Framing :-

- Since as data-size increases, complexity of finding error also increaces.

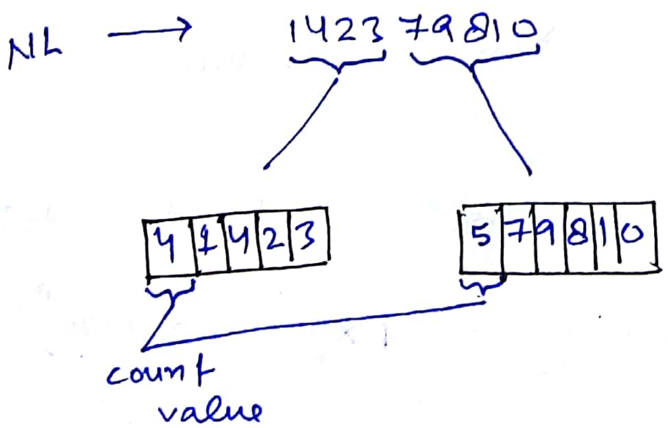
- Dividing large amount of data into small parts, so that error detection policies can easily detect error is known as framing.

- So, we can say the efficiency of error detection policies decreases as the length of data increases.

(i) Character count :-

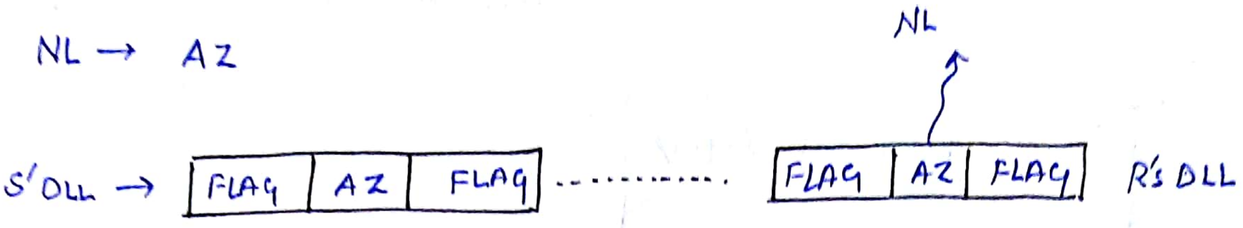
- In this technique count value indicates the size of the frame.

- If noise modifies the data, CRC can detect it, but if noise modifies the count value both sender & reciever are out of synchronization.



(ii) Character stuffing :-

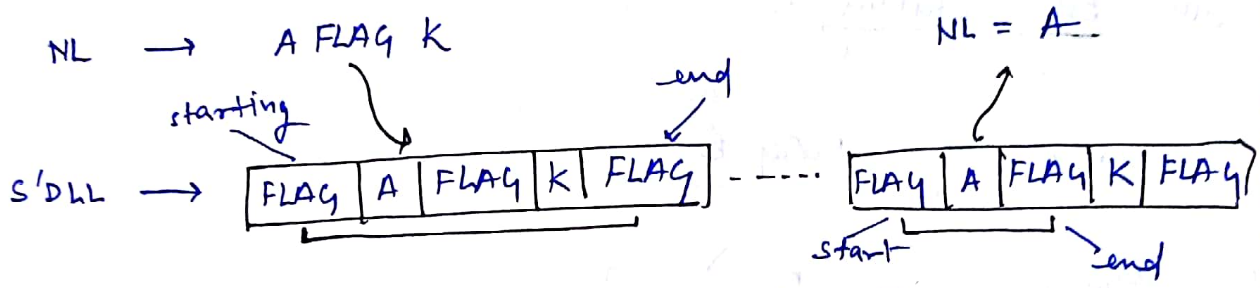
NL → AZ



if noise changes data part then CRC can detect it and if FLAG value is changed which is nothing but a pattern of bits known at both sender & reciever side, Reciever ~~discard~~ will know that FLAG is changed due to noise.

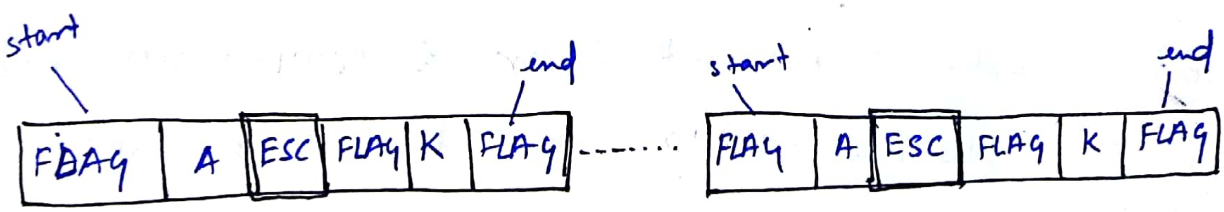
Now, if

NL → A FLAG K



so, due to presence of FLAG in data Packet, reciever side can't able to get actual data, as it accept it as a ending FLAG and "A" is sended to NL as data.

So, to resolve this problem -



* ESC character used to escape the FLAG in data part.

so, if $\boxed{\text{ESC}\;|\;\text{FLAG}}$ flag is prepended with ESC then it act as a data.

$\boxed{\text{size of FLAG and ESC : 8-bits}}$

* its drawback is if more number of FLAG appears in data packet then same number of ESC character (8-bits) has to be added in frame, hence size of frame increases and efficiency of error detection decreases.

(iii) <u>Bit - stuffing</u> :-

NL : A FLAG B

S'DLL : FLAG A FLAG B FLAG

01111110 01000001 011111010 01000010 01111110

insert 0 after appearing of 5 consecutive 1's.

Q. Data at Network layer is 0111110111110 and FLAG bits are 01111110, then data at DLL after bit stuffing.

data at DLL : FLAG datapacket FLAG

$\overline{01111110}$ 011111010111100 $\overline{01111110}$

stuffed - bits

Q. Data at NL → 0111101110 , FLAG → 011110 , so what is data at DLL after bit stuffing.

Data at DLL : FLAG datapacket FLAG

011110 011110101111100 011110

add 0 after each 4 consecutive 1's

so, addition of zero after consecutive 1's of any count is decided by the pattern,

eg. 01111110 → add 0 after 5 consecutive 1's

011110 → " 4 "

01110 → " 3 "

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Q: Data at NL = 1000001 000001 and FLAG = 1000001

what is frame at DLL?

∴ After every 4 consecutive 0's insert 1,

~~Dead~~ Frame : FLAG Packet FLAG

1000001 10000101000011 1000001

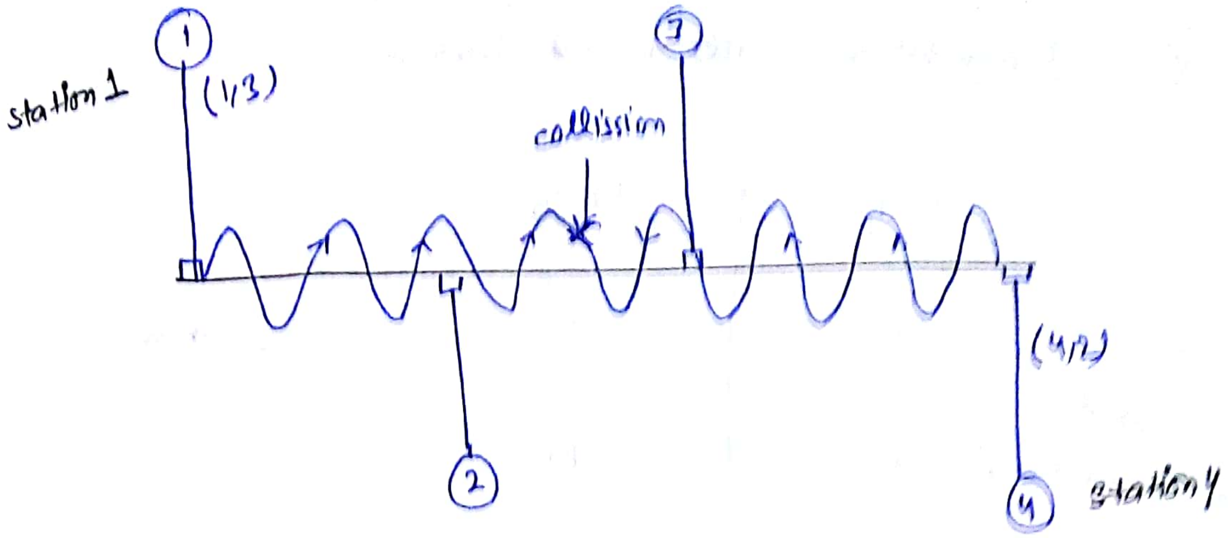
Sub-Layers of Data Link Layer -

- Data Link Layer
  - (Logical ~~layer~~ Link control ~~Layer~~ layer) → flow control, error control
  - (MAC layer) → access the shared channel or to overcome collisions.

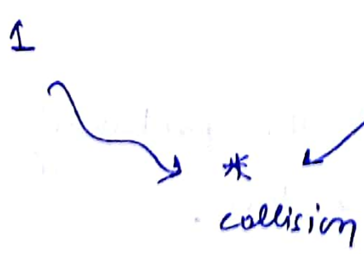
MAC Layer

Pure ALOHA -

- Any system having a data, it can transmit immediately.
- Two or more stations transmits the data at the same time, then there is a collision. The time at which the collision occurs is known as vulnerable time.



Q: Station 1 and 2 ~~are~~ have transmitted there data for first time is collided and waited some random amount of time using exponential algorithm. Then what is the probability will retransmit before system 2.



Exponential back off algo :-

station 1 | station 2

$WT_1 = (0 \text{ to } 2^k - 1) \cdot PT$

$WT_2 = (0 \text{ to } 2^k - 1)\, PT$

since $k = 1$ as collision is first time

so, $WT_1 = (0 \text{ to } 1) \cdot PT$ $\qquad$ $WT_2 = (0 \text{ to } 1)\, PT$

$\therefore$ 0 or PT $\qquad$ $\therefore$ 0 or PT

Now 4 possibilites will be there –

	WT_1	WT_2	
	0	0	→ collision
station 1 sends before station 2 →	0	PT	
station 1 sends after station 2 →	PT	0	
	PT	PT	→ collision

so,

<u>Probability = 1/4</u>

Q. In the above what is the probability that both are retransmitting at same time.

$$P(E) = \frac{2}{4} = \frac{1}{2} = 50\%$$

Q. Station 1 and 2 have transmitted there ~~data~~ second time and waited some random amount of time, then what is the probability that station 1 will re transmit before station 2.

$WT_1 = (0 \text{ to } 2^k - 1)\, PT$ $\quad$ $WT_2 = (0 \text{ to } 2^k - 1)\, PT$

$k = 2$

$(0, PT, 2PT, 3PT)$ $\quad$ $(0, PT, 2PT, 3PT)$

Total number of chances $= 4 \times 4 = 16$

cases in which event occurs $\Rightarrow$

WT_1	WT_2
0	PT
0	2PT
0	3PT
PT	2PT
PT	3PT
2PT	3PT

so, $P(E) = 6/16 = 3/8$

Q. In the above problem what is the probability that collision occurs.

Event:

WT_1	WT_2
0	0
PT	PT
2PT	2PT
3PT	3PT

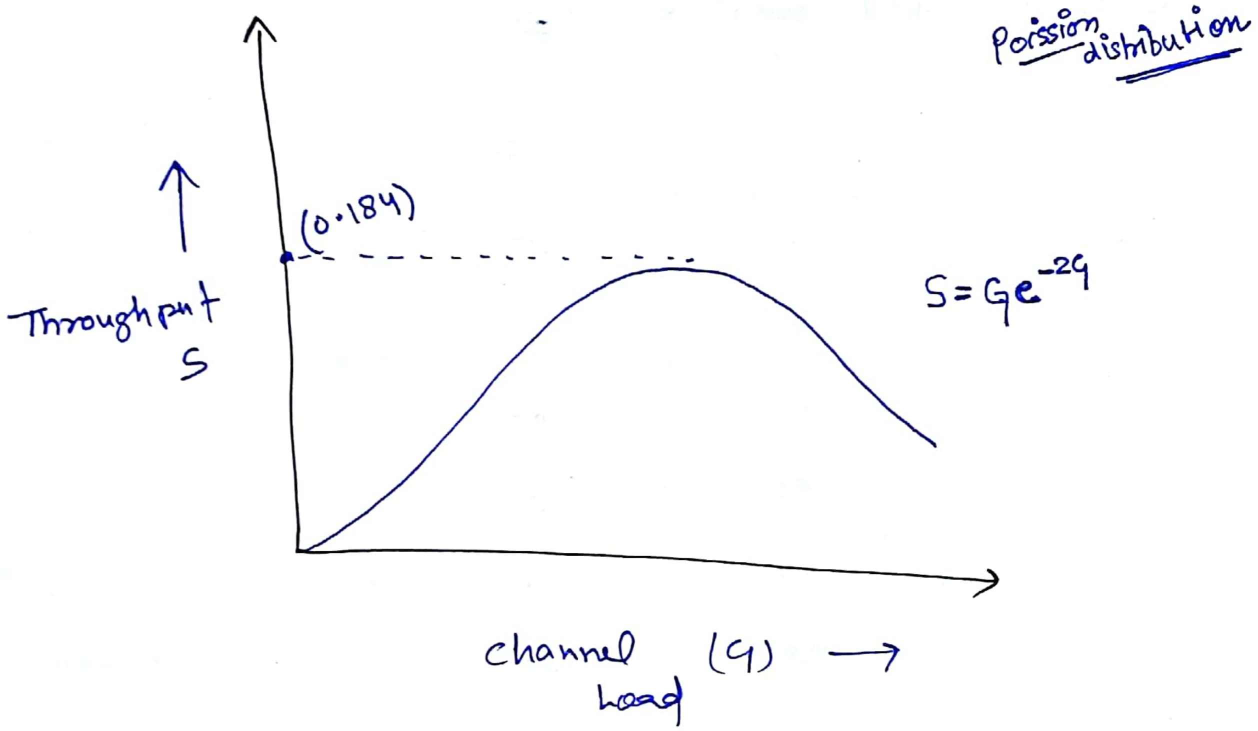
$P(E) = 4/16 = 1/4$

25%

* So, after each retransmission of data chances of collision decreases by $1/2$ value.

at $K=1$ $\longrightarrow$ at $K=2$ $\longrightarrow$ at $K=3$

$P = 50\%$. $\quad P = \frac{50}{2} = 25\%$. $\quad P = 25/2 = 12.5\%$.



NO. of station	Ready stations	Collision	data safely
100	50	20	30
100	100	50	50
100	50	10	40

- The rate at which user transmit the data, the data should reach safely is known as throughput.

- channel Load = $\frac{\text{Ready station}}{\text{Total no. of stations}}$.

- $S = G e^{-2G}$

$$\frac{dS}{dG} = e^{-2G} + G(-2)\, e^{-2G}$$

$$= e^{-2G} - 2G\, e^{-2G}$$

$$= (1-2G)(e^{-2G})$$

for maximum $\frac{dS}{dG} = 0$ equate it

$$(1-2G)\, e^{-2G} = 0$$

so, $G = 1/2$ or ∞

so, $\boxed{G = 1/2}$

S_{max} is at $G = 1/2$

so, $S_{max} = \frac{1}{2} e^{-1} = \frac{1}{2e}$

$$\boxed{S_{max} = 0.184 = 18.4\%}$$

- So, this means in Pure ALOHA out of 100 ~~data~~ frames ~~packets~~ only 18.4 ~~packets~~ frames will reached there destination.

Remaining 82.6 frames will suffers collissions.

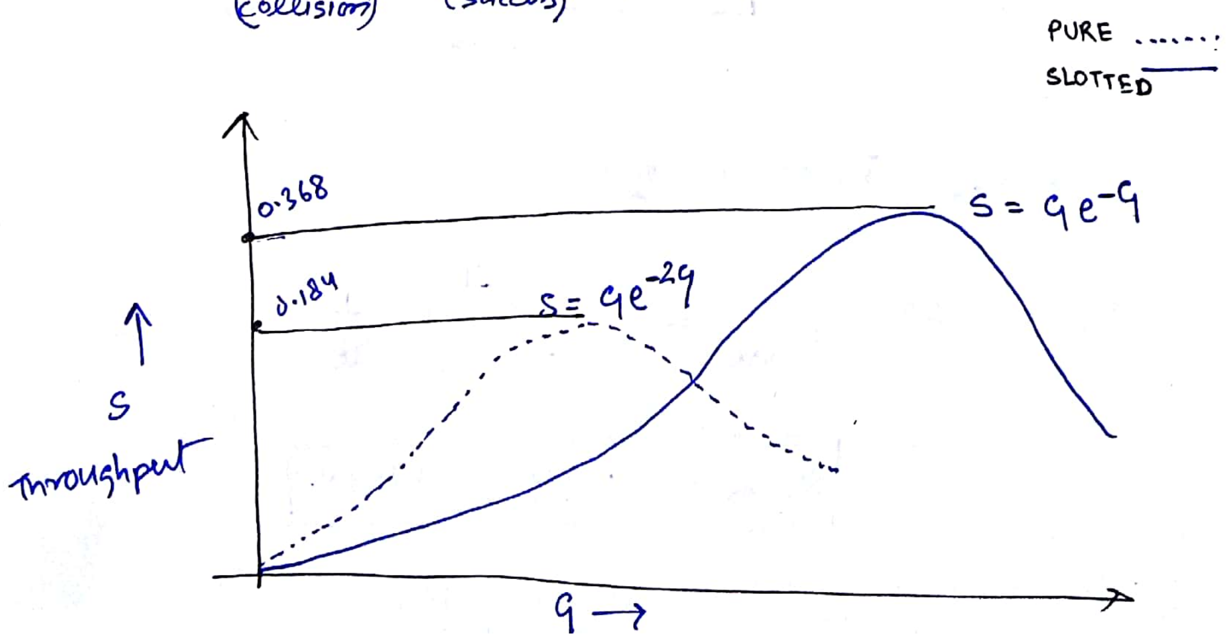
Slotted ALOHA :-

- In this the total time is divided into time slots & the stations are allowed to transmit only at starting of timeslots.

- In this the number of collisions are less compared to pure ALOHA.

eg.

no. of station	T_1	T_2	T_3	T_4
100	20	30	20	30
	5 (collision) → 15 (success)	15 → 15	10 → 10	2 → 28



for S_{max} $\left(\frac{ds}{dG} = 0\right)$

$$e^{-G} + (-1)\, G\, e^{-G} = 0$$

$$(1-G)\, e^{-G} = 0$$

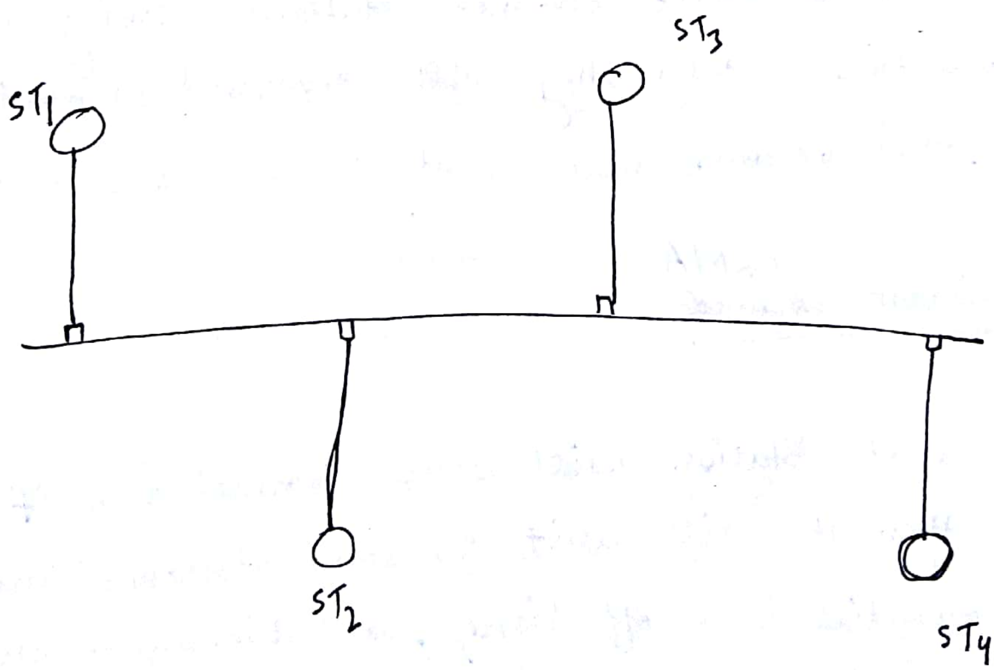
$$\boxed{G = 1}$$

$$\boxed{S_{max} = e^{-1} = 1/e = 36.8\,\%}$$

- so, out of 100 frames maximum 36.4 frames reached safely.

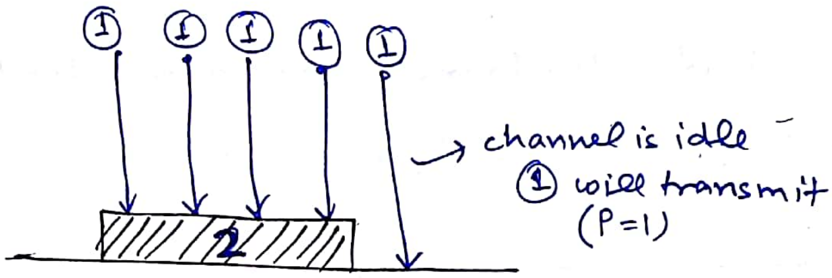
* Both Pure and slotted ALOHA are non-deterministic techniques

Carrier sense Multiple Access (CSMA) :-



- when the energy of channel is low, channel is idle
- when energy is moderate, channel is busy.
- And when energy is high, channel is suffering from collisions.

(i) 1-persistent CSMA :-



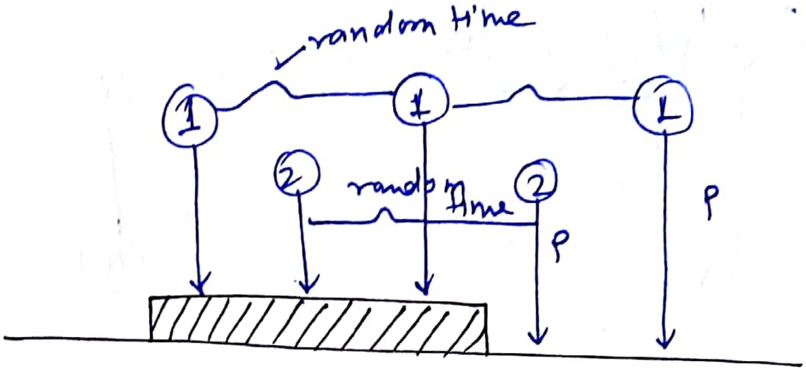
- In this ready stations will continously or persistently sensing channel and once it is free, they will transmit.
- So if two or more ~~channel~~ stations sensing channel at same time, then they will transmit simuntaneously as channel becomes idle, and hence collision occurs.

(ii) Non-persistent ~~channel~~ CSMA :-

- In this ready station will sense channel once if it is busy then it will wait for some random time (exponential back-off time), and then again sense the channel.

- so in this technique chance of collision is less than 1-persistent CSMA.

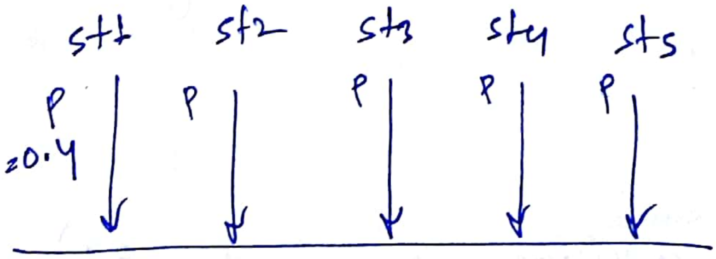
(iii) <u>P-persistent CSMA</u> –



P is the probability of transmission

- In this once the channel is idle it may transmit with probability P or it may not transmit with probability 1-P.

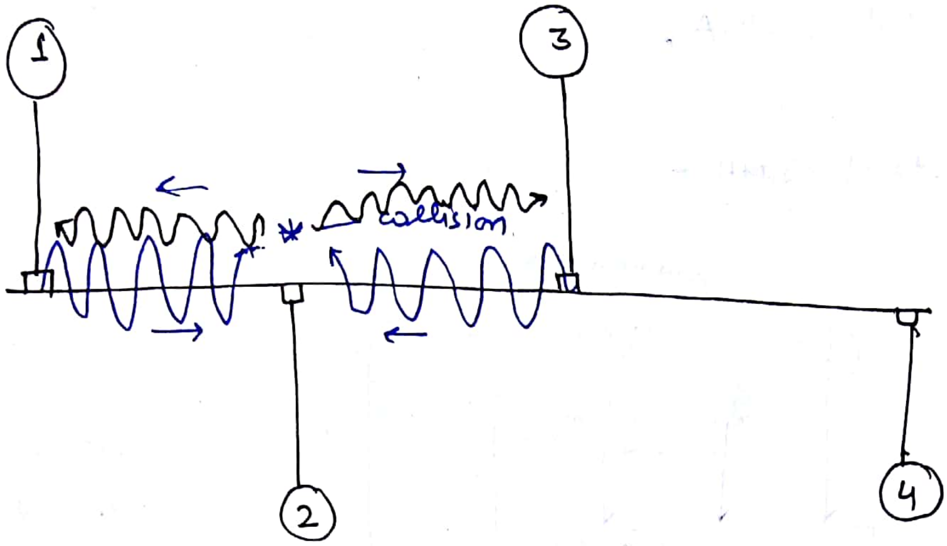
Q. There are 5 stations in a slot, probability of transmitting the data is 0.4. Only 1 station should transmit in the slot. What is the probability that only 1 station will transmit in the given slot.



$$P(E) = {}^5C_1\, P(1-P)^4$$

$$= 5 \times 0.4 \times (0.6)^4 = 0.2592 \doteq 25.9\%$$

CSMA/CD :-



every station → sense for collisions
every station → transmit data

collision occurs	collision detection
eg: 0.1 PT	0.2 PT

* when collision detected then only stations stops transmitting.

- Range of collision → (0 to PT) time

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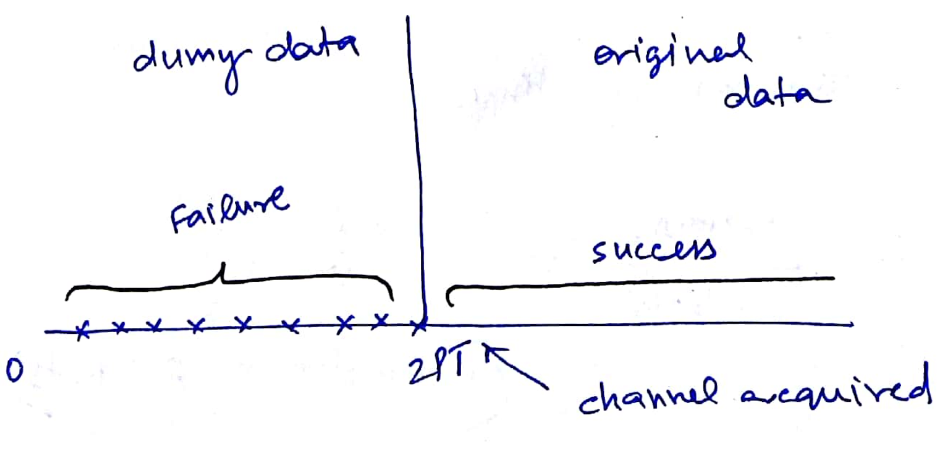
eg -

collision occurs	collision detection
0.1 PT	0.2 PT
0.2 PT	0.4 PT
0.3 PT	0.6 PT
⋮	⋮
PT	2PT

∴ collision detection = 2 × collision occurs

- If the collision is detected at < 2PT or in the worst case of 2PT then the station will stop transmitting the dumy data and applies exponential back-off algo. (It is a failure).

- If the collision is not detected at ≤ 2PT then the station confirms that it acquired or captured the channel. From that time onwards station starts transmitting original data.



- The maximum time where a collision detected is same as the minimum time where a station acquire the channel. i.e 2PT.

Q: In CSMA/CD ethernet B.W = 10Mbps, l = 200m, $v = 2\times10^8$ m/s. Calculate minimum frame size to acquire the channel?

T.T = 2 × PT

$$\frac{\text{Frame size}}{B.W} = 2\times\frac{l}{v}$$

(Framesize = 200 bits)

Q. B.W = 100 Mbps, l = 230m, $v = 23\times10^8$ m/s, Calculate maximum frame size to detect collision.

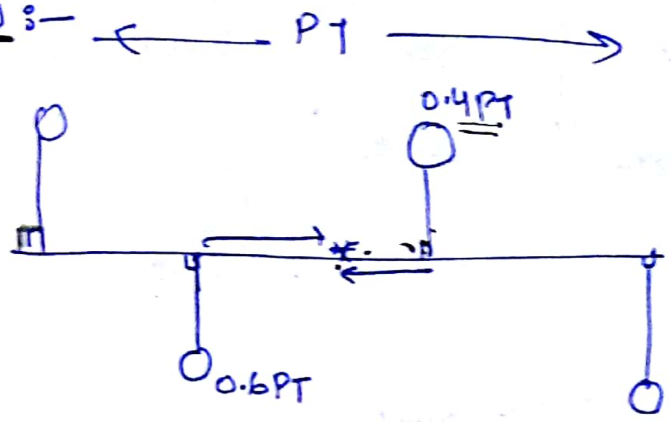
TT = 2×PT

Transmission time

$$\frac{\text{Framesize}}{B.W} = 2\times\frac{l}{v}$$

(Frame size = 200 bits)

Special cases :-



- The purpose of jam signal is to inform to unknown station about the collision.

- If the collision is detected at <2PT then upto 2PT jam signal is transmitted then at 2PT exponential Back-of algo is applied.

- The station who ditect the collision first will send the JAM signal and the JAM signal will reach to all stations in the worst case of 2PT.

IEEE 802.3 : Frame Format

Preamble	SFD
7 bytes	1 byte

← It is added at Physical Layer

SFD → starting Frame delimiter

DA	SA	Type	Data	CRC 32
6 Bytes	6 Bytes	2 Bytes	NL data packet	4 bytes

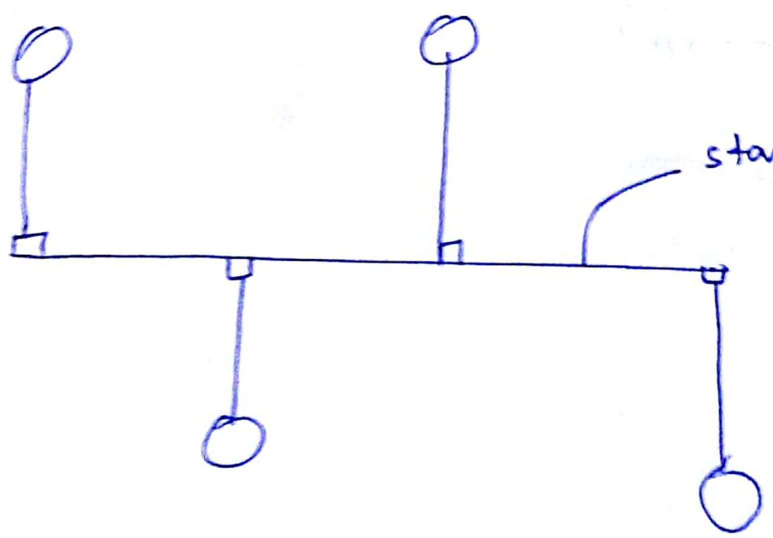
Frame

- The only one layer which is having the trailer along with the header is Data Link Layer.

- CRC is attached at the end of the data because Processing time is less.

- CRC provide error control for entire frame.

- <u>Preamble & SFD</u> are ~~used~~ transmit to alert the stations that data is coming ie it is used for synchronization b/w sender and reciver.



standard ethernet

10base5

$\downarrow$ B.W = 10Mbps

$\downarrow$ $l = 500m$

So, ~~for~~

$$T.T = 2 \times PT$$ (for acquiring channel in CSMA/CD)

$$\frac{\text{Frame size}}{B.W} = 2 \times \frac{l}{v}$$

$$\frac{\text{Frame size}}{10^7} = 2 \times \frac{500}{v}$$

$$(\text{Frame size} = 64 \text{ Bytes})$$

∴ The minimum frame size in IEEE 802.3 is 64 Bytes. This restriction is to support a protocol CSMA/CD.

Similarly minimum data packet size in IEEE 802.3 is 46-Bytes.

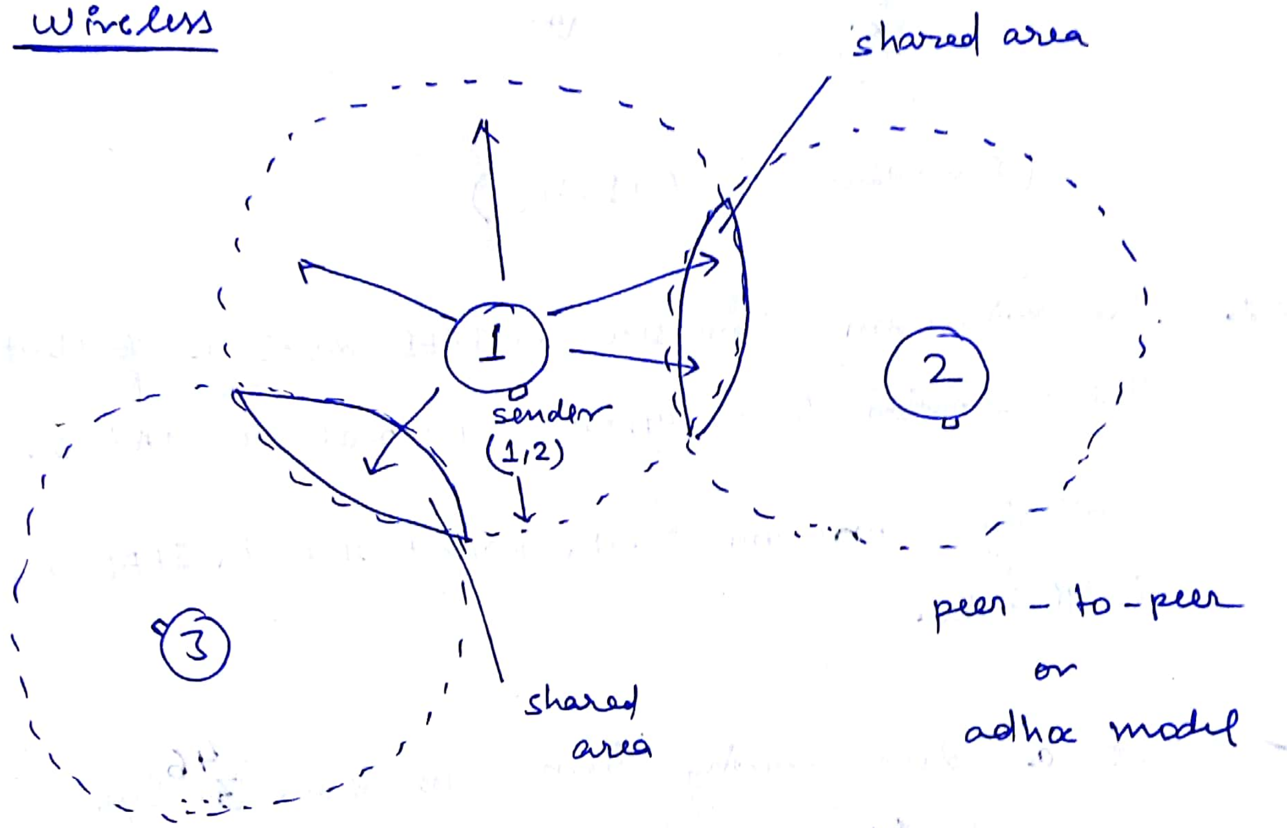
- If a data coming from less than 46 Bytes then upto 46 Bytes padding bits are added so the channel can be acquired.

- The maximum frame size in IEEE 802.3 is 1518 Bytes or maximum data in IEEE 802.3 is 1500 Bytes. This restriction is to prevent other station from starvation.

- CRC can detect the errors easily by puting the restriction on the size of the data.

- Type field is going to indicate wheather we are sending data frame or control frame.

Wireless



- signal is sended in ripple wave form.

- As in wired LAN or BUS topology all nodes used singe shared channel whereas in wireless LAN each node has its own shared channel.

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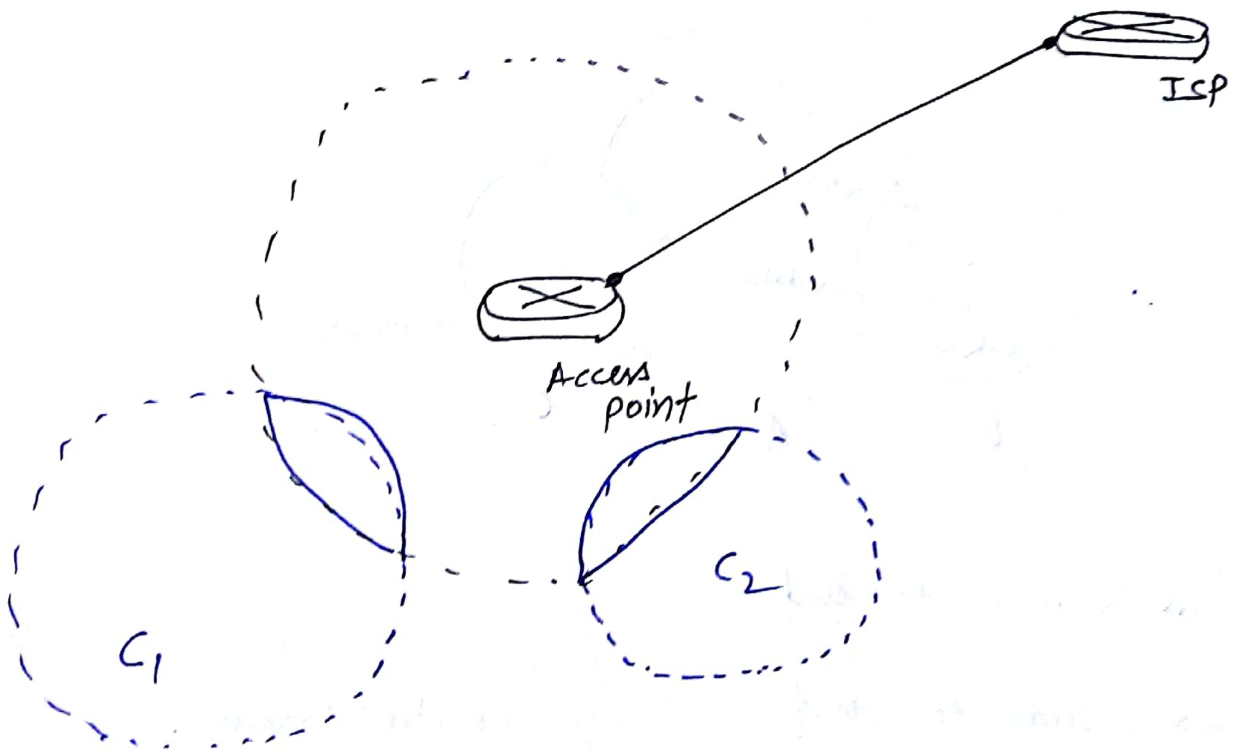
- In peer - to - peer modal ~~all~~ each node will have its own resources to transmit the data, whereas in client to server modal all nodes will use the resources of server to transmit data.

- Effect of noice is more in wireless than wired, so loss of data is more in wireless.

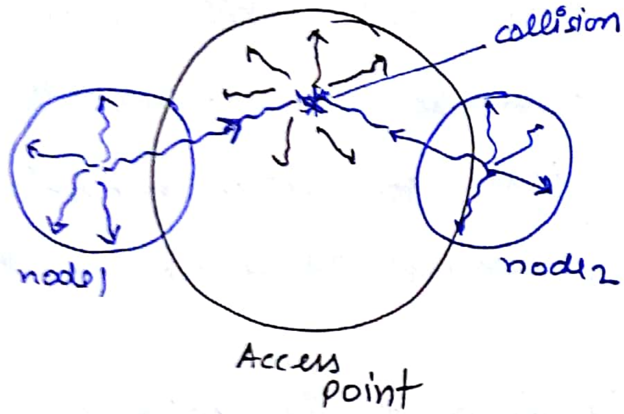
- Retransmissions are more in wireless due to more percentage of loss.

<u>Infrastructure mode :-</u>



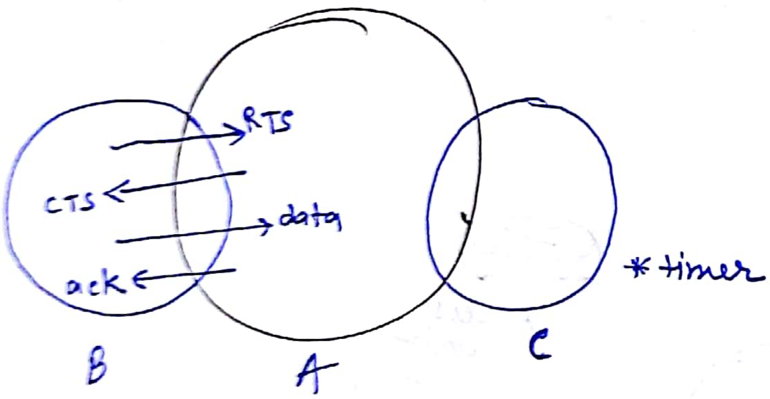
This is BSS (Basic - service set)

hidden node problem



- As we know collision will occurs but the collision energy is lost before reaching to the nodes so CSMA/CD can't be applied in wireless LAN.

CSMA/CA (collision avoidance) :-

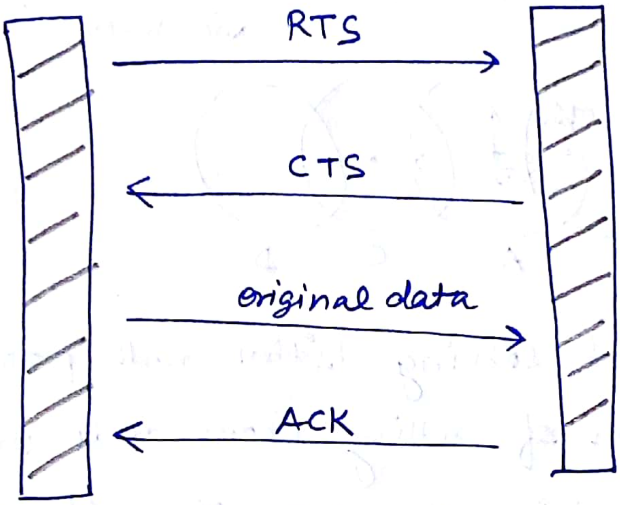


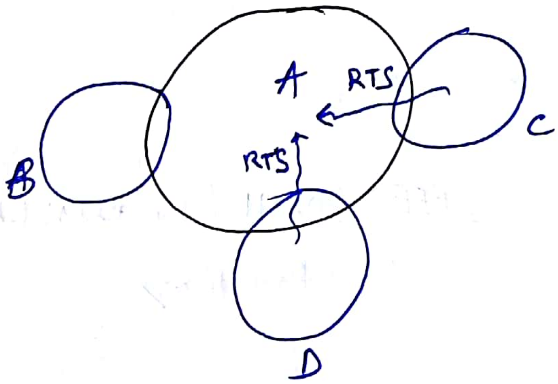
RTS → Request to send
CTS → Clear to send
Ack → acknowledgment

} control frame.

- When a node wants to transmit the data to an ~~excess~~ access node, it uses 4-way handshaking. Hidden node problem can be solved using CSMA/CA.

4-way handshaking process





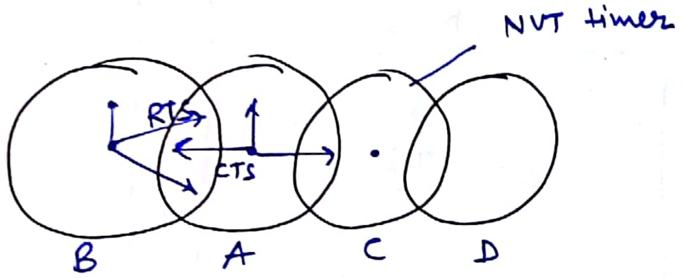
- When both node C and D sends RTS at the same time then there is a collision at node A. Not getting the CTS from A is a confirmation that there is a collision at node A. (virtual sensing).

- Then Both C and D will apply exponential back off algorithm.

- In the BUS topology or wired LAN i.e JAM signal will act as the acknowledgment.

- Not getting a JAM signal is a confirmation that the station has acquired the channel.

<u>Exposed-node problem :-</u>

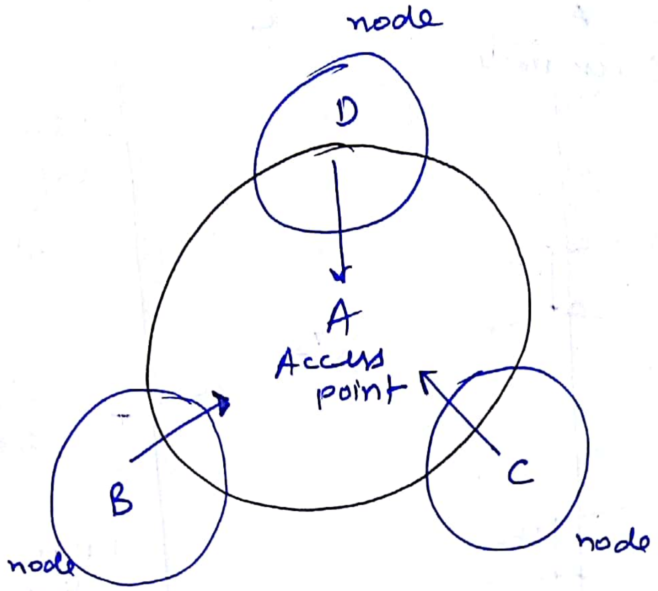


- At the cost of solving hidden-node problem there might be a possibility of getting Expose-node problem, i.e during the waiting time of C it can't send any data to node D.

IEEE 802.11 [Wireless LAN]
functions

↙ (DCF) ~~Distributed~~ Distributed coordination function → f(RTS, CTS, DATA, ACK)

↘ (PCF) Point coordination function → f(Data, ACK)



$\left.\begin{array}{l} B \to A \\ C \to A \\ D \to A \end{array}\right\}$ DCF function

$\left.\begin{array}{l} A \to B \\ A \to C \\ A \to D \end{array}\right\}$ PCF function

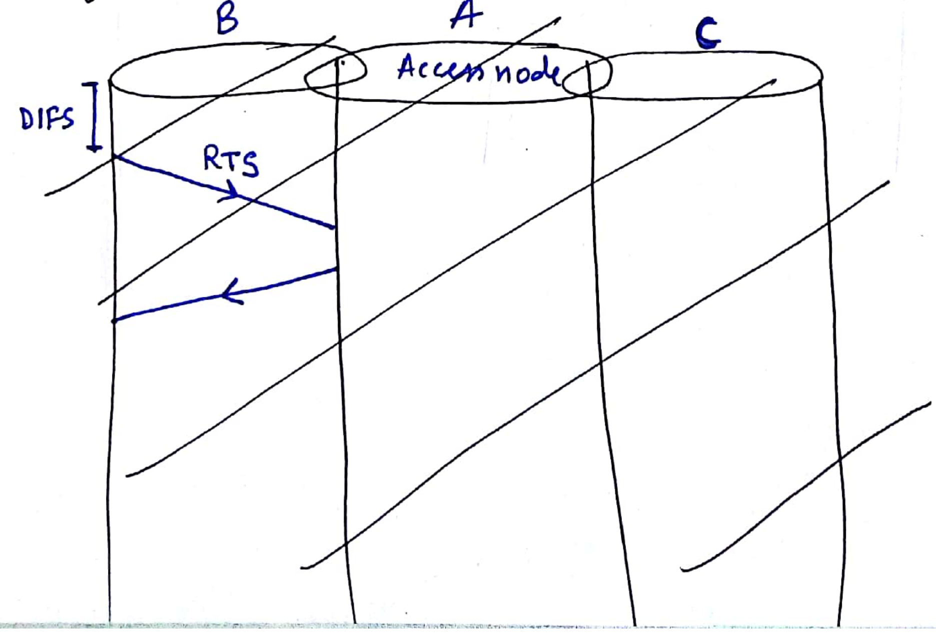
* PCF has high priority than DCF.

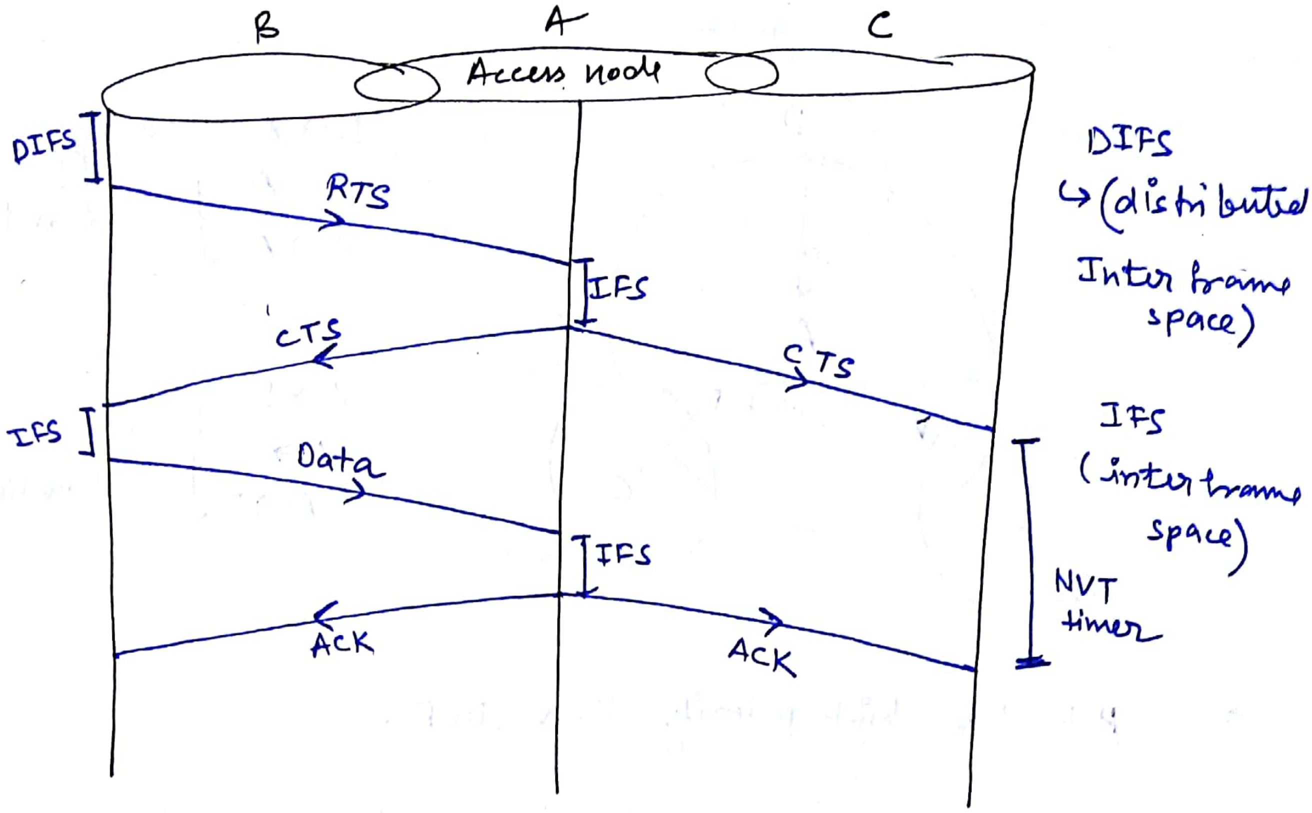
- When a node wants to transmit data to a Access point, it uses DCF function. During that time the channel is a collision channel (contention or distributed or shared)

- when an access point want to transmit a data to a node, it uses PCF function. During that time the channel is a contention-less (collision less) channel.

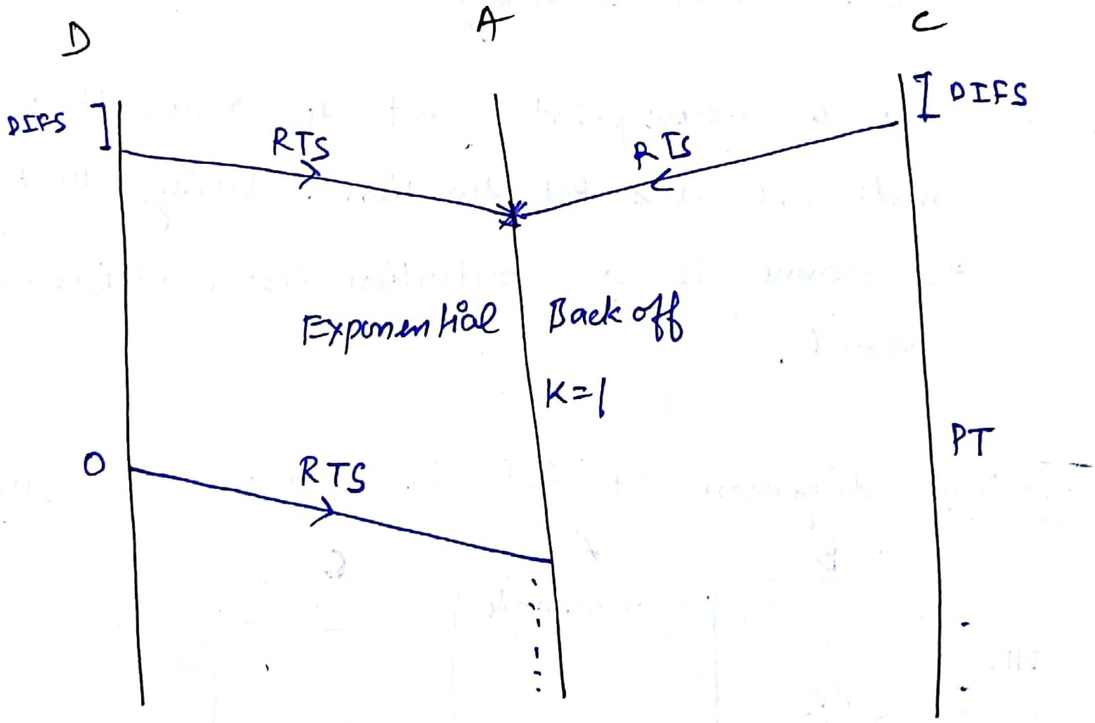
Timing diagram of DCF function :-

DIFS





- other node (C) will send RTS only after getting ACK.



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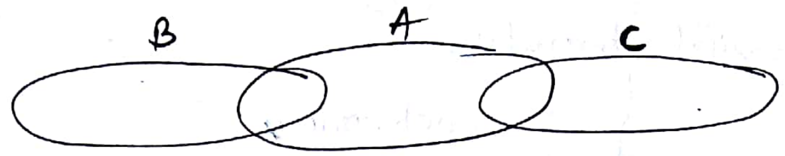
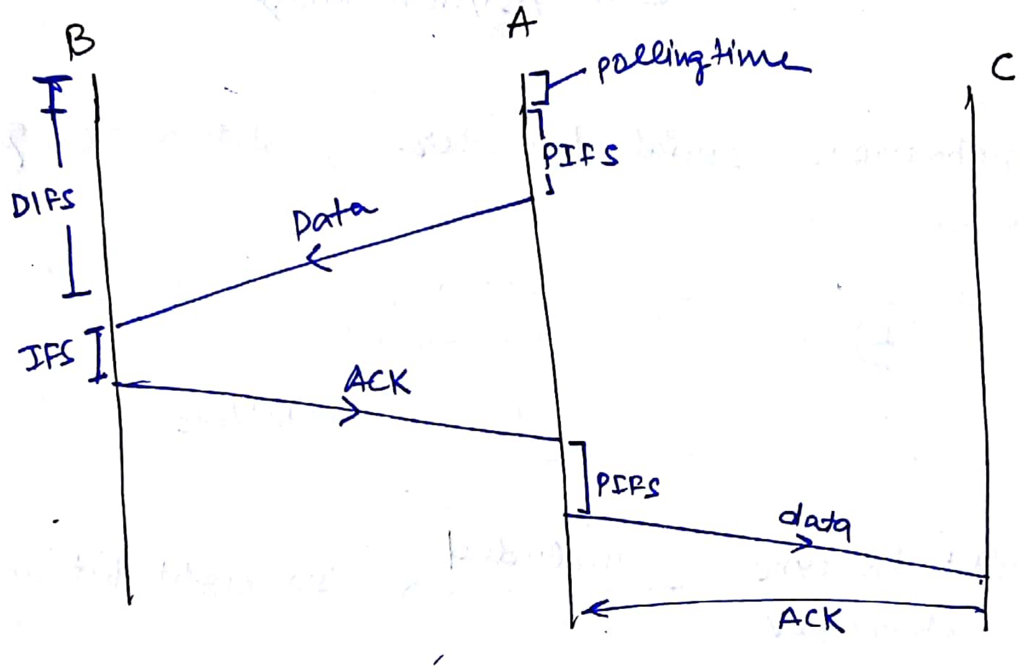
Timing diagram of PCF function :-



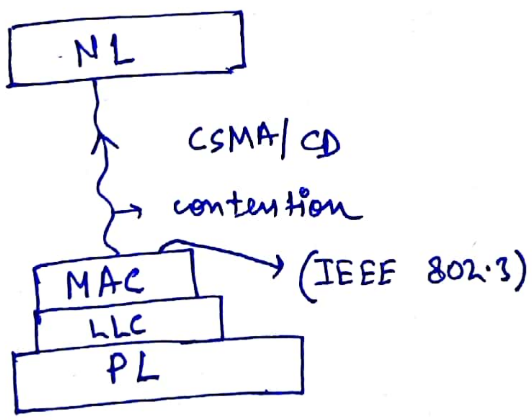


- Since PCF has more priority than DCF so

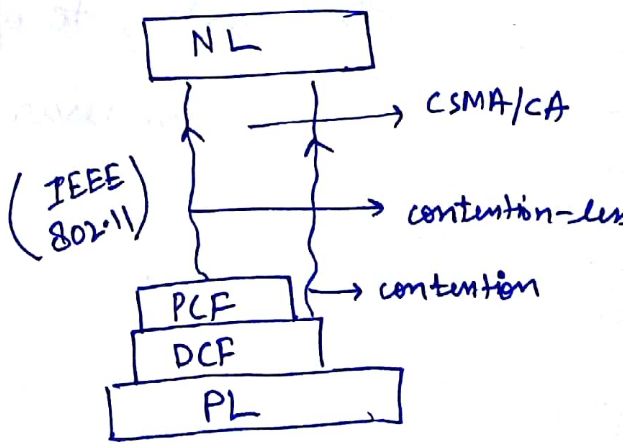
  (PIFS < DIFS)

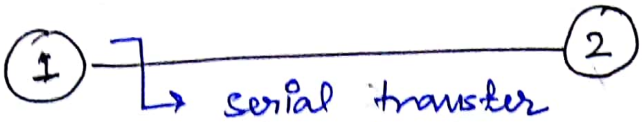
- Polling time is the time required to choose a client first to send a data.

Wired LAN (reciever)



Wireless LAN (reciever)





serial transfer
- → synchronous
- → Asynchronous

Q. Synchronous serial transfer, data rate = ?

B.W = 1200 bit/sec

3 eight bit sync characters $\xrightarrow{\text{included}}$ 30 eight bit info characters

24 sync bits $\xrightarrow{\text{included}}$ 240 bits

since B.W = 1200 bits/sec

so, in 1200 bits → $\frac{24}{240} \times 1200 = 120$ sync bits are included

so, data rate of reciever = $(1200 - 120)$ bits/sec

- In synchronous serial transmission extra bits are added for group of characters.

- In synchronous serial transmission, sync bits are not taken by reciever.

Q. In asynchronous serial transmission, ~~one~~ 1 start bit, 2 parity bits, 1 stop bits are added for a character or byte. B.W = 1200 bits/sec. Then what is the data rate of the reciever?

$$1 \text{ start bit} + 2 \text{ parity bits} + 1 \text{ char} + 1 \text{ stop bit}$$

$$\text{data rate} = 1200 \text{ bits/sec}$$

$$= \frac{1200}{1+2+8+1} \text{ char/sec}$$