CS & IT ENGINEERING

Computer Network

Flow Control

Lecture No. - 02

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Recap of Previous Lecture

Topic Network delays

Topic Stop-and-Wait Protocol

Topics to be Covered

Topic Stop-and-Wait Protocol

Topic Stop-and-Wait ARQ

[MCQ] [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

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

Solution:-

$\underbrace{\text{Packet Size}} = \boxed{50{,}000 \text{ bytes}} = \boxed{4 * 10^5 \text{ bits}}$

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

$$\underline{p} = \frac{\text{Packet Size}}{\text{Bandwidth}} = \frac{4 * 10^5 \cancel{\text{bits}}}{\underline{10^6} \cancel{\text{bits}} / \underline{\text{sec}}} = 400\text{ms}$$

$\underbrace{\text{Distance}}$ $= \boxed{10{,}000 \text{ Km}} = \boxed{10^7 \text{ m}}$

$\underbrace{\text{Signal Speed}}$ $= \boxed{2 \times 10^8 \text{ m/s}}$

$$q = \frac{\text{Distance}}{\text{Signal Speed}} = \frac{10^7 \text{ m}}{2 \times 10^8 \text{ m/s}} = 50 \text{ ms}$$

[NAT] [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 ______ .

Solution:-

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

Bandwidth = 100 Mbps = $\boxed{10^8 \text{ bits / sec}}$

$$t_x = \frac{\text{Packet Size}}{\text{Bandwidth}} = \frac{8 * 10^3 \text{ bits}}{10^8 \text{ bits / sec}} = 0.08 \text{ ms}$$

Distance = $\boxed{2100 \text{ Km}}$ = $\boxed{21 * 10^5 \text{ m}}$

Signal Speed = 3×10^8 m/s

$$t_p = \frac{\text{Distance}}{\text{Signal Speed}} = \frac{21 * 10^5 \cancel{m}}{3 \times 10^8 \cancel{m}/s} = 7 \text{ ms}$$

End-to-end delay = $(t_x + t_p)$

$= (7 + 0.08)$ ms

$= 7.08$ ms

IIT KGP

Ans =

7.07 to 7.09

Topic : Flow Control

→ Synchronization between transmitter and receiver to control the flow

→ Flow Control Protocols for :

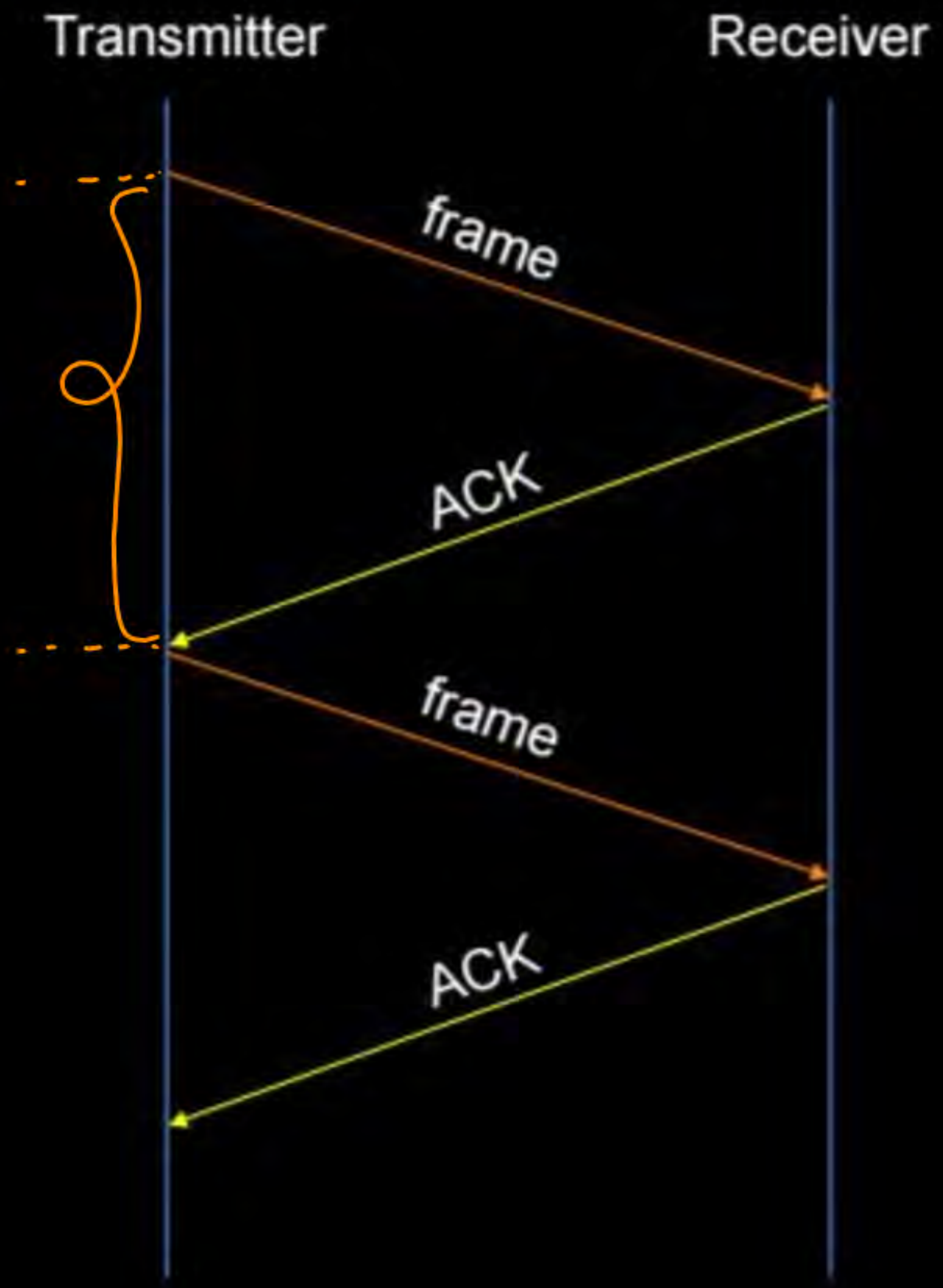
1. Noiseless Channel
2. Noisy Channel

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



Topic : Cycle Time

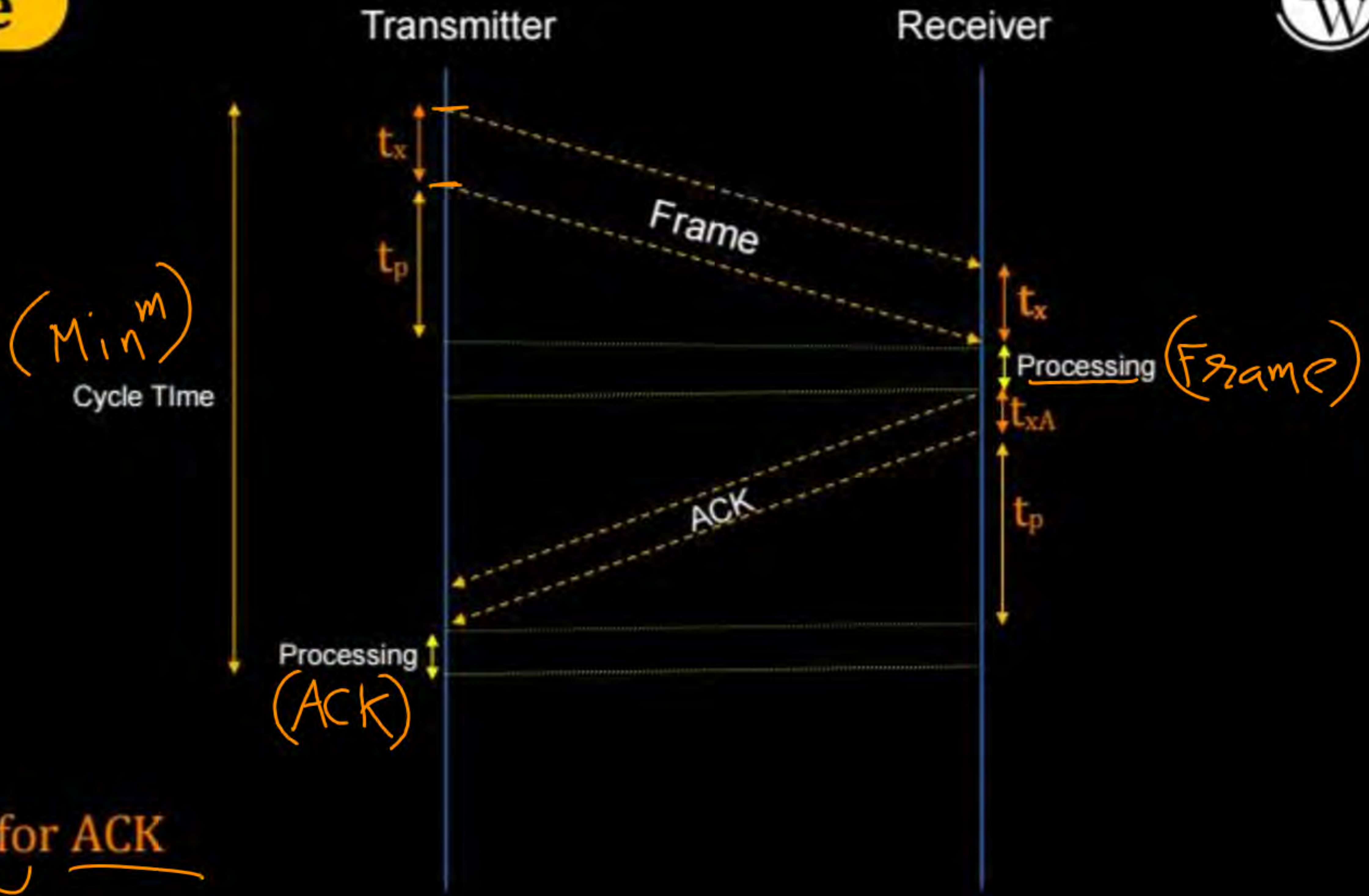
Cycle time = Transmission delay + Propagation delay

+ Queuing delay at receiver + Processing delay by receiver for frame

+ Transmission delay for ACK + Propagation delay

+ Queuing delay at transmitter + Processing delay by transmitter for ACK

Topic : Cycle Time



$$t_{xA} = \frac{\text{ACK Size}}{\text{Bandwidth}}$$

t_{xA} : Transmission delay for ACK

$\boxed{t_{xA} << t_x}$

Topic : Cycle Time

Cycle time = Transmission delay + Propagation delay
+ Queuing delay at receiver + Processing delay by receiver for frame
+ Transmission delay for ACK + Propagation delay
+ Queuing delay at transmitter + Processing delay by transmitter for ACK

Suppose queuing and processing delays are negligible at both the end.

Cycle time = Transmission delay + Propagation delay
+ Transmission delay for ACK + Propagation delay

$= (t_x + t_p) + (t_{xA} + t_p)$

Topic : Cycle Time

$$\boxed{\begin{aligned}\text{Cycle time} = {} & \text{Transmission delay} + \text{Propagation delay} \\ & + \text{Transmission delay for ACK} + \text{Propagation delay}\end{aligned}}$$

Suppose Transmission delay for ACK is also negligible.

$$\boxed{\text{Cycle time} = \text{Transmission delay} + \text{Round Trip Propagation delay}}$$

$$= (t_x + 2t_p)$$

Topic : Round Trip Delay

For Data Link Layer :

Round Trip Delay / Time (RTT) = Cycle time

For Transport Layer :

Round Trip Delay / Time (RTT) = Round Trip Propagation delay

$= 2t_p$

Topic : Efficiency

$$\boxed{0 < \eta < 1}$$

→ For Stop-and-Wait Protocol :

$$\text{Efficiency } (\eta) = \left[\frac{\text{Transmission delay}}{\text{Cycle Time}}\right] = \frac{t_x}{\text{cycle time}}$$

$$\text{Efficiency } (\eta) = \left[\frac{\text{Transmission delay}}{\text{Cycle Time}}\right] * 100\ \%$$

$$\text{cycle time} = (t_x + 2t_p)$$

$$\eta = \frac{t_x}{\text{cycle time}}$$

$$= \frac{t_x}{t_x + 2t_p}$$

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

$a \rightarrow$ normalized propagation delay

$$\left[a = \frac{t_p}{t_x}\right]$$

Example 5 :-

#Q. Consider two hosts A and B directly connected through point to point link using stop and wait protocol for flow control. Suppose packet size is 1000 bytes, link bandwidth is 1 Mbps, distance is 2 Km and signal speed is 4 millisecond per kilometer. Calculate efficiency in percent (round off to nearest integer) ?

Link utilization

Solution 5 :-

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

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

$$t_x = \frac{\text{Packet Size}}{\text{Bandwidth}} = \frac{8 * 10^3 \ \cancel{\text{bits}}}{10^6 \ \cancel{\text{bits}} \text{ / sec}} = 8 * 10^{-3} \text{ sec}$$

$$= 8 \text{ ms}$$

Distance $=\boxed{2\text{ Km}}$

Signal Speed $=\boxed{4\text{ ms/Km}}$

t_p = Distance * Signal Speed = 2km * 4ms/km

= 8ms

Cycle time $= (t_x + 2 * t_p) = (8+2*8)\ ms = 24\ ms$

For Stop-and-Wait Protocol :

$$\text{Efficiency } (\eta) = \frac{\text{Transmission delay}}{\text{Cycle Time}} * 100\ \%$$

$$= \left(\frac{8\ ms}{24\ ms}\right) * 100\%$$

$$= 33.33\% \approx 33\%$$

$\boxed{Ans = 33}$

[MCQ] IIT-R, H.W. [GATE-2025] [2 Mark]

#Q. Suppose we are transmitting frames between two nodes using Stop-and-Wait protocol. The frame size is 3000 bits. The transmission rate of the channel is 2000 bps (bits/second) and the propagation delay between the two nodes is 100 milliseconds. Assume that the processing times at the source and destination are negligible. Also, assume that the size of the acknowledgement packet is negligible. Which ONE of the following most accurately gives the channel utilization for the above scenario in percentage?

A. 88.23

B. 93.75

C. 85.44

D. 66.67

Topic : Efficiency

→ To achieve 100% utilization ($\eta = 1$) in Stop-and-Wait Protocol

$$\text{Efficiency } (\eta) = \frac{\text{Transmission delay}}{\text{Cycle Time}}$$

$$\text{Cycle Time} = \text{Transmission delay}$$

→ 100% utilization ($\eta = 1$) in Stop-and-Wait Protocol
[Only when propagation delay and other latency are Zero]

Topic : Efficiency

→ To achieve 50% utilization ($\eta = 1/2$) in Stop-and-Wait Protocol

$$\boxed{\text{Efficiency } (\eta) = \frac{\text{Transmission delay}}{\text{Cycle Time}}}$$

$$\boxed{\text{Cycle Time} = 2 * \text{Transmission delay}}$$

Example 6 :-

#Q. Consider two hosts A and B directly connected through point to point link using stop and wait protocol for flow control. Suppose link bandwidth is 2 Mbps and one-way propagation delay is 8 millisecond. To achieve a link utilization of at least 50% the minimum frame size is ______ bytes.

Solution 6 :-

Bandwidth = $\boxed{2 \text{ Mbps}}$ = $\boxed{2 * 10^6 \text{ bits / sec}}$

t_p = $\boxed{8 \text{ ms}}$ = $\boxed{8 * 10^{-3} \text{ Sec}}$

To achieve 50% utilization in Stop-and-Wait Protocol

$$\boxed{\text{Cycle time} = 2 * t_x}$$

$$(t_x + 2 * t_p) = 2 * t_x$$

$$\boxed{t_x = 2 * t_p}$$

$$\boxed{t_x = 2 * t_p}$$

$$\text{Frame Size} = (2 * t_p) * \text{Bandwidth}$$

$$= (2 * 8 * 10^{-3}\,\cancel{sec}) * 2 * 10^{6}\ \text{bits}/\cancel{sec}$$

$$= 32 * 10^{3}\ \text{bits}$$

$$= 4000\ \text{bytes}$$

$$\boxed{\text{Ans} = 4000}$$

Topic : Efficiency

→ To achieve 25% utilization ($\eta = 1/4$) in Stop-and-Wait protocol

$$\text{Efficiency } (\eta) = \frac{\text{Transmission delay}}{\text{Cycle Time}}$$

$$\text{Cycle Time} = 4 * \text{Transmission delay}$$

[NAT] IIT-K, H.W. [GATE-2015][2 Mark]

#Q. A link has a transmission speed of 10^6 bits/sec. It uses data packets of size 1000 bytes each. Assume that the acknowledgment has negligible transmission delay, and that its propagation delay is the same as the data propagation delay. Also assume that the processing delays at nodes are negligible. The efficiency of the stop-and-wait protocol in this setup is exactly 25%. The value of the one-way propagation delay (in milliseconds) is ________.

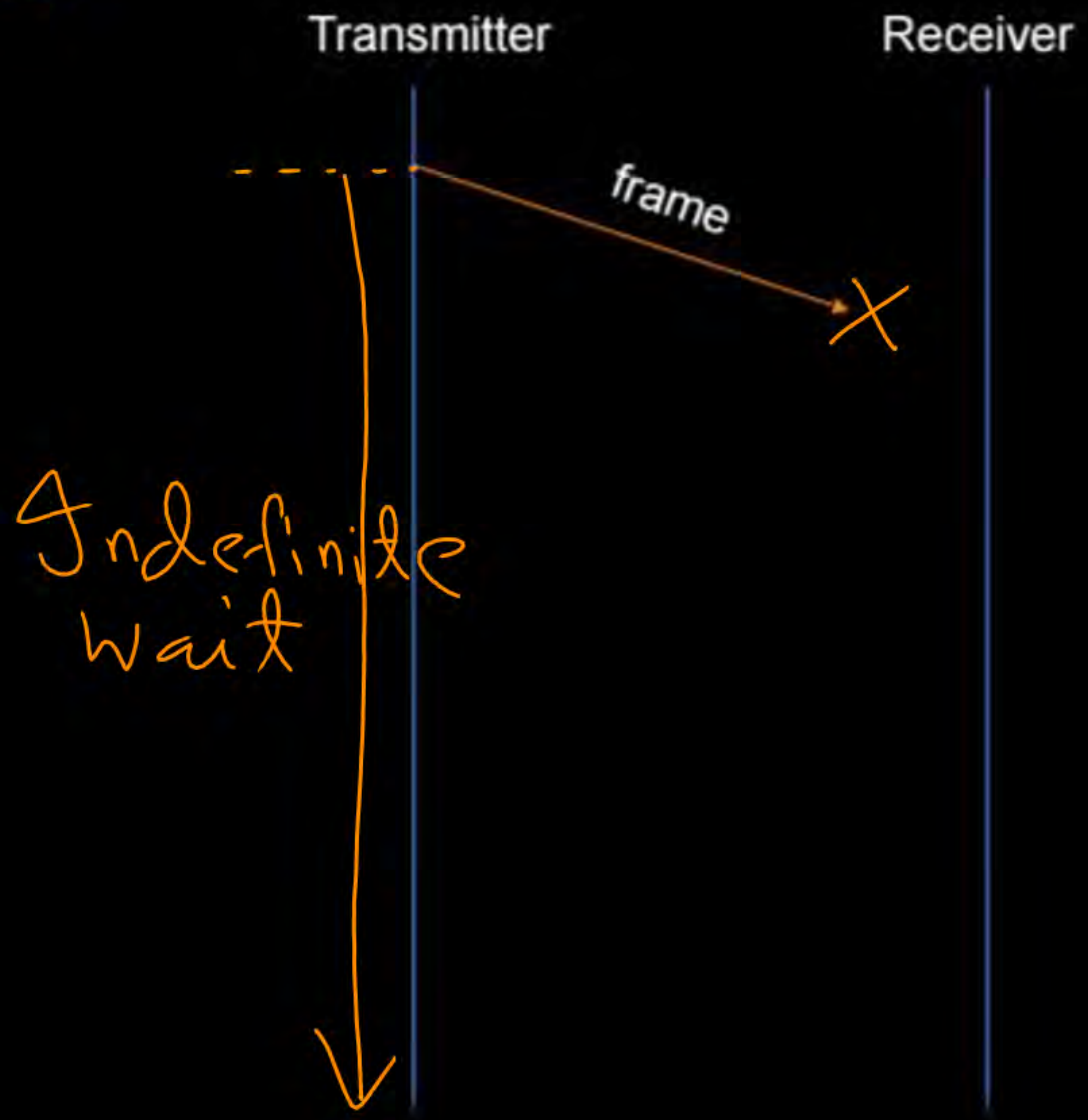
Topic : Stop-and-Wait Protocol

→ In case of, Noisy Channel

Case I :

→ Either frame or ACK,
gets lost in the channel

→ Transmitter may goes in
indefinite wait for ACK



Topic : Stop-and-Wait Protocol

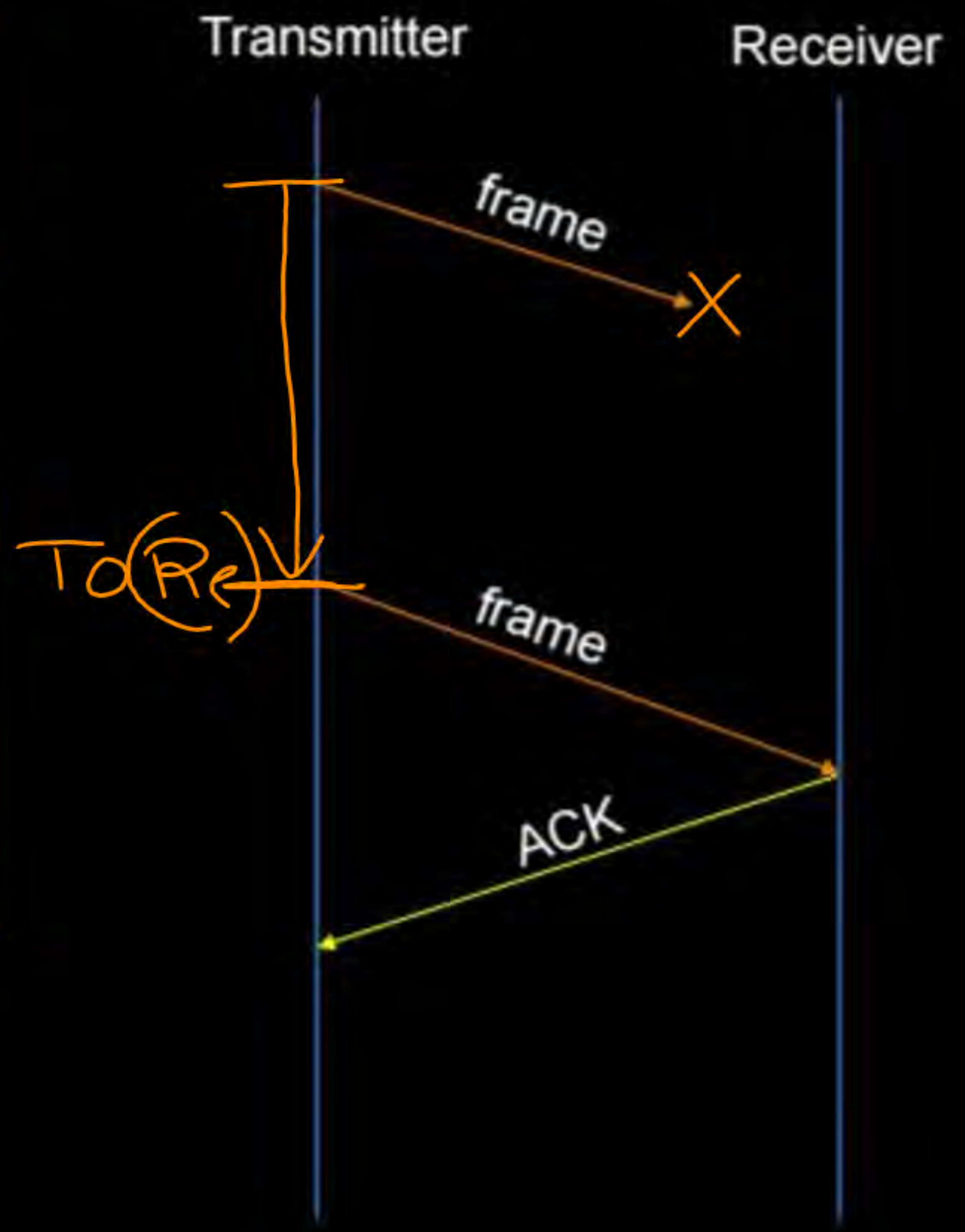
→ To avoid "indefinite wait for ACK", transmitter uses "Automatic Repeat Request" (ARQ)

Automatic Repeat Request (ARQ) :

→ Transmitter wait for ACK till time-out

→ After time-out, transmitter retransmit the frame

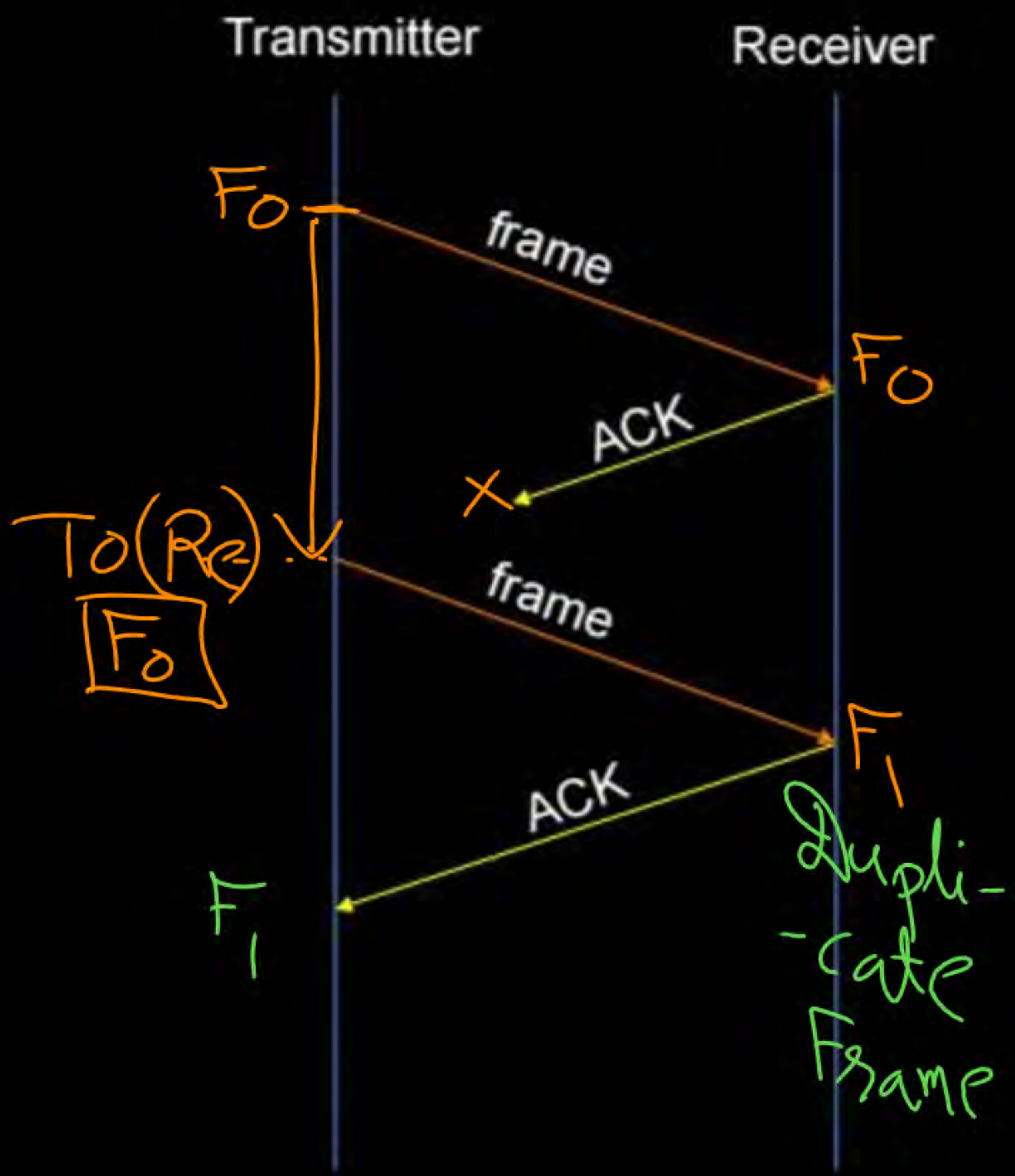
TO Value > cycle time



Topic : Stop-and-Wait ARQ

Case II :

→ Receiver not able to identify duplicate frame



Topic : Stop-and-Wait ARQ

→ To identify duplicate frame at receiver transmitter uses "Sequence Number" field in the frame

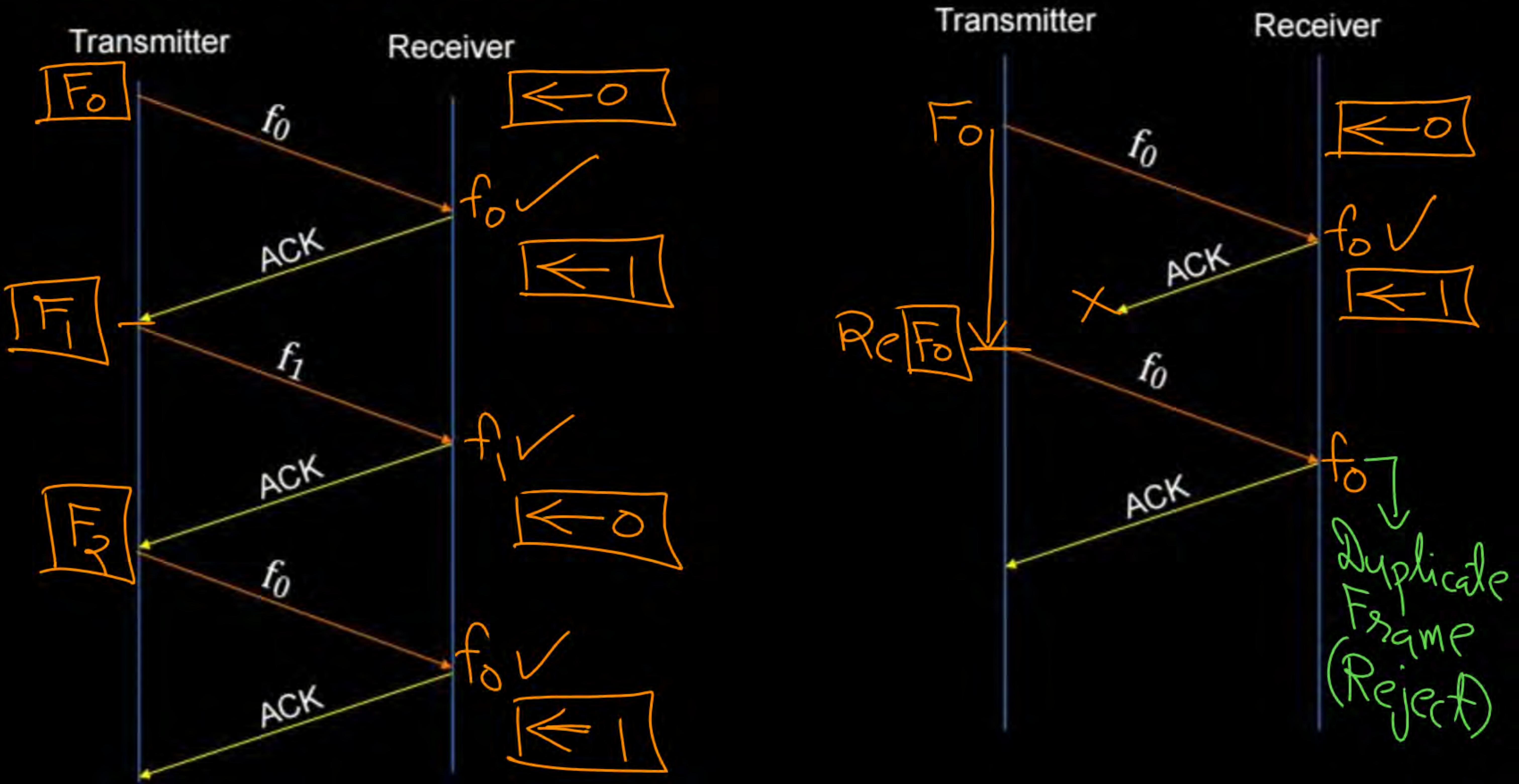
⇒ one bit sequence no.

Sequence Number ← (Frame Number) mod 2

F_0	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}
f_0	f_1	f_0	f_1	f_0	f_1	f_0	f_1					

→ Stop-and-Wait ARQ is also known as "Alternate bit protocol"

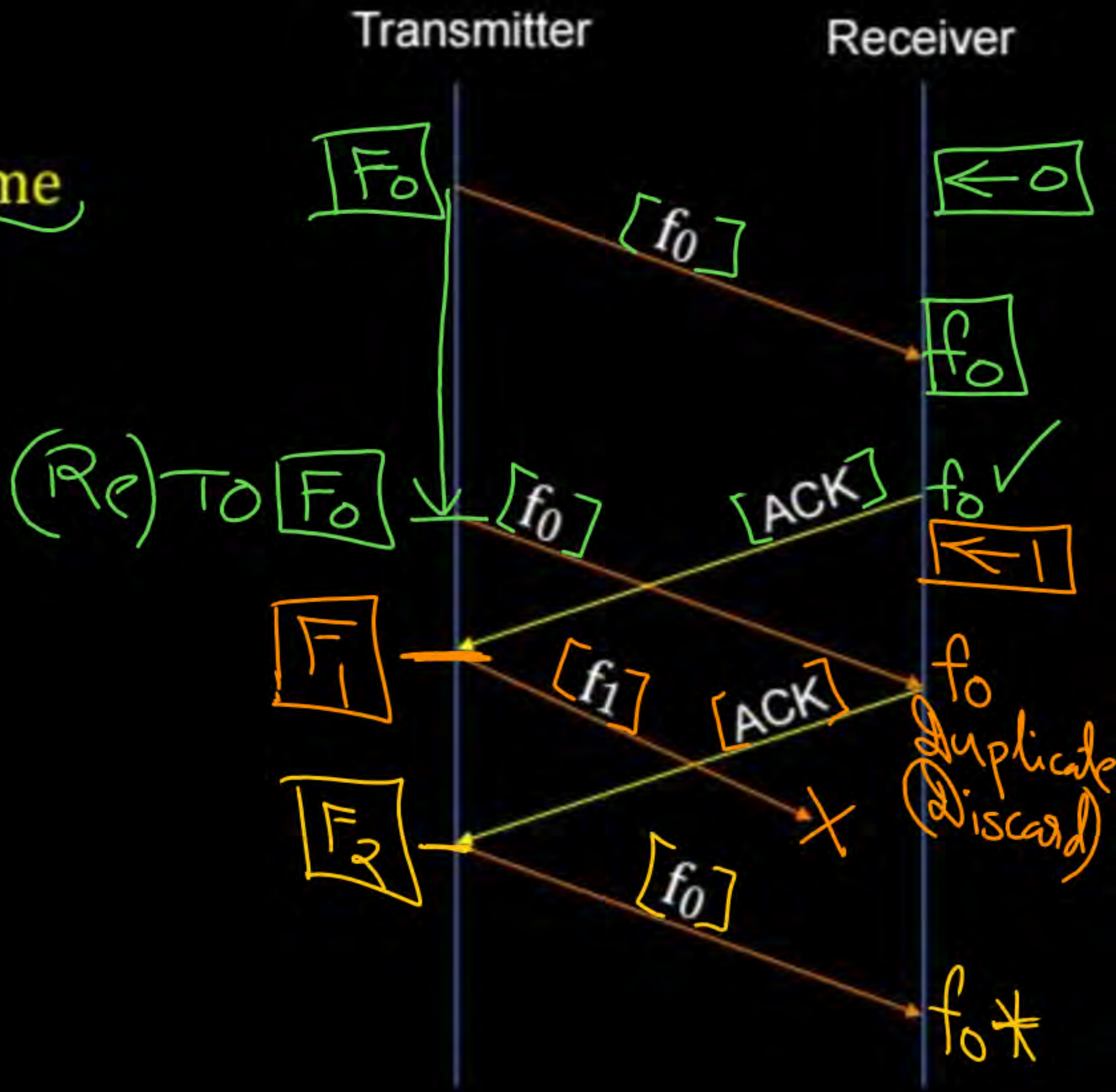
Topic : Stop-and-Wait ARQ



Topic : Stop-and-Wait ARQ

Case III :

→ Transmitter may missed to retransmit lost frame

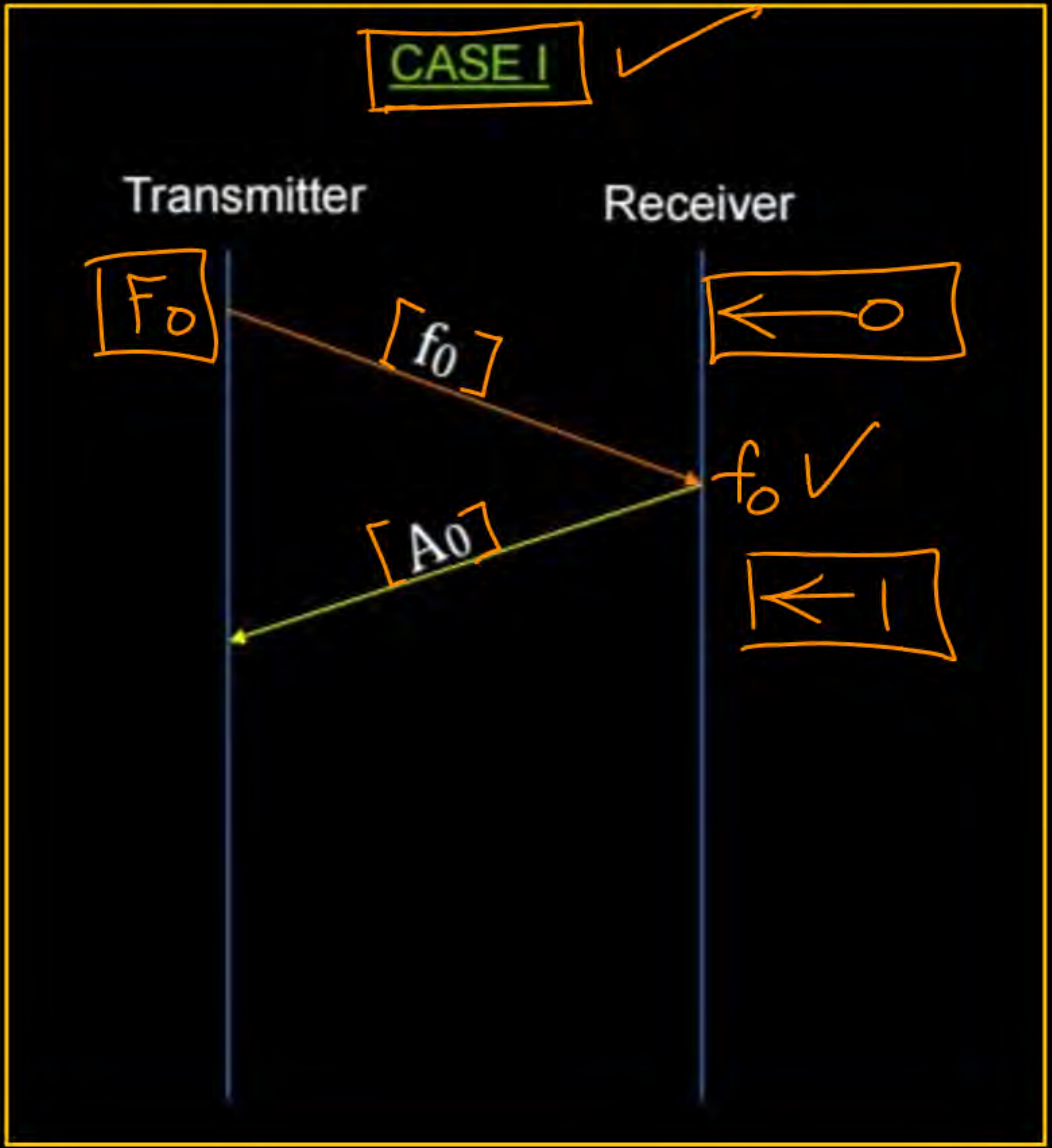


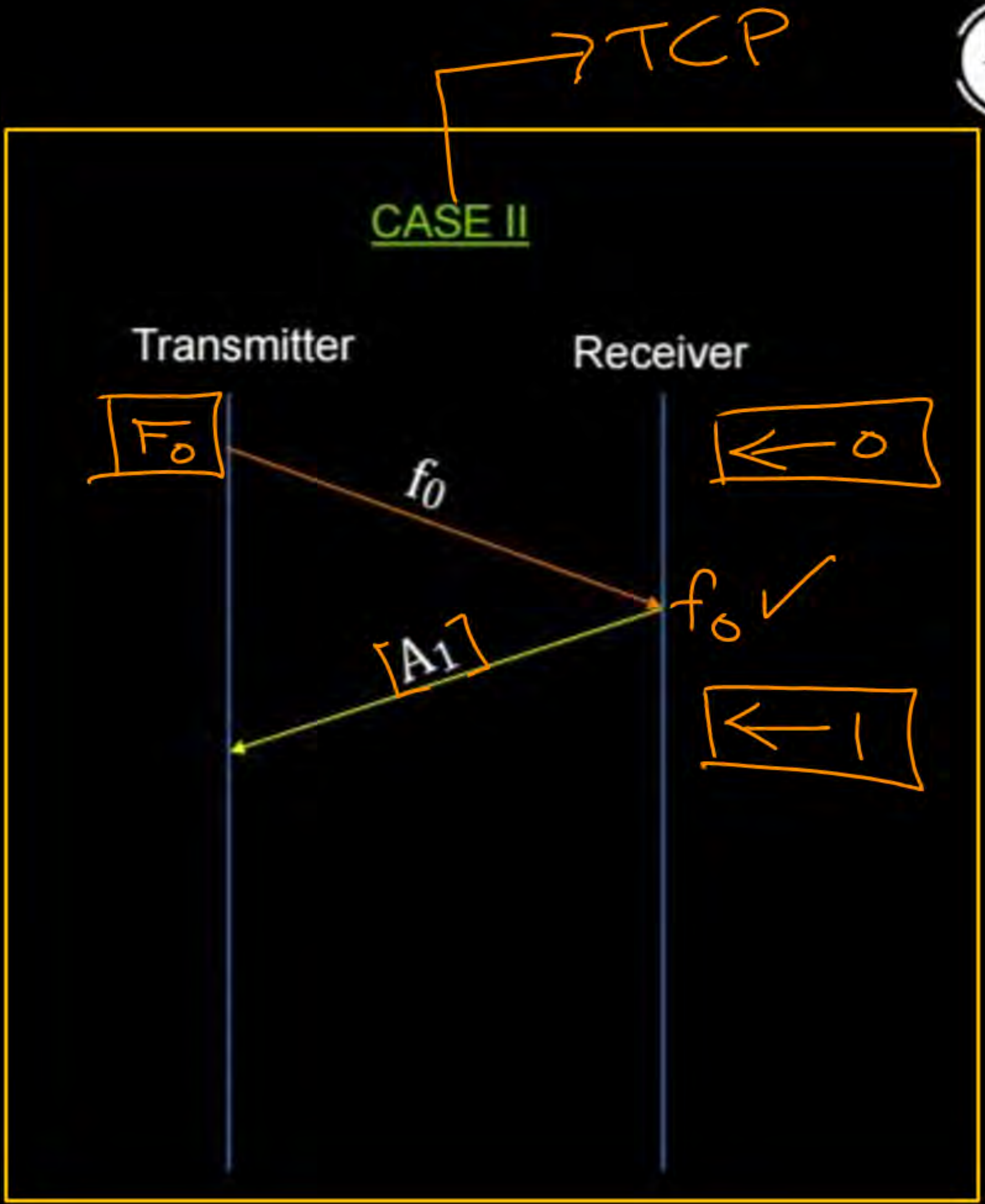
Topic : Stop-and-Wait ARQ

→ To ensure retransmission of every lost frame receiver uses "Acknowledgment Number" in the ACK

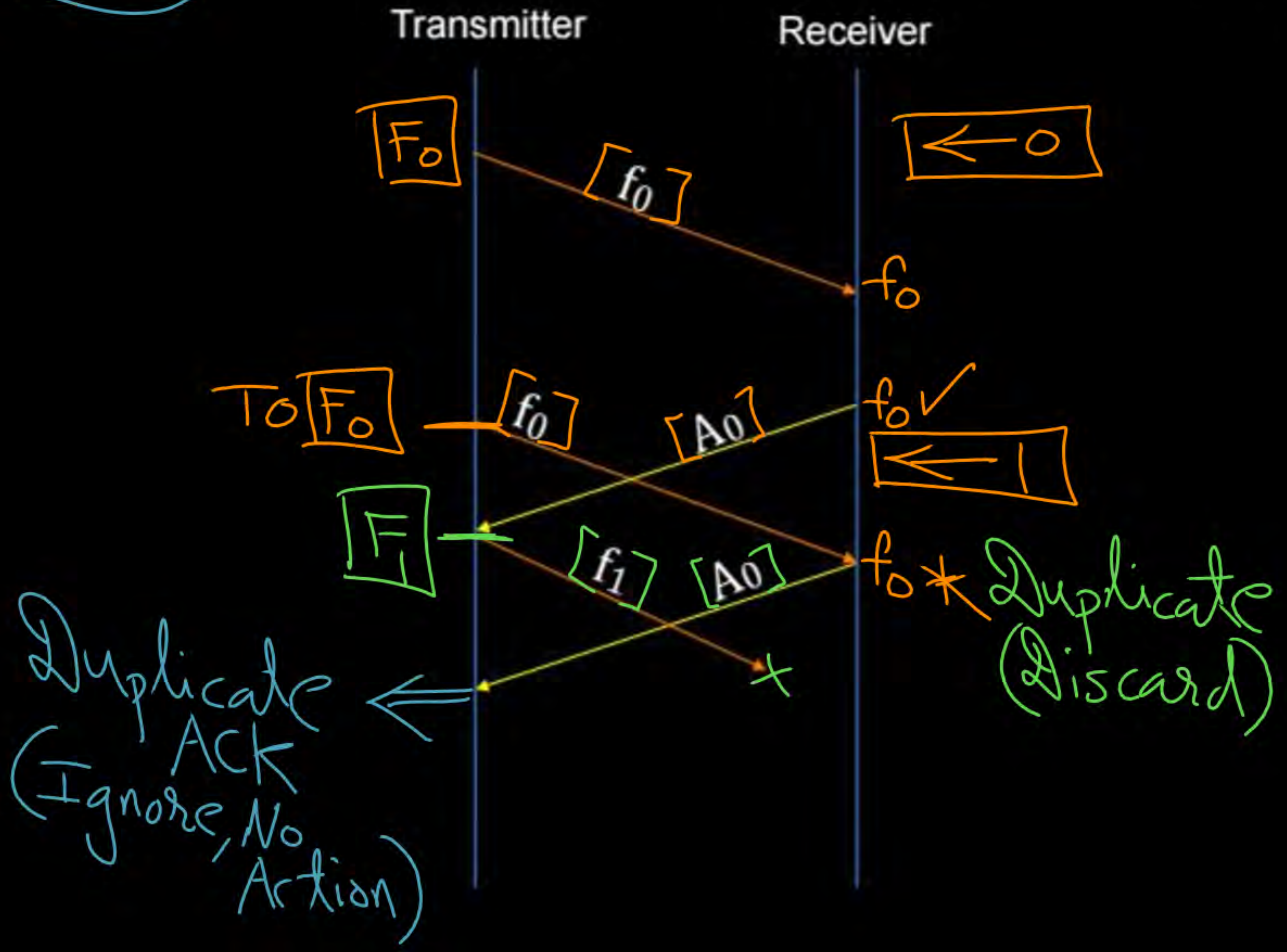
⇒ Reliable communication

Topic : Stop-and-Wait ARQ





Topic : Stop-and-Wait ARQ



Topic : Stop-and-Wait ARQ ⟹ Noisy Channel

Transmitter Protocol :

→ Transmitter transmit one frame (with sequence number) and wait for ACK of it until time-out

→ After time-out, transmitter retransmit the frame (same sequence number) and wait for ACK of it until time-out

→ Transmitter transmit next frame (with alternate sequence number) only after receiving ACK of transmitted frame

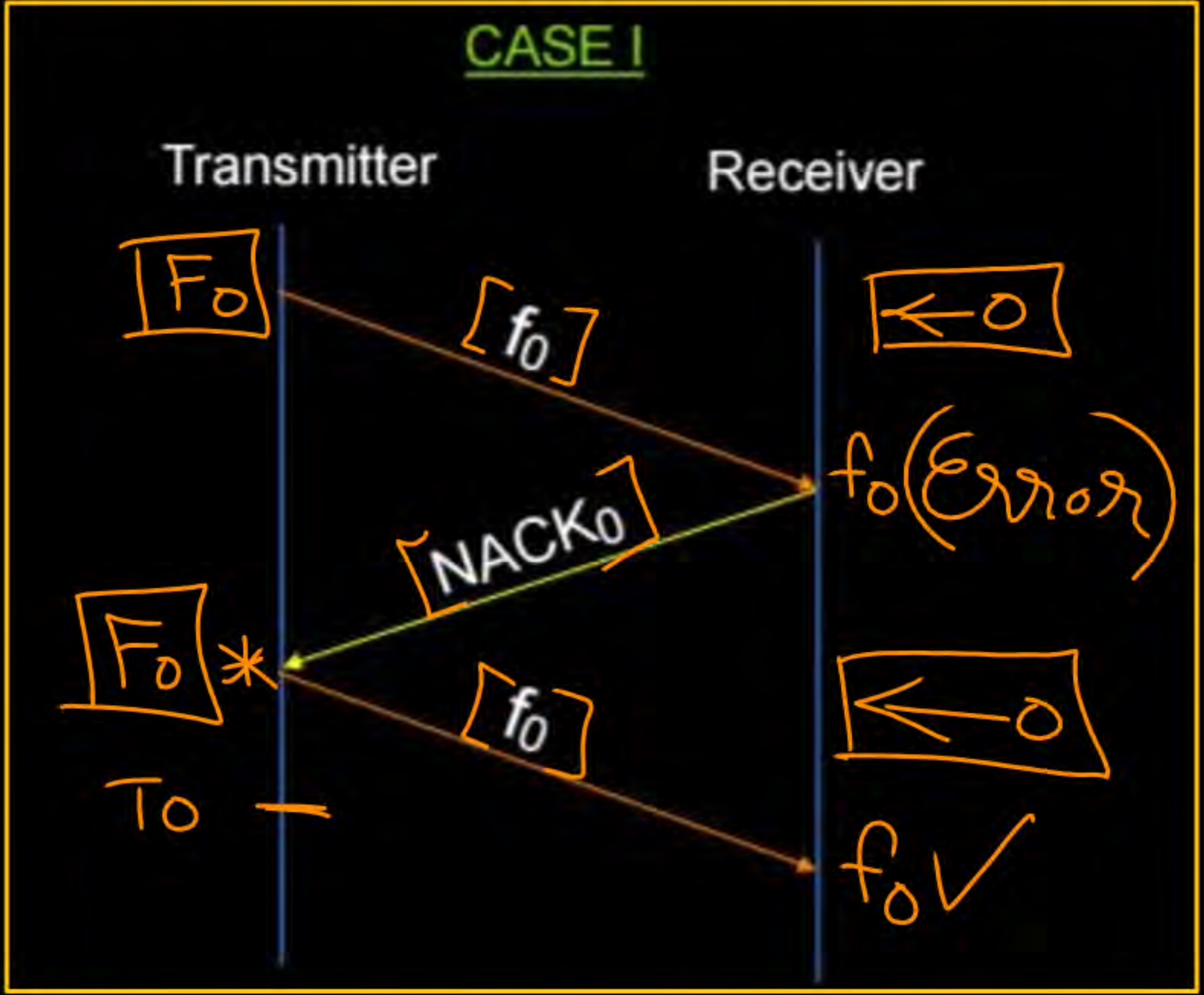
Topic : Stop-and-Wait ARQ

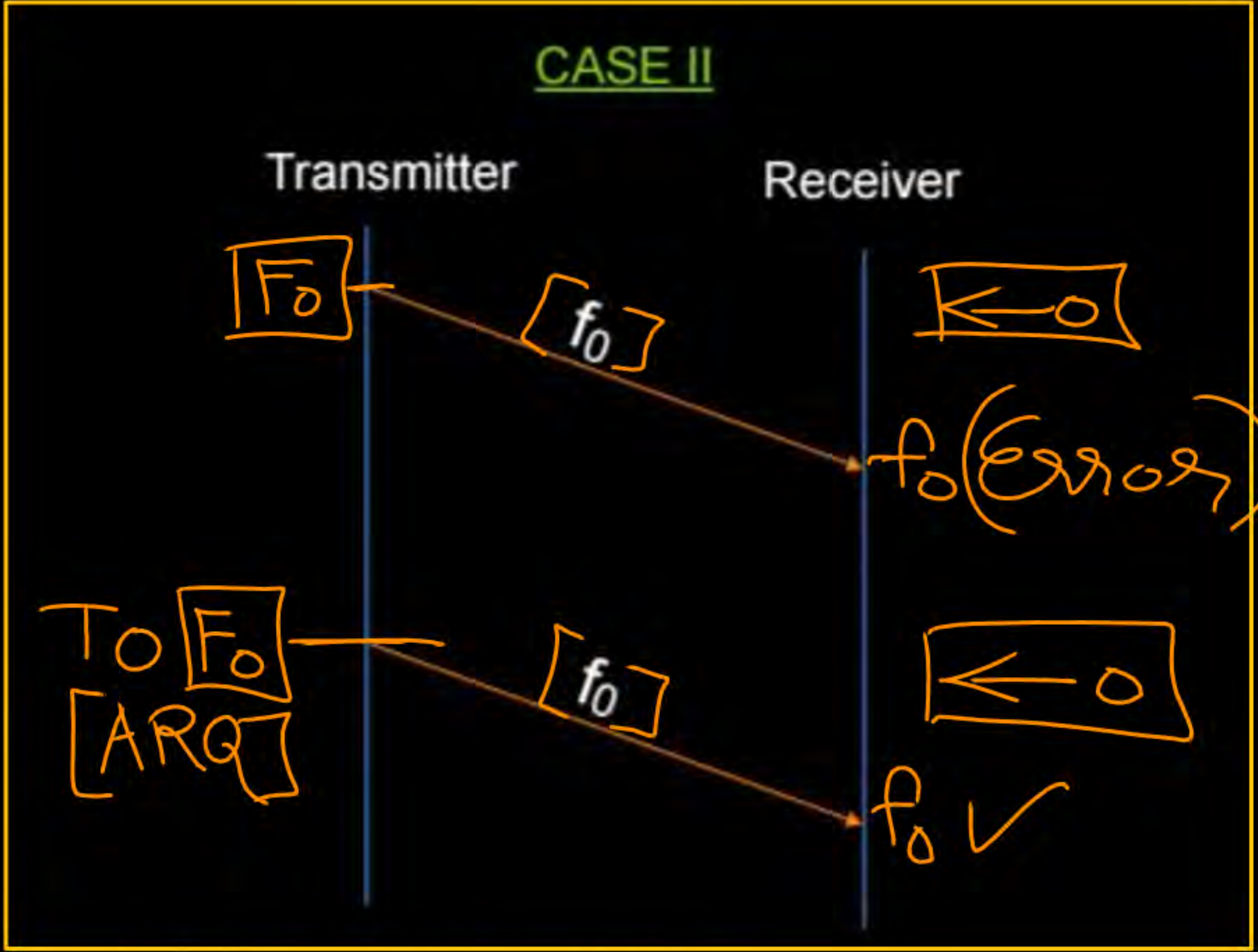
Receiver Protocol :

→ Receiver transmit acknowledgment for every received frame after processing

→ Acknowledgments carry corresponding frame sequence number

Topic : Stop-and-Wait ARQ





ACK (positive acknowledgment) : Leads next frame transmission

NACK (Negative acknowledgment) : Leads retransmsission of the frame

Time-out : Leads retransmsission of the frame

Topic : Stop-and-Wait ARQ

→ Transmitter's transmitting window size = $\boxed{1}$

→ Receiver's receiving window size = $\boxed{1}$

→ Total number of sequences = $\boxed{2}$

$\boxed{0 \text{ or } 1}$

[NAT] IIT-R H.W [GATE-2017][2 Mark]

#Q. The values of parameters for the Stop-and–Wait ARQ protocol are as given below.

Bit rate of the transmission channel = 1 Mbps

Propagation delay from sender to receiver = 0.75 ms

Time to process a frame = 0.25 ms

Number of bytes in the information frame = 1980

Number of bytes in the acknowledge frame = 20

Number of overhead bytes in the information frame = 20

Assume that there are no transmission errors. Then the transmission efficiency (expressed in percentage) of the Stop-and–Wait ARQ protocol for the above parameters is ________ (correct to 2 decimal place).

2 mins Summary

Topic Stop-and-Wait Protocol

Topic Stop-and-Wait ARQ

THANK - YOU

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