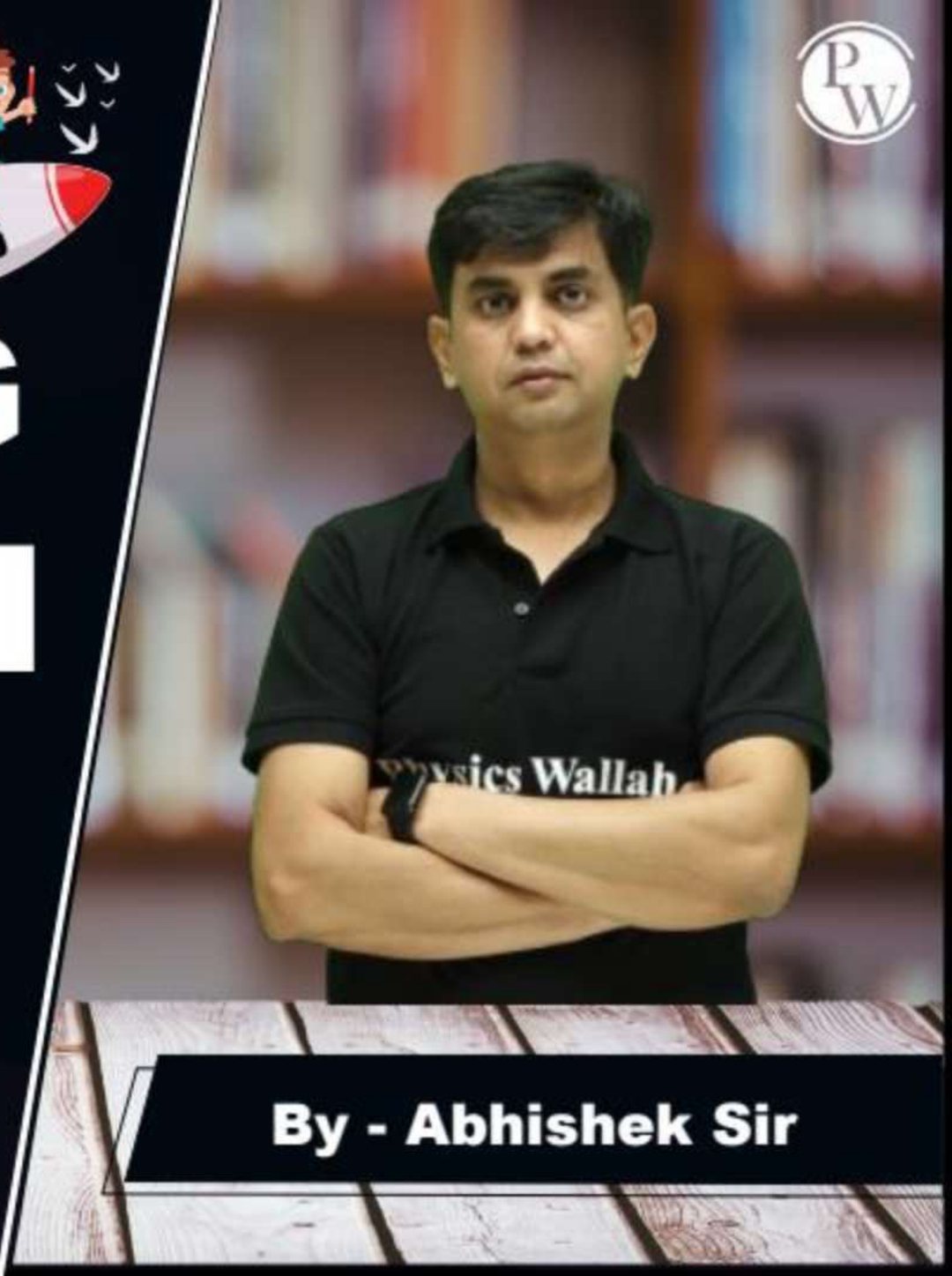
CS & IT ENGINEERING

Computer Network

Flow Control

Lecture No. - 06



By - Abhishek Sir

Recap of Previous Lecture

Topic

Stop and Wait ARQ

Topics to be Covered

Topic Sliding Window ARQ

Topic Go Back N ARQ

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 : Efficiency

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

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

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

#Q. A channel has a bit rate of 4 kbps and one-way propagation delay of 20 ms. The channel uses stop and wait protocol. The transmission time of the acknowledgement frame is negligible. To get a channel efficiency of at least 50%, the minimum frame size should be

[GATE 2005]

A 80 bytes

B 80 bits

C 160 bytes

D 160 bits

Ans: D

Solution:-

Bandwidth = 4 Kbps = $4 * 10^3$ bits / sec

t_p = 20 ms = $20 * 10^{-3}$ Sec

To achieve 50% utilization in Stop-and-Wait ARQ.

Cycle time = $2 * t_x$

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

$t_x = 2 * t_p$

Frame Size = $(2 * t_p)$ * Bandwidth

= $(2 * 20 * 10^{-3}$ Sec) * $(4 * 10^3$ bits / sec)

= 160 bits

= 20 bytes

#Q. Suppose that the stop-and-wait protocol is used on a link with a bit rate of 64 kilobits per second and 20 milliseconds propagation delay. Assume that the transmission time for the acknowledgment and the processing time at nodes are negligible. Then the minimum frame size in bytes to achieve a link utilization of at least 50% is _____.

[GATE 2015]

Ans : 320

Solution:-

Bandwidth = 64 Kbps = $64 * 10^3$ bits / sec

t_p = 20 ms = $20 * 10^{-3}$ Sec

To achieve 50% utilization in Stop-and-Wait ARQ.

Cycle time = $2 * t_x$

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

t_x = $2 * t_p$

Frame Size = $(2 * t_p)$ * Bandwidth

= $(2 * 20 * 10^{-3}\ \text{Sec}) * (64 * 10^3\ \text{bits / sec})$

= 2560 bits

= 320 bytes

Topic : Efficiency

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

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

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

#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 _____.

[GATE 2015]

Solution:-

Packet Size = 1000 bytes = $8 * 10^3$ bits

Bandwidth = 10^6 bits / sec

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

To achieve ~~50~~ 25% utilization in Stop-and-Wait ARQ.

$$\text{Cycle time} = 4 * t_x$$

$$(t_x + 2 * t_p) = 4 * t_x$$

$$t_p = (3 * t_x / 2)$$

$$= (3 * 8\text{ ms} / 2)$$

$$= 12\text{ ms}$$

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

$$\frac{1}{4} = \frac{t_x}{\text{Cycle time}}$$

$$\text{Cycle time} = 4 t_x$$

$$(t_x + 2t_p) = 4 t_x$$

Ans = 12

Topic : Channel Utilization

→ Link Utilization or Throughput

byte/sec

$$\text{Throughput} = \frac{\text{Packet Size}}{\text{Cycle Time}}$$

$$\text{Throughput} = \text{Efficiency} * \text{Data Transfer Rate}$$

#Q. A sender uses the Stop-and-Wait ARQ protocol for reliable transmission of frames. Frames are of size 1000 bytes and the transmission rate at the sender is 80 Kbps (1Kbps = 1000 bits/second). Size of an acknowledgement is 100 bytes and the transmission rate at the receiver is 8 Kbps. The one-way propagation delay is 100 milliseconds. Assuming no frame is lost, the sender throughput is _____ bytes/second.

[GATE 2016]

Solution:-

Packet Size = 1000 bytes = $8 * 10^3$ bits

Bandwidth = 80 Kbps = $8 * 10^4$ bits / sec

$$t_x = \frac{\text{Packet Size}}{\text{Bandwidth}} = \frac{8 * 10^3 \text{ bits}}{8 * 10^4 \text{ bits / sec}} = 100 \text{ ms} = \frac{10^3}{10} * 10^{-3} \text{ sec}$$

t_p = 100 ms

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

Bandwidth = 8 Kbps = $8 * 10^3$ bits / sec

$$t_{xA} = \frac{\text{ACK Size}}{\text{Bandwidth}} = \frac{8 * 10^2 \text{ bits}}{8 * 10^3 \text{ bits / sec}} = 100 \text{ ms} = 10^2 * 10^{-3} \text{ sec}$$

$$\text{Cycle time} = (t_x + t_p) + (t_{xA} + t_p) = 400 \text{ ms}$$

$$= (100 + 100) + (100 + 100) \text{ ms}$$

$$\text{Throughput} = \frac{\text{Packet Size}}{\text{Cycle Time}} = \frac{1000 \text{ bytes}}{400 \text{ ms}} = \frac{10^3 \text{ bytes}}{400 * 10^{-3} \text{ sec}}$$

$$= \frac{10^4}{4} \text{ bytes/sec}$$

$$= 2500 \text{ bytes / sec}$$

$$\eta = \frac{t_x}{\text{cycle time}} = \frac{100 \text{ ms}}{400 \text{ ms}} = \frac{1}{4}$$

$$\text{Throughput} = \eta * DTR_{(sender)} = \frac{1}{4} * 80 \text{ Kbps} = 20 \text{ Kbps}$$

$$= 2500 \text{ bytes/sec}$$

Topic : Sliding Window ARQ

→ Transmitter's transmitting window size = N [N>1]

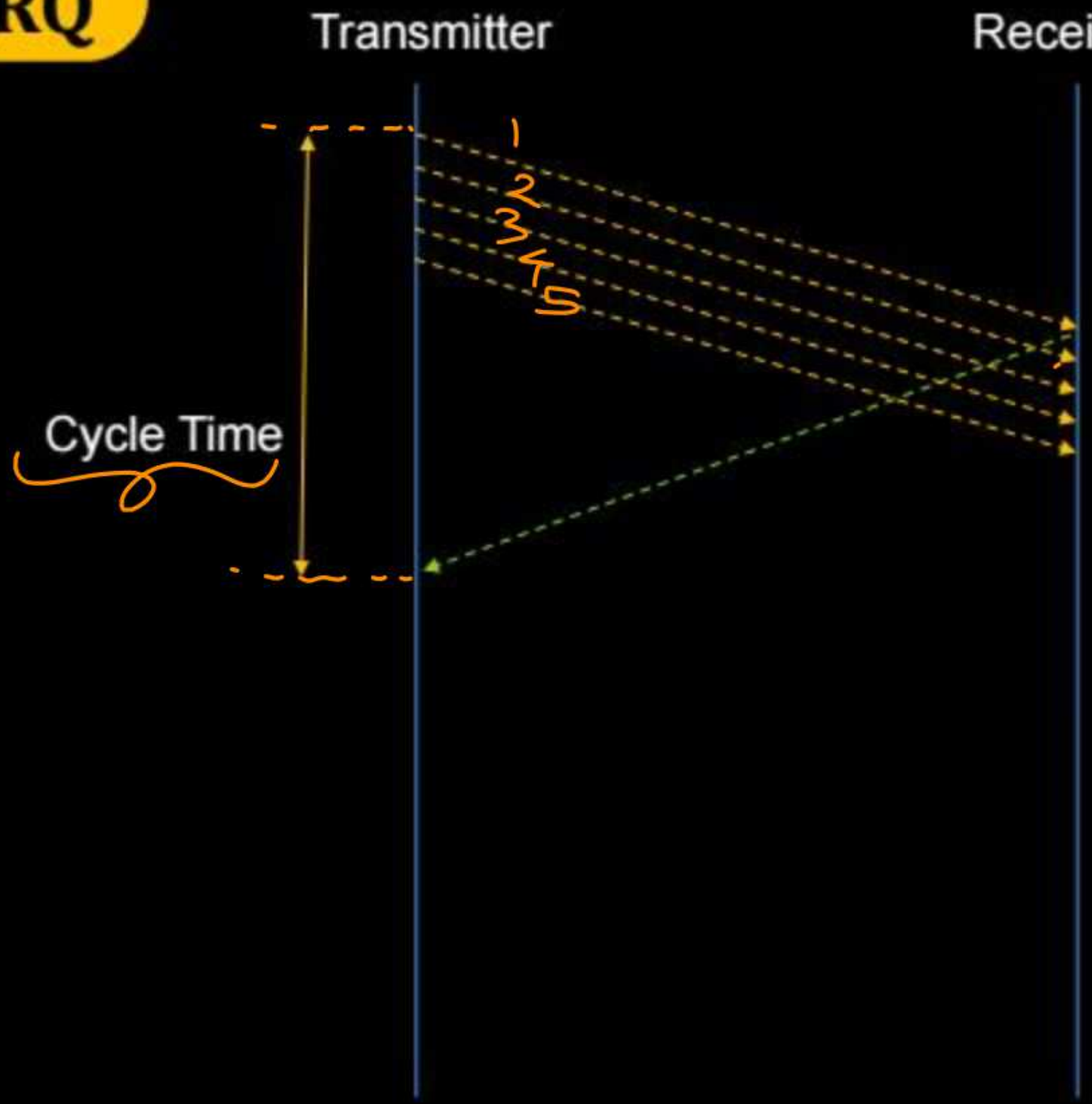
→ Transmitter's transmit N frames continuously without any ACK

→ Overlapping, unlike Stop-and-Wait ARQ
[To increase utilization]

$$\text{Efficiency} = \frac{[\text{Window Size} * \text{Packet transmission time}]}{\text{Cycle Time (RTT)}}$$

$$\eta = \frac{N * t_x}{\text{Cycle time}}$$

Topic : Sliding Window ARQ



Topic : Channel Utilization

→ Link utilization or Throughput [in bits or bytes per sec]

→ Total number of bytes (or bits) transmitted in Cycle time (RTT)

$$\text{Throughput} = \frac{[\text{Transmitter Window Size} * \text{Packet Size}]}{\text{Cycle Time (RTT)}} = \frac{N * \text{Packet Size}}{\text{cycle time}}$$

$$\text{Throughput} = \text{Efficiency} * \text{Data transfer rate at transmitter}$$

#Q. Host A is sending data to host B over a full duplex link. A and B are using the sliding window protocol for flow control. The send and receive window sizes are 5 packets each. Data packets (sent only from A to B) are all 1000 bytes long and the transmission time for such a packet is 50 microsecond. Acknowledgement packets (sent only from B to A) are very small and require negligible transmission time. The propagation delay over the link is 200 microsecond. What is the maximum achievable throughput in this communication?

[GATE 2003]

IIT-M

H.W.

(A) $7.69 * 10^6$ bytes per sec

(B) $11.11 * 10^6$ bytes per sec

(C) $12.33 * 10^6$ bytes per sec

(D) $15.00 * 10^6$ bytes per sec

Topic : Optimal Window Size

→ Optimal Window Size =

For maximum channel utilization, minimum transmitter's transmitting window size.

$$\text{Optimal Window Size} = \left\lceil \frac{\text{Cycle Time (RTT)}}{\text{Frame transmission time}} \right\rceil$$

$$\text{Optimal Window Size} = \frac{1}{\text{Efficiency}_{\text{[Stop-and-Wait]}}}$$

$$\eta = \frac{N * t_x}{\text{Cycle time}}$$

For 100% utilization

$$\eta = 1$$

$$1 = \frac{N * t_x}{\text{cycle time}}$$

$$N = \left\lceil \frac{\text{cycle time}}{t_x} \right\rceil$$

#Q. Station A uses 32 byte packets to transmit messages to Station B using a sliding window protocol. The round trip delay between A and B is 80 milliseconds and the bottleneck bandwidth on the path between A and B is 128 kbps. What is the optimal window size that A should use?

[GATE 2006]

Round Trip Delay / Time

RTT (cycle time) = 80 ms

IIT-KGP

A 20

B 40

C 160

D 320

Ans : B

Solution:-

Packet Size = 32 bytes = 2^8 bits $= 2^5$ bytes $= 2^5 * 2^3$ bits

Bandwidth = 128 Kbps = $2^7 * 10^3$ bits / sec

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

RTT (Cycle Time) = 80 ms

For Sliding Window ARQ :

$$\text{Optimal Window Size} = \left\lceil \frac{\text{Cycle Time (RTT)}}{\text{Transmission delay}} \right\rceil = \left\lceil \frac{80\,ms}{2\,ms} \right\rceil$$

$$= 40$$

Topic : Sliding Window ARQ

→ Transmitter's transmitting window size = N [N>1]

→ Receiver's receiving window size = N

→ Total number of sequences = N [0 to (N-1)]

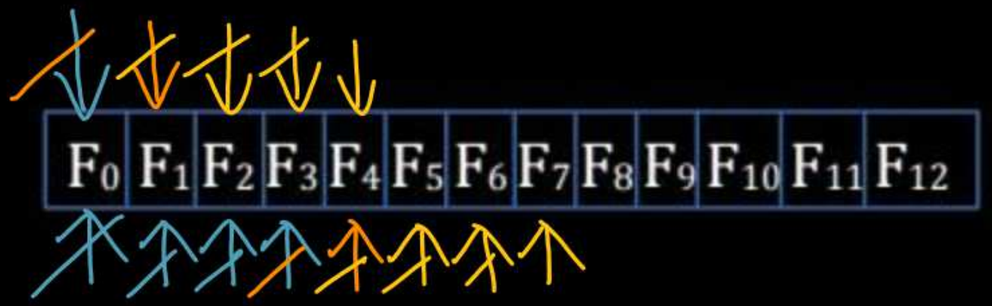
Total number of sequences
= Transmitter's transmitting window size

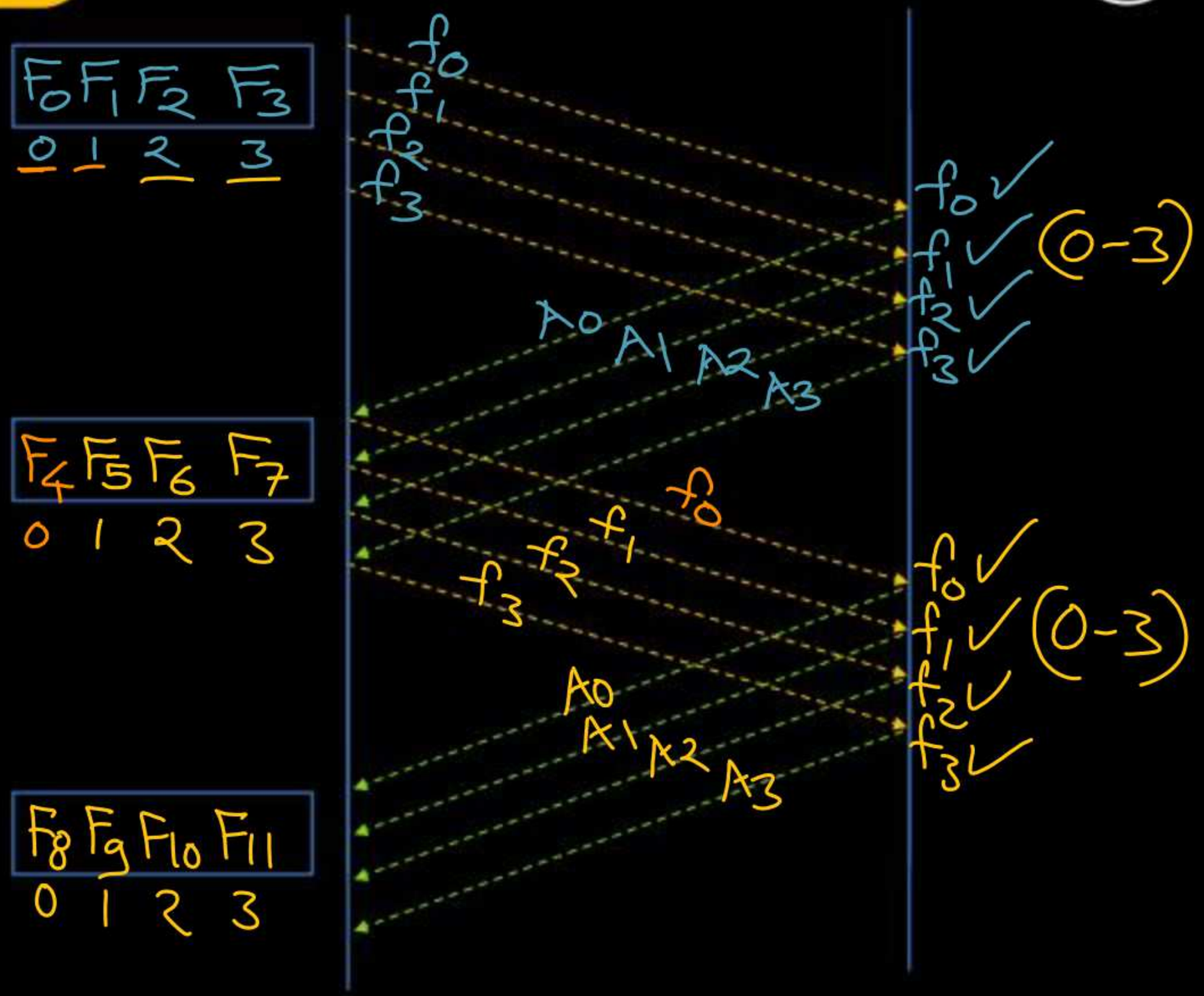
Sequence number ← (Frame number) mod (N)

Topic : Sliding Window ARQ

Suppose N = 4

Sequence Number = 0 to 3

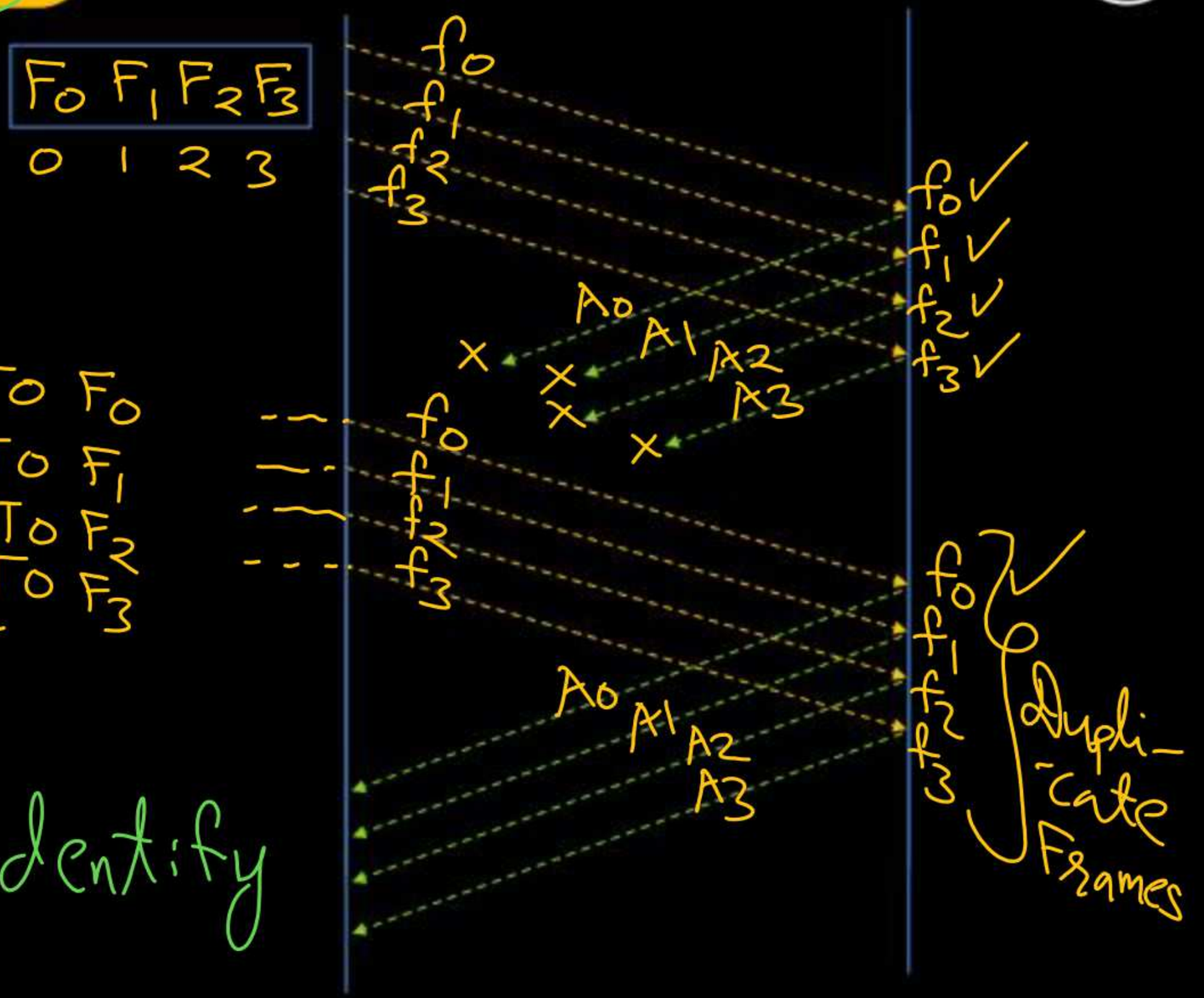




Topic : Sliding Window ARQ

Suppose N = 4

Sequence Number = 0 to 3



Sliding window :-

Disadvantag :-

Receiver unable to identify duplicate frame.

2 mins Summary

Topic Sliding Window ARQ

Topic

THANK - YOU