CS & IT ENGINEERING

Computer Network

Flow Control

Lecture No. - 01

By - Abhishek Sir

Recap of Previous Lecture

Topic Checksum

Topic Hamming Distance

Topics to be Covered

Topic — Network delays

Topic — Stop-and-Wait Protocol

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

@ABHISHEKSIRCS_PW

#Q. An error correcting code has the following code words:

00000000, 00001111, 01010101, 10101010, 11110000

c_1 c_2 c_3 c_4 c_5

What is the maximum number of bit errors that can be corrected ?

[GATE 2007]

(A) 0

(B) 1

(C) 2

(D) 3

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

Solution :-

$$C_1 = 00000000$$
$$C_2 = 00001111$$
$$C_3 = 01010101$$
$$C_4 = 10101010$$
$$C_5 = 11110000$$

minimum Hamming Distance (D) =

Minimum[$d(C_1, C_2)$, $d(C_1, C_3)$, $d(C_1, C_4)$, $d(C_1, C_5)$,
$d(C_2, C_3)$, $d(C_2, C_4)$, $d(C_2, C_5)$,
$d(C_3, C_4)$, $d(C_3, C_5)$, $d(C_4, C_5)$]

→ $\boxed{D = 4}$

→ Receiver can correct upto Floor[(D-1)/2] bits error

$$\left\lfloor \frac{(D-1)}{2} \right\rfloor = \left\lfloor \frac{(4-1)}{2} \right\rfloor = 1$$

#Q. Consider a binary code that consists only four valid codewords as given below.

00000, 01011, 10101, 11110

c_1 c_2 c_3 c_4

Let minimum Hamming distance of code be $\boxed{p}$ and maximum number of erroneous bits that can be corrected by the code be $\boxed{q}$. The value of p and q are:

[GATE 2017]

(A) p = 3 and q = 1

(B) p = 3 and $\boxed{q = 2}$

(C) p = 4 and q = 1

(D) p = 4 and q = 2

$$d(c_1, c_2) = 3$$

$$\boxed{p < 3}$$

$$q = \left\lfloor \frac{(p-1)}{2} \right\rfloor = \left\lfloor \frac{(3-1)}{2} \right\rfloor = 1$$

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

Solution :-

$$C_1 = 00000$$
$$C_2 = 01011$$
$$C_3 = 10101$$
$$C_4 = 11110$$

minimum Hamming Distance (p) =

$$\text{Minimum}[\, d(C_1, C_2), d(C_1, C_3), d(C_1, C_4), d(C_2, C_3), d(C_2, C_4), d(C_3, C_4) \,]$$

→ $p = 3$

→ Receiver can correct upto Floor[(p-1)/2] bits error

→ $q = \text{Floor}[(p-1)/2]$

→ $q = 1$

Topic : Network Delays

Four types of network delays :

1. Transmission delay
2. Propagation delay
3. Queuing delay $\Rightarrow$ Best case : Always zero
4. Processing delay $\Rightarrow$ if given

Major

$\Rightarrow$ IP packet ----> Frame

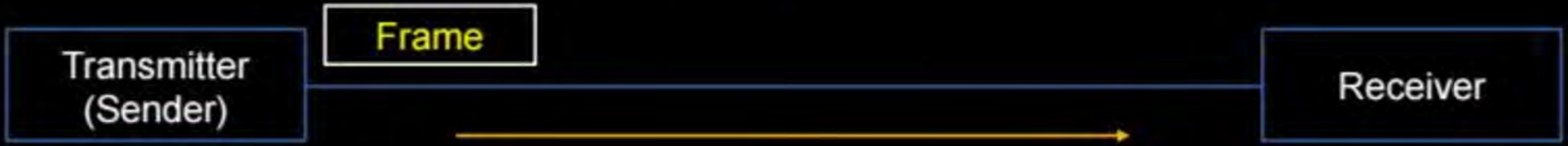
* Consider negligible overhead

Topic : Transmission Delay

→ Transmission Time / Delay $\boxed{[\,t_x\,]}$ (in seconds)

→ Time required to transmit a packet over a link

(Frame)



$$\text{Transmission Delay} = \frac{[\text{Packet Size}]}{[\text{Data Transfer Rate}]}$$

Topic : Packet Size

→ Packet Length or Frame Size

→ Number of bits or bytes in one packet

→ Size of Data (Digital) (Base-2)

1 KB = 2^{10} bytes

1 MB = 2^{20} bytes

1 GB = 2^{30} bytes

1 TB = 2^{40} bytes

B → Byte
b → Bit

Topic : Data Transfer Rate

→ Data Transfer Rate or Bandwidth

→ Number of bits or bytes transmitted per seconds ⟹ Bit Rate

→ Number or signals generated into channel per seconds ⟹ Baud Rate

→ Data Transfer Rate (Analog) (Base-10) [Count or Frequency]

1 Kbps = 10^3 bits per second

1 Mbps = 10^6 bits per second

1 Gbps = 10^9 bits per second

1 Tbps = 10^{12} bits per second

Topic : Network Delays

→ 1 second $= 10^3$ milliseconds (ms)

$= 10^6$ microseconds (μs)

$= 10^9$ nanoseconds (ns)

$= 10^{12}$ picoseconds (ps)

	Analog	Digital
1 K	10^3	2^{10}
1 M	10^6	2^{20}
1 G	10^9	2^{30}

Example 1 :-

#Q. Consider frame size is $\boxed{1000 \text{ bytes}}$ and bandwidth of a link is $\boxed{1 \text{ Mbps,}}$ then calculate transmission delay in milliseconds ?

Solution 1 :-

$\underbrace{\text{Frame Size}}$ = $\boxed{\text{1000 bytes}}$ = $\boxed{8 * 10^3 \text{ bits}}$

$\underbrace{\text{Bandwidth}}$ = $\boxed{\text{1 Mbps}}$ = $\boxed{10^6 \text{ bits / sec}}$

10^6 bits $\rightarrow$ 1 sec

$8*10^3$ bits $\rightarrow \dfrac{8*10^3}{10^6}$ sec

$$\underline{t_x} = \frac{\text{Frame Size}}{\text{Bandwidth}} = \frac{[8 * 10^3 \text{ bits}]}{[10^6 \text{ bits / sec}]} = 8*10^{-3} \text{ sec}$$

$= 8$ ms

$\boxed{\text{Ans} = 8}$

Example 2 :-

#Q. Consider packet size is $\boxed{4\ \text{KB}}$ and data transfer rate of a link is 256 Kbps, then Calculate transmission delay in milliseconds ?

Solution 2 :-

$\underbrace{\text{Packet Size}}$ = $\boxed{4\text{ KB}}$ = $\boxed{2^{15}\text{ bits}}$ $= 2^2 * 2^{10} * 8$ bits

$\underbrace{\text{Bandwidth}}$ = $\boxed{256\text{ Kbps}}$ = $\boxed{2^8 * 10^3 \text{ bits / sec}}$

$$t_x = \frac{\text{Packet Size}}{\text{Bandwidth}} = \frac{2^{15}\ \cancel{\text{bits}}}{2^8 * 10^3\ \cancel{\text{bits}} / \text{sec}} = 2^7 * 10^{-3} \text{ sec}$$

$= 128$ ms

$\boxed{\text{Ans} = 128}$

Topic : Propagation Delay

→ Propagation Time / Delay $[\, t_p \,]$ (in seconds)

→ Time required to travel a signal (bit) from one end to other end of a link

→ One-way

$$\text{Propagation Delay} = \frac{\text{Distance}}{\text{Signal Speed}}$$

Example 3 :-

#Q. Consider distance between two host is 200 meter and signal speed of a link is 10^5 meter per second then calculate propagation delay in milliseconds ?

Solution 3 :-

Distance $= \boxed{200 \text{ meter}}$

Signal Speed $= \boxed{10^5 \text{ meter / sec}}$

$$t_p = \frac{\text{Distance}}{\text{Signal Speed}} = \frac{200\ \cancel{\text{meter}}}{10^5\ \cancel{\text{meter}} / \text{sec}} = 2 * 10^{-3} \text{ sec}$$

$$= 2 \text{ ms}$$

$$\boxed{\text{Ans} = 2}$$

Example 4 :-

#Q. Consider distance between two host is $\boxed{2 \text{ Km}}$ and signal speed of a link is 5 microsecond per Km then calculate propagation delay in microseconds ?

$$\cancel{\boxed{t_p = \frac{2\,\text{Km}}{5\,\mu s/\text{Km}}}}$$

Solution 4 :-

Distance $= \boxed{2\ Km}$

Signal Speed $= \boxed{5\ \mu s / Km}$

$$t_p = \underbrace{\text{Distance}}_{} * \underbrace{\text{Signal Speed}}_{} = \underbrace{2\ \cancel{Km}}_{} * \underbrace{5\ \mu s / \cancel{Km}}_{} = \boxed{10\ \mu s}$$

$\boxed{Ans = 10}$

Topic : Propagation Delay

→ if signal speed given in "meter per second"

$$\text{Propagation Delay} = \frac{\text{Distance}}{\text{Signal Speed}}$$

→ if signal speed given in "second per meter"

$$\text{Propagation Delay} = \text{Distance} \times \text{Signal Speed}$$

Topic : Round Trip Propagation Delay

→ Two-way

→ 2 * Propagation Time $\boxed{[\,2 * t_p\,]}$

[MCQ] (IIT-R, H.W.) [GATE-2017][2 Mark]

#Q. Consider two hosts X and Y, connected by a single direct link of rate 10^6 bits/sec. The distance between the two hosts is 10,000 km and the propagation speed along the link is 2×10^8 m/s. Hosts X send a file of 50,000 bytes as one large message to hosts Y continuously. Let the transmission and propagation delays be p milliseconds and q milliseconds, respectively. Then the vales of p and q are :

(A) p = 50 and q = 100

(B) p = 50 and q = 400

(C) p = 100 and q = 50

(D) p = 400 and q = 50

Topic : End-to-End Delay

1. Send Buffer (window/queue)
2. Receive Buffer

1. Send Buffer
2. Receive Buffer

Topic : End-to-End Delay

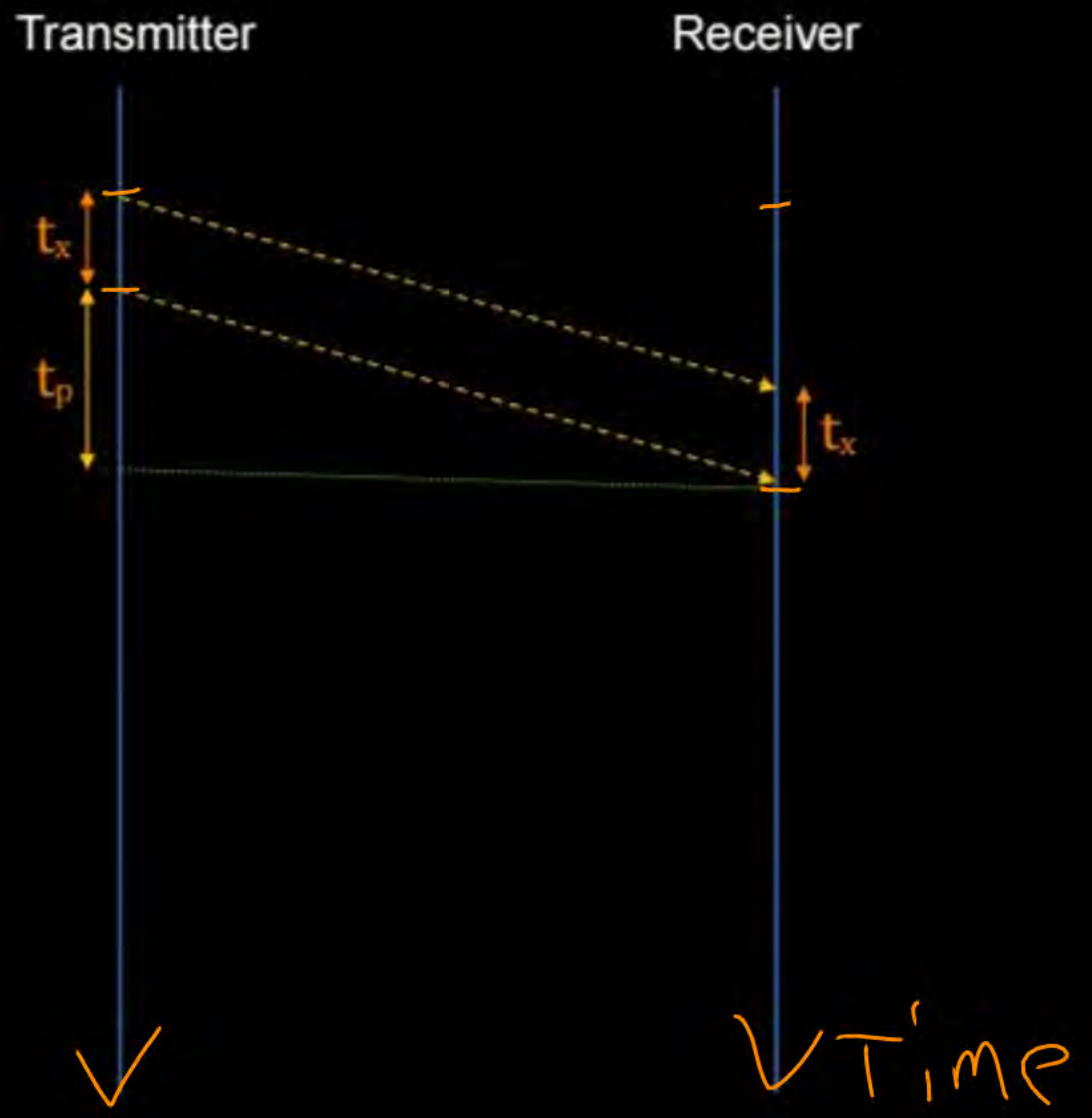
→ One-way delay ✓

→ Time required for a packet to be transmitted from Transmitter to Receiver

End-to-end delay = Transmission delay + Propagation delay

$$= (t_x + t_p)$$

Topic : End-to-End Delay



[NAT] IIT-KGP, H.W. [GATE-2022][2 Mark]

#Q. Consider a 100 Mbps link between an earth station (sender) and a satellite (receiver) at an altitude of 2100 km. The signal propagates at a speed of 3×10^8 m/s. The time taken (in milliseconds, rounded off to two decimal places) for the receiver to completely receive a packet of 1000 bytes transmitted by the sender is ______ .

Topic : Network Delays

CASE I :

$$\boxed{\text{Transmission delay} < \text{Propagation delay}}$$

Topic : Network Delays

CASE II :

$$\boxed{\text{Transmission delay} = \text{Propagation delay}}$$

Topic : Network Delays

CASE III :

$\underbrace{\text{Transmission delay}} > \underbrace{\text{Propagation delay}}$

Topic : Queuing Delay

(Receiving window)

→ Waiting time of a packet at input buffer, before processing

→ Cannot be determined

→ if not given, consider negligible

In Best Case, consider zero.

Topic : Processing Delay

→ Time required to process a packet after receiving

→ Based on CPU processing speed and packet size

→ if not given, consider negligible

Topic : Flow Control

→ Synchronization between transmitter and receiver to control the flow

→ Flow Control Protocols for :

1. Noiseless Channel $\Longrightarrow$ Error Rate = 0
2. Noisy Channel

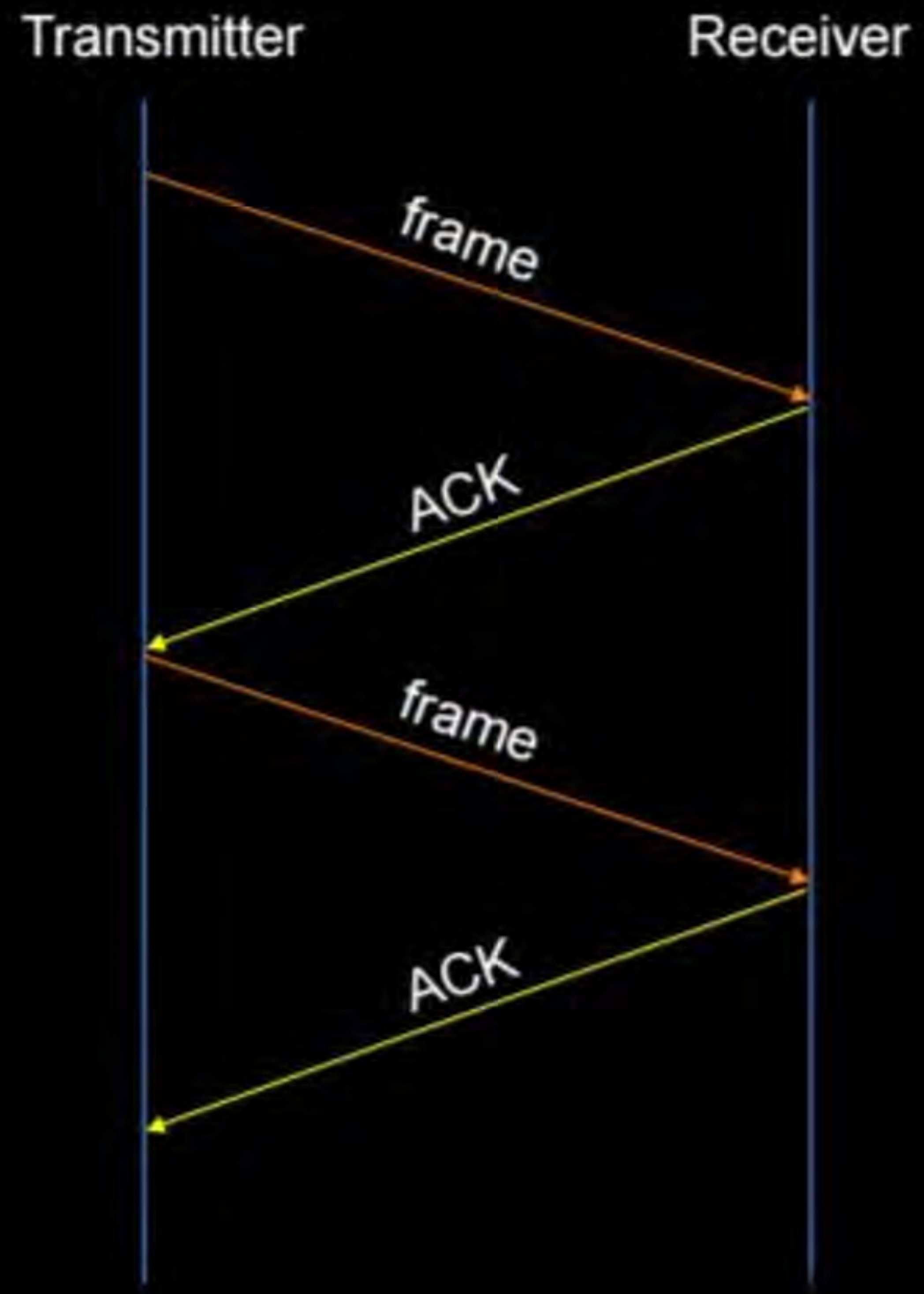
Topic : Stop-and-Wait Protocol

⟹ Noiseless Channel

→ Transmitter transmit one frame and wait for ACK of it

→ Receiver transmit acknowledgment for every received frame

→ Transmitter transmit next frame only after receiving ACK of transmitted frame



2 mins Summary

Topic Network delays

Topic Stop-and-Wait Protocol

THANK - YOU

@ABHISHEKSIRCS_PW