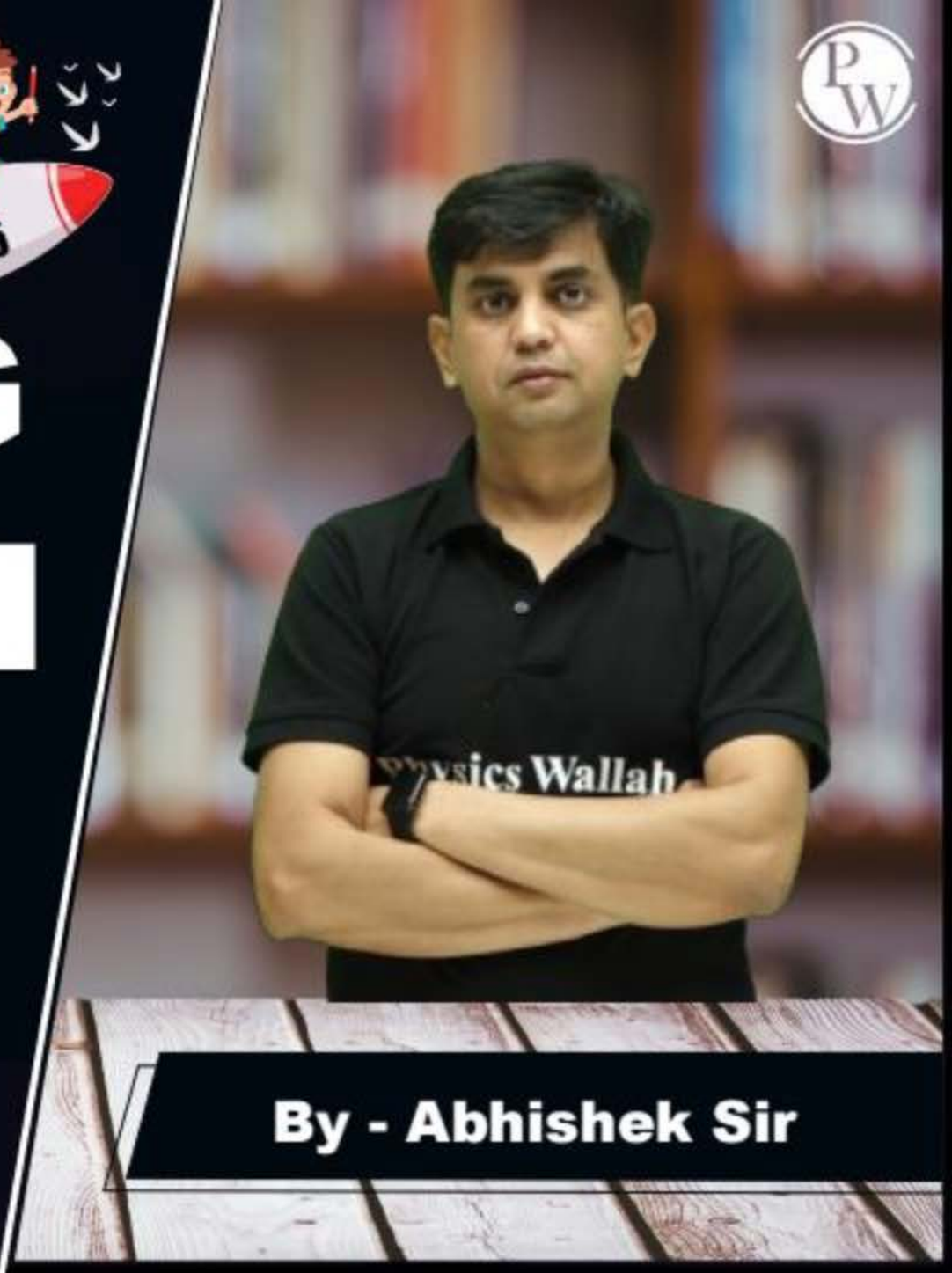
CS & IT ENGINEERING

Computer Network

MAC Layer

Lecture No. - 02



By - Abhishek Sir

Recap of Previous Lecture

Topic Media Access Control

Topic Multiple-access protocol

Topics to be Covered

Topic Pure ALOHA

Topic Slotted ALOHA

ABOUT ME

Hello, I'm Abhishek

- GATE CS AIR - 96
- M.Tech (CS) - IIT Kharagpur
- 12 years of GATE CS teaching experience

Telegram Link : https://t.me/abhisheksirCS_PW

Topic : Pure ALOHA

-> When node has packet to transmit, it transmit immediately

-> Allow collision to happen
[recover via "retransmission"]

-> Use randomization in choosing "when to retransmit"
[Back-off time]

Topic : Pure ALOHA

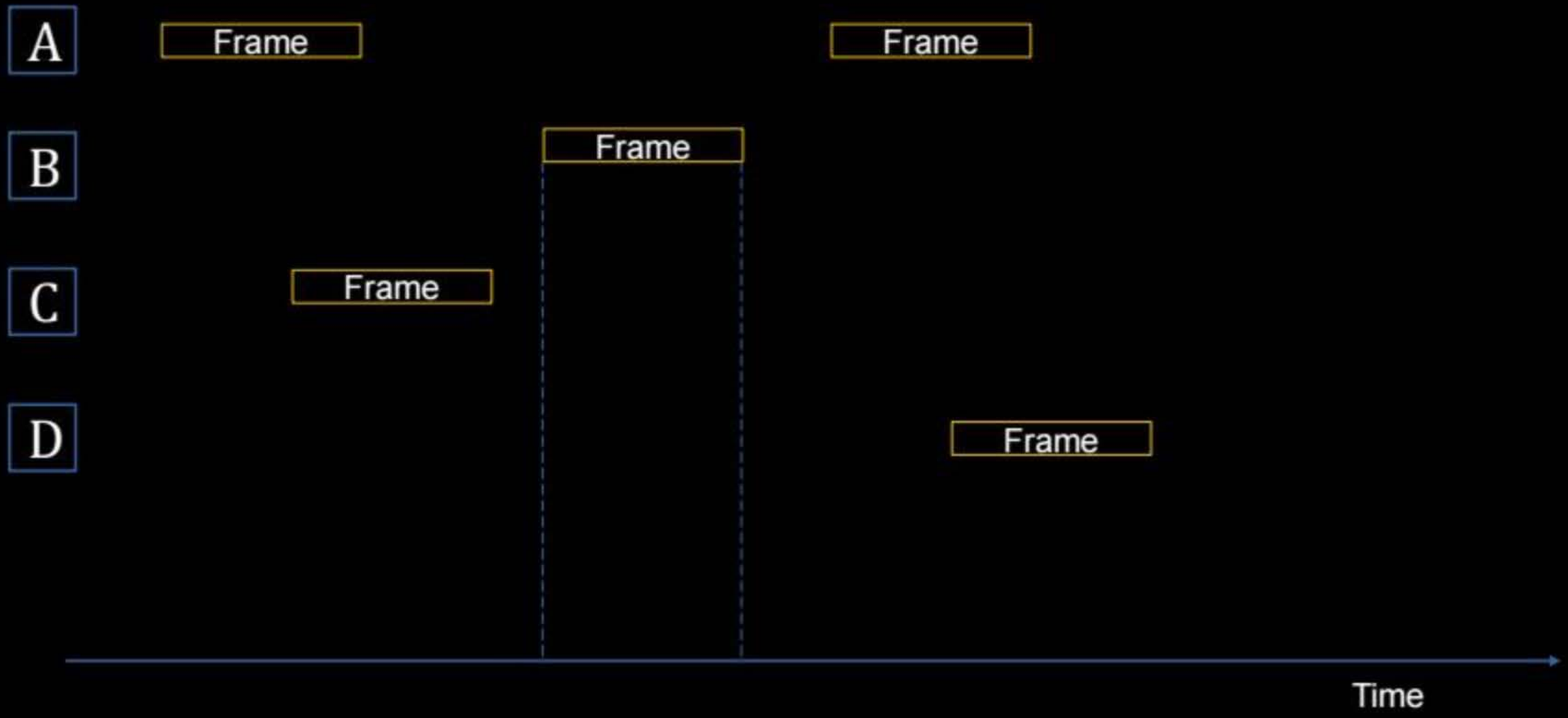
-> All frames are of equal size

-> Receiver send acknowledgement to Source
[for every correctly (without collision) received frame]

-> After transmitting a frame, Source wait for an ACK upto time-out

-> Time-out time = Round Trip Propagation Delay

Topic : Pure ALOHA



Topic : Pure ALOHA

Vulnerable time :

-> Time duration in which no transmission should done to avoid collision

Vulnerable time = 2 * Frame Transmission Time

$= 2 * t_x$

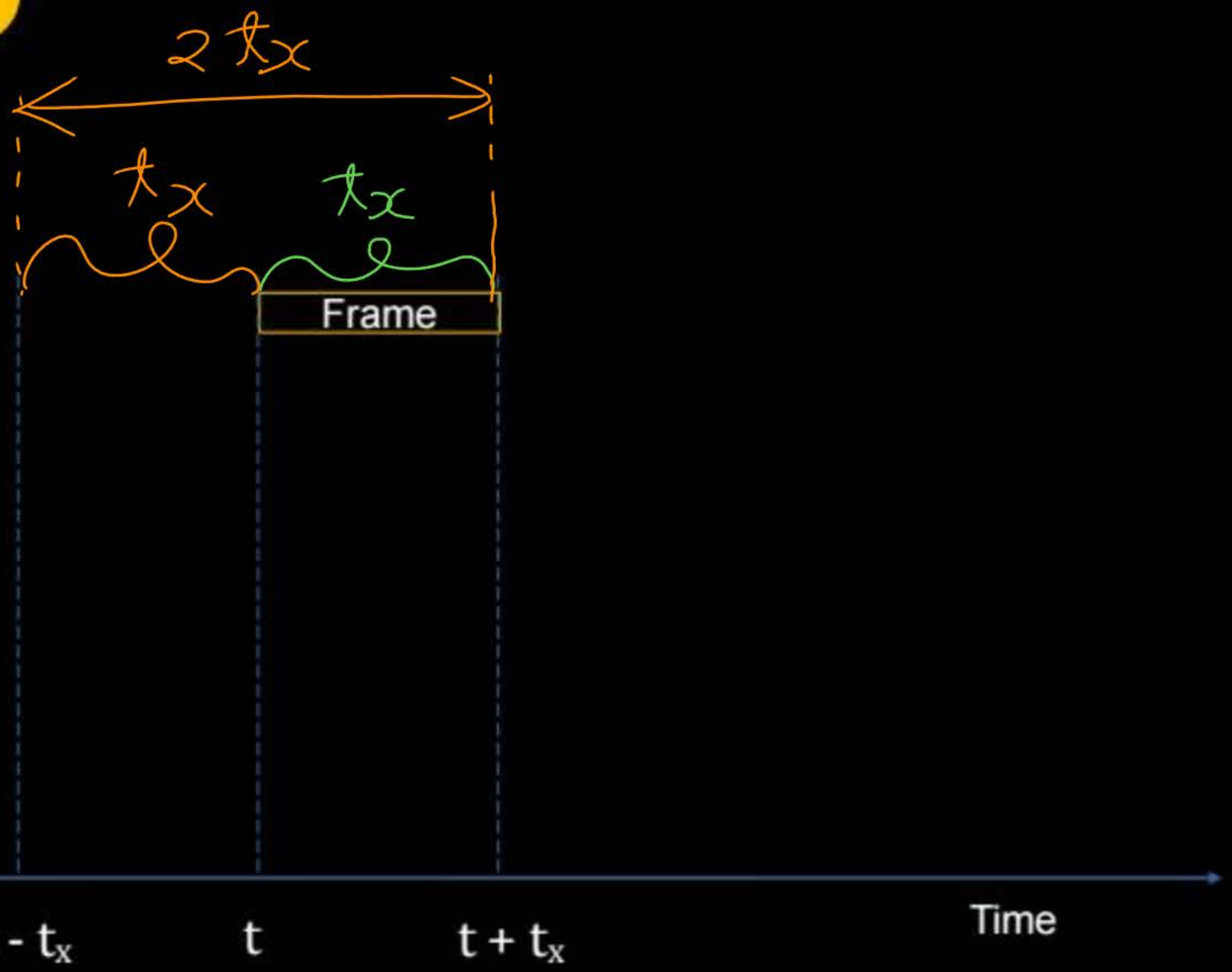
Topic : Pure ALOHA

A

B

C

D



Example 1 :-

Consider a network using the pure ALOHA medium access control protocol, where each frame is of length 2,000 bytes. The channel transmission rate is 1 Mbps. Calculate vulnerable time (in miliseconds) ?

Solution:-

Packet Size = 2000 Bytes = $16 * 10^3$ bits

Bandwidth = 1 Mbps = 10^6 bits / sec

$$t_x = \frac{\text{Packet Size}}{\text{Bandwidth}} = \frac{16 * 10^3 \text{ bits}}{10^6 \text{ bits / sec}} = 16 \text{ ms} = 16 * 10^{-3} \text{ sec}$$

Vulnerable time (Pure ALOHA) = $2 * t_x$ = 32 ms

Topic : Pure ALOHA

G : Mean number of transmissions per frame time

[Average number of frame transmitted in one frame transmission time]

S : Throughput per frame time

[Average number of frame transmitted successfully in one frame transmission time]

P = Probability that a frame does not involve in a collision

$$S = G * P$$

$$S \leq G$$

$$P = \frac{S}{G}$$

Example 2 :-

Consider a network using the pure ALOHA medium access control protocol, where each frame transmission delay is 10 milisecond. The aggregate number of transmissions across all the nodes is 5,000 frames per second. Calculate mean number of frame transmissions per frame time?

$t_x = 10\,ms$

G : mean no of frame transmissions per frame time

$G = 50$

1 sec $\longrightarrow$ 5000 frames

10^3 ms $\longrightarrow$ 5000 frames

1 ms $\longrightarrow$ $\frac{5000}{10^3}$ frame

$(t_x = 10ms) \longrightarrow 50$ frame

Ans = 50

Topic : Pure ALOHA

According to Poisson's distribution

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

then

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

$$S = G * P$$

Example 3 :-

Consider a network using the pure ALOHA medium access control protocol, where each frame transmission delay is 2 milisecond. The aggregate number of transmissions across all the nodes is 4,000 frames per second. Calculate throughput per frame time?

$t_x = 2ms$

1 sec $\longrightarrow$ 4000 frames

10^3 ms $\longrightarrow$ 4000 frames

1 ms $\longrightarrow$ 4 frames

$(t_x = 2ms) \longrightarrow$ 8 frame

$G = 8$

Pure Aloha

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

$= 8 * e^{-16}$

$= 9.002 * e^{-7}$

#Q. Consider a network using the pure ALOHA medium access control protocol, where each frame is of length 1,000 bits. The channel transmission rate is 1 Mbps (=10^6 bits per second). The aggregate number of transmissions across all the nodes (including new frame transmissions and retransmitted frames due to collisions) is modelled as a Poisson process with a rate of 1,000 frames per second. Throughput is defined as the average number of frames successfully transmitted per second. The throughput of the network (rounded to the nearest integer) is _____ .

[GATE 2021]

H.W.
IIT-B

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

$$\frac{dS}{dG} = \frac{d}{dG}\left[G \times e^{-2G}\right]$$

$$= G \times \frac{d}{dG} e^{-2G} + e^{-2G} \times \frac{d}{dG} G$$

$$= \left(G \times e^{-2G} \times -2\right) + e^{-2G}$$

$$= \left(e^{-2G} - 2G e^{-2G}\right)$$

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

$$\frac{dS}{dG} = 0$$

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

$$1 - 2G = 0$$

$$\boxed{G = \frac{1}{2}}$$

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

at $G = \frac{1}{2}$, max^m throughput per frame time

$$S = \frac{1}{2} \times e^{-2 \times \frac{1}{2}}$$

$$S = \frac{1}{2} \times e^{-1}$$

$$S = \frac{1}{2e}$$

[$e = 2.718281828$]

Topic : Pure ALOHA

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

Maximum throughput can achiev at $G = 0.5 = \frac{1}{2}$

Maximum throughput = $1/2e = 0.1839 = 18.39\ \%$

Topic : Slotted ALOHA

-> To improve the efficiency in Pure ALOHA

-> Divide the time into equal size slots
[Slot time = One frame transmission time] = t_x

-> Nodes are synchronized ✓

-> Wheneven a node has packet to transmit,
it will start transmission only at begin of slot

Topic : Slotted ALOHA

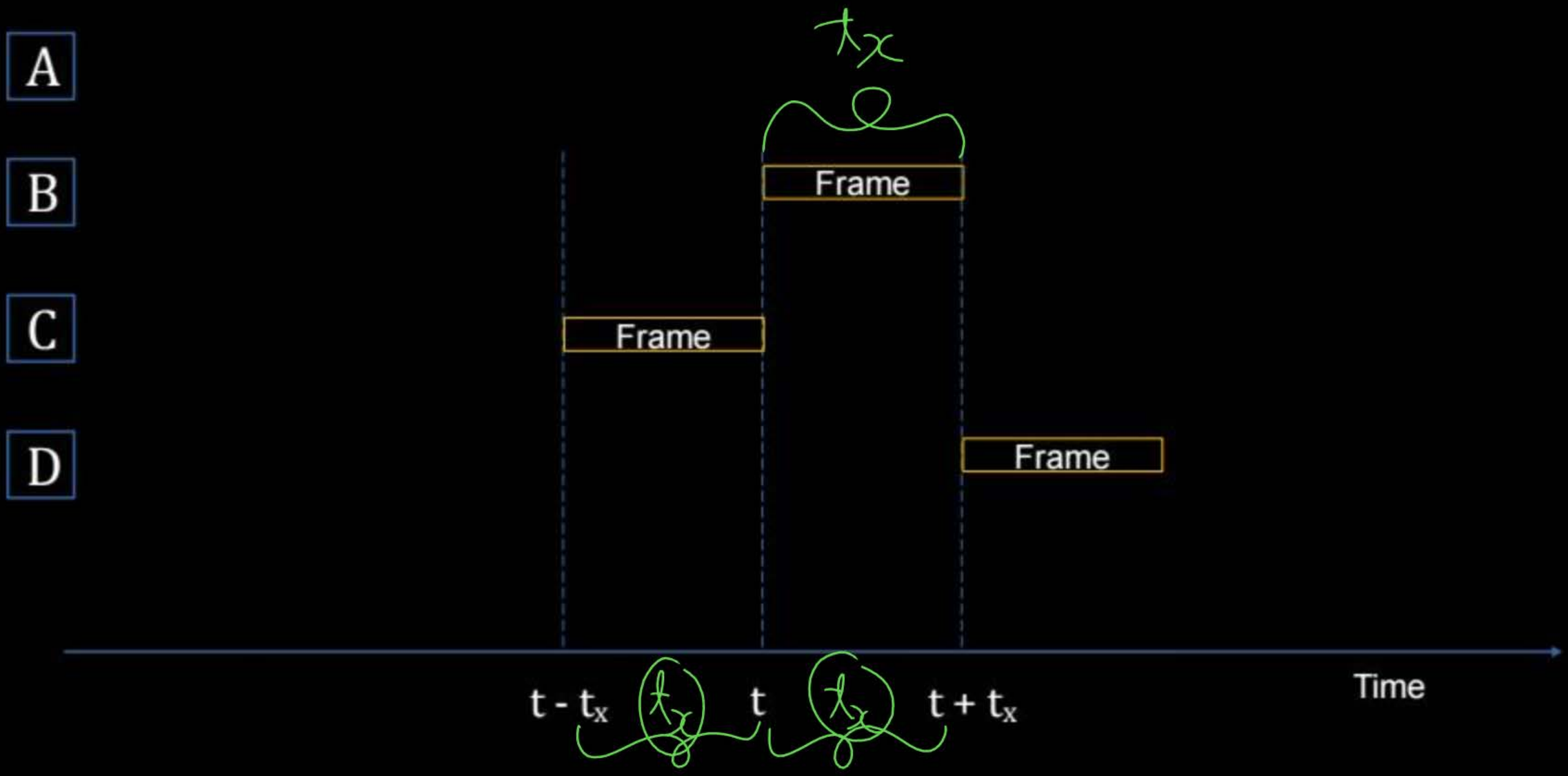
Vulnerable time

-> Time duration in which no transmission should done to avoid collision

Vulnerable time = Frame Transmission Time

$= t_x$

Topic : Slotted ALOHA



Example 4 :-

Consider a network using the slotted ALOHA medium access control protocol, where each frame is of length 2,000 bits. The channel transmission rate is 1 Kbps. Calculate vulnerable time (in seconds) ?

Solution:-

Packet Size = 2000 bits = $2 * 10^3$ bits

Bandwidth = 1 Kbps = 10^3 bits / sec

$$t_x = \frac{\text{Packet Size}}{\text{Bandwidth}} = \frac{2 * 10^3 \text{ bits}}{10^3 \text{ bits / sec}} = 2 \text{ Sec}$$

Vulnerable time (Slotted ALOHA) = t_x = 2 Sec

Ans = 2

Topic : Slotted ALOHA

According to Poisson's distribution

$$P = e^{-G} = \frac{1}{e^{G}}$$

Then

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

$$S = G * P$$

Example 5 :-

Consider a network using the slotted ALOHA medium access control protocol, where each frame is of length 4,000 bits. The channel transmission rate is 2 Mbps. The aggregate number of transmissions across all the nodes with a rate of 1,000 frames per second. Throughput is defined as the average number of frames successfully transmitted per frame time. The throughput of the network is _____.

H.W.

$$S = G \times e^{-G}$$

$$\frac{dS}{dG} = \frac{d}{dG}\left[G \times e^{-G}\right]$$

$$= G \times \frac{d}{dG} e^{-G} + e^{-G} \times \frac{d}{dG} G$$

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

$$= e^{-G} \times \left[1 - G\right]$$

$$\frac{dS}{dG} = 0$$

$$e^{-G} \times \left[1 - G\right] = 0$$

$$1 - G = 0$$

$$\boxed{G = 1}$$

Topic : Slotted ALOHA

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

Maximum throughput can achiev at $G = 1$

Maximum throughput = $1/e$ = 0.3678 = $36.78\,\%$

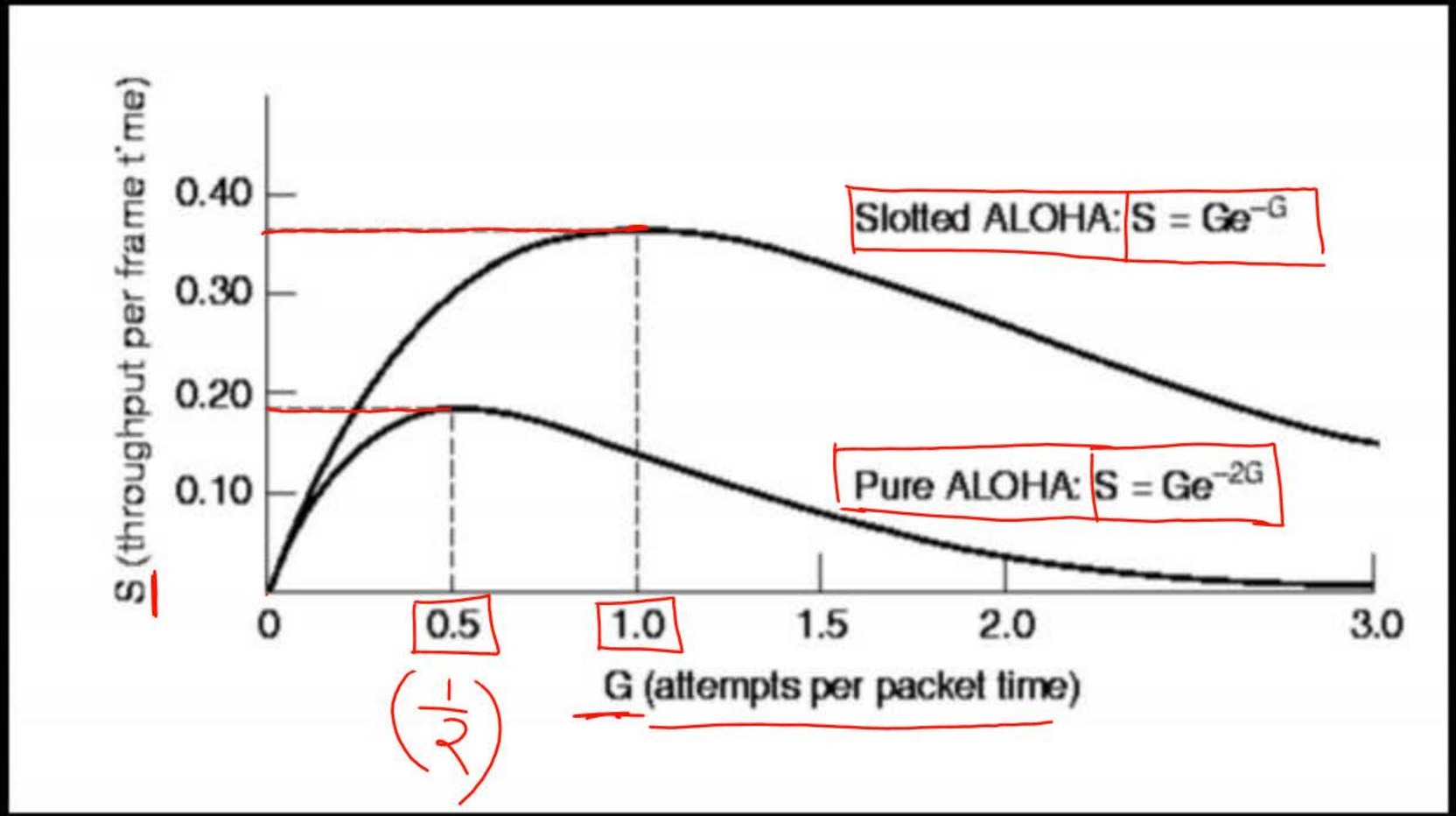
$S = G * e^{-G}$

$G = 1$

$S = 1 * e^{-1}$

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

Topic : Efficiency



2 mins Summary

Topic Pure ALOHA

Topic Slotted ALOHA

THANK - YOU