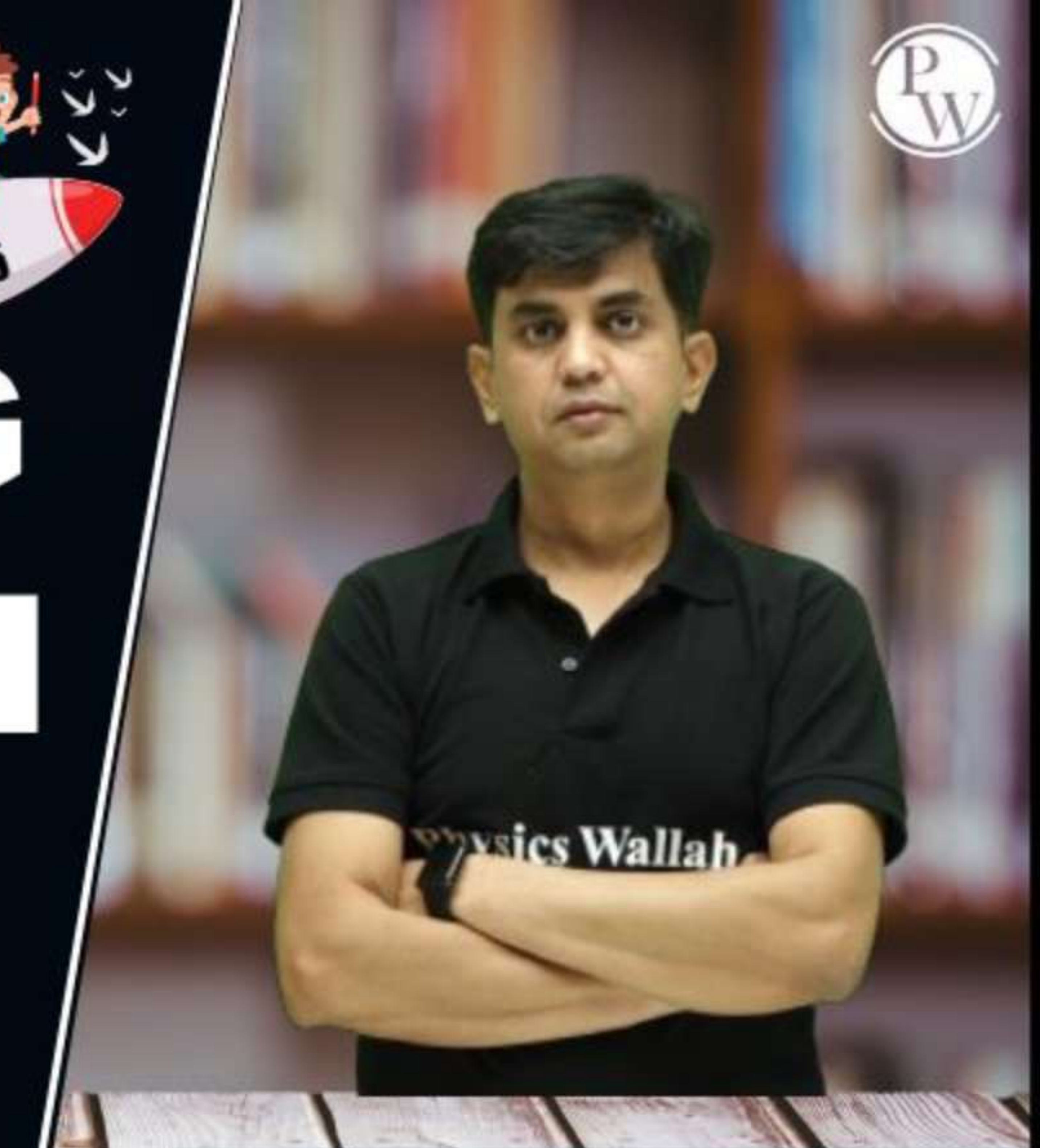
CS & IT ENGINEERING

Computer Network

MAC Layer

Lecture No. - 03



By - Abhishek Sir

Recap of Previous Lecture

Topic: Pure ALOHA

Topic: Slotted ALOHA

Topics to be Covered

Topic Slotted ALOHA

Topic CSMA/CD

ABOUT ME

Hello, I'm Abhishek

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#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]

Frame Size $= 10^3$ bits

Bandwidth $= 10^6$ bits/sec

$$t_x = \frac{10^3 \text{ bits}}{10^6 \text{ bits/sec}} = 10^{-3} \text{ sec}$$

G → Avg no. of transmission per frame time

1 sec → 10^3 frames

$(t_x = 10^{-3}$ sec$)$ → 1 frame

$$\boxed{G = 1}$$

Pure ALOHA

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

[put $G=1$]

$S = e^{-2}$

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

$S = 0.13533$

Avg. no of successful transmission per frame time

$(t_x = 10^{-3}\ sec) \longrightarrow 0.13533$ frame

$1\ sec \longrightarrow 0.13533 * 10^3$ frames

$1\ sec \longrightarrow 135.33$ frames

$\boxed{\text{Ans: 130 to 140}}$

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 ________.

Frame Size $= 4 * 10^3$ bits

Bandwidth $= 2 * 10^6$ bits/sec

$$t_x = \frac{4 * 10^3 \text{ bits}}{2 * 10^6 \text{ bits/sec}} = 2 * 10^{-3} \text{ sec}$$

1 sec $\longrightarrow 10^3$ frames

$(t_x = 2 * 10^{-3}$ sec$) \longrightarrow 10^3 * 2 * 10^{-3}$ frames

$\rightarrow$ 2 frames

$$\boxed{G = 2}$$

Slotted ALOHA

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

[put G=2]

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

$$= \frac{2}{e^{2}}$$

$$= 0.27066$$

$$\boxed{\text{Ans} = 0.270}$$

#Q. There are n stations in a slotted LAN. Each station attempts to transmit with a probability p in each time slot. What is the probability that perticular one station transmits in a given time slot?

(A) $(1 - p)^{(n-1)}$

(B) $p * (1 - p)^{(n-1)}$

(C) $n * p * (1 - p)^{(n-1)}$

(D) $1 - (1 - p)^{(n-1)}$

$\boxed{H_A}$ H_B H_C H_D

$$\boxed{p * (1-p) * (1-p) * (1-p)}$$

$$p * (1-p)^{(n-1)}$$

$\boxed{\text{Ans: B}}$

#Q. There are n stations in a slotted LAN. Each station attempts to transmit with a probability p in each time slot. What is the probability that ONLY one station transmits in a given time slot?

[GATE 2007]

(A) $n * p * (1 - p)^{(n-1)}$

(B) $(1 - p)^{(n-1)}$

(C) $p * (1 - p)^{(n-1)}$

(D) $1 - (1 - p)^{(n-1)}$

$H_A \quad H_B \quad H_C \quad H_D$

$$P*(1-P)^{(n-1)} + P*(1-P)^{(n-1)} + P*(1-P)^{(n-1)} + P*(1-P)^{(n-1)}$$

$$\boxed{n * P * (1-P)^{(n-1)}}$$

$\boxed{\text{Ans : A}}$

Topic : Slotted ALOHA Efficiency

-> Suppose N nodes with many frames to transmit

-> Each node transmits in slot with probablity p

Prabability that perticular node has success in a given slot $= p * (1 - p)^{(N-1)}$
(Throughout of Host)

Prabability that any node has success in a given slot $= N * p * (1 - p)^{(N-1)}$
(Throughout of Channel)

$$\frac{d}{dP}\left[N \times P \times (1-P)^{(N-1)}\right] = 0$$

$$N \times \left[P \times \frac{d}{dP}(1-P)^{(N-1)} + (1-P)^{(N-1)} \times \frac{d}{dP} P\right] = 0$$

$$\left[P \times (N-1) \times (1-P)^{(N-2)} \times (-1) + (1-P)^{(N-1)}\right] = 0$$

$$(1-P)^{(N-1)} \times \left[P \times (N-1) \times \frac{1}{(1-P)} \times (-1) + 1\right] = 0$$

$$1 - \frac{P \times (N-1)}{(1-P)} = 0$$

$$1 - \frac{P \times (N-1)}{(1-P)} = 0$$

$$P \times (N-1) = 1 - P$$

$$PN - P = 1 - P$$

$$PN = 1$$

$$\boxed{P = \frac{1}{N}}$$

Topic : Slotted ALOHA Efficiency

$$\boxed{\text{Efficiency} = N * p * (1 - p)^{(N-1)}}$$

Maximum efficiency can achiev at $\boxed{p = 1/N}$

Maximum efficiency $= \boxed{1/e} = \frac{1}{e}$

Throughput of Channel

$= N * p * (1 - p)^{(N-1)}$

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

$= \lim_{N \to \infty} \left(1 - \frac{1}{N}\right)^{(N-1)}$

$= \frac{1}{e}$

#Q. Consider a simplified time slotted MAC protocol, where each host always has data to send and transmits with probability $p = 0.2$ in every slot. There is no backoff and one frame can be transmitted in one slot. If more than one host transmits in the same slot, then the transmissions are unsuccessful due to collision. What is the maximum number of hosts which this protocol can support, if each host has to be provided a minimum through put of 0.16 frames per time slot?

[GATE 2004]

H.W.

(A) 1

(B) 2

(C) 3

(D) 4

#Q. Consider a LAN with four nodes S1, S2, S3 and S4. Time is divided into fixed-size slots, and a node can begin its transmission only at the beginning of a slot. A collision is said to have occurred if more than one node transmit in the same slot. The probabilities of generation of a frame in a time slot by S1, S2, S3 and S4 are 0.1, 0.2, 0.3 and 0.4, respectively. The probability of sending a frame in the first slot without any collision by any of these four stations is ______ .

$\underbrace{\text{[GATE 2015]}}_{\text{H.W.}}$

Topic : Exponential Backoff Algorithm

-> Binary Exponential Backoff Algoriithm

-> At k^{th} collision of perticular frame : [k = 1, 2, 3, ...]

if $k < 15$

then transmitter chooses a number R randomely in between 0 to $(2^i - 1)$ where $i = \min(k, 10)$

else

Abort the retransmission

-> Wait Time = $R * t_p$ OR $R * t_x$

-> Transmitter will retransmit the frame after Wait Time.

K	Range
1	0 or 1
2	0, 1, 2, 3
3	0, 1, 2, 3, 4, 5, 6, 7
4	0 15
5	0 31
6	0 63
⋮	
10	0 1023
11	0 1023
⋮	
14	0 1023

Topic : CSMA

→ Carrier Sense Multiple Access

→ Sense before transmit
[Sense the channel, before transmission]

→ if channel sensed idle : "transmit entire frame"

→ if channel sensed busy : "defer transmission"

Topic : CSMA

Different variations of CSMA protocols :

i. 1 – Persistent CSMA

ii. Non – Persistent CSMA

iii. p – Persistent CSMA

2 mins Summary

Topic Slotted ALOHA

Topic CSMA

THANK - YOU