CS & IT ENGINEERING

Computer Network

Flow Control

Lecture No. - 09

By - Abhishek Sir

Recap of Previous Lecture

Topic Go Back N ARQ

Topic Selective Repeat ARQ

Topics to be Covered

Topic Selective Repeat ARQ

ABOUT ME

Hello, I'm Abhishek

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#Q. Station A needs to send a message consisting of 9 packets to Station B using a sliding window (window size 3) and go-back-n flow control strategy. All packets are ready and immediately available for transmission. If every 5^{th} packet that A transmits gets lost (but no ACKs from B ever get lost), then what is the number of packets that A will transmit for sending the message to B?

[GATE 2006]

A 12

B 14

C 16

D 18

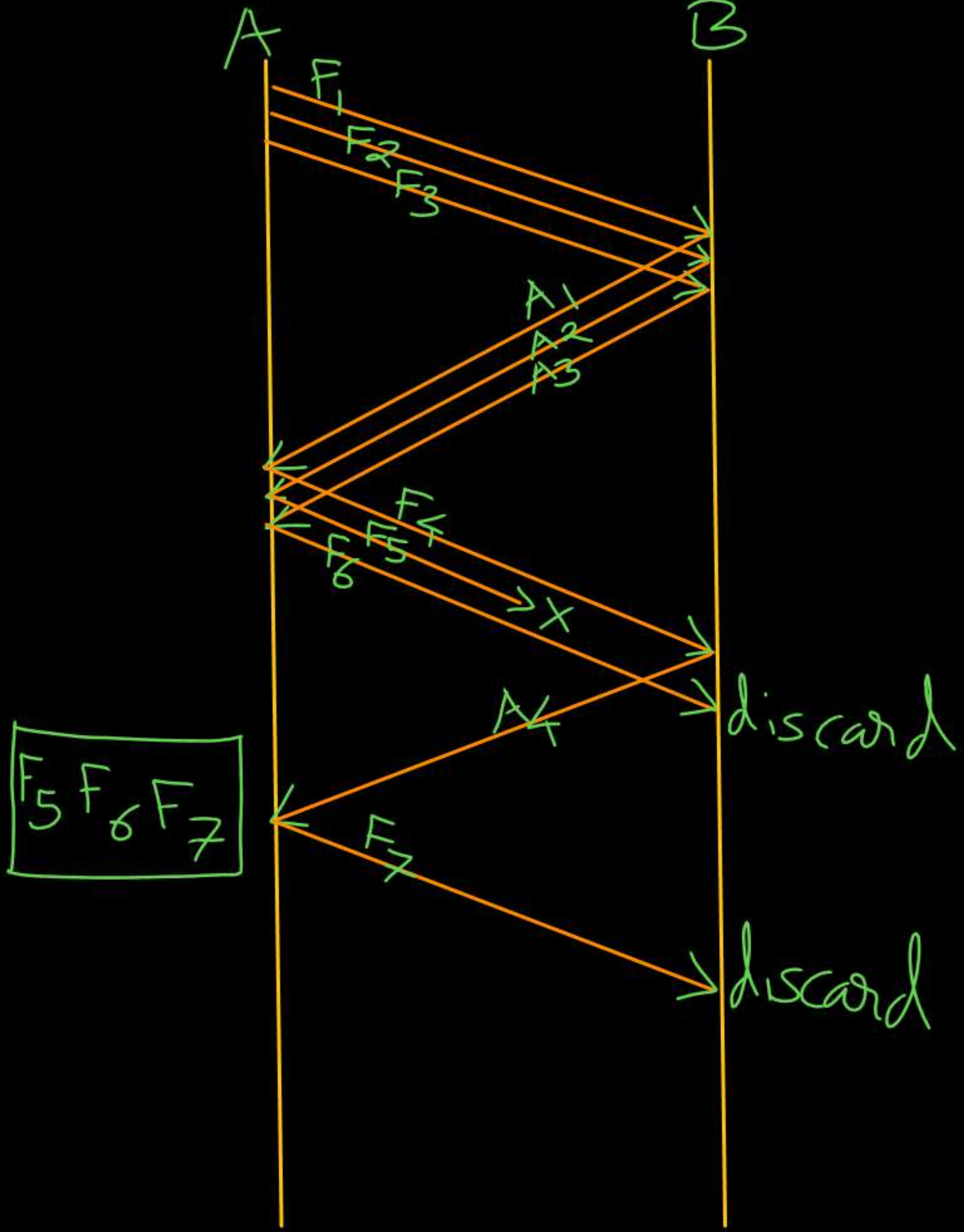
1 2 3 4 5 $\underbrace{6\ 7}_{\text{discard}}$ | 5 6 7 $\underbrace{8\ 9}_{\text{discard}}$ |

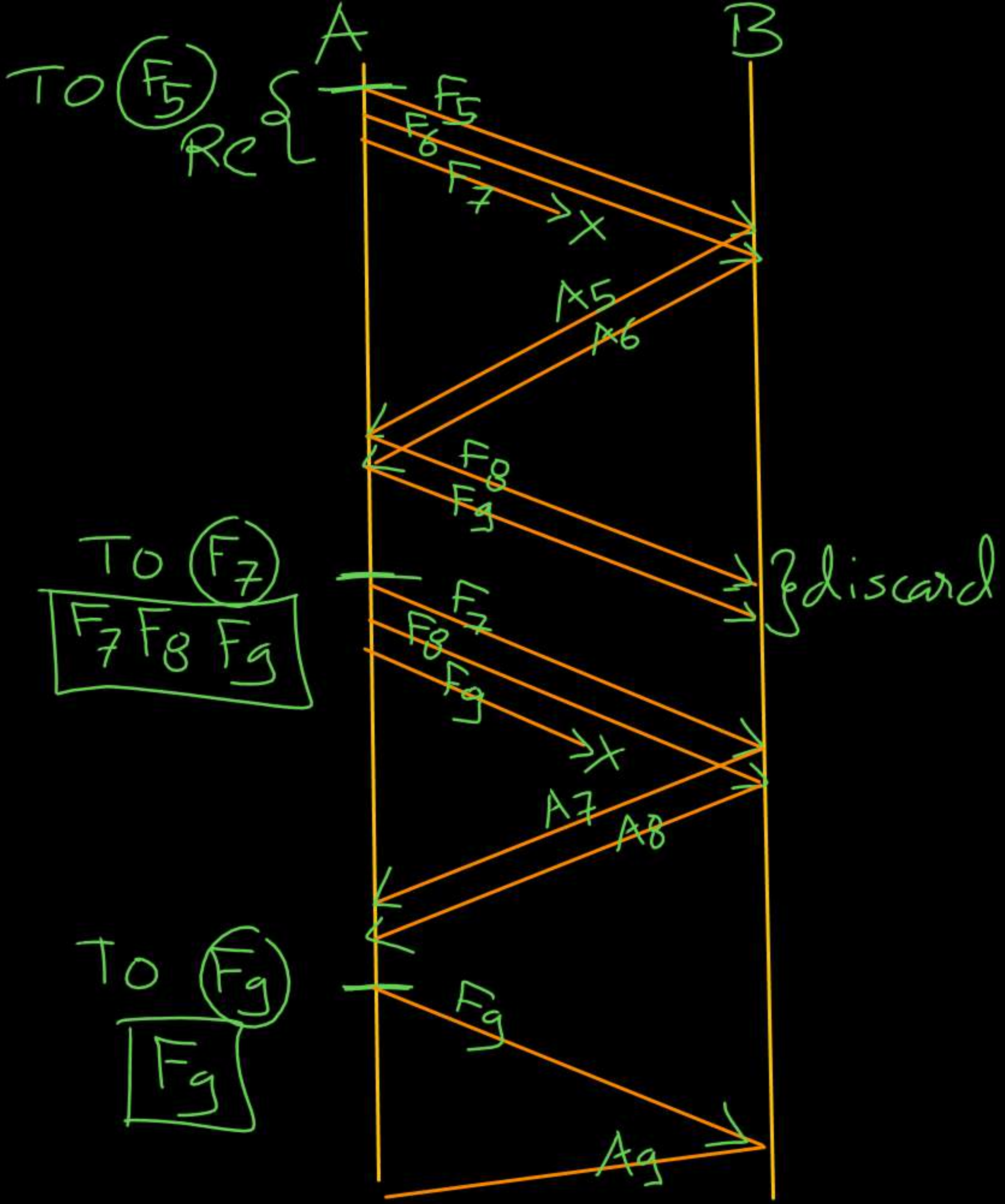
✓ ✓ ✓ ✓ | ✓ ✓

7 8 9 | 9

✓ ✓ | ✓

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


A
B
F1
F2
F3
A1
A2
A3
F4
F5
F6
discard
A4
F5 F6 F7
F7
discard


TO F5
RC
A
B
F5
F6
F7
A5
A6
F8
F9
discard
TO F7
F7 F8 F9
F7
F8
F9
A7
A8
TO F9
F9
F9
A9

#Q. Consider a network connecting two systems located 8000 kilometers apart. The bandwidth of the network is 500×10^6 bits per second. The propagation speed of the media is 4×10^6 meters per second. It is needed to design a Go-Back-N sliding window protocol for this network. The average packet size is 10^7 bits. The network is to be used to its full capacity. Assume that processing delays at nodes are negligible. Then, the minimum size in bits of the sequence number field has to be ______.

[GATE 2015]

Solution:-

Packet Size = 10^7 bits

Bandwidth = $500 * 10^6$ bits / sec

$$t_x = \frac{\text{Packet Size}}{\text{Bandwidth}} = \frac{10^7 \text{ bits}}{500 * 10^6 \text{ bits / sec}} = \frac{1}{50} \text{ sec}$$

Distance = 8000 Km = $8 * 10^6$ m

Signal Speed = 4×10^6 m/s

$$t_p = \frac{\text{Distance}}{\text{Signal Speed}} = \frac{8 * 10^6 \text{ m}}{4 \times 10^6 \text{ m/s}} = 2 \text{ sec}$$

$$\text{Cycle Time} = (t_x + 2 * t_p) = \left(\frac{1}{50} + 2 * 2\right) \text{sec} = \left(\frac{201}{50}\right) \text{sec}$$

$$\text{Optimal Window Size } (N) = \left\lceil \frac{\text{Cycle Time (RTT)}}{\text{Transmission delay}} \right\rceil = \left\lceil \frac{\frac{201}{50}\text{ sec}}{\frac{1}{50}\text{ sec}} \right\rceil = 201$$

For Go Back N ARQ : $\boxed{N = 201}$

$$\text{Total number of sequences} = (N + 1) = (201 + 1) = 202$$

Minimum number of bits required for sequence number field

$$= \lceil \log_2 [\text{Total number of sequences}] \rceil \text{ bits}$$

$$= \lceil \log_2 (202) \rceil \text{ bits} = 8 \text{ bits}$$

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

#Q. A 20 Kbps satellite link has a propagation delay of 400 ms. The transmitter employs the "go back n ARQ" scheme with n set to 10. Assuming that each frame is 100 bytes long, what is the maximum data rate possible?

Throughput

[GATE 2004]

(A) 5Kbps

(B) 10Kbps

(C) 15Kbps

(D) 20Kbps

Ans: B

Solution:-

Packet Size = 100 bytes = $8 * 10^2$ bits

Bandwidth = 20 Kbps = $2 * 10^4$ bits / sec

$$t_x = \frac{\text{Packet Size}}{\text{Bandwidth}} = \frac{8 * 10^2 \text{ bits}}{2 * 10^4 \text{ bits / sec}} = \underbrace{40 \text{ ms}} = 40 * 10^{-3} \text{ sec}$$

t_p = 400 ms

$$\text{Cycle time} = (t_x + 2 * t_p) = \underbrace{840 \text{ ms}} = 840 * 10^{-3} \text{ sec}$$

$$= (40 + 2 * 400) \text{ ms}$$

Window Size = 10

$$\text{Throughput} = \frac{\text{Window Size} * \text{Packet Size}}{\text{Cycle Time}} = \frac{10 * 8 * 10^{3}\ \text{bits}}{840 * 10^{-3}\ \text{sec}}$$

$$= \frac{8000}{840} * 10^{3}\ \text{bits/sec}$$

$$= 9.52\ \text{Kbps}$$

#Q. A 1Mbps satellite link connects two ground stations. The altitude of the satellite is 36,504 km and speed of the signal is 3×10^8 m/s. What should be the packet size for a channel utilization of 25% for a satellite link using go-back-127 sliding window protocol? Assume that the acknowledgment packets are negligible in size and that there are no errors during communication.

[GATE 2008]
IISc

(A) 120 bytes

(B) 60 bytes

(C) 240 bytes

(D) 90 bytes

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

Solution:-

Packet Size = ? (in bytes)

Bandwidth = 1 Mbps = 10^6 bits / sec

Distance = 2 * 36504 Km = $73008 * 10^3$ m

Signal Speed = 3×10^8 m/s

$$t_p = \frac{\text{Distance}}{\text{Signal Speed}} = \frac{73008 * 10^3 \text{ m}}{3 \times 10^8 \text{ m/s}} = 24336 * 10^{-5} \text{ Sec}$$

To achieve 25% utilization ($\eta = 1/4$) in Go Back 127 ARQ

$\boxed{N = 127}$

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

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

$$\boxed{(t_x + 2 * t_p) = 4 * 127 * t_x}$$

$$\boxed{t_x = 2 * t_p / 507}$$

$$\begin{aligned}
\text{Frame Size} &= (2 * t_p / 507) * \text{Bandwidth} \\
&= (2 * 24336 * 10^{-5} \text{ Sec} / 507) * 10^{6} \text{ bits / sec} \\
&= 960 \text{ bits} = 120 \text{ bytes}
\end{aligned}$$

Topic : Selective Repeat ARQ

→ Transmitter's transmitting window size = N $(N > 1)$

→ Receiver's receiving window size = N

→ Total number of sequences = $\underbrace{2N}$ $\underbrace{[0 \text{ to } (2N-1)]}$

$0 \text{ - - - - } (N-1)$
$N \text{ - - - - } (2N-1)$

Total number of sequences =
Transmitter's transmitting window size
\+ Receiver's receiving window size

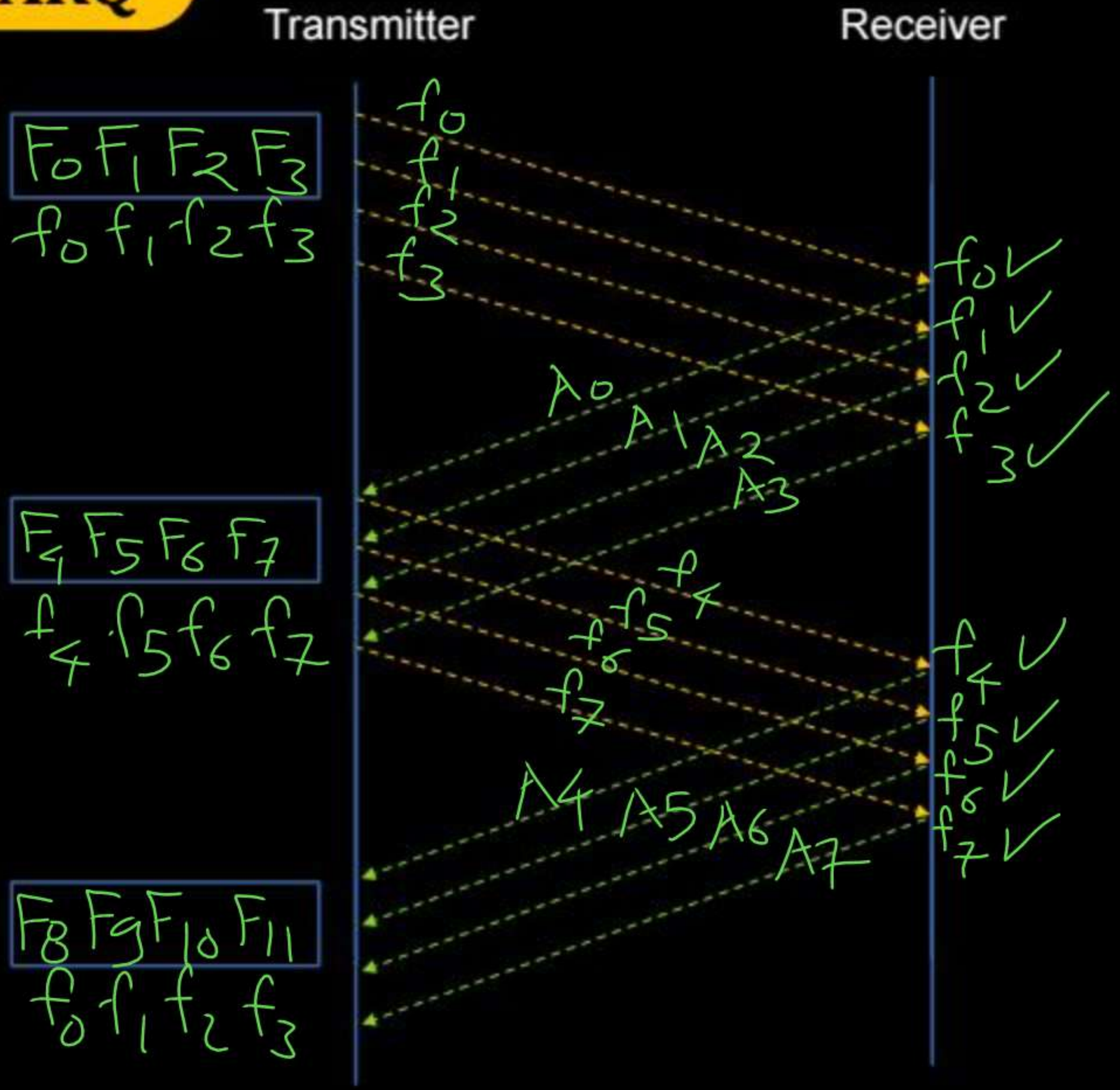
Sequence number ← (Frame number) mod (2N)

Topic : Selective Repeat ARQ

CASE I :

Suppose N = 4

Sequence Number = 0 to 7



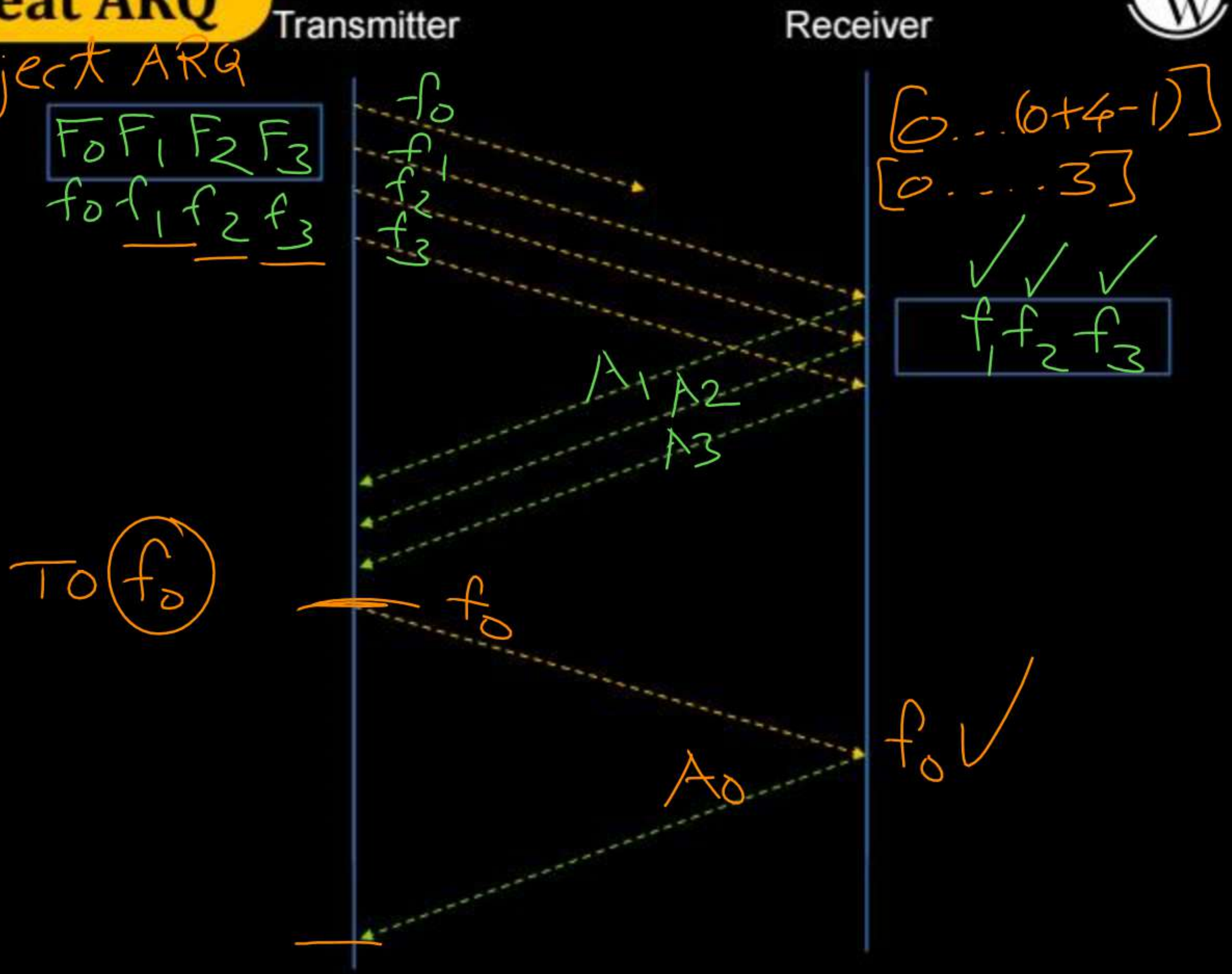
Topic : Selective Repeat ARQ

Selective Reject ARQ

CASE II :

Suppose N = 4

Sequence Number = 0 to 7

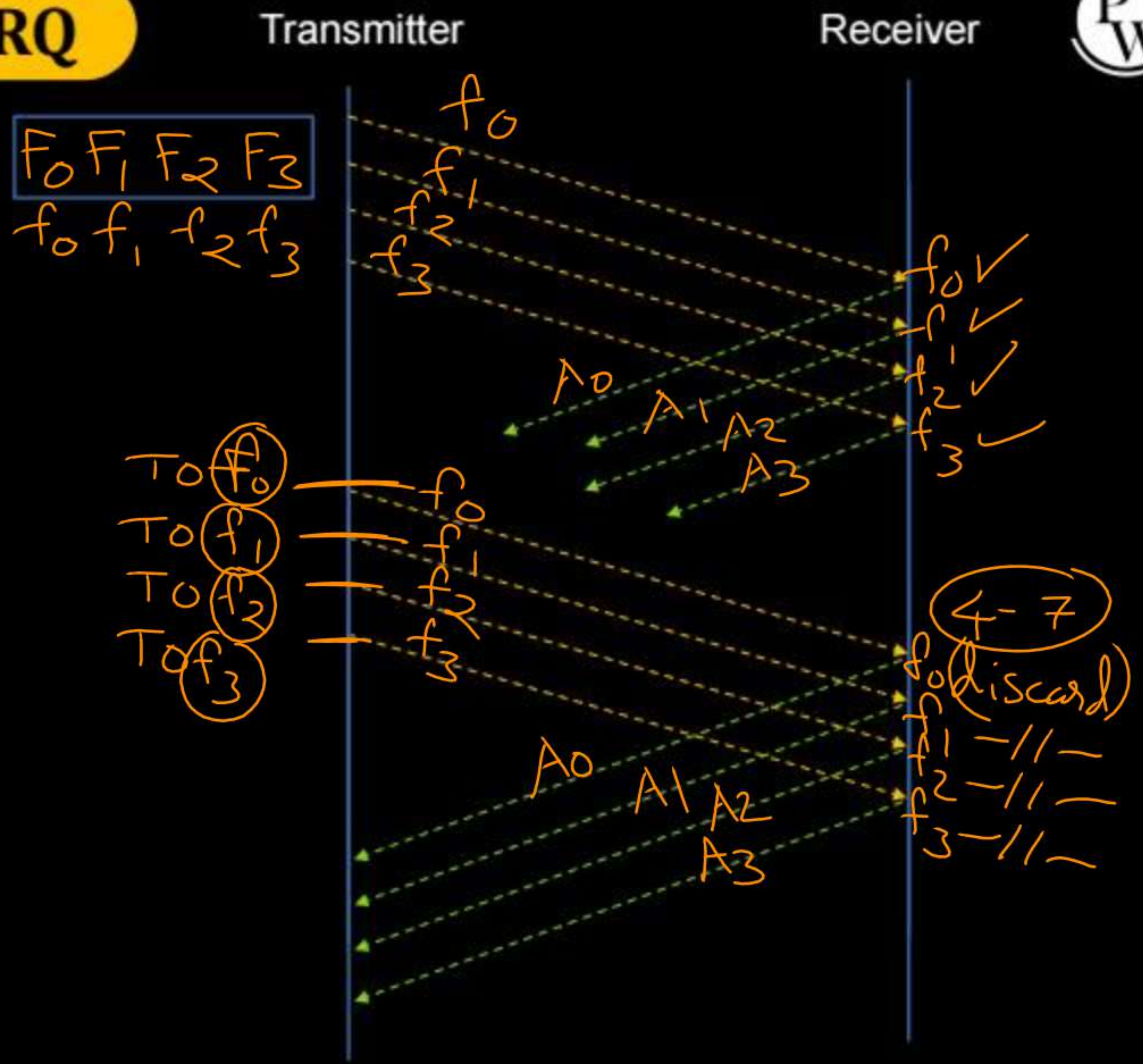


Topic : Selective Repeat ARQ

CASE III :

Suppose N = 4

Sequence Number = 0 to 7



Topic : Selective Repeat ARQ

→ Transmitter transmit N frames without any acknowledgment

→ Receiver transmit "individual acknowledgment" [for every successfully received frame]

→ "Cumulative (combine) acknowledgment" does not exist in this protocol

Topic : Selective Repeat ARQ

→ Whenever transmitter gets time-out or received NACK, it retransmit that perticular frame only [mostly first frame, resides in transmitting window]

→ Receiver buffer the frame which is out of order (expected sequence numbers) and send individual acknowledgment of that frame

$$\boxed{\text{Expected sequence no. to (Expected seq no.} + N - 1)}$$

#Q. Consider a 128×10^3 bits/second satellite communication link with one-way propagation delay of 150 milliseconds. Selective retransmission (repeat) protocol is used on this link to send data with a frame size of 1 kilobyte. Neglect the transmission time of acknowledgment. The minimum number of bits required for the sequence number field to achieve 100% utilization is ________.

[GATE-2016, Set-2, 2-Mark]

IISC

H.W

#Q. Consider a selective repeat sliding window protocol that uses a frame size of 1 KB to send data on a 1.5 Mbps link with a one-way latency of 50 msec. To achieve a link utilization of 60%, the minimum number of bits required to represent the sequence number field is ______.

[GATE-2014, Set-1, 2-Mark]

IIT KGP

H.W.

#Q. In a sliding window ARQ scheme, the transmitter's window size is N and the receiver's window size is M. The minimum number of distinct sequence numbers required to ensure correct operation of the ARQ scheme is

[GATE 2004]

IIT-D

A min(M, N)

B max(M, N)

C M + N

D MN

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

Solution :-

Transmitter's transmitting window size = N

Receiver's receiving window size = M

Total number of sequences = (N + M)

Total number of sequences =
Transmitter's transmitting window size
+ Receiver's receiving window size

Sliding Window ARQ
$(M = N)$

No of seq. $= N$

Go Back N ARQ
$M = 1$

No. of seq $= (N+M)$
$= (N+1)$

Selective Repeat ARQ
$M = N$

No of seq. $= (N+M)$
$= 2N$

Transmitter's transmitting window size = N

1. Sliding Window Protocol

Total number of sequences = N

2. Go Back N ARQ

Total number of sequences = (N+1)

3. Selective Repeat ARQ

Total number of sequences = (N+N) = (2N)

Minimum number of bits required for sequence number field

$$= \lceil \log_2(\text{Total number of sequences}) \rceil \text{ bits}$$

Number of bits in sequence number field $= k$

Total number of sequences $= 2^k$

Number of bits in sequence number field = k

1. Sliding Window Protocol

Transmitter's transmitting window size = 2^k

2. Go Back N ARQ

Transmitter's transmitting window size = $(2^k - 1)$

3. Selective Repeat ARQ

Transmitter's transmitting window size = $2^{(k-1)}$ $= \left(\frac{2^k}{2}\right)$

#Q. The maximum window size for data transmission using the selective reject protocol with n-bit frame sequence numbers is:

[GATE 2005]

IIT-B

seq no. field ⇒ n bit

No of distinct seq. $= 2^n$

A 2^n

B $2^{(n-1)}$

C $(2^n) - 1$

D $2^{(n-2)}$

max^m (sending) window size $= \left(\frac{2^n}{2}\right)$

$= 2^{(n-1)}$

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

Topic : Bit Error Rate

=> Bit Error Rate (BER)

→ Number of bit errors per unit time

=> Bit Error Ratio or Bit Error Probability (P_b)

→ Probability that a bit is corrupted

Topic : Bit Error Rate

Suppose P_b = bit error probability

and Frame Length = L bits

What is the probability that a frame has received by receiver does not contain any error?

Answer : $\underbrace{(1 - P_b)^L}$

$$\boxed{(1-P_b) * (1-P_b) * \ldots\ldots (1-P_b)}$$

$$(1-P_b)^L$$

#Q. In a communication network, a packet of length L bits takes link L1 with a probability of p_1 or link L2 with a probability of p_2. Link L1 and L2 have bit error probability of b_1 and b_2 respectively. The probability that the packet will be received without error via either L1 or L2 is

[GATE 2005]

A $(1 - b_1)^L p_1 + (1 - b_2)^L p_2$

B $[1 - (b_1 + b_2)^L] p_1 p_2$

C $(1 - b_1)^L (1 - b_2)^L p_1 p_2$

D $1 - (b_1^l p_1 + b_2^l p_2)$

$$\boxed{P_1 * (1-b_1)^L + P_2 * (1-b_2)^L}$$

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

Topic : Bit Error Rate

Suppose P_b = bit error probability

and Frame Length = L bits

What is the probability that a frame has received by receiver contains some error(s)?

Answer : $\underbrace{1 - (1 - P_b)^L}$

Topic : Packet Error Ratio

=> Packet Error Ratio or Packet Error Probability (P_p)

→ Probability that a packet ~~is corrupted~~ has corrupted bits

Suppose P_b = bit error probability

and Frame Length = L bits

Packet error probability $\boxed{(P_p) = 1 - (1 - P_b)^L}$

#Q. On a wireless link, the probability of packet error is 0.2. A stop-and-wait protocol is used to transfer data across the link. The channel condition is assumed to be independent from transmission to transmission. What is the average number of transmission attempts required to transfer 100 packets?

[GATE 2006]

- ~~A~~ 100
- B 125
- C 150
- D 200

Packet Error Probability $= P = 0.2$

No. of packets $= N = 100$

Total no of transmission attempts

$$= N + N*P + N*P^2 + N*P^3 + \ldots$$

$$= N*[1+P+P^2+P^3+\ldots]$$

$$= N*\frac{1}{(1-P)} = \frac{N}{(1-P)} = \frac{100}{(1-0.2)} = \frac{100}{0.8} = 125$$

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

2 mins Summary

Topic Selective Repeat ARQ

Packet Error Probability

THANK - YOU