CS & IT ENGINEERING

COMPUTER NETWORKS

Flow Control

Lecture No-12

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TOPICS TO BE COVERED

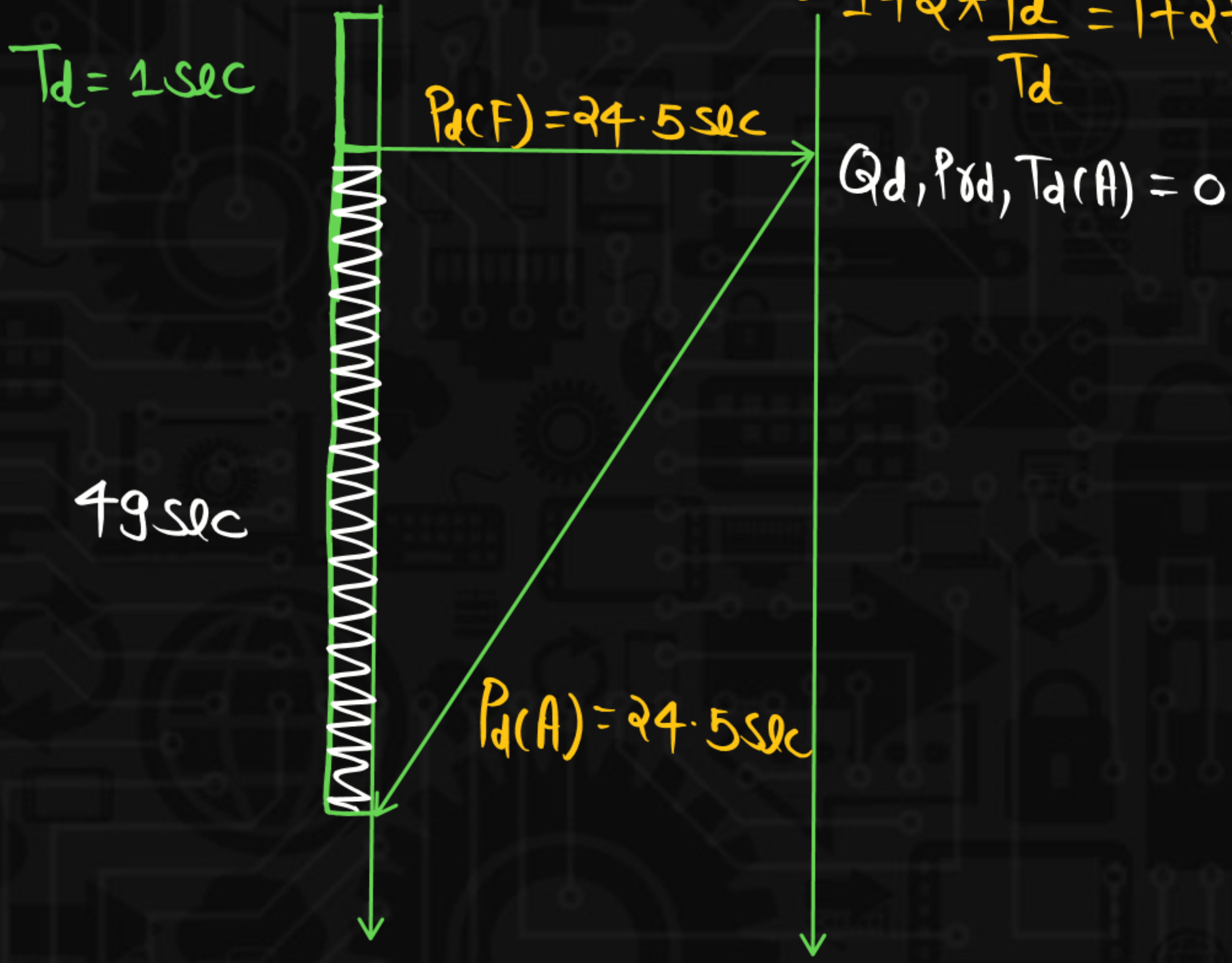
Selective Repeat ARQ

Selective Repeat ARQ

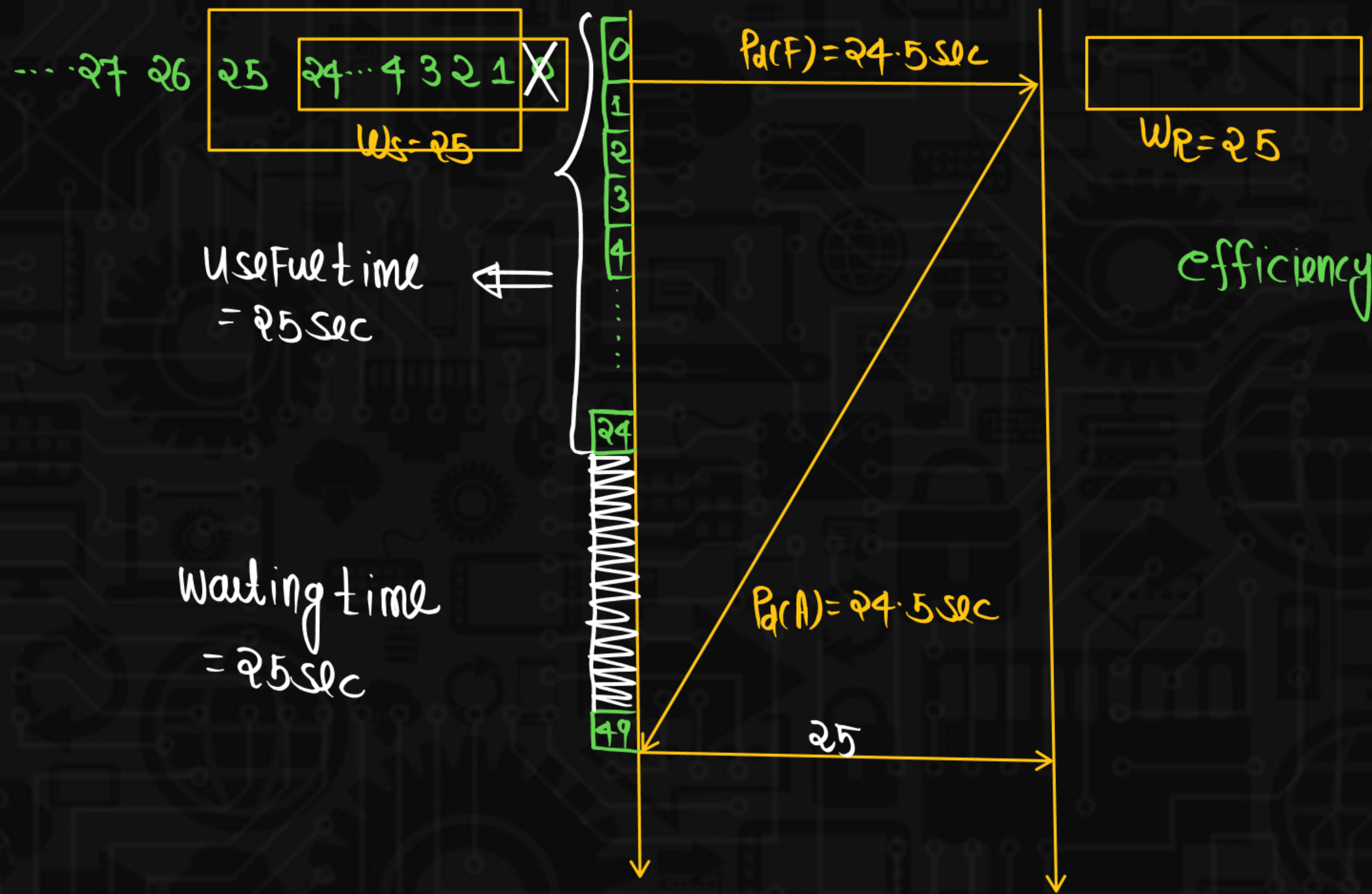
Q: $T_d(F) = 1\,sec$, $P_d = 24.5\,sec$, $Q_d = 0$, $Pr_d = 0$, $T_d(A) = 0$, $W_s = 25$, $\eta = ?$

Maximum window size $= (1+2a)$ Packet

$$= 1 + 2 * \frac{P_d}{T_d} = 1 + 2 * \frac{24.5}{1} = 50 \text{ Packets}$$



SeqNo = 50 (0-49)



Useful time = 25 sec

Waiting time = 25 sec

$$\text{efficiency} = \frac{25}{50} = \frac{1}{2} = 50\%$$

$$\text{efficiency} = \frac{\text{useful time}}{\text{total time}}$$

$$\boxed{\text{efficiency} = \frac{W_s * T_d(F)}{T_d(F) + 2*P_d + Q_d + P_{rd} + T_d(A)}}$$

$$\text{efficiency} = \frac{25*1\,sec}{1\,sec + 2*24.5\,sec + 0 + 0 + 0}$$

$$\text{efficiency} = \frac{\cancel{25}\,\cancel{sec}}{\cancel{50}\,\cancel{sec}}$$

$$\boxed{\text{efficiency} = \frac{1}{2} = 50\%}$$

Q: $\eta = \frac{1}{2}$, $B = 40$ mbps, Throughput = ?

Throughput $= \frac{1}{2} * 40$ mbps

$\boxed{\text{Throughput} = 20 \text{ mbps}}$

$\boxed{\text{Throughput} = \eta * B}$

OR

$\boxed{\text{Throughput} = \frac{W_s * \text{Frame size}}{\text{Total time}}}$

Comparison between stop & wait, GB-N and SR

1. SR Protocol required more sequence number in comparison of GBN.

(i) Seq No = 8 (0-7)

GB-N	$W_S = 7$	$W_R = 1$
SR	$W_S = 4$	$W_R = 1$

(ii)

			min. seq No required
GB-N	$W_S = 7$	$W_R = 1$	8
SR	$W_S = 7$	$W_R = 7$	14

(iii)

			min. seq. No. required
GBN	$W_S = N$	$W_R = 1$	$N+1$
SR	$W_S = N$	$W_R = N$	$2N$

2. SR Protocol required more buffer space in comparison of GBN.

			Buffer space
GB-N	$W_S = N$	$W_R = 1$	$N+1$
SR	$W_S = N$	$W_R = N$	$2N$

3. Traffic is very high in SR protocol because SR Protocol uses independent acknowledgement

Total time = $T_d(F) + 2 * P_d + Q_d + P_{rd} + T_d(A)$

	Stop & wait	GBN	SR
Efficiency	$\eta = \frac{\text{useful time}}{\text{Total time}}$ or $\boxed{\eta = \frac{T_d}{\text{Total time}}}$	$\eta = \frac{\text{useful time}}{\text{Total time}}$ or $\boxed{\eta = \frac{N * T_d}{\text{Total time}}}$	$\eta = \frac{\text{useful time}}{\text{Total time}}$ or $\boxed{\eta = \frac{W_S * T_d}{\text{Total time}}}$
Throughput	$\frac{\text{Length of } the\ frame}{\text{Total time}}$ or $\boxed{\eta * B}$	$\frac{N * \text{Length of } the\ frame}{\text{Total time}}$ or $\boxed{\eta * B}$	$\frac{W_S * \text{Length of } the\ frame}{\text{Total time}}$ or $\boxed{\eta * B}$
Buffer	1 + 1	N + 1	N + N
Seq No.	2 (0,1)	N + 1	2N
Seq. No. = K bit		$\frac{W_S}{2^K - 1}$ $\frac{W_R}{1}$	$\frac{W_S}{2^{K-1}}$ $\frac{W_R}{2^{K-1}}$

Problem Solving
on
SR Protocol

Q.1

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

$\boxed{\text{GATE}}$

(A) 2^n

(B) $2^{(n-3)}$

(C) 2^{n-1} ✓

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

Seq No = n bit

SR

W_s W_R

2^{n-1} 2^{n-1}

Q.2 If senders Window size(W_S) is 75. What will be sequence numbers required in Go-Back-N and SR protocol?

(A) 0 to 75 and 0 to 76

(B) 0 to 75 and 0 to 149 ✓

(C) 0 to 75 and 0 to 150

(D) 0 to 74 and 0 to 150

If window sender size = N

min. seq No. required in GBN = N+1 [0 − N]

min. " " " " SR = N+N = 2N [0 − 2N−1]

N = 75

min. seq No. required in GB-N = 75+1 = 76 [0−75]

min. " " " " SR = 75+75 = 150 [0 − 149]

Q.3 If 'N' is the maximum sequence number then window size in GB-N and SR is

(A) $\frac{N}{2}$, N – 1

(B) N – 1, $\frac{N}{2}$

(C) N, $\frac{N+1}{2}$

(D) $\frac{N+1}{2}$, N

Seq No = 8 (0, 1, 2, 3, 4, 5, 6, 7)
N

GB-N

W_S	W_R
7	1
N	1

SR

W_S	W_R
4	4
$\frac{7+1}{2}$	$\frac{7+1}{2}$
$\frac{N+1}{2}$	$\frac{N+1}{2}$

Q.4

Suppose sliding window ARQ is used for flow control and optimal window size for maximum utilization of link is 5. If stop & wait ARQ is used instead of sliding window then the link utilization (in percent) is 20.

sender window size

$\eta_{\text{sliding window}} = 1$, IF, $N = 5$

$$\boxed{\eta_{\text{sliding window}} = N * \eta_{\text{stop \& wait}}}$$

$$\eta_{\text{stop \& wait}} = \frac{1}{N} * \eta_{\text{sliding window}}$$

$$= \frac{1}{5} * 1 = 20\,\%$$

Q.5 Consider minimum number of bits required for sequence number field in selective repeat ARQ for maximum utilization are 4 then the efficiency of stop & wait ARQ (in percent) is ____.

$\eta_{\text{sliding window}} = N * \eta_{\text{stop \& wait}}$

$\eta_{\text{stop \& wait}} = \frac{1}{N} * \eta_{\text{sliding window}}$

$= \frac{1}{8} * 1$

$= .125$

$= 12.5\%$

Seq No = 4 bit

W_S	W_R
2^{4-1}	2^{4-1}
8	8

$N = 8$

↳ sender window size

Q.6 Assume we need to design selective repeat protocol for a network in which bandwidth is 1 Mbps and average distance between sender and receiver is 5000 Km. Assume that average packet size is 5000 bits. Propagation speed in the media is 2×10^8 m/sec. If window sender size is 8 and process delay is 0.5 Msec and queuing delay is 2msec then what is the efficiency.

(A) 99%

(B) 57%

(C) 87%

(D) 70%

$B = 1\,\text{mbps} = 10^6$ bits/sec, $d = 5000$ km, Packet size $= 5000$ bits

$v = 2 * 10^8$ m/sec

$v = 2 * 10^5$ km/sec

$W_s = 8$, $P_{rd} = 0.5$ msec, $Q_d = 2$ msec

$$T_d(F) = \frac{\text{Frame size}}{\text{Bandwidth}}$$

$$= \frac{5000 \text{ bits}}{10^6 \text{ bits/sec}}$$

$$= 5 \times 10^{-3} \text{ sec}$$

$$= 5 \text{ msec}$$

$$P_d = \frac{d}{v} = \frac{5000 \text{ km}}{2 \times 10^5 \text{ km/sec}}$$

$$= 25 \times 10^{-3} \text{ sec}$$

$$= 25 \text{ msec}$$

$$\eta = \frac{\text{Useful time}}{\text{total time}}$$

$$\eta = \frac{W_s * T_d(F)}{T_d(F) + 2 * P_d + Q_d + P_{rd} + T_d(A)}$$

$$= \frac{8 * 5}{5 + 2 \times 25 + 2 + 0.5 + 0}$$

$$= \frac{40}{57.5}$$

$$\eta = 0.6956$$

$$\eta = 69.56\% \simeq 70\%$$

Q.7

H.W

In selective repeat ARQ, packet size is 2000 bytes transmission time for one packet is 1ms. If distance between hosts is 10km and signal speed is 4ms per km (4ms/km) and frame sequence number are 6 bit long in frame format then the throughput (in Mbps) is 6.32 mbps

Seq No = 6 bit

$$\boxed{\text{Throughput} = \eta * B}$$

OR

$$\boxed{\text{Throughput} = \frac{W_s * \text{Frame size}}{\text{Total time}}}$$

W_s	W_R
2^{6-1}	2^{6-1}
32	32

Q.8 Suppose you are designing a sliding window protocol for a 1-Mbps point to point link to the moon, which has a one way latency (delay) of 1.25 seconds. Assuming that each frame carries 1 KB of data, the minimum number of bits you need for the sequence number

(i) for RWS = 1 (GBN) and

(ii) for SWS = RWS (SR) is

(A) 6, 7

(B) 7, 8

(C) 8, 9

(D) 9, 10

$B = 10^6$ bits/sec

$P_d = 1.25$ sec

Frame size = 1 KB
= 1024 Byte
= 8 * 1024 bits
= 8192 bits

$T_d(F) = \frac{8192 \text{ bits}}{10^6 \text{ bits/sec}} = 8192 * 10^{-6}$ sec

$T_d(F) = 0.008192$

$$\text{efficiency} = \frac{\text{useful time}}{\text{total time}}$$

$$\frac{1}{1} = \frac{N * Td(F)}{Td(F) + 2 * Pd + \cancel{Qd}_{0} + \cancel{Pcd}_{0} + \cancel{Td(A)}_{0}}$$

$$\frac{306 * 0.008192}{0.008192 + 2 * 1.25}$$

$$= 0.99$$

$$N = \frac{Td(F) + 2 * Pd}{Td(F)}$$

$$N = \frac{0.008192 + 2 * 1.25}{0.008192}$$

$$N = \lceil 306.17 \rceil$$

$N = 307$ → sender window size

Sliding window	GB-N	S.R
minimum seq.No. required in sliding window = 307	minimum seq. No. required in GB-N = 307 + 1 = 308	minimum sequence No. required in SR = 307 + 307 = 614
$2^K = 307$	$2^K = 308$	$2^K = 614$
$2^K = 2^9$	$2^K = 2^9$	$2^K = 2^{10}$
$\boxed{K = 9 \text{ bit}}$	$\boxed{K = 9 \text{ bit}}$	$\boxed{K = 10 \text{ bit}}$

Q.9

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

H.W

Q.10

H.W

A 3000 km long trunk operating at 1.536 Mbps is used to transmit 64 bytes frames and uses SWP. If the propagation speed is 6 µsec/km, then the number of bits should the sequence numbers be

Sliding window Protocal

(A) 5

(B) 6

(C) 7

(D) 8

Q.11

Consider selective repeat ARQ is used for flow control, frame size is 4000 bits, data transfer rate of channel is 1 Mbps and one way propagation delay is 18 ms then minimum number of bits required for sequence number field for maximum utilization is ____ .

$\boxed{\text{H.W}}$

Q.12 Consider the sliding window flow-control protocol operating between a sender and a receiver over a full-duplex error-free link. Assume the following:

- The time taken for processing the data frame by the receiver is negligible.
- The time taken for processing the acknowledgement frame by the sender is negligible.
- The sender has infinite number of frames available for transmission.
- The size of the data frame is 2,000 bits and the size of the acknowledgement frame is 10 bits.
- The link data rate in each direction is 1 Mbps (= 10^6 bits per second).
- One way propagation delay of the link is 100 milliseconds.
- The minimum value of the sender's window size in terms of the number of frames, (rounded to the nearest integer) needed to achieve a link utilization of 50% is__________.

GATE-2021

Q.13 Station A uses 32 bytes 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?

(A) 20

(B) 40

(C) 160

(D) 41

AD steps to solve SWP Problem

1. Calculate RTT
2. Based on the given Bandwidth and RTT calculate No. of bits we are able to transfer with in RTT and Equate it as window in terms of bits (W_{bits}) = B*RTT
3. W_{pkt} or W_p = $\dfrac{W_{bits}}{(\text{Packet size})\text{ bits}}$
4. Minimum sequence No. required = W_p
5. $2^K = W_P$

   Where K = No. of bits required in the sequence number field

Q.14

Consider two node A and B round trip delay between these is 80 ms and bottle neck bandwidth of link between A and B is 512 KBps, the optimal window size (in packets) if the packet size is 64 Byte ______.

H.W


THANK YOU
GW
SOLDIERS !