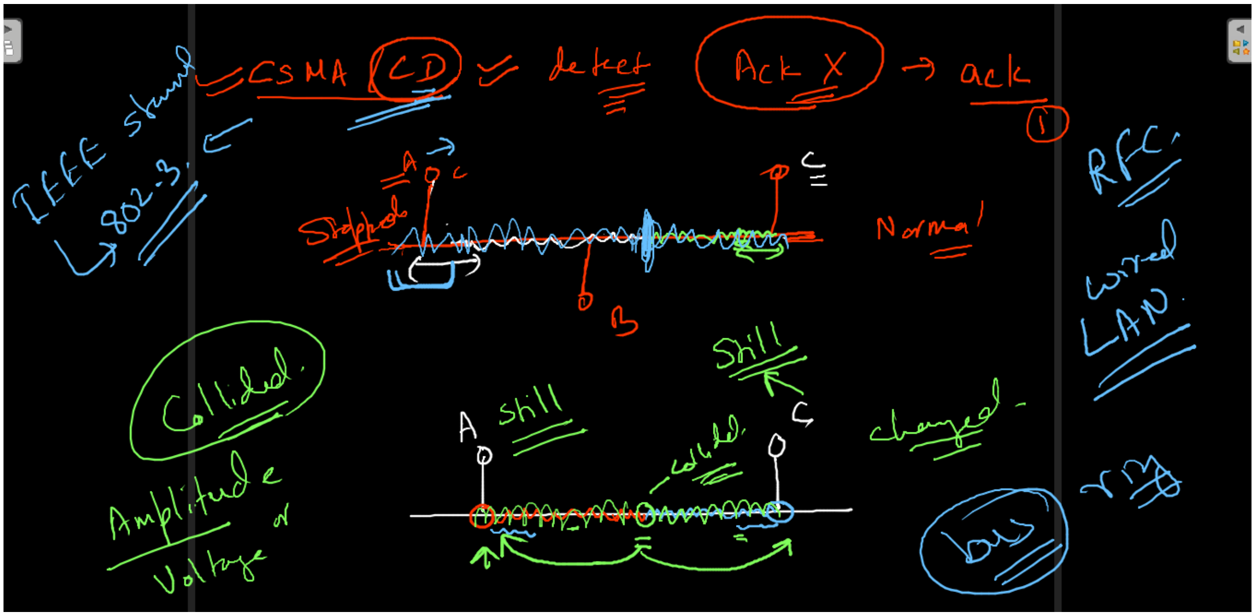

S1 S2 S3
G = 1/2
C.O n
n = G x e^-G
A
B
C
D
E
no collision
Collision will
when to start
VT = 1 T_t
VT = dur^n of time when collision will happen at a time.
100 kb
10 kb
36.8%
G = 1

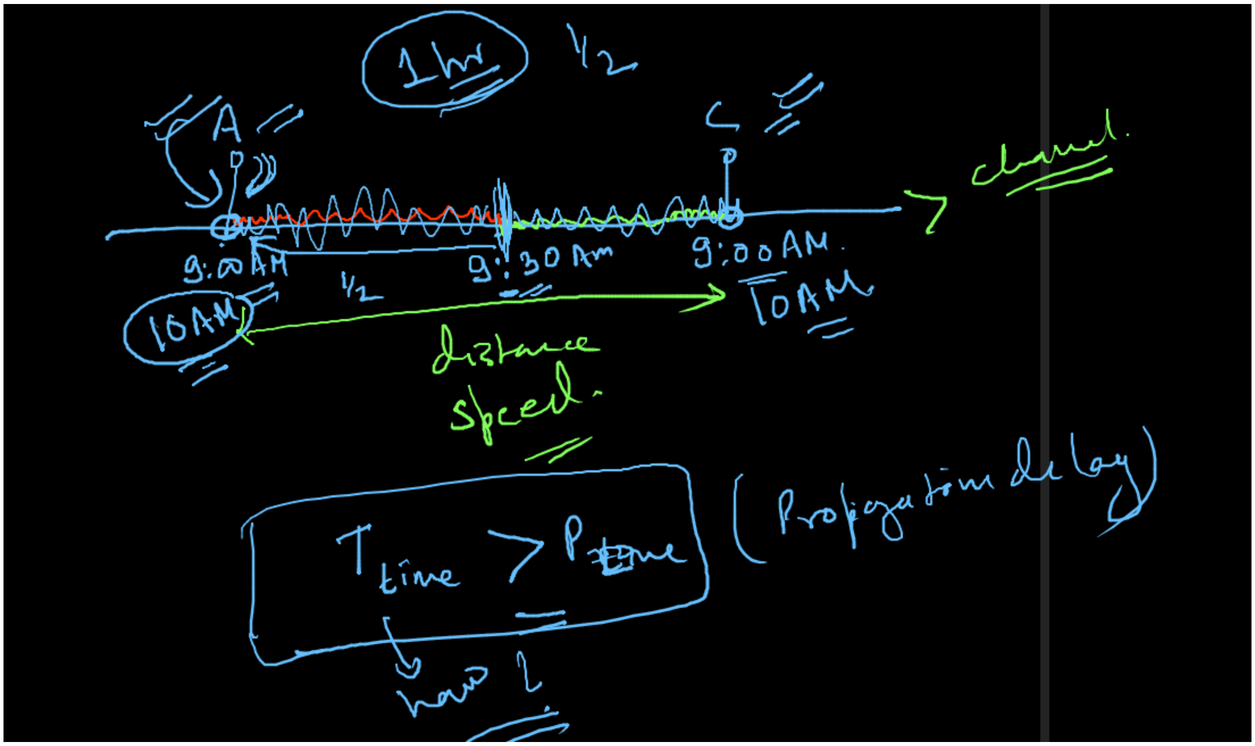

CSMA : Every station sense
Carrier Sense Multiple Access
wired → CD
CA
sense
A
B
C
D
E

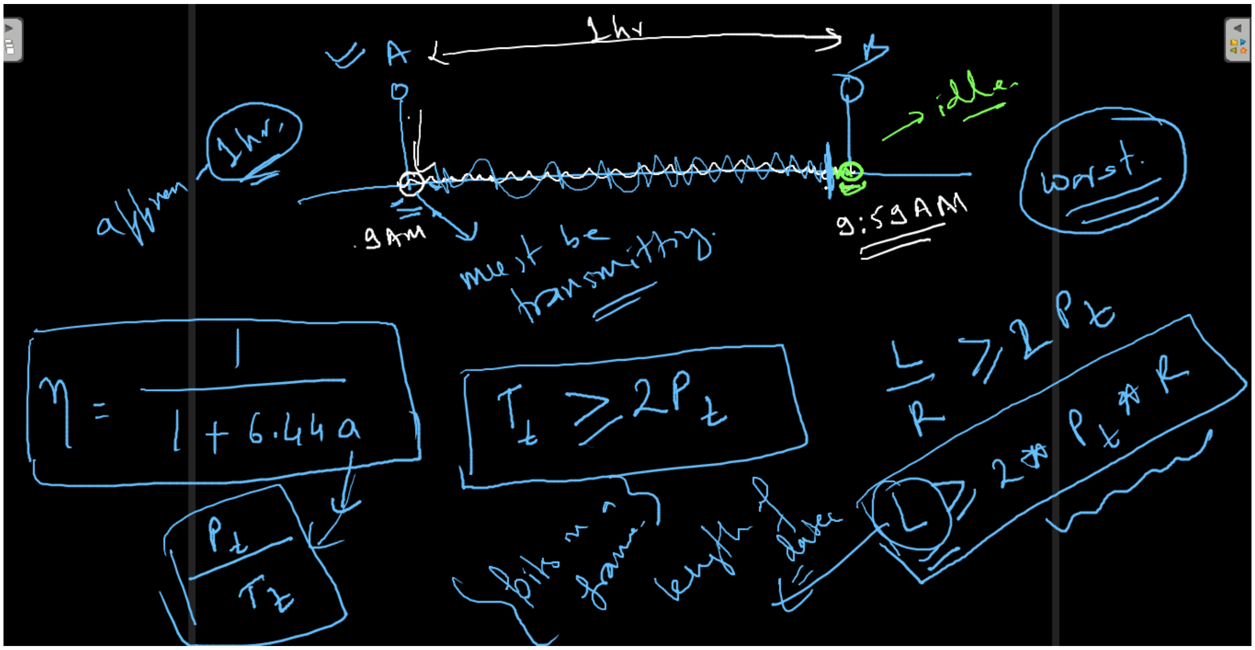

(1) 1 - persistent
(2) 0 - persistent
(3) p - persistent
wait for random amount of time
back-off
exponentially
it continue to sense
& as and when finds the medium
starts transmitted
Station
not do continuous sensing
transmits

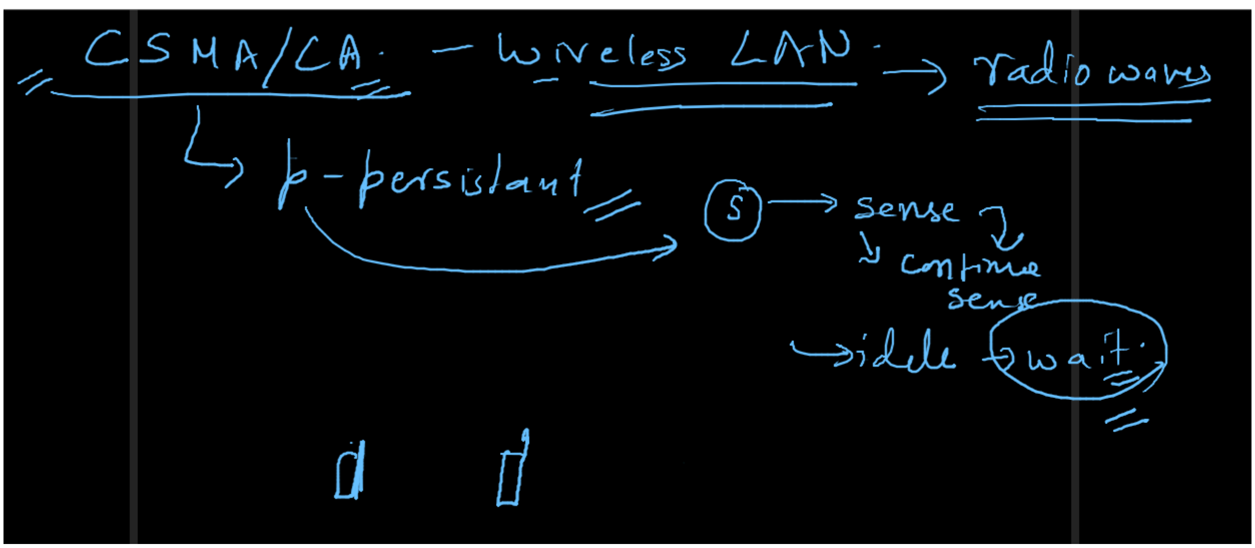

free
B
D
A
C
1 hr
1/2
1/2
Continuously
Back off
10 min
loop
t
transmit
5m
E

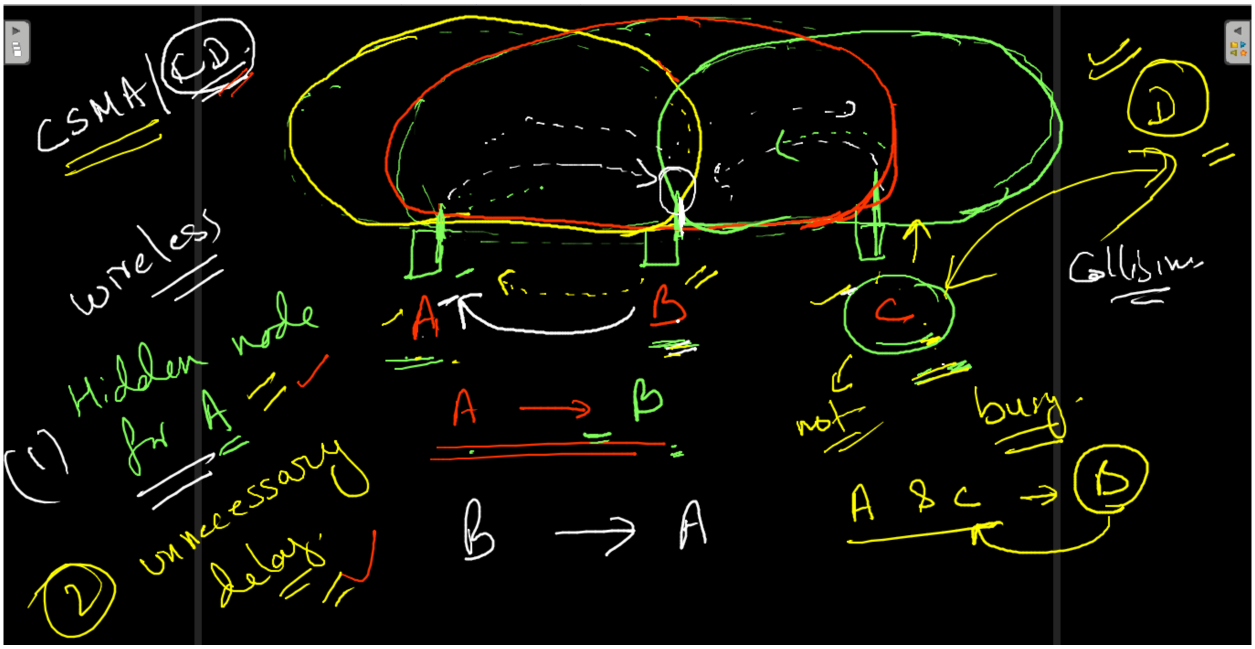

random
5min
20 min
busy
Same
A
B
C
D
E
10 min
0
1
waiting
p - per
1
&
0
wait time
immediately
probability
p

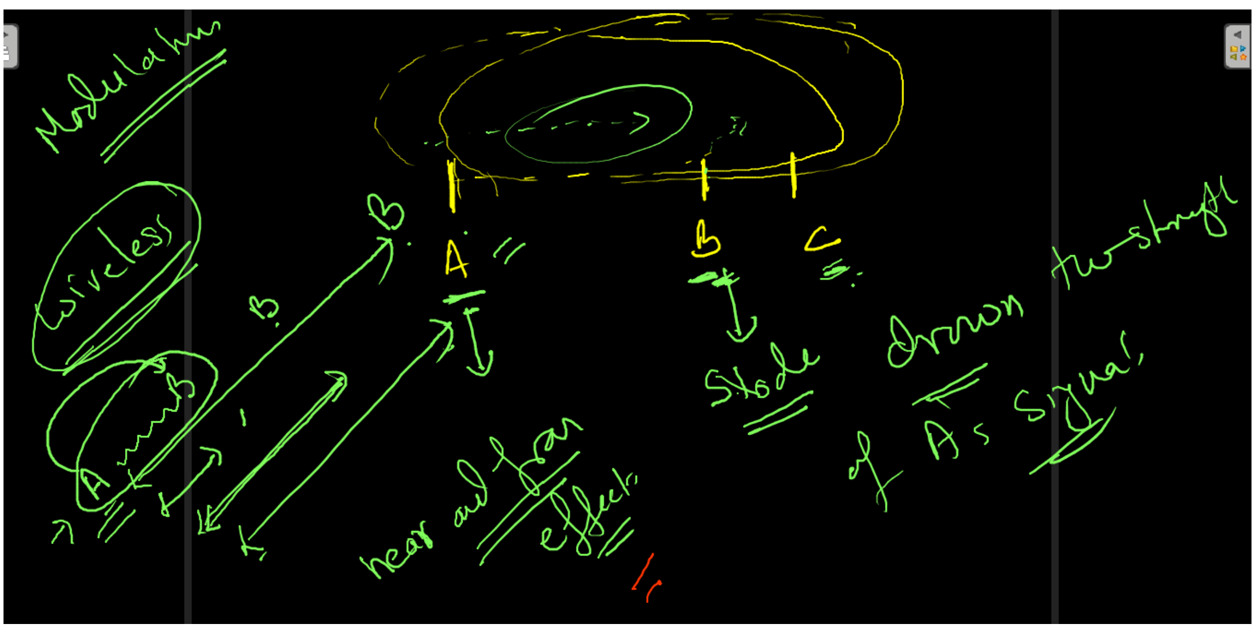

CSMA CD
detect
Ack X
ack
IEEE standard
802.3
RFC
wired LAN
Stopped
Normal
Collided
Amplitude or Voltage
still
changed
loss


1 hr
1/2
A
C
channel
9:00 AM
9:30 AM
9:00 AM
10 AM
10 AM
distance
speed
T time > P time
(Propagation delay)
how ?


A
B
1hr
idle
approx 1hr
worst
9AM
9:59AM
must be transmitting
$\eta = \frac{1}{1+6.44a}$
$\frac{P_t}{T_t}$
$T_t \geq 2P_t$
$\frac{L}{R} \geq 2P_t$
$L \geq 2 * P_t * R$
bits in a frame
length of data


CSMA/CA — wireless LAN → radio waves
p-persistant
S → sense
continue sense
idle → wait


CSMA/CD
wireless
(1) Hidden node for A
(2) unnecessary delay
A
B
C
D
A → B
B → A
not busy
A & C → D
Collision


Modulations
wireless
A
B
C
near and far effect
B node drown the strength of A's signal

CSMA/CA → Avoiding. wireless LAN

(1) Node sense

(2) idle, → DIFS. (DCF - IFS)

{Distributed Coordinated function inter frame size.}

(3) send → RTS signal. (actual data frame)

control signal ↳ ready to send.

CTS

SIFS.

---

(4) CTS → Clear to send the

timer

waits SIFS

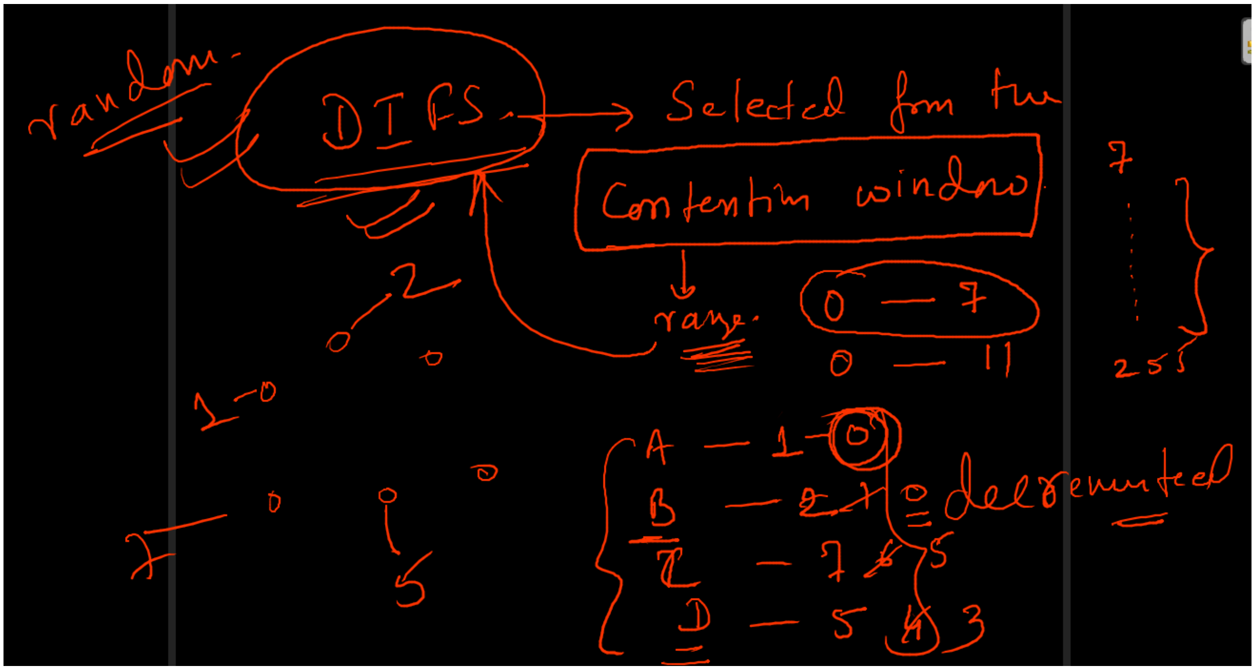
↓ Short.

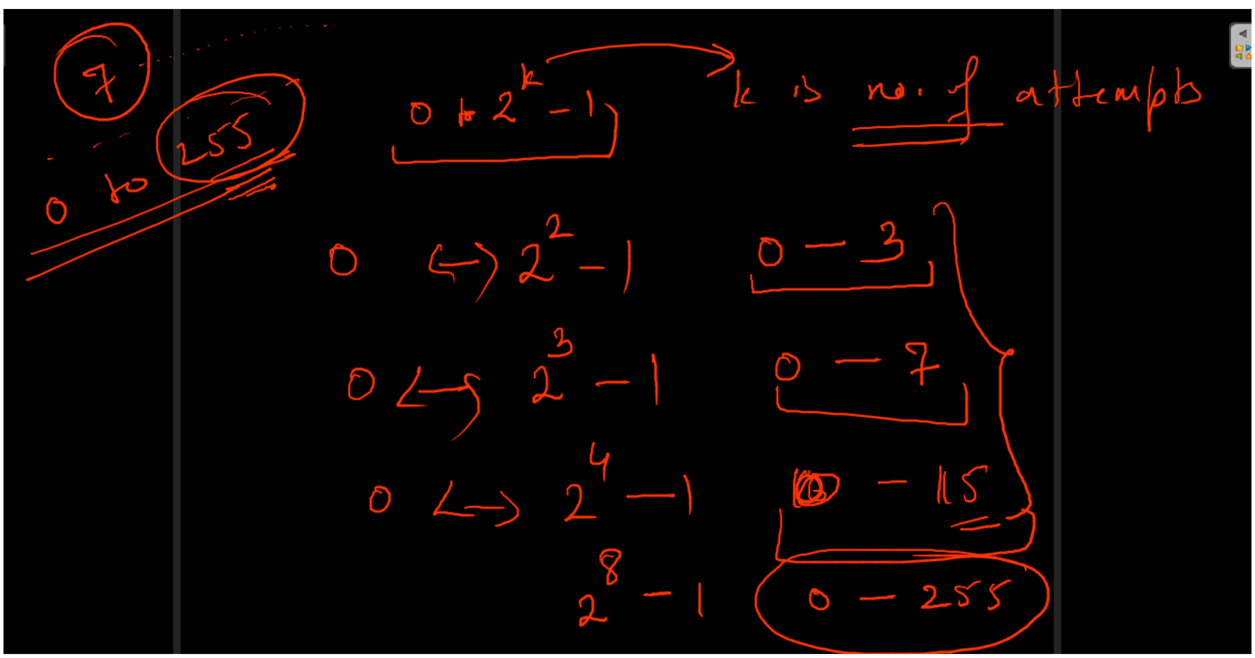
CA.

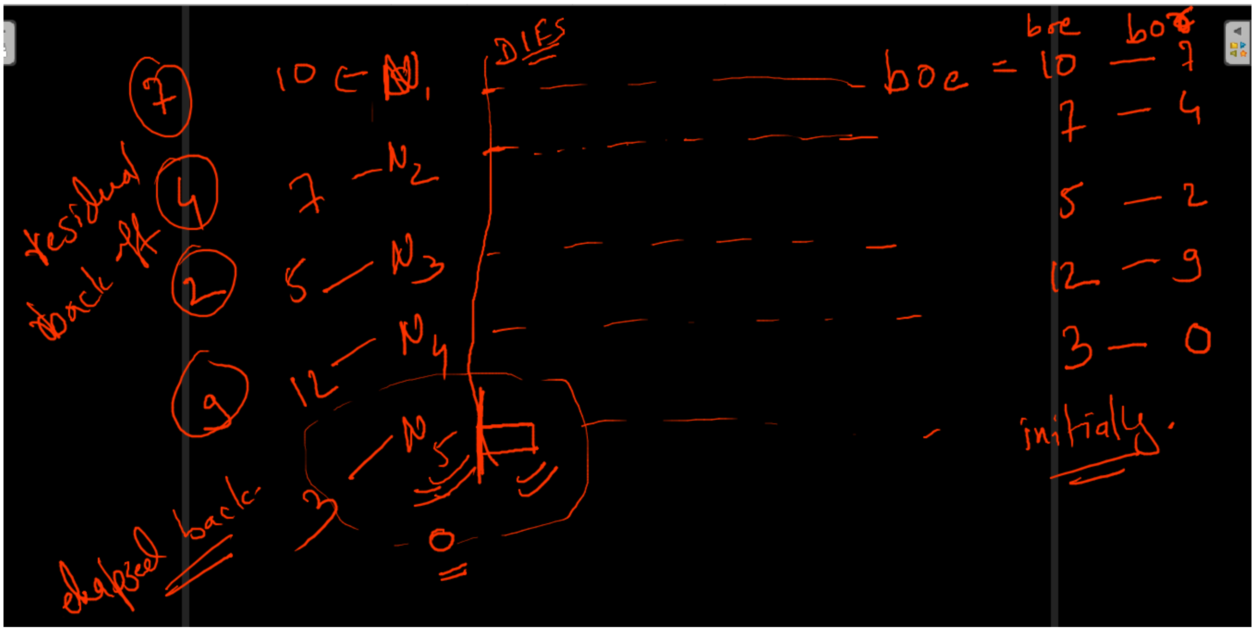
(5) busy? → continue sensing the medium

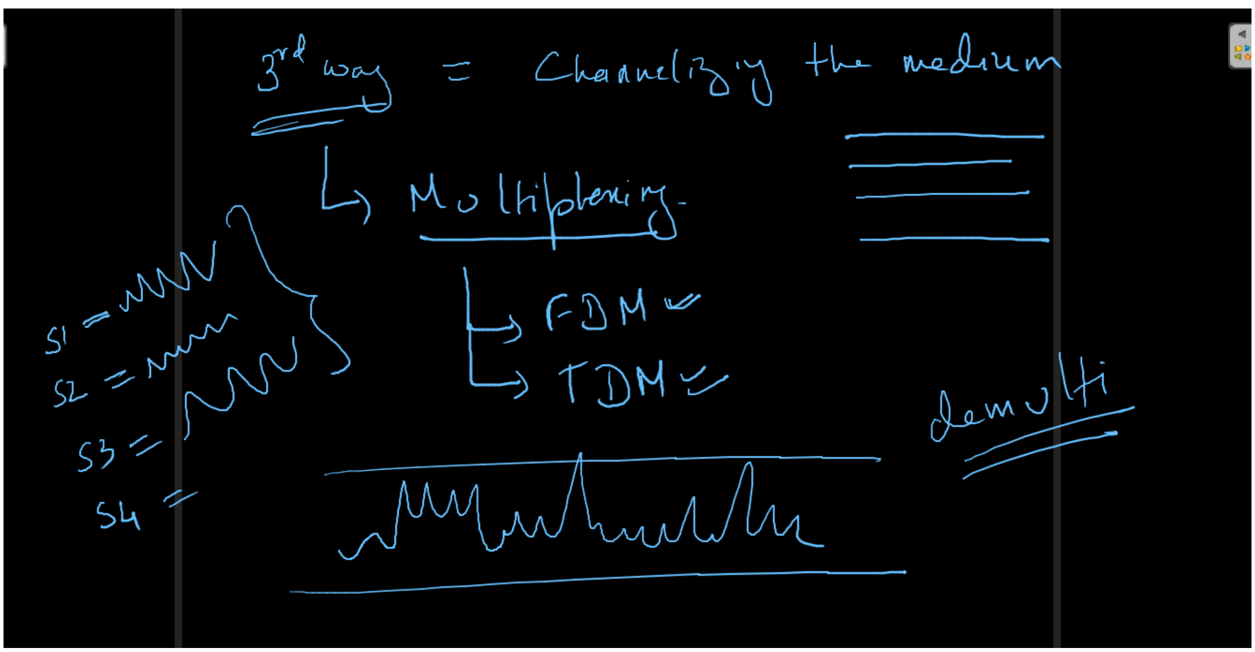
5 sec 5 min. 5m

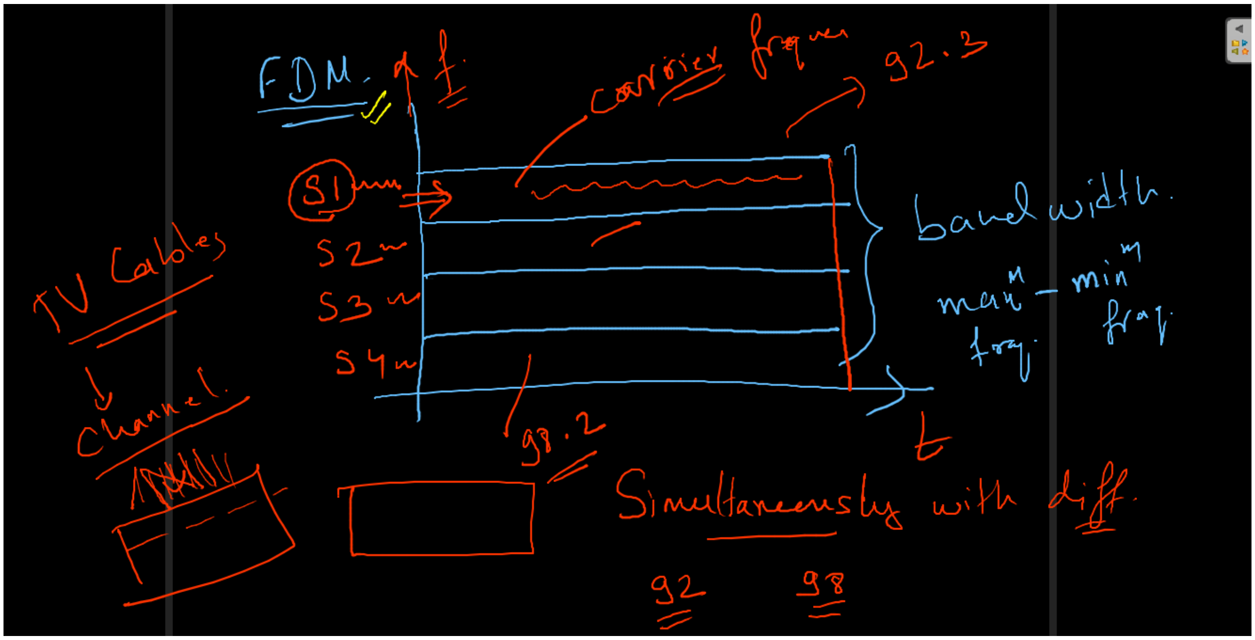
p-pr.

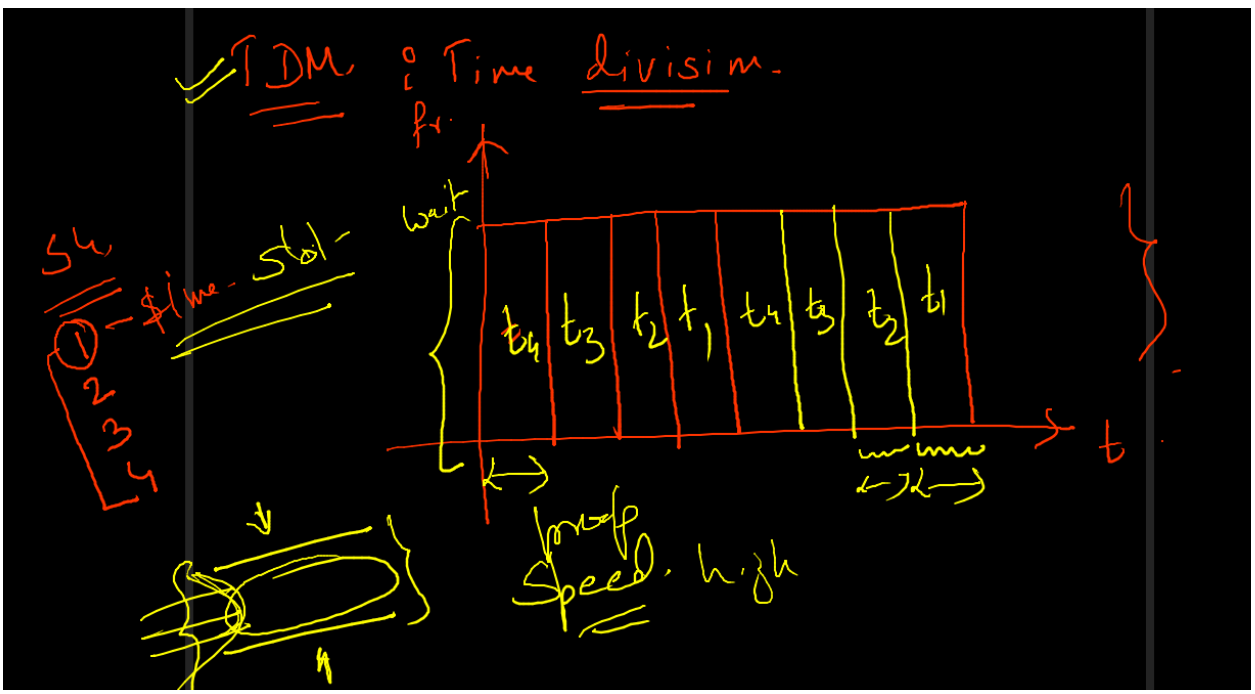

random
DIFS
Selected from the
Contention window
range
0 — 7
0 — 11
7
255
A — 1 0
B — 2 1 0
C — 7 6 5
D — 5 4 3
decremented

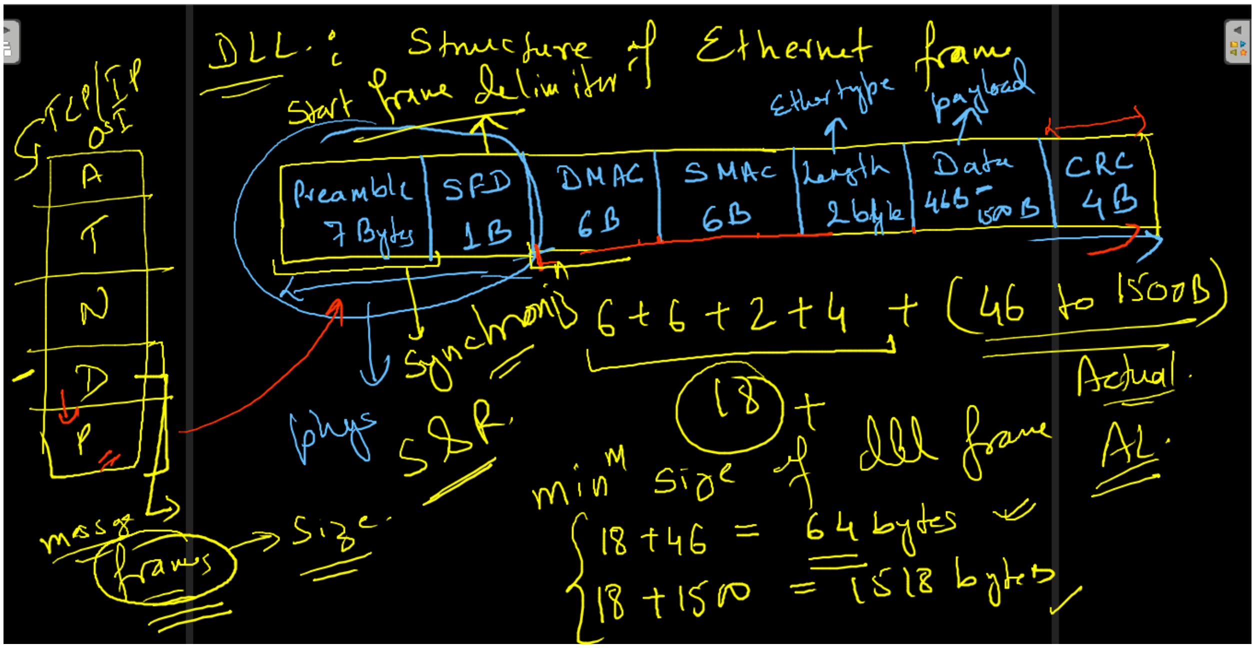

7
0 to 255
0 to 2^k − 1
k is no. of attempts
0 ⟷ 2^2 − 1
0 — 3
0 ⟷ 2^3 − 1
0 — 7
0 ⟷ 2^4 − 1
0 — 15
2^8 − 1
0 — 255

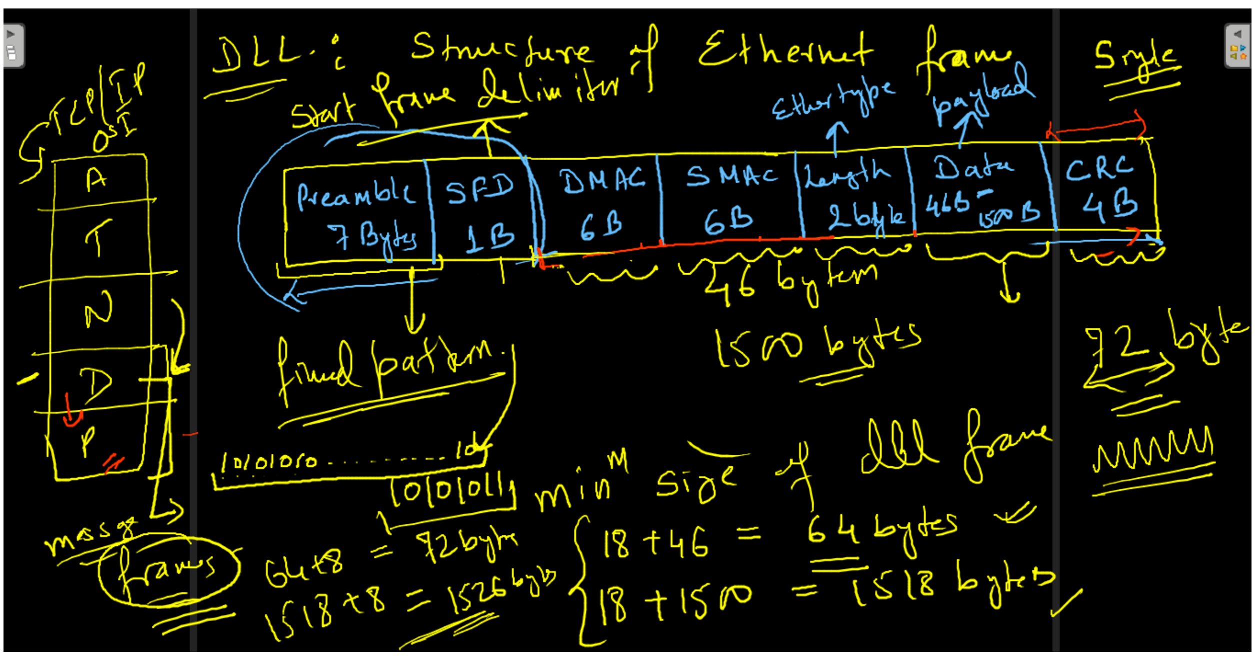

DIFS
10 ← N1
7 — N2
5 — N3
12 — N4
3 — N5
0
7
4
2
9
residual back off
elapsed back
boe = 10 — 7
7 — 4
5 — 2
12 — 9
3 — 0
initially.


3rd way = Channelizing the medium
Multiplexing
FDM
TDM
S1 =
S2 =
S3 =
S4 =
demulti


FDM.
f
carrier frequen
92.3
S1
S2
S3
S4
bandwidth.
max^n - min^n
freq. freq.
TV Cables
channel.
98.2
t
Simultaneously with diff.
92
98


TDM : Time division.
fr.
wait
S4
1 - time-slot-
2
3
4
t4 t3 t2 t1 t4 t3 t2 t1
t
Speed. high


DLL: Structure of Ethernet frame
Start frame delimiter
Ethertype
payload
Preamble 7 Bytes
SFD 1B
DMAC 6B
SMAC 6B
Length 2 byte
Data 46B - 1500 B
CRC 4B
TCP/IP
OSI
A
T
N
D
P
message
frames
size
synchronis
phys
SDR
6 + 6 + 2 + 4 + (46 to 1500B)
18 +
Actual
AL
min^M size of DLL frame
18 + 46 = 64 bytes
18 + 1500 = 1518 bytes


DLL: Structure of Ethernet frame
Start frame delimiter
Ethertype
payload
Style
Preamble 7 Bytes
SFD 1B
DMAC 6B
SMAC 6B
Length 2 byte
Data 46B - 1500 B
CRC 4B
TCP/IP
OSI
A
T
N
D
P
message
frames
46 bytes
1500 bytes
72 byte
fixed pattern.
10101010 10
10101011
64+8 = 72 bytes
1518+8 = 1526 bytes
min^M size of DLL frame
18 + 46 = 64 bytes
18 + 1500 = 1518 bytes