Previous year questions

(Flow control & Error control)

1. 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 error control strategy. All packets are ready and immediately available for transmission. If every 5th 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? **[Gate2006]**

PYQ's

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1 2 3 4 5 6 7 5 6 7 8 9 7 8 9 9

(A) 12
(B) 14
(C) 16
(D) 18

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Explanation: The window size is 3, so a maximum of 3 packets can be remained unacknowledged. In go-back 'n', if acknowledgement for a packet is not received, then packets after that packet are also retransmitted.

The frame sequence for nine frames is shown below. Frame with bold sequence number gets lost.

1 2 3 4 5 6 7 5 6 7 8 9 7 8 9 9

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(A) 12
(B) 14
(C) 16
(D) 18

Ans. C

2. 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 size is five packets each. Data packets (sent only from A to B) are all 1000 bytes long, and the transmission time for such a packet is 50µs. Acknowledgement packets are very small (sent only from B to A) and require very negligible time. The propagation delay over the link is 200 µs. What is the maximum achievable throughput in this communication? **[Gate2003]**

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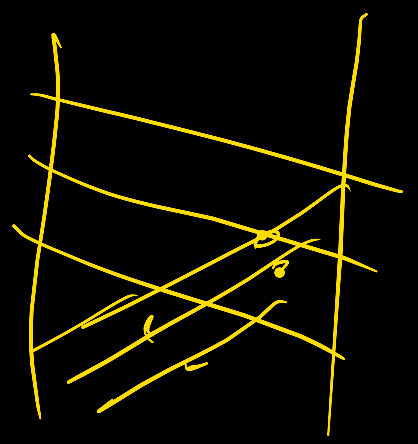
(A) 7.69 x 10^6 bytes per second
(B) 11.11 x 10^6 bytes per second
(C) 12.33 x 10^6 bytes per second
(D) 15.00 x 10^6 bytes per second



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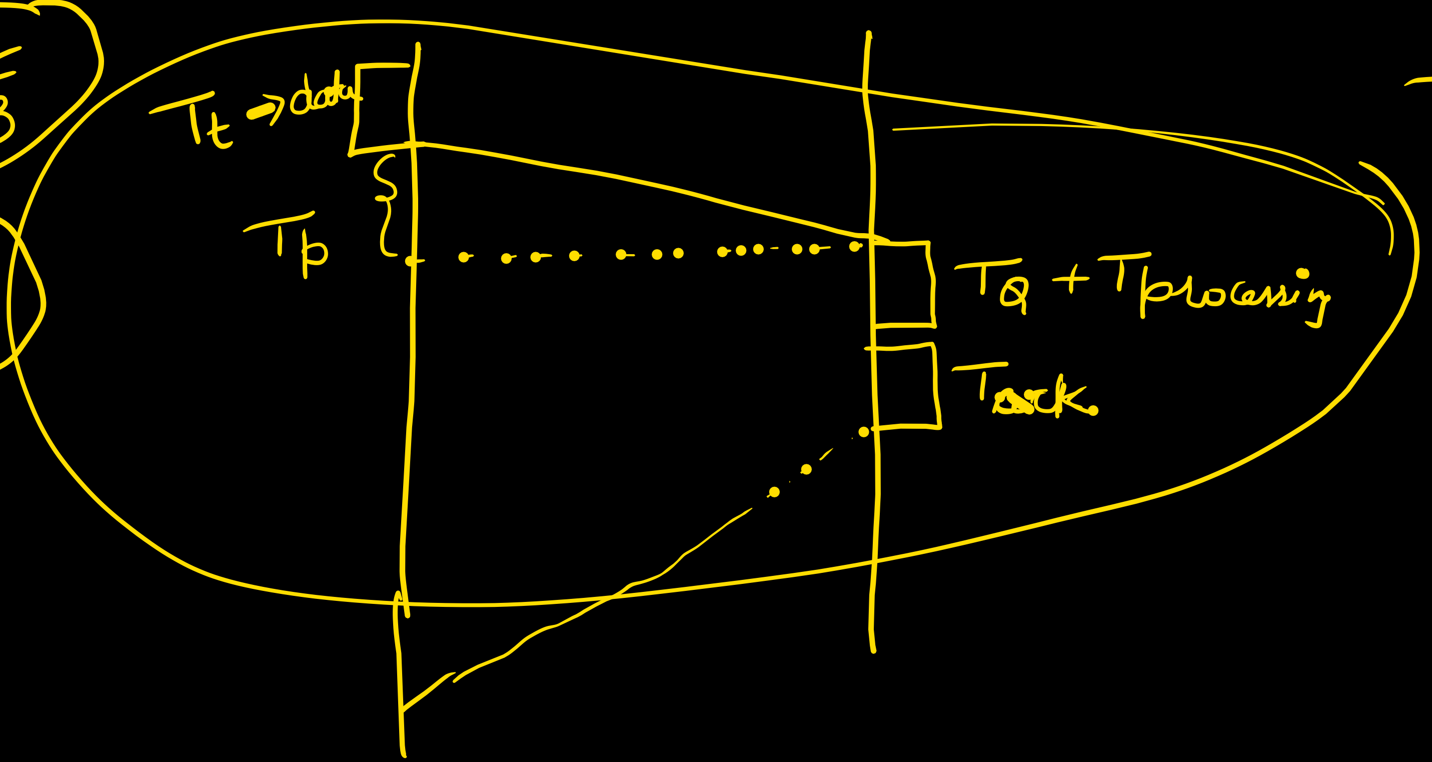
$T_t = \frac{L}{B}$

$B = \frac{L}{T_t}$



Total time

$\eta = \frac{UT}{TT}$

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$10^{-6} \rightarrow 10^{6}$

BW $\quad T_t \quad L \quad T_t$

Explanation: ~~Transmission rate~~ , T_t is= 1000 bytes/ 50 µs=8000bits /50 µs=$\boxed{160 \text{ Mbps}}$

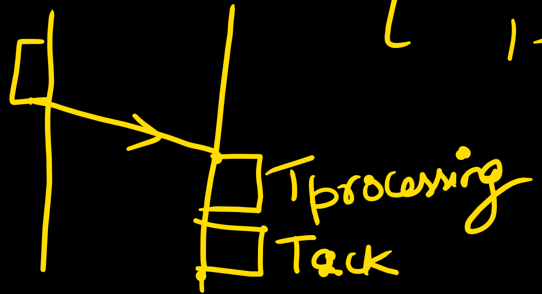
Efficiency= 5* 50/(50+400)=250/450=5/9

$T_t = L/B \qquad B = T_t * L$

Maximum achievable throughput=(5/9)*160 Mbps=88.88Mbps$\boxed{=11.11 \text{ x } 10\text{^}6 \text{ bytes per second}}$

$$\eta = \frac{W_s}{1+2a} = \frac{5}{1+2*\frac{T_p}{T_t}} = \frac{5}{9}$$

$$Th = \eta * B.$$



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(C) 12.33 x 10^6 bytes per second
(D) 15.00 x 10^6 bytes per second

Ans. B

3. The maximum window size for data transmission using the selective reject protocol with n bit frame sequence numbers is: [Gate2005]

$$n \rightarrow \text{Seq} \rightarrow 2^n$$

$$SR \rightarrow \frac{2^n}{2} = 2^{n-1}$$

3. The maximum window size for data transmission using the selective reject protocol with n bit frame sequence numbers is: [Gate2005]

(a) 2^n
(b) $2^{(n-1)}$
(c) $2^n - 1$
(d) $2^{(n-2)}$

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Ans. b

- If the question is for sliding window, then option a If question is for GBN, then option c

4. 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? **[Gate2006]**

4. 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? **[Gate2006]**

(A) 20
(B) 40
(C) 160
(D) 320

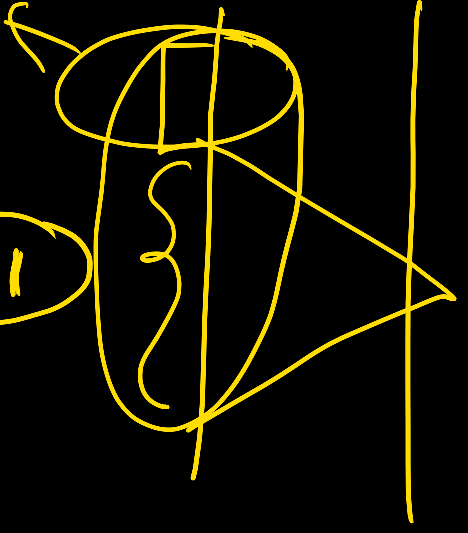
$1+2a$ L $2 * T_p$

window

$1 + 2a$

$1 + \frac{2 * T_p}{T_t}$

$$1 + \frac{80 \times 10^{-3}}{\frac{32 \times 8}{128 \times 10^{3}}} = 41$$



$1+2a$

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Explanation: Tx= 32bytes/ 128kbps=32*8/128 ms= 2ms
Round trip delay = 2 * Tp = 80 ms(given)
Optimal window size is = (Tx+2Tp)/Tx =82 / 2 =41.
Option is not given; the closest option is 40

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(A) 20
(B) 40
(C) 160
(D) 320

Ans. B

5. The distance between two stations, M and N, is L kilometres. All frames are K-bit long. The propagation delay per kilometre is t seconds. Let R bits/second be the channel capacity. Assuming that the processing delay is negligible, the minimum number of bits for the sequence number field in a frame for maximum utilisation when the sliding window protocol is used is: **[Gate2007]**

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(A) Log 2 ((2LtR+2k)/k)
(B) Log 2 (2LtR/k)
(C) Log 2 ((2LtR+k)/k)
(D) Log 2 ((2LtR+k)/2k)

$1+2a$

$= 1 + 2\left(\frac{Lt}{K/R}\right)$

$\log_2\left(\frac{K + 2LtR}{K}\right)$

$d = L$ km

T_p/km $\rightarrow$ t sec

$T_p \rightarrow Lt$ sec

$B \rightarrow R$ bps

$L \rightarrow K$ bit

$T_t = K/R$

Hi Lidia

1 km $\rightarrow$ t ses

L km $\rightarrow$ Lt sec

5 min break

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Explanation:

Maximum window size(Wmax)= (Tx+2Tp)/Tx.

Here, Tp = Lt (look at the units of propagation delay)

Tx = K/R

Wmax = (Tx+2*Tp)/Tx

= (K/R + 2Lt) / (K/R)

= (2LtR+k)/k

Let minimum n number of bits required, then 2^n = Wmax=(2LtR+k) / k

n=log2 ((2LtR+2k)/k)

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(C) Log 2 ((2LtR+k)/k)
(D) Log 2 ((2LtR+k)/2k)

Ans. A

6. 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 the correct operation of the ARQ scheme is **[Gate2004]**

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(A) min(M, N)
(B) max(M, N)
(C) M+N
(D)MN

$$\boxed{Seq \geq \omega_S + \omega_R.}$$

$N + 1$

$N + N$

$1 + 1$

$M + N$

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(C) M+N
(D)MN

Ans. M+N

7. A 25 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? [**Gate2004**]

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Throughput

&

Eff BW

&

BW utilization

(A) 5 Kbps
(B) 10 Kbps
(C) 15 Kbps
(D) 20 Kbps

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T_t

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

Explanation: Tx=100*8 bits/25Kbps=32 ms

Tp = 400ms, a=Tp/Tx = 400/32 = 12.5

Efficiency of GBN = W/(1+2a), where w= window size = 10

= 10/(1+25) = 10/26

BW utilisation or throughput or max datarate = efficiency * BW

= (10/26) * 25

It is nearly 10 Kbps

$1+2a$

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(A) 5 Kbps
(B) 10 Kbps
(C) 15 Kbps
(D) 20 Kbps

Ans. B

8. A channel has a bit rate of 4 kbps and a one-way propagation delay of 20 ms. The channel uses the 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 [Gate2005]

8. A channel has a bit rate of 4 kbps and a one-way propagation delay of 20 ms. The channel uses the 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 [Gate2005]

(A) 80 bytes
(B) 80 bits
(C) 160 bytes
(D) 160 bits

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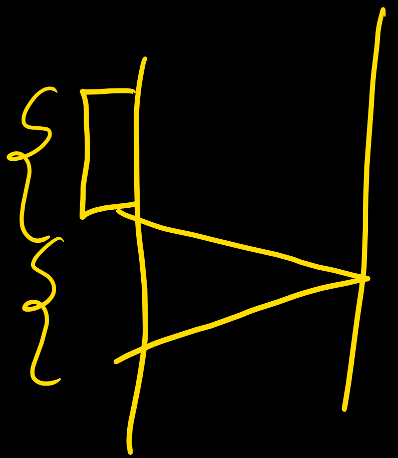
$\eta = \frac{1}{1+2a}$

$\frac{1}{1+2a} \geq 0.5$



Explanation:

Efficiency of stop and wait = $\boxed{1/(1+2a)}$

If 1/(1+2a) = 0.5 => 2*Tp = Tx. => L = 2*B*Tp =160 bits

$T_t = 2 * T_p.$

$\frac{L}{B} = 2 * T_p$

$\boxed{L = 2 * B * T_p}$

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(A) 80 bytes
(B) 80 bits
(C) 160 bytes
(D) 160 bits

Ans. D

9. 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? **[Gate2006]**

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(a) 100
(b) 125
(c) 150
(d)200

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Explanation: error rate 0.2,

In the stop-and-wait protocol, the sender will transmit

100*(1+0.2+0.2

$$\frac{n}{1-p} \quad \frac{100}{1-0.2} =$$

2 +0.2

3 +0.2

4 +..............) packets

= 100 *(1/(1-.02))=100/0.8 = 125 (sum of infinite G.P. is a/(a-r))

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(a) 100
(b) 125
(c) 150
(d)200

Ans. b

10 . Determine the maximum length of the cable (in km) for transmitting data at a rate of 500 Mbps in an Ethernet LAN with frames of size 10,000 bits. Assume the signal speed in the cable to be 2,00,000 km/s. **[Gate2013]**

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(A) 1
(B) 2
(C) 2.5
(D) 5

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Explanation:

500×10^6 bits ------ 1 sec

$$\therefore 10^4 \quad bits \text{ ------- } \frac{5\times10^8}{10^4} = \frac{10^4}{5\times10^8} sec = \frac{1}{5\times10^4} sec$$

1 sec------2×10^5 km

$$\frac{1}{5\times10^4} \text{ ------ } \frac{2\times10^5}{5\times10^4} = 4 \text{ km}$$

$$Maximum\ length\ of\ cable = \frac{4}{2} = 2\ km$$

10 . Determine the maximum length of the cable (in km) for transmitting data at a rate of 500 Mbps in an Ethernet LAN with frames of size 10,000 bits. Assume the signal speed in the cable to be 2,00,000 km/s. **[Gate2013]**

(A) 1
(B) 2
(C) 2.5
(D) 5

Answer: (B)

11. 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). The 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. **[Gate2016]**

$$\left(\frac{1}{1+2a}\right)B \qquad \eta * B$$

Explanation:

Given,

Frame size (L) =1000 bytes

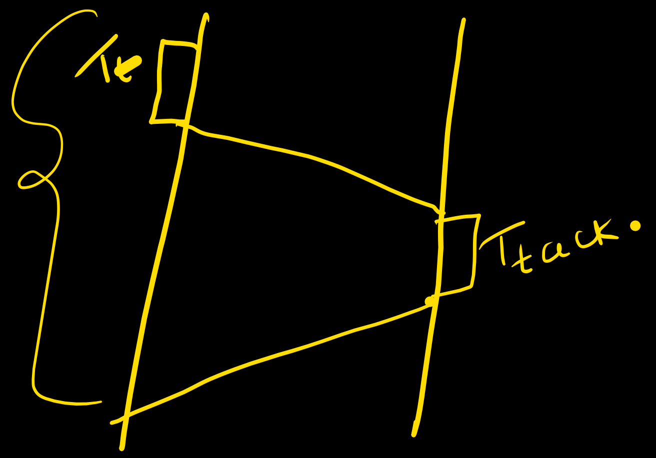
Sender side bandwidth (BS) = 80 kbps = 10 * 10^3 bytes/sec

Acknowledgement size (LA) =100 bytes

Receiver side bandwidth (BR) = 8 kbps = 1 * 10^3 bytes/sec

Propagation delay (Tp) =100 ms

$$\frac{80 \times 10^3 \text{ bps}}{10 \times 10^3}$$



$$\eta = \frac{UT}{TT} = \frac{T_t}{T_t + 2 * T_p + T_{tack}}$$

Explanation:

Given,

Frame size (L) =1000 bytes

Sender side bandwidth (BS) = 80 kbps = 10 * 103 bytes/sec

Acknowledgement size (LA) =100 bytes

Receiver side bandwidth (BR) = 8 kbps = 1 * 103 bytes/sec

Propagation delay (Tp) =100 ms

By formula:

Transmission delay (Tt) = L/BS = 1000 bytes / 10 * 103 bytes/sec = 100 ms

Acknowledge delay (Tack) = LA / BR = 100 bytes / 1 * 103 bytes/sec = 100 ms

Explanation:

$$\eta = \frac{T_t}{T_t + 2 * T_p + T_{ack}}$$

Given,

Frame size (L) =1000 bytes

Sender side bandwidth (BS) = 80 kbps = 10 * 103 bytes/sec

Acknowledgement size (LA) =100 bytes

Receiver side bandwidth (BR) = 8 kbps = 1 * 103 bytes/sec

Propagation delay (Tp) =100 ms

By formula:

Transmission delay (Tt) = L/BS = 1000 bytes / 10 * 103 bytes/sec = 100 ms

Acknowledge delay (Tack) = LA / BR = 100 bytes / 1 * 103 bytes/sec = 100 ms

Total cycle time = Tt + 2 * Tp + Tack = 100 ms + 2 * 100 ms + 100 ms = 400 ms

Efficiency (η) = Tt / Total cycle time = 100 ms / 400 ms = 1 / 4 = 0.25

$Th = \eta * BW$

Explanation:

Tt S BW R Tt BW

Given,

Frame size (L) =1000 bytes

Sender side bandwidth (BS) = 80 kbps = 10 * 103 bytes/sec

Acknowledgement size (LA) =100 bytes

Receiver side bandwidth (BR) = 8 kbps = 1 * 103 bytes/sec

Propagation delay (Tp) =100 ms

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Total cycle time = Tt + 2 * Tp + Tack = 100 ms + 2 * 100 ms + 100 ms = 400 ms

Efficiency (η) = Tt / Total cycle time = 100 ms / 400 ms = 1 / 4 = 0.25

Throughput = Efficiency (η) * Bandwidth (BS) = 0.25 * 10 *103 bytes/s = **2500 bytes/second**

11. 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). The 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 n frame is lost, the sender throughput is _________ bytes/ second. **[Gate2016]**

Answer: 2500 bytes/second

12. 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 acknowledgement and the processing time at nodes are negligible. Then, the minimum frame size in bytes to achieve a link utilisation of at least 50% is __________.
[Gate2015]

12. 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 acknowledgement and the processing time at nodes are negligible. Then, the minimum frame size in bytes to achieve a link utilisation of at least 50% is __________.
[Gate2015]

(A) 160
(B) 320
(C) 640
(D) 220

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Explanation:

Transmission or Link speed = 64 kb per sec
Propagation Delay = 20 milliseconds

Since stop and wait is used, a packet is sent only when the previous one is acknowledged.

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Let x be the size of a packet, transmission time = x / 64 millisecond

Explanation:

Transmission or Link speed = 64 kb per sec
Propagation Delay = 20 milliseconds

Since stop and wait is used, a packet is sent only when the previous one is acknowledged.

Let x be the size of a packet, transmission time = x / 64 millisecond

Since utilisation is at least 50%, the minimum possible total time for one packet is twice the transmission delay, which means
x/64 * 2 = x/32

$T_t \geq 2 * T_p$ 50%

$\Rightarrow L \geq 2 * T_p * B$

x/32 > x/64 + 2*20
x/64 > 40
x > 2560 bits = 320 bytes

12. 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 acknowledgement and the processing time at nodes are negligible. Then, the minimum frame size in bytes to achieve a link utilisation of at least 50% is __________.
[Gate2015]

(A) 160
(B) 320
(C) 640
(D) 220

Answer: (B)

13. A link has a transmission speed of 106 bits/sec. It uses data packets of size 1000 bytes each. Assume that the acknowledgement 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 ____________. **[Gate2015]**

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10^6 bits/sec

(A) 4
(B) 8
(C) 12
(D) 16

$\eta = 25\%$ $1/4$

$$\frac{1}{1+2a} = \frac{1}{4}$$

$4 = 1 + 2a$

$3 = 2a \Rightarrow \frac{T_p}{T_t} = \frac{3}{2}$

$T_p = \frac{3}{2} * T_t = \frac{3}{2} * \frac{1000 \times 8}{10^6}$

12×10^{-3}

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$T_t = L/B = \frac{1000*8}{10^6}$

Explanation:

Transmission time Tt=1000*8/10^6=8/10^3 sec=8 ms

efficiency =25%=1/4=Tt/(Tt+2*Tp)

8/(8+2*Tp)=1/4

Tp=12

So the propagation Delay is 12 ms.

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Answer: (C)

14. Suppose two hosts are connected by a point-to-point link, and they are configured to use a Stop-and-Wait protocol for reliable data transfer. Identify in which one of the following scenarios is the utilisation of the link the lowest. **[Gate2023]**

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$$\eta = \frac{1}{1+2a} = \frac{1}{1+2 \times \underset{V}{d} \times \underset{L}{B}}$$

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Explanation

Utilisation of Link = Efficiency

Efficiency of Stop and wait protocol is

$$\eta = \left(\frac{1}{1 + \left(\frac{2T_p}{T_t} \right)} \right) = \left(\frac{1}{1 + \left(\frac{2d * B}{v * L} \right)} \right)$$

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where,

d= link length (distance), v= speed, B = bandwidth (Transmission Rate) and L = packet Length

As Efficiency η is inversely proportional to distance d, a longer Distance means lower efficiency.

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where,
d= link length (distance), v= speed, B = bandwidth (Transmission Rate) and L = packet Length
As Efficiency η is inversely proportional to distance d, a longer Distance means lower efficiency.

As Efficiency η is also inversely proportional to Bandwidth B, So Higher Bandwidth means lower efficiency.
Hence, option B is correct.

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Answer: (B)

15. Consider the sliding window flow-control protocol operating between a sender and a receiver over a full-duplex error-free link. Assume the following: **[Gate2021]**

- 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 an 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).
- The one-way propagation delay of the link is 100 milliseconds.

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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 utilisation of 50% is_______________.

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- The 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 utilisation of 50% is_______________.

(A) 51
(B) 50
(C) 25
(D) 52

$100\% \rightarrow (1+2a)$

$50\% \rightarrow \frac{(1+2a)}{2} = 1+2\times\frac{100}{\frac{2000}{10^6}} = (1+2*50) =$

$\frac{101}{2} = 50.5$

51

Explanation:

Explanation:

Tt(packet) = L / B.W => 2000 bits / 10^6 bps = 2 x 10^-3 sec = 2 millisecond
Tt(Ack) = L / B.W. => 10 bits / 10^6 bps = 10^-5 sec = 10^-2 millisecond = 0.01 millisecond
Tp = 100 millisecond
Total time = Tt(packet) + 2 x Tp + Tt(Ack)

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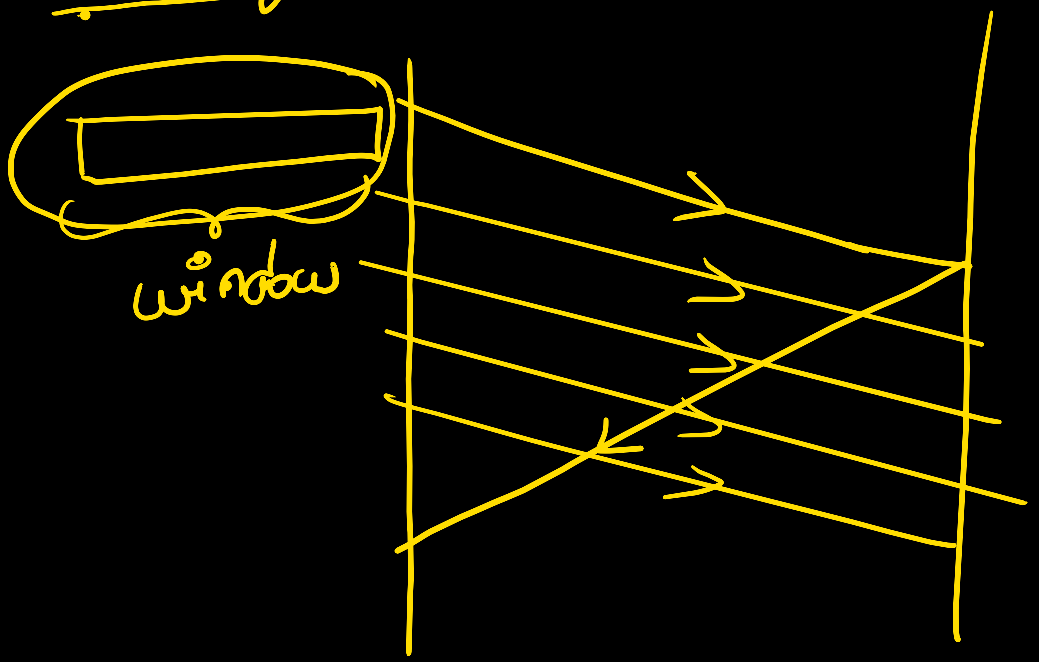
Tp = 100 millisecond
Total time = Tt(packet) + 2 x Tp + Tt(Ack)
=> 2 + 2 x 100 + 0.01 = 202.01 millisecond
Efficiency = 50 % = ½
Efficiency = Useful Time / Total time
½ = n x Tt / Total time
=> 2 x n x Tt = Total time
=>2 x n x 2 = 202.01
=> n = 202.01 / 4 => 50.50
For minimum, we have to take ceil, Hence the size of the window = 51

Answer: 51

Hi

Sliding window protocol

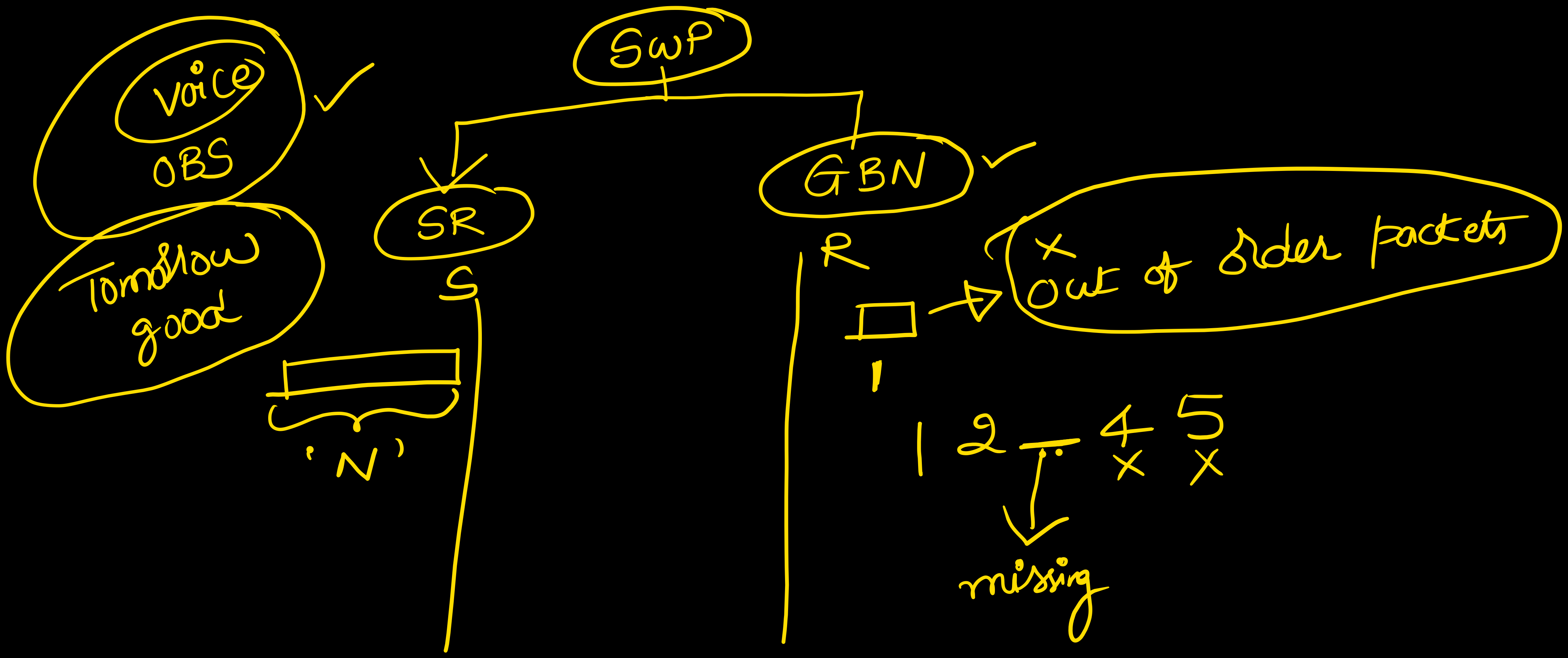


(voice)

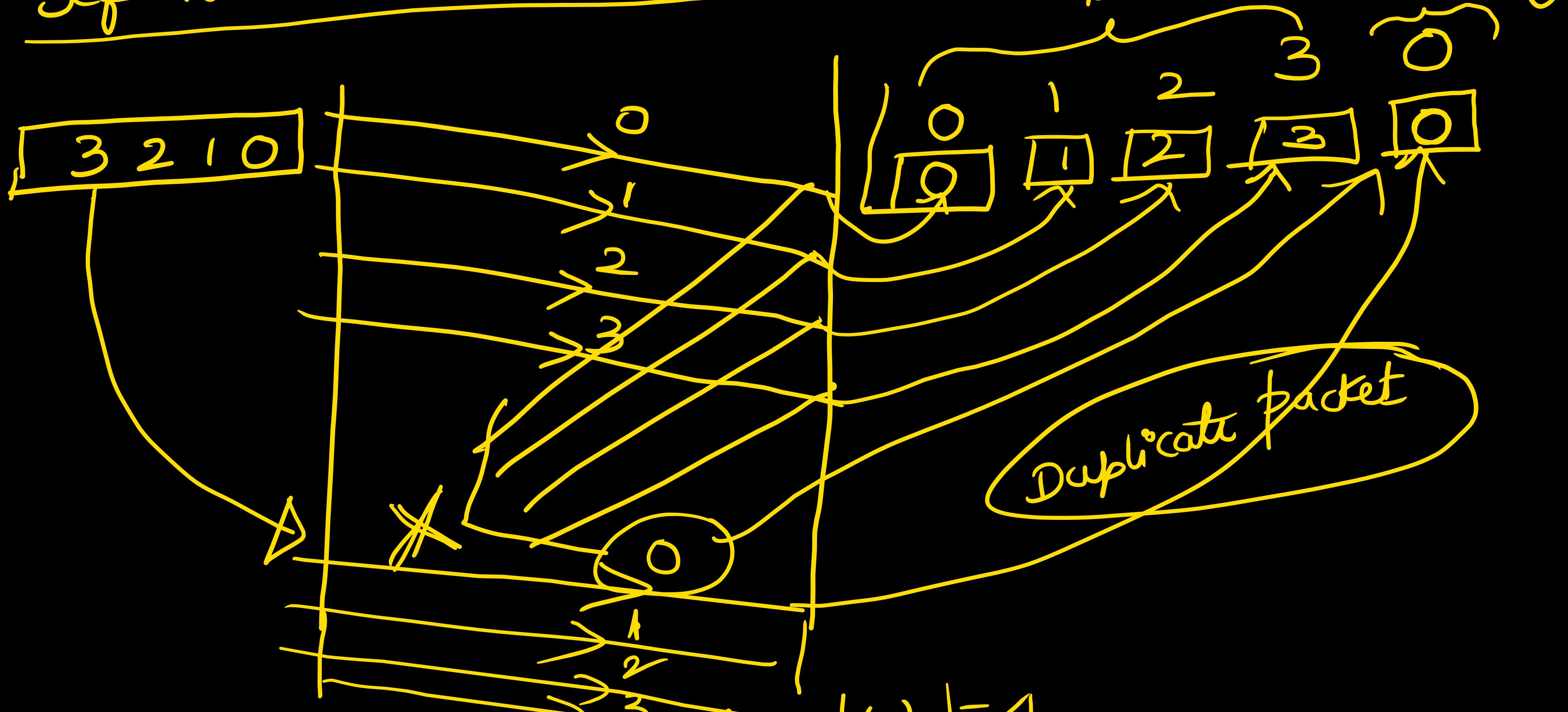
$$\boxed{100\% \rightarrow (1+2a)}$$

Seq $\rightarrow$ $1+2a$

bits $\lceil \log_2 1+2a \rceil$

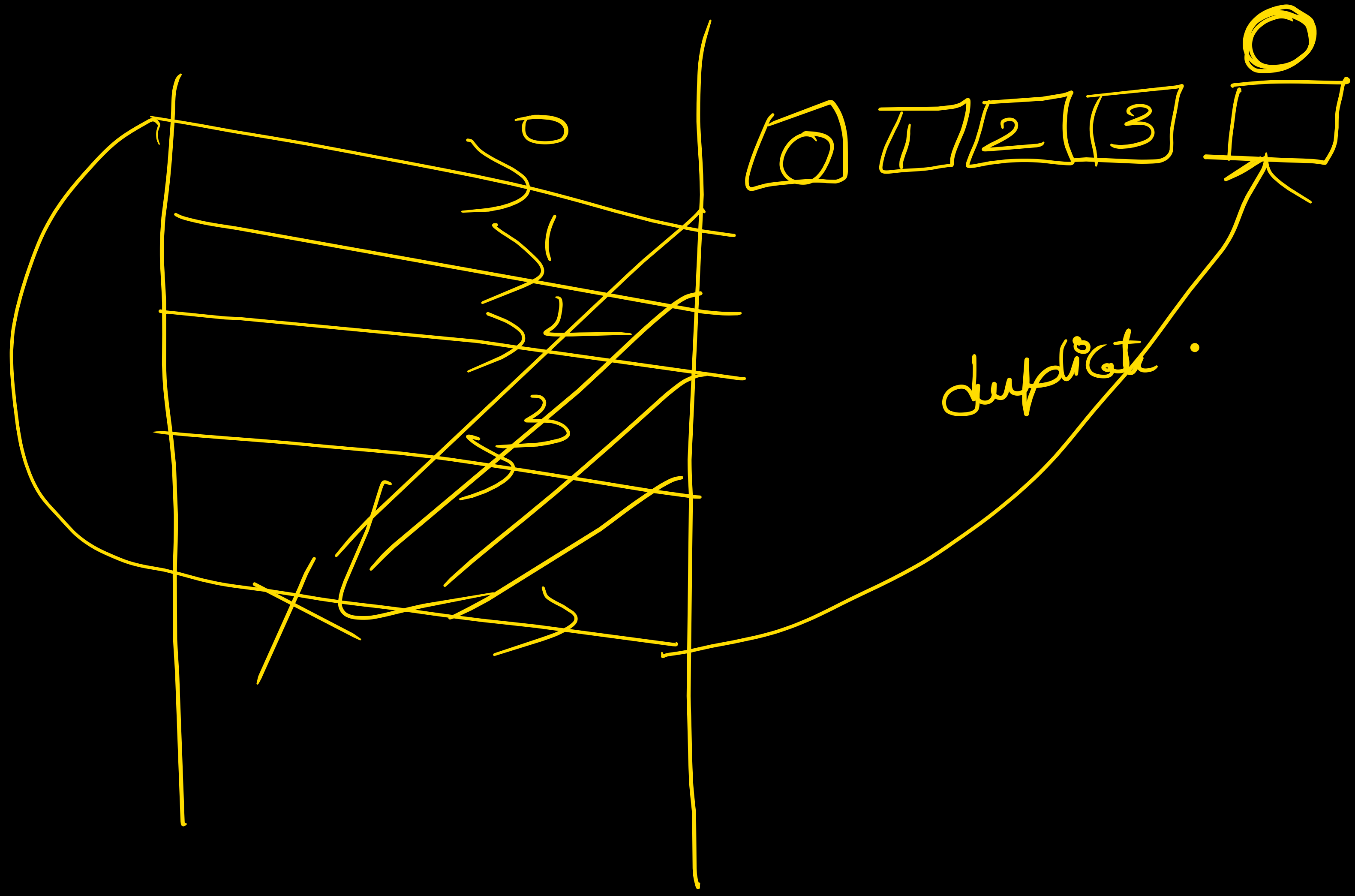

SWP
SR
GBN
voice
OBS
Tomorrow
good
S
'N'
R
Out of order packets
1 2 _ 4 5
missing

Seq numbers needed in GBN:



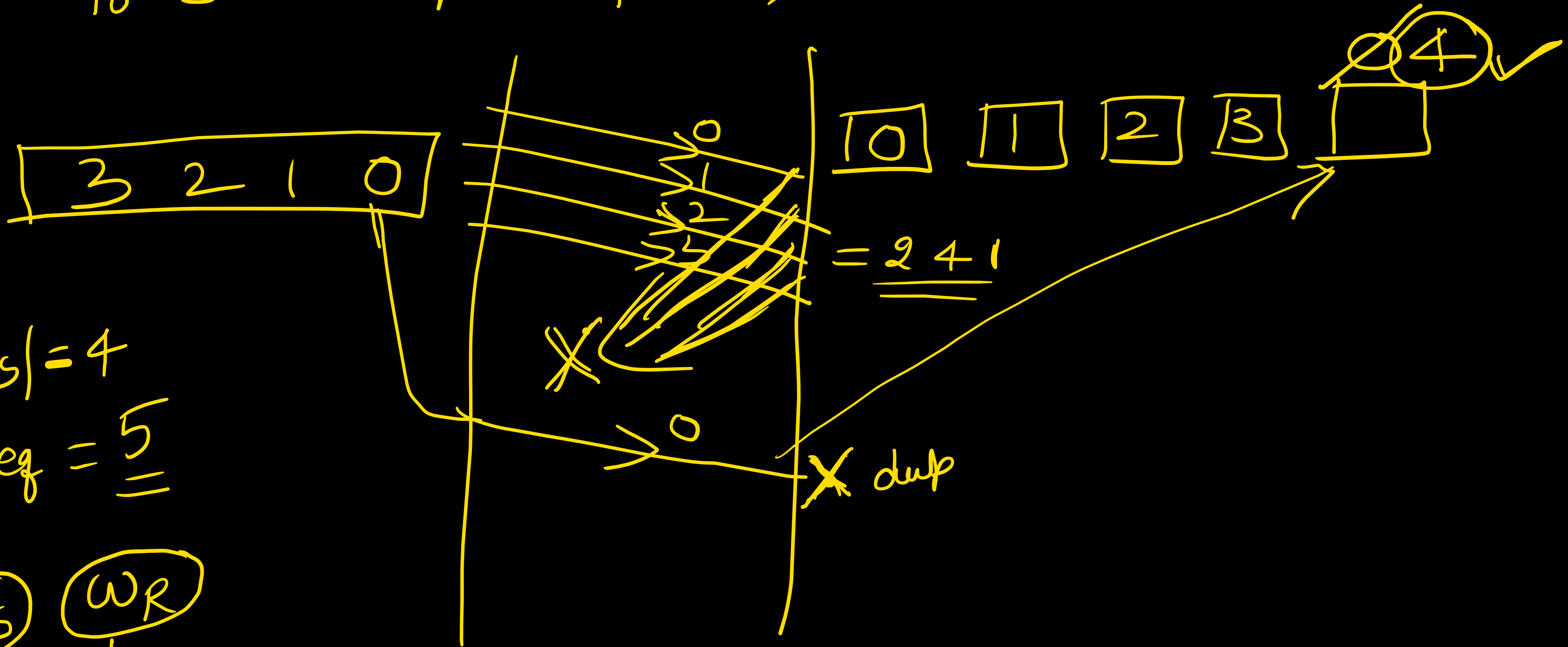
assume that $|W_s| = 4$

$\underline{Seq = 4}\ (0, 1, 2, 3)$



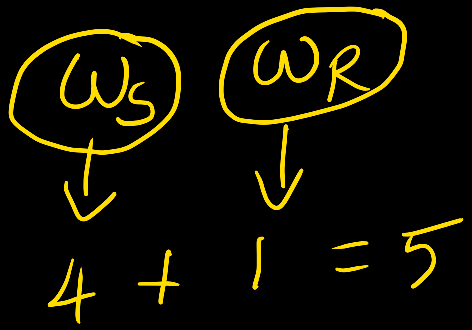
0
1
2
3
0 1 2 3 0
duplicate

To solve duplicate packets, we need more seq numbers.



$|W_S| = 4$

Seq = 5



Rule in any implimentation of SWP.

Seq number $\geq W_S + W_R$

$$\underline{\underline{(N + 1)}}$$

How many seq numbers are required in GB100?

$\boxed{\text{atleast } \boxed{101}}$ ✓

If seq numbers available are 'N', then what is $|W_S|$, $|W_R|$ in GBN?

$W_S = (N-1)$ $\quad W_R = 1$

If 'K' bits are available in seq number field then what is $|W_S|$, $|W_R|$ in GBN?

$$seq = 2^K$$

$$2^K - 1 \rightarrow W_S$$

$$1 \rightarrow W_R$$

SR protocol.

Selective Repeat (Reject)

Hi lidia

welcome to the class
Be on time

In SR, $\boxed{W_S = W_R}$

4	4
10	10
20	20

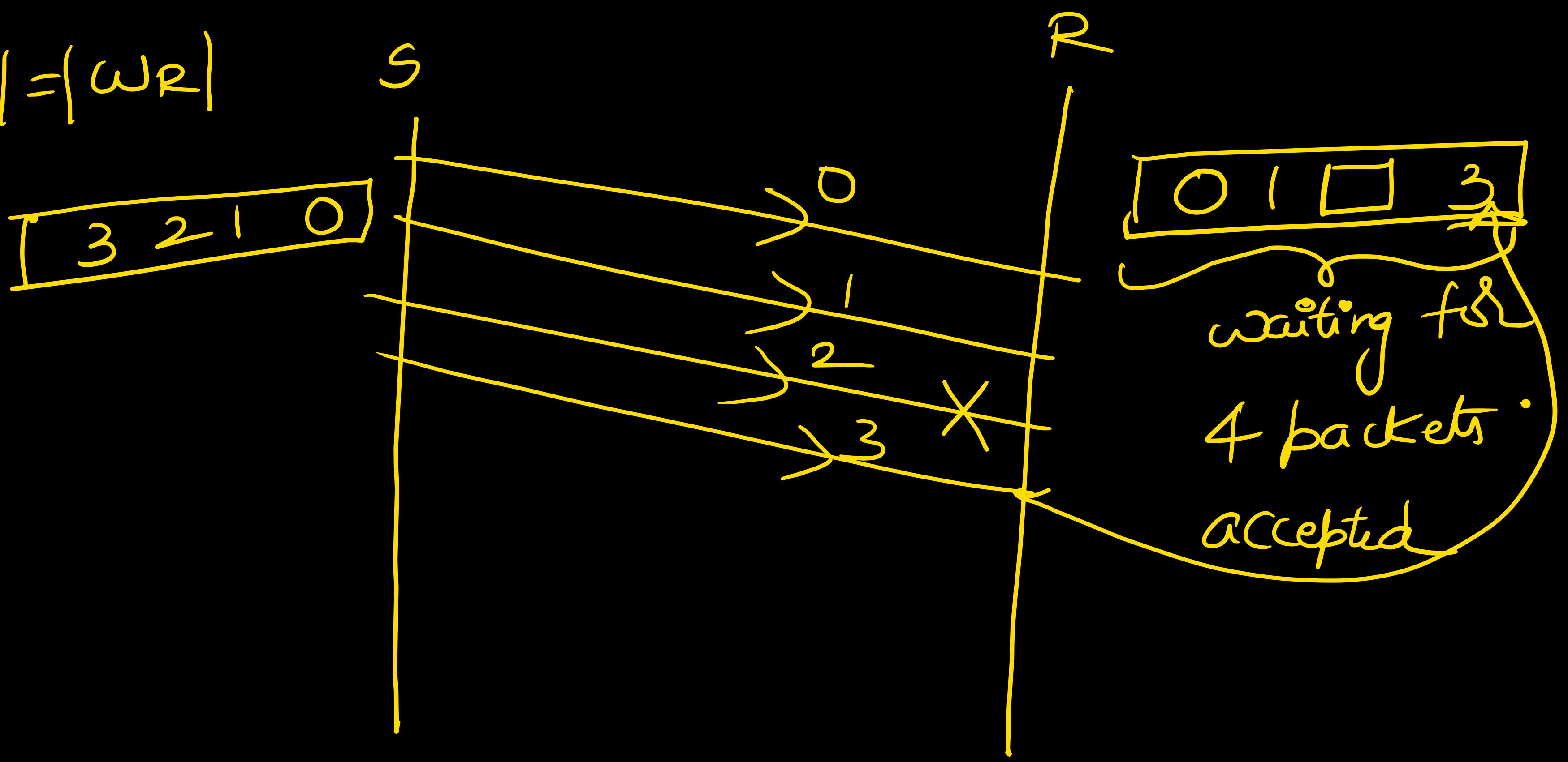
$T_t = 1ms$ $T_p = 49.5 ms$, $W_S = 50$, η?

$1+2a = 100$

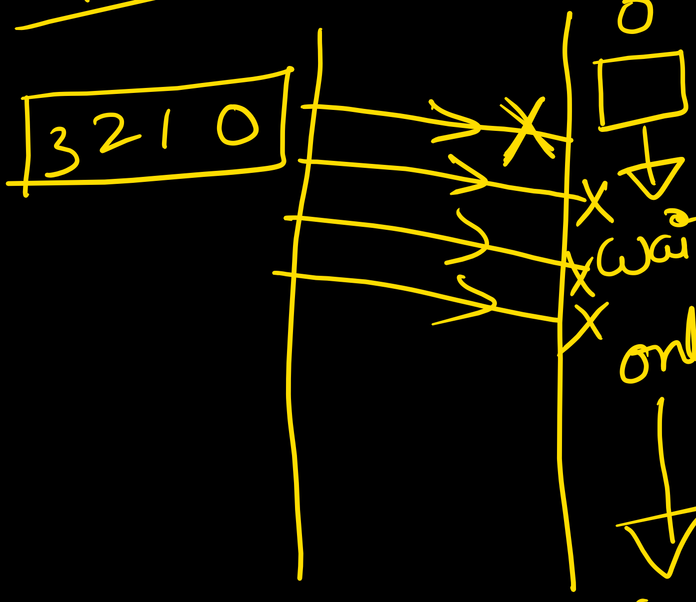
$$\boxed{\eta = \frac{W_S}{100} = \frac{50}{100} = 50\%.}$$

$$\boxed{\text{Remember} \rightarrow \eta \text{ does not depend on } |W_R|}$$

$$|W_S| = |W_R|$$



GBN

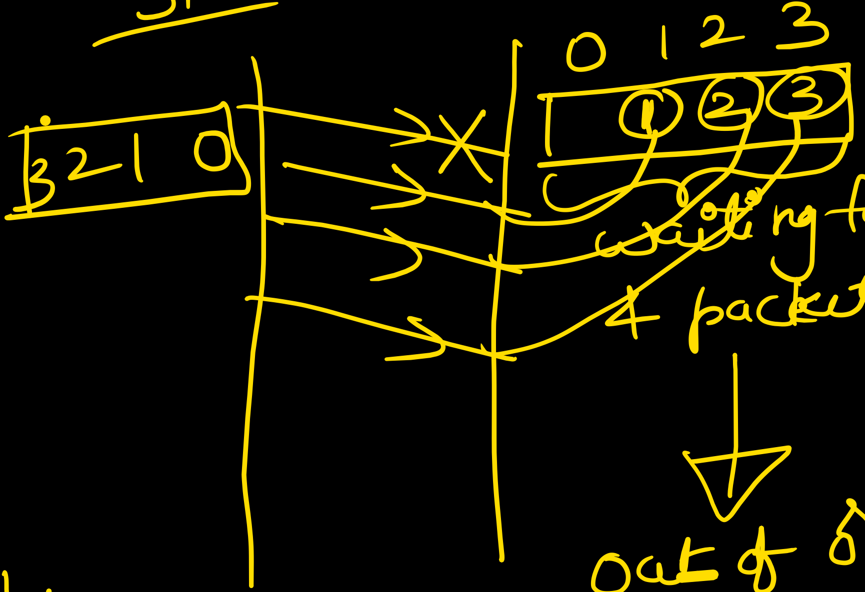


waiting for only one

out of order packets are rejected

0 1 2 — 4 5
✗ ✗

SR

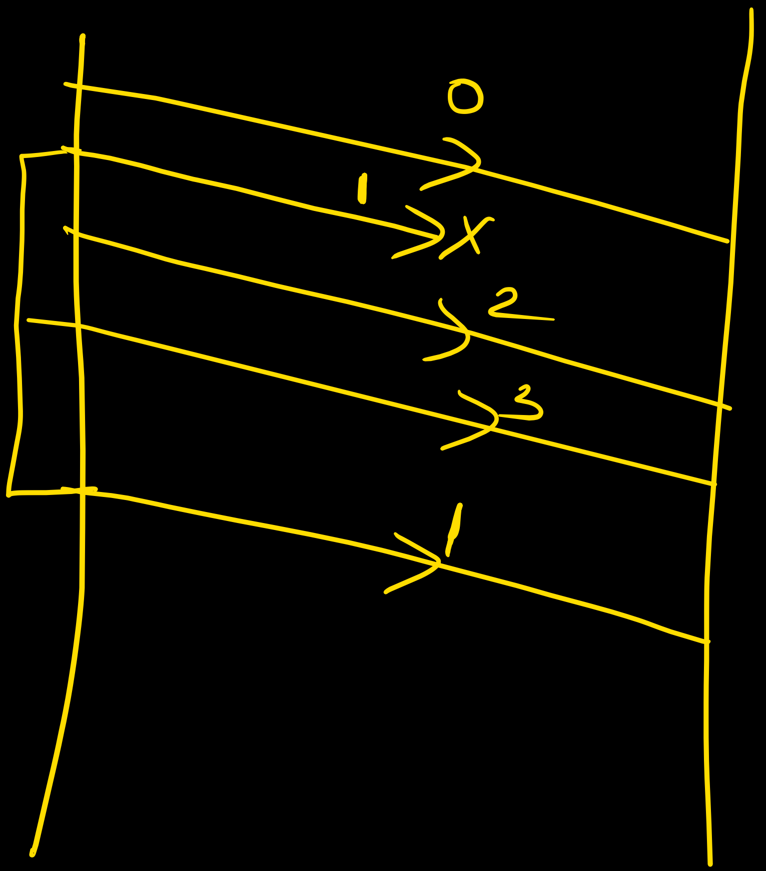


waiting for 4 packets

out of order packets are accepted

0 1 2 — 4 5
✓ ✓

SR



only lost packet will be retransmitted

GBN

entire window will be retransmitted

In SR, $W_s = 3$, 10 packets to be sent, every 5^{th} packet is lost $\rightarrow$ # packets totally transmitted

Same as $\rightarrow$ stop and wait

1 2 3 4 5 5 6 7 8 9 10 9

$\eta \rightarrow$ (GBN & SR) $\rightarrow$ high $|W_s| > 1$

Retransmissions $\rightarrow$ (SR and stop and wait) $\rightarrow$ low

SR :- 10 packet → every $\boxed{4^{th} \text{ lost}}$

$\boxed{\text{DO you need } |W_S| \text{ size?}}$

$\boxed{\text{NO need}}$ → Because only one packet is retransmitted

$\boxed{\text{NO need of } |W_R|}$

1 2 3 4 4 5 6 7 7 8 9 10 10

4 4 ↑

13

ACK:

In GBN

0 1 2 3 4 5 6 7

GBN

0 1 2 3 4

ack 5

means (0 1 2 3) → Rec

otherwise 4 will not be accepted

Cummulative work

one ack → ack many packets

InSR :

0   1   ~~2~~   3   4

ACK 5

doesn't mean 0123 are rec

↓

even without rec 0 1 2 3 → 4 will be accepted.

∴ 1 ack → X many packets

Cummulative → ?

↓

Independent

↓

Traffic high

↓

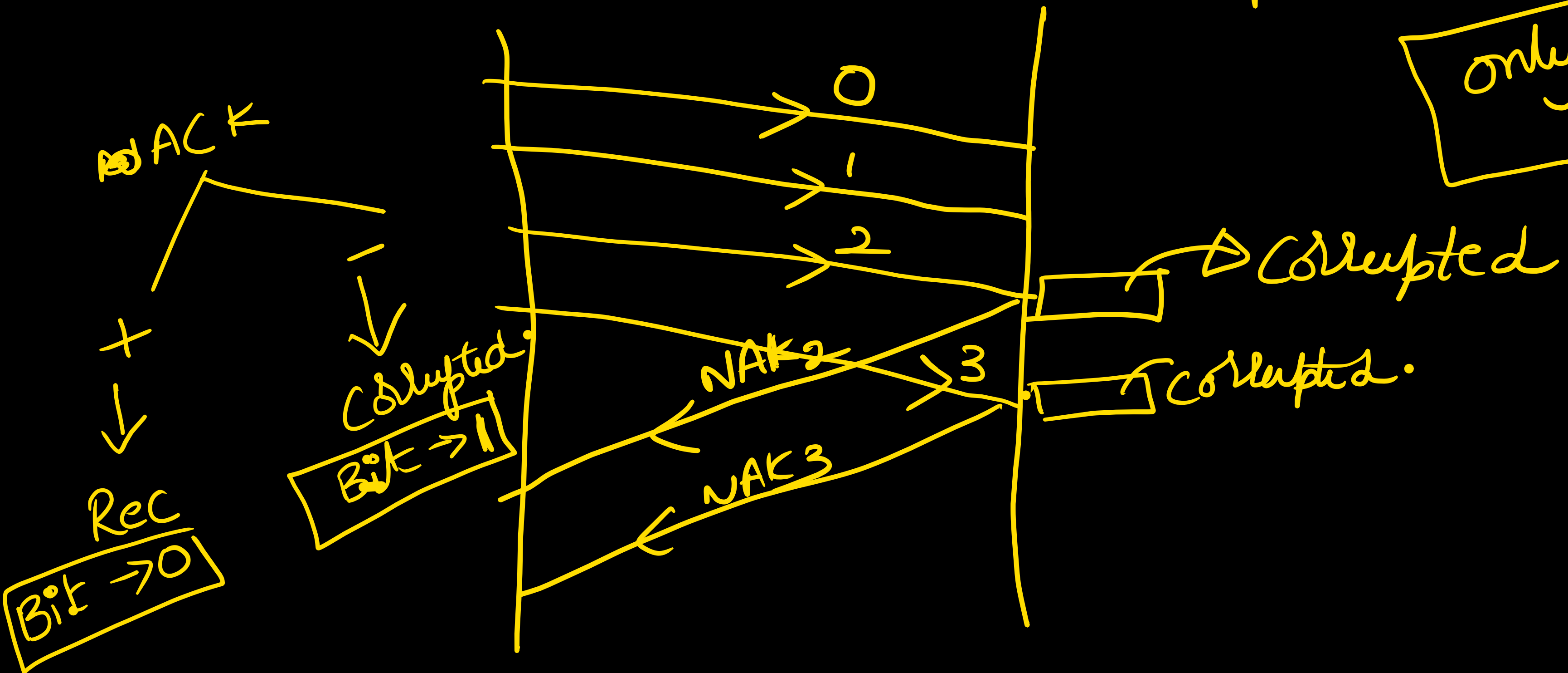
No option

SR also uses neg ack:

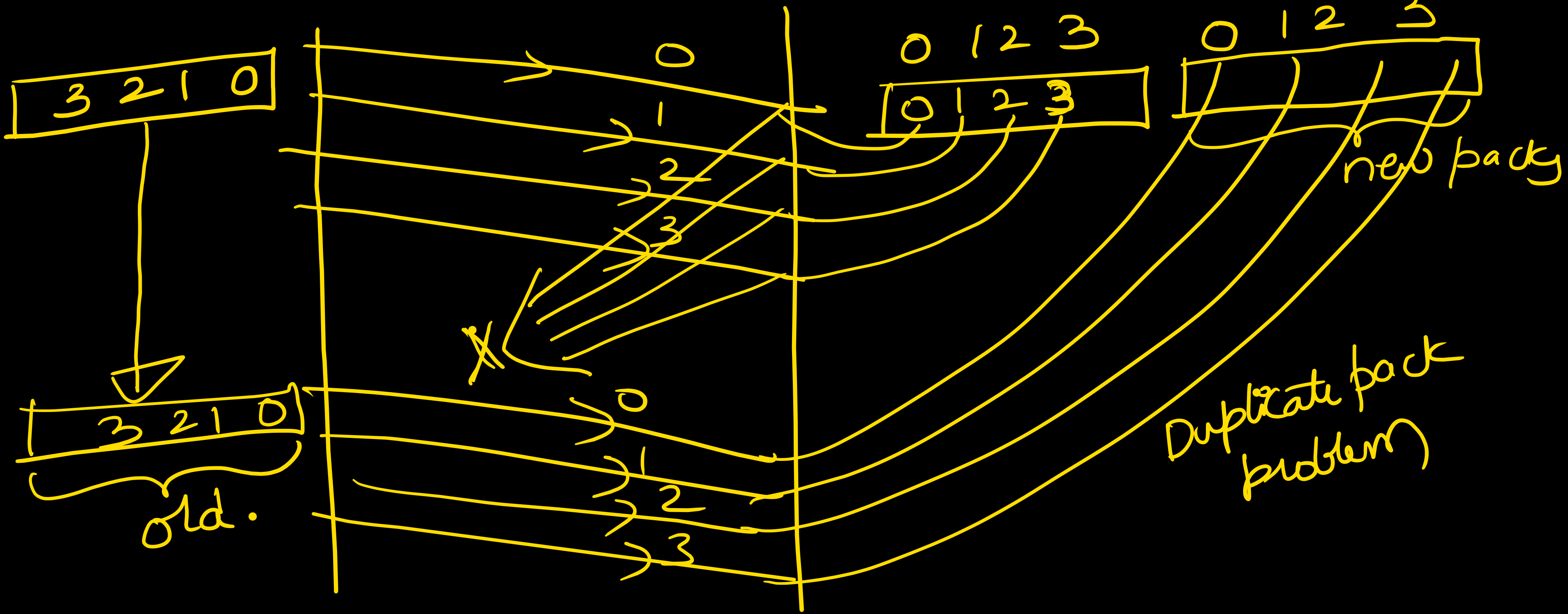
NAK → Same number.

only SR uses -ve

GBN ✗



Sequence numbers in SR:



$|W_S| = |W_R| = 4$

seq = 4

Rec

$\underbrace{3\ 2\ 1\ 0}$ Duplicate

$\underbrace{4\ 5\ 6\ 7}$ diff seq number

$$\boxed{Seq \geq \boxed{|W_S| + |W_R|}}$$

always

Imagine a new protocol: Subham protocol:

$|W_S| = 100$

$|W_R| = 50$

Seq = 150

In SR: $|W_S| = N$ $|W_R| = N$ Seq = ?

$$\boxed{Seq \geq 2N}$$

In SR: If 'N' → Seq numbers available, then

$|W_S| = N/2$ $|W_R| = N/2$

In SR: If k bits are in seq number field, then

$\frac{2^k}{2}$ $|W_S| = 2^{k-1}$ $|W_R| = 2^{k-1}$

size should be same.

16

8	8
7	7
6	6
5	5
⋮	⋮

→ max efficiency

$\boxed{\text{Difficult}}$ → understood?

$\boxed{\text{PYQ}}$ → on SWP

$\boxed{\text{Break} \rightarrow \text{5 min}}$

Ayan

↓

Thankyou

webinar → In your college

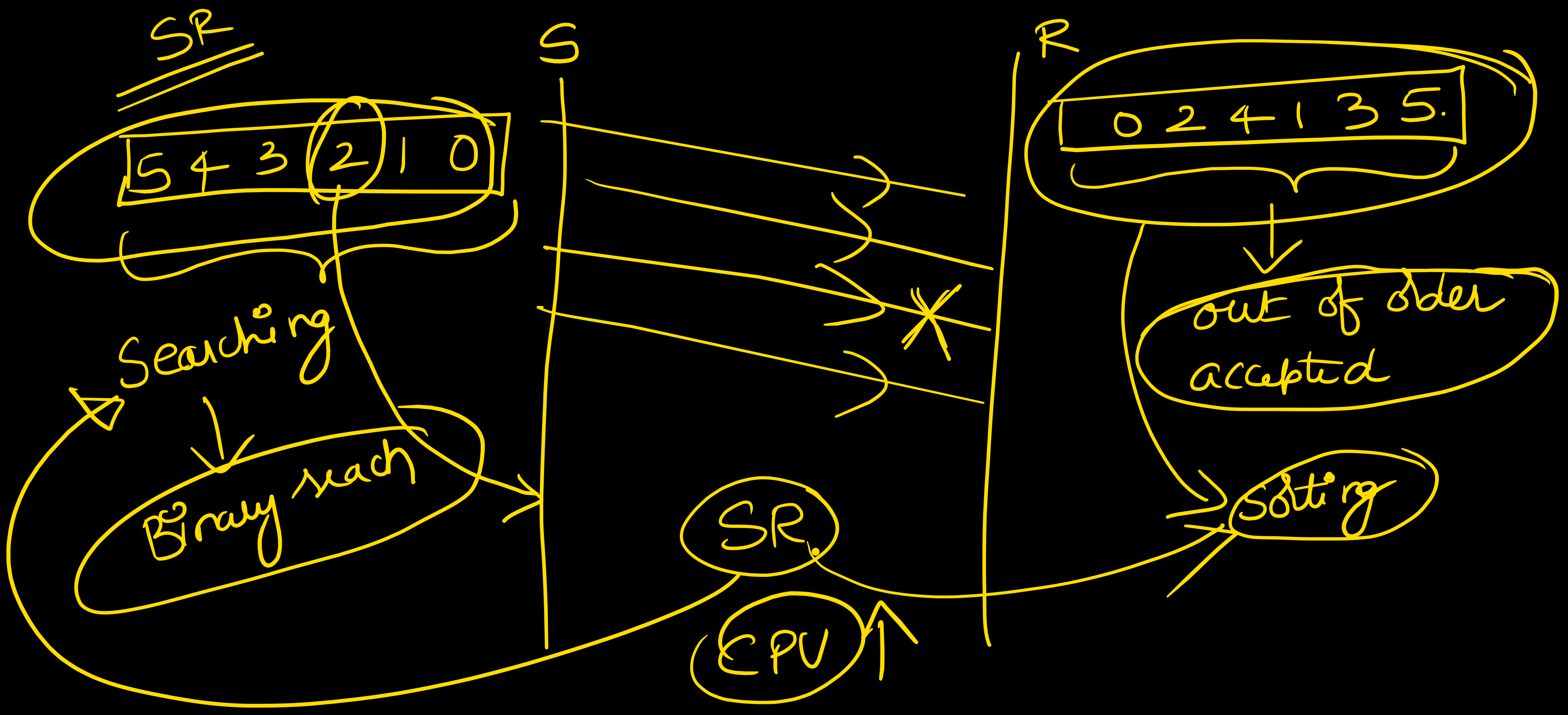
↓

let me know

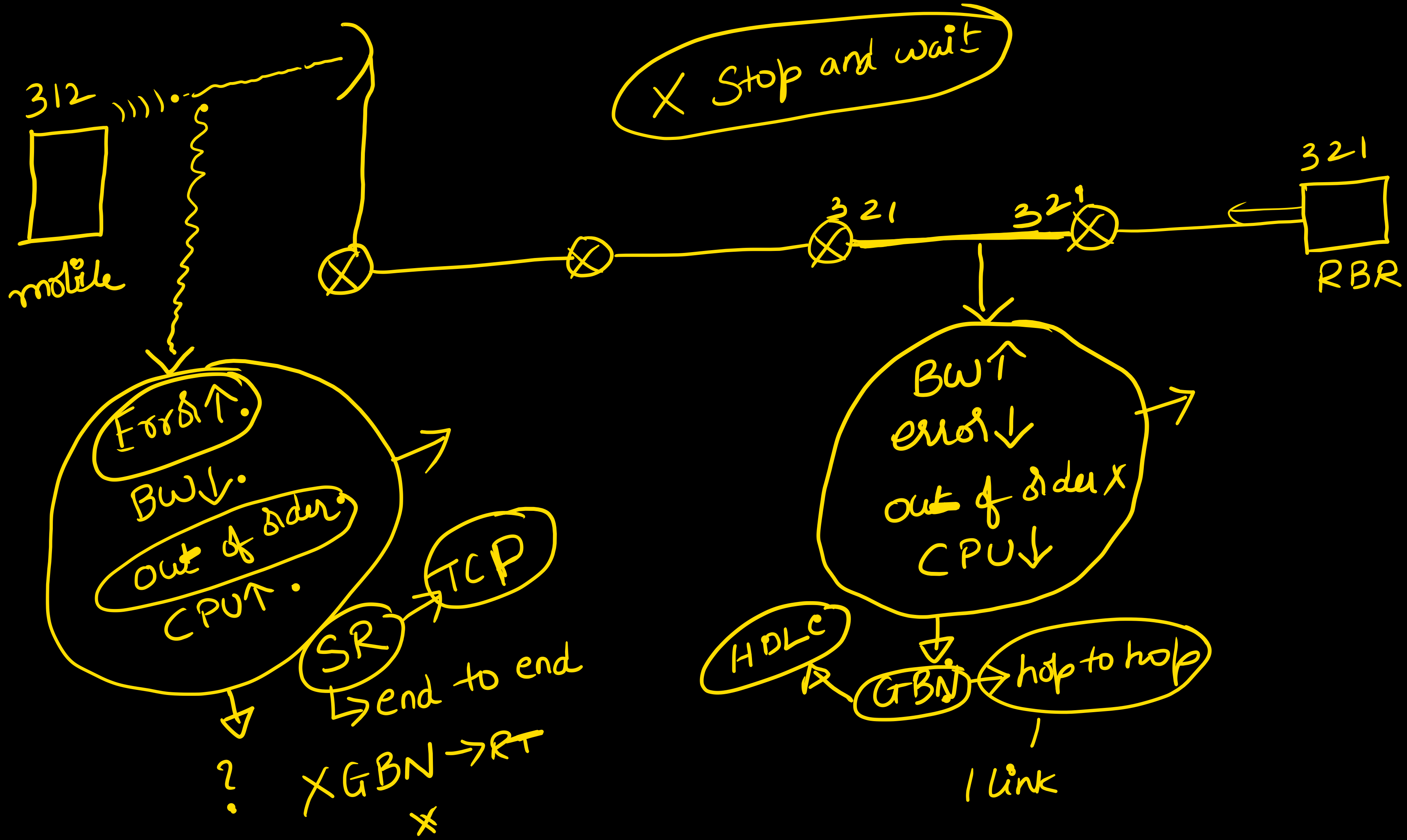
↓

Talk to your HOD.

	Stop and Wait	GBN	SR
η :	$1/1+2a$	$N/1+2a$	$W_s/1+2a$
memry (Buffers) $W_S + W_R$	$1+1$	$N+1$	$W_S + W_R = 2W_S$
seq :	,,	,,	,,
RT :	1	'N'	'1'
BW :	low	high $\to$ RT	moderate
CPU :	low	moderate	high
Implementation	easy	moderate	complex



SR
S
R
5 4 3 2 1 0
0 2 4 1 3 5.
Searching
Binary search
out of order accepted
Sorting
SR.
CPU


X Stop and wait
312
mobile
321
321
321
RBR
Error↑
BW↓
out of order
CPU↑
SR
TCP
end to end
?
X GBN → RT
BW↑
error↓
out of order X
CPU↓
HDLC
GBN
hop to hop
1 link