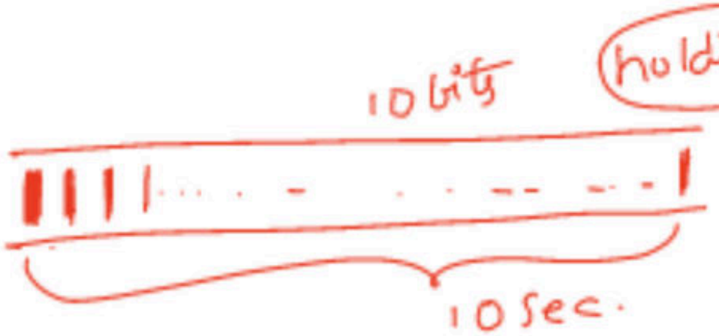
Hardware and Various Devices used in Networking

Complete Course on Computer Networks - Part I

Ravindrababu RAVULA • Lesson 17 • Feb 5, 2021

Computer Networks

Capacity of Pipe, Pipelining, Sliding Window



Cap = Bw * Tb.

1 bps * 10 sec
= 10 bits ✓

pipe

Tb = Bw = 1 bps

1 bit - 1 sec.

Tb = 10 sec.

Thick pipe ✓

Cap ↑

Thin pipe ✓

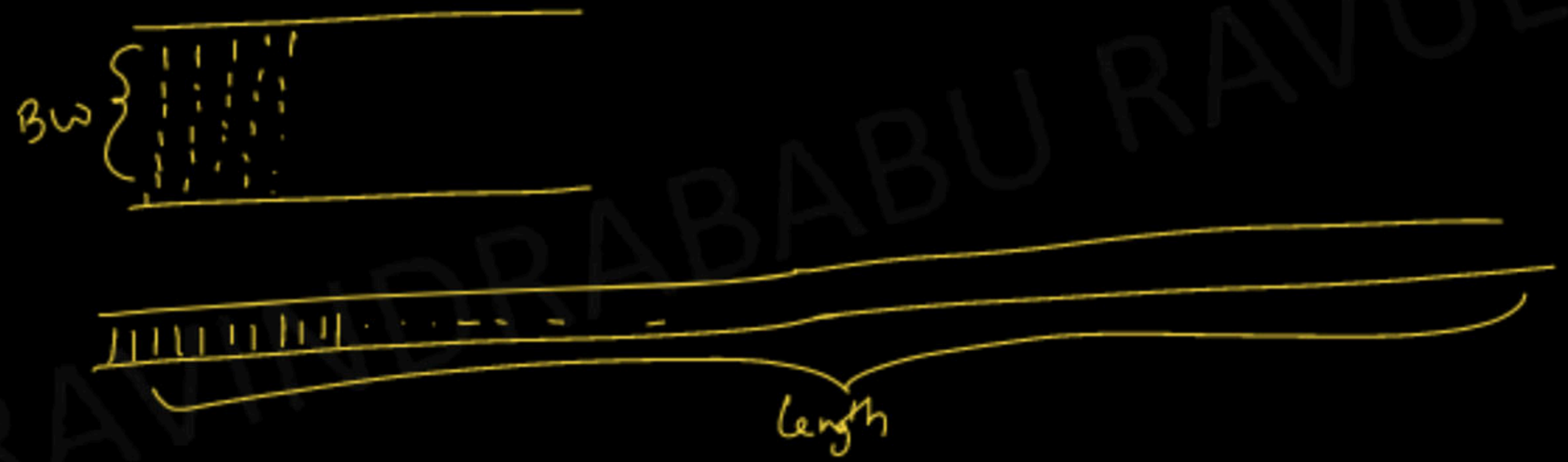
Cap ↓

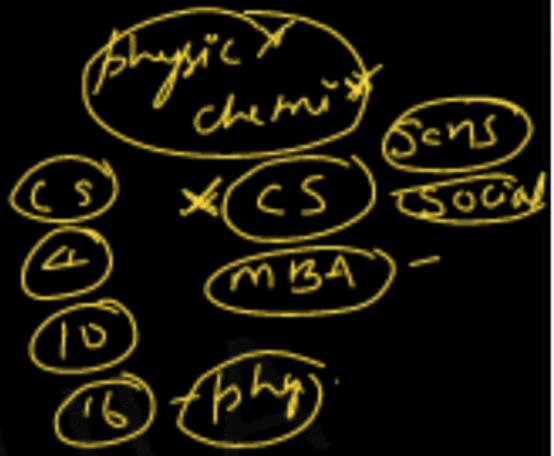
pipe = Area * length

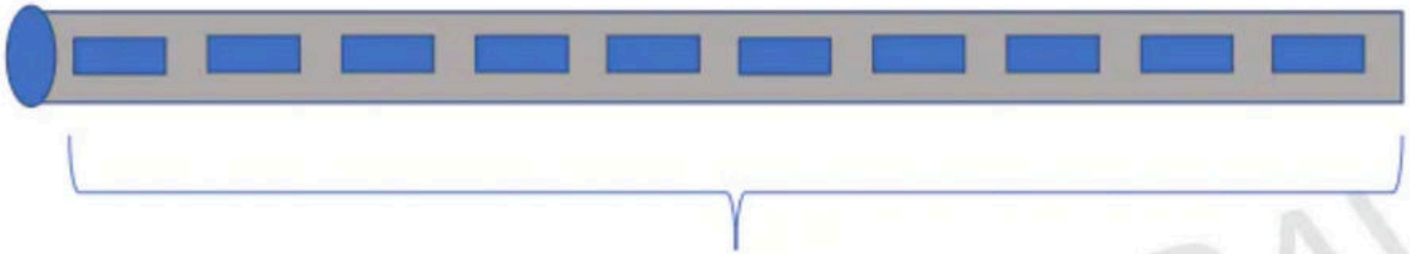
Thin

Cap = ↑ (BW) * (Tprop) ↑

BW = 10bps







The wire is carrying bits a much as it can, this is what is the **capacity of link**

Capacity of the link depends on 2 parameters:

1.) Bandwidth

2.)Propagation Delay (Tp)

CAPACITY = BANDWIDTH x PROPAGATION DELAY

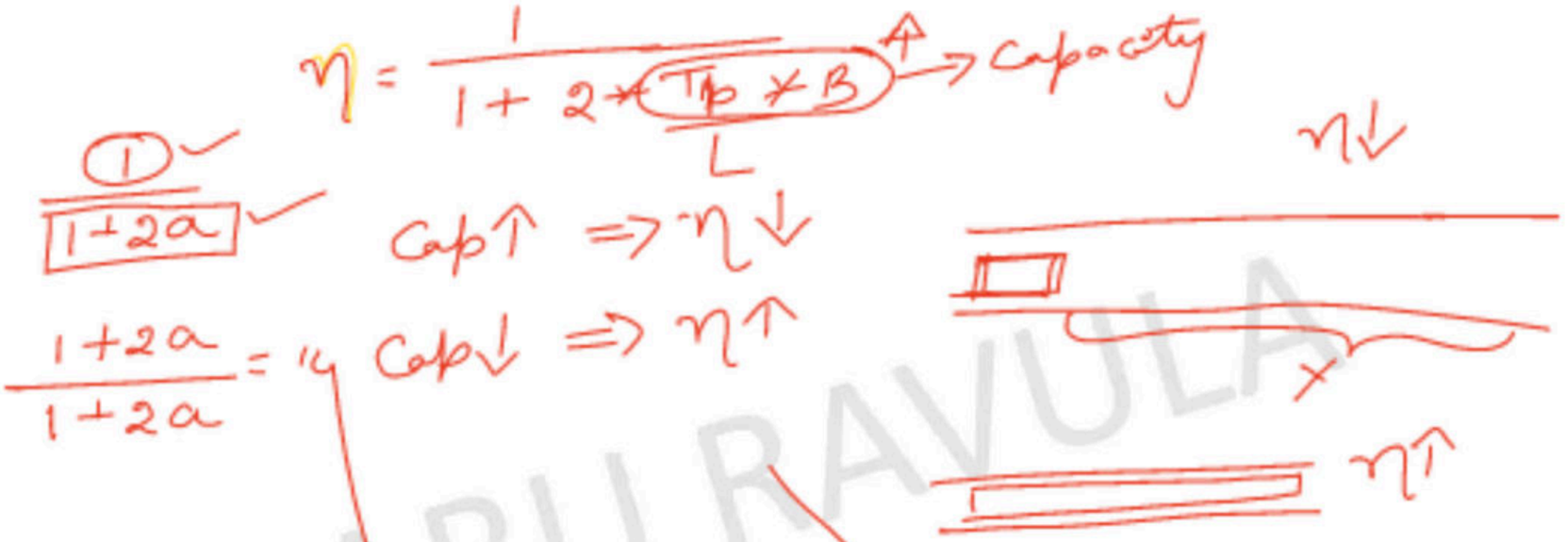
In case of half duplex

CAPACITY = 2 x BANDWIDTH x PROPAGATION DELAY

In case of ~~half~~ full duplex

$\eta = 1 / 1 + 2\ Tt/Tp$

$\eta = 1 / 1 + 2Tp * B/L$



This is capacity

We can see as the capacity increases, efficiency decreases.

We can increase the efficiency by the method called as **Pipelining.**

PIPELINING

Tt ---------> 1 Packet sent

1 Sec -------> 1/Tp Packets sent

Tt + 2Tp-----> Tt + 2Tp/Tt
-----> 1+2a sent

Basically in Stop and Wait, we need to transfer more number of packets,
In order to increase the efficiency.

$T_t \rightarrow 1$ packet

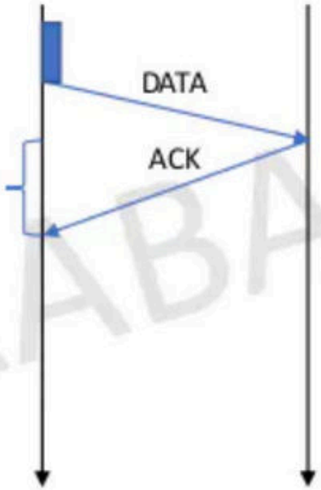
$\Rightarrow 1$ sec $\rightarrow \frac{1}{T_t}$ packets

$\Rightarrow T_t + 2T_p \rightarrow \frac{T_t + 2T_p}{T_t} = 1 + 2a$ pipelining.

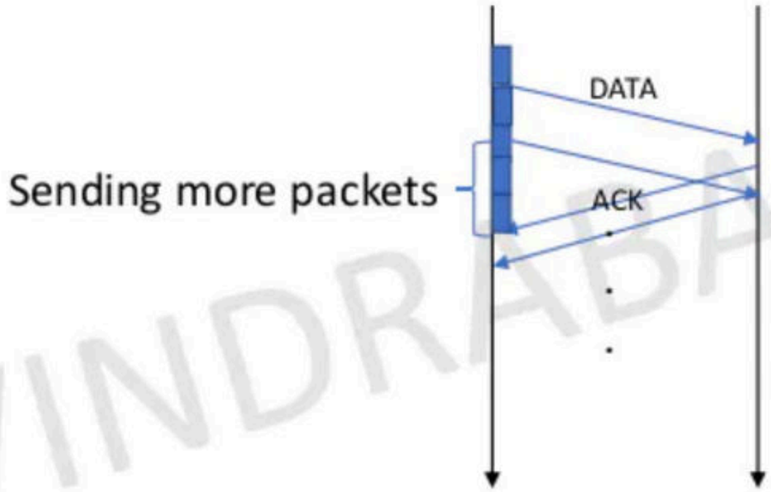
Henry.

CO → pipe.

In this remaining time
Sender is not sending
any packet and just waiting



So to make more utilization of the available channel and increase efficiency
We can transmit more packets in that particular period of time.



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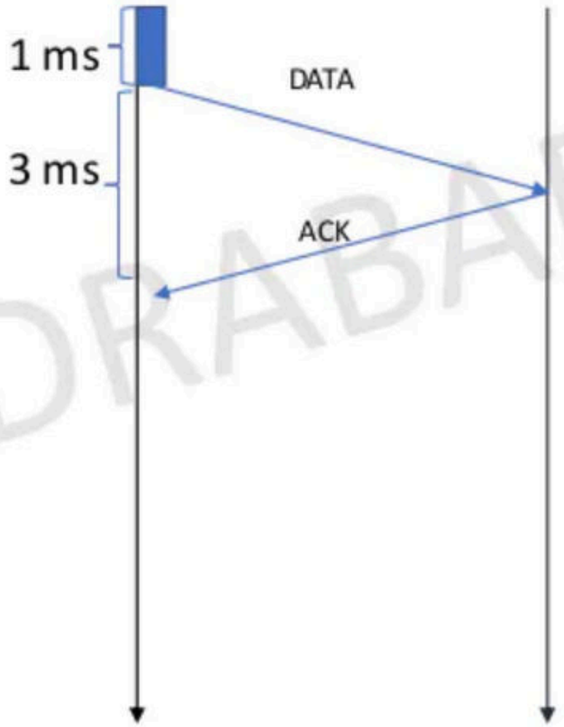
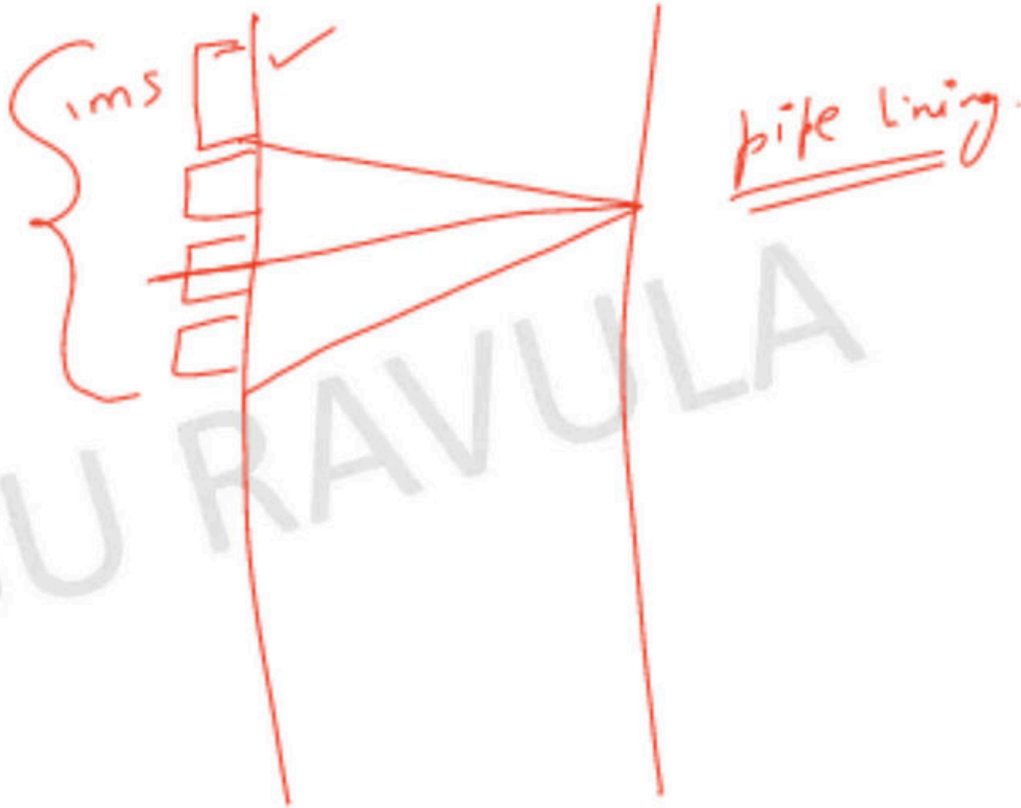
We can transmit more packets in that particular period of time.

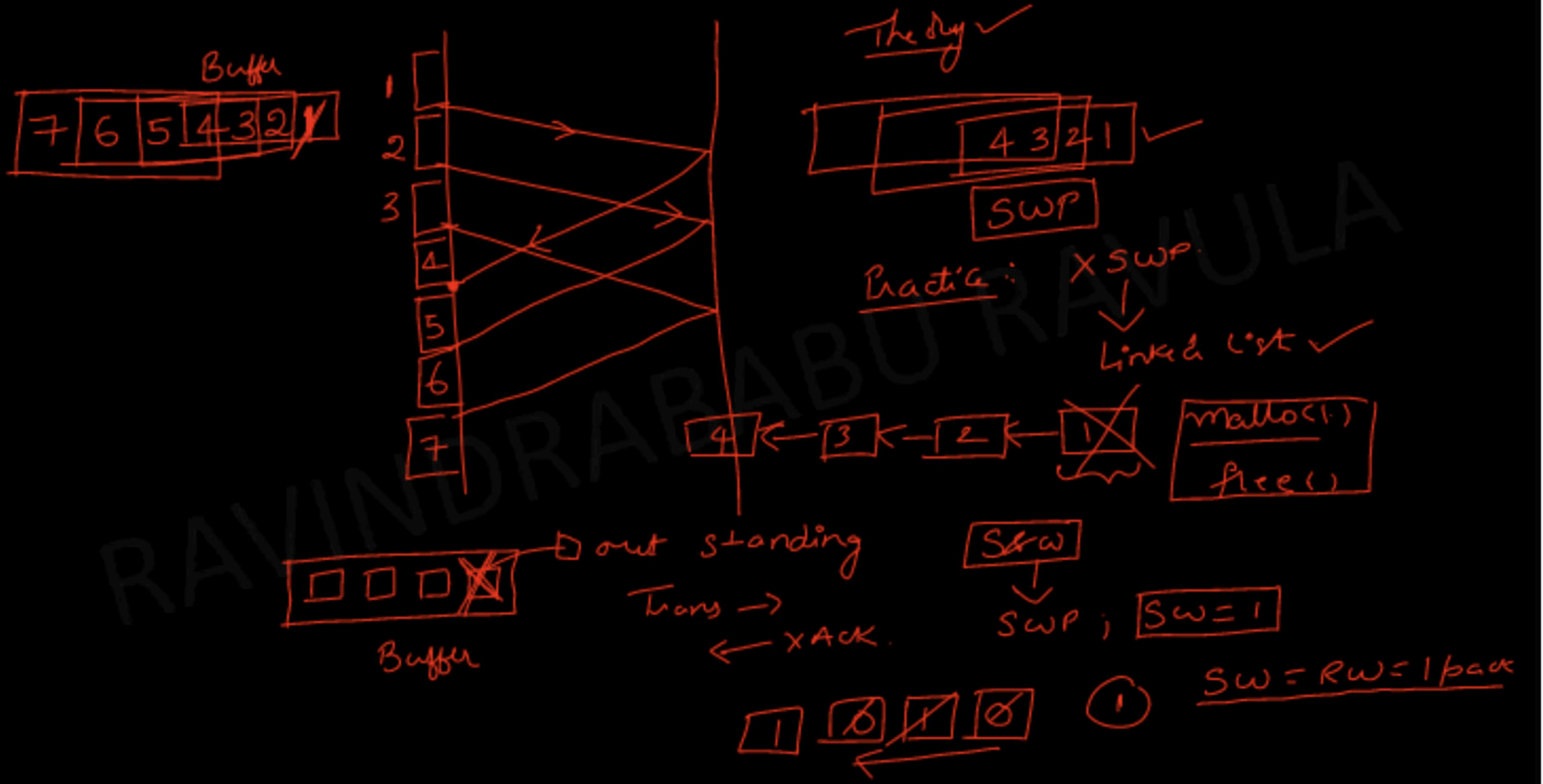
LET'S SEE ONE EXAMPLE

Given that, Tt =1 ms and Tp=1.5 ms

Therefore, $\eta = \frac{1}{1+2*1.5} = 1/4$







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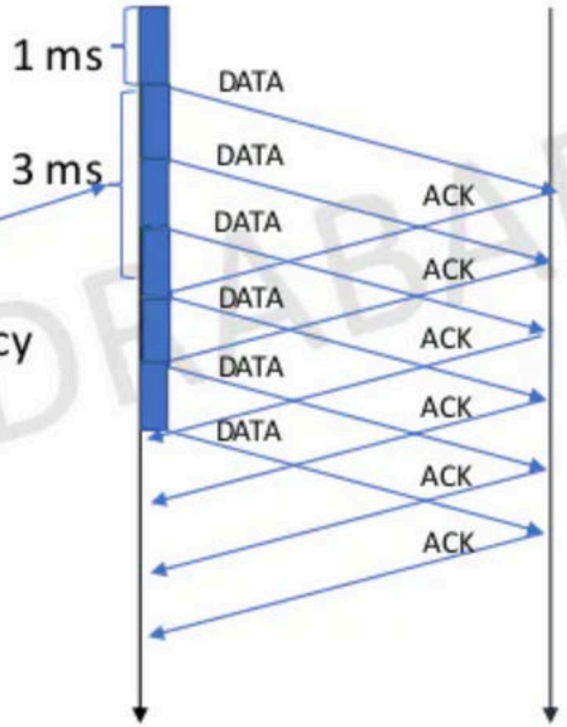
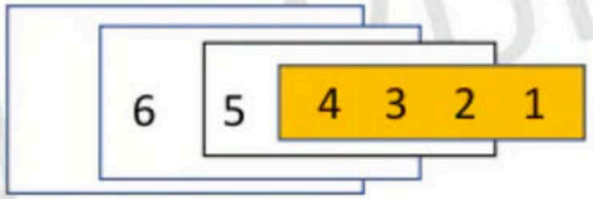


We can increase the efficiency by increasing the number of packets sent here



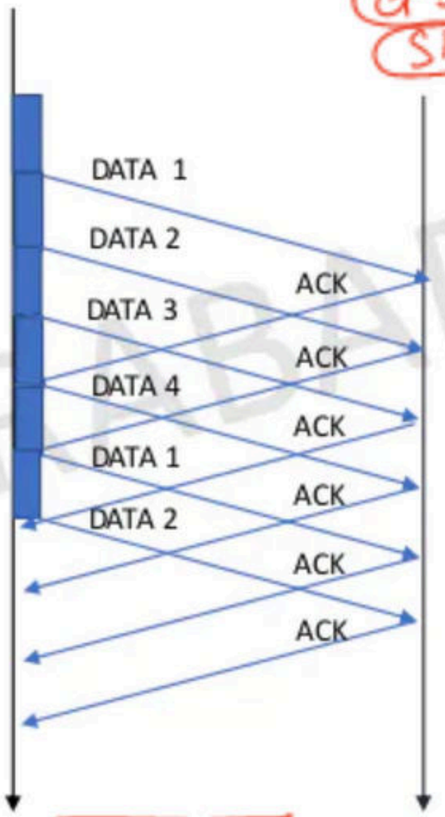
This is buffer which is holding packets
This is also known as **Sliding Window Protocol**

Ws = 1+2a

Window size in case of Sliding window protocol

LET'S SEE HOW MANY SEQUENCE NOS AND BITS ARE REQUIRED

Given that, Tt =1 ms and Tp=1.5 ms



SW = 10 packets

$\log_2 10 = \lceil 3.2 \rceil$

$= 4$ → 16

10 → Seq.

4.

SW = 1+2a

Bits = $\lceil \log_2(1+2a) \rceil$

SWP ✓ GBN SR

XGBN XSR

pick SWP.

SWP

SWP

Ws = 1+2a

1+2a

SW = 1
RW = 1
2 Seq
1 bit

min. bits.

Nos used = 1 2 3 4

Minimum sequence nos required = 1+2a

Bits in sequence no field = $\lceil \log_2 (1+2a) \rceil$

0 3 2 1 0 — 4

0 2 1 0 ✗

4

3 2 1 0

0 is lost

Outstanding

numbers should be distinct / unique

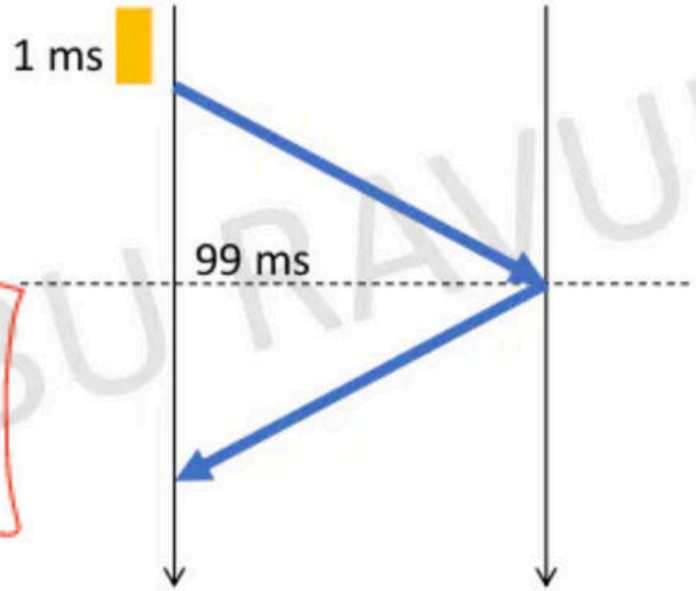
QUESTION:

T_t = 1 ms Tp=49.5 ms

Ws = ?

Sequence no =?

Minimum no of bits in seq no field= ?



SOLUTION:

Ws = 1+2a = 100

Sequence no = 1+2a = 100

Minimum no of bits in seq no field= $\lceil \log_2(100) \rceil$ = 6.8 = 7

NOTE:

Sometimes, the minimum no of bits in sequence no field (n) is already given in such cases:

$$W_s = \min(1+2a, 2^n)$$

SWP

$1+2a, 2^n$

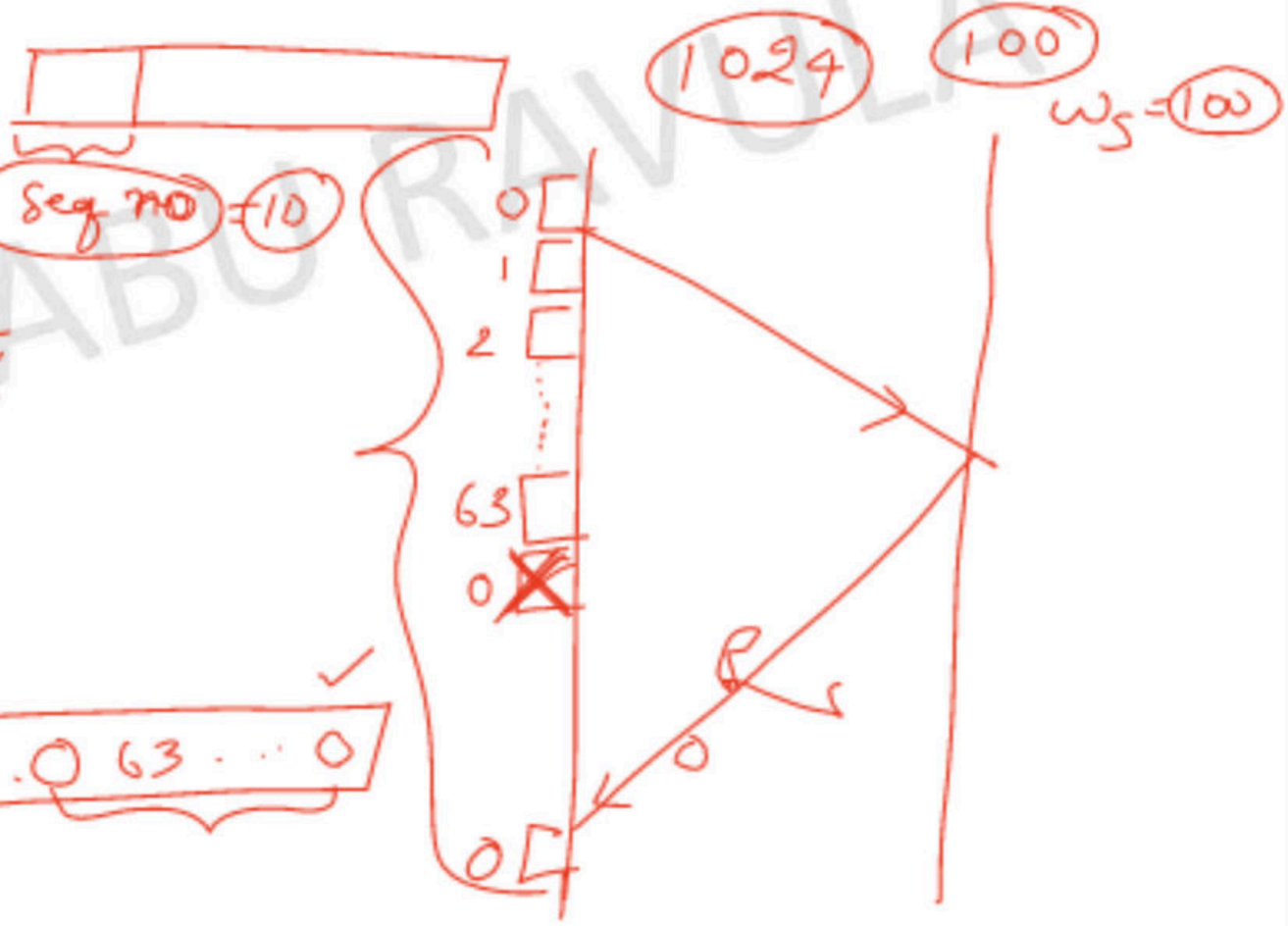
$1+2a = 100$

Seq no field = 6 bits

How many?

$$\eta = \frac{64}{100} = 64\%$$

$$W_S = \min(1+2a, 2^n)$$



Computer Networks

Sliding Window Protocol - Go Back N

Go Back N

Point 1 : Sender Window Size in GBN is N

Ex– If we say GB10 then sender window size is 10

Note : N must be greater than 1 (N>1)

Example – Tt =1ms Tp=49.5ms BW =40Mbps. What is the efficiency(η) in case of GB10 ad also calculate throughput?

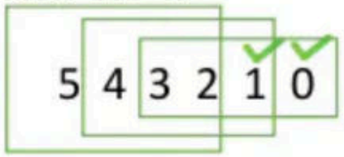
$$\eta = \frac{\text{sender window size}}{1+2a} = \frac{10}{100} = 10\ \%$$

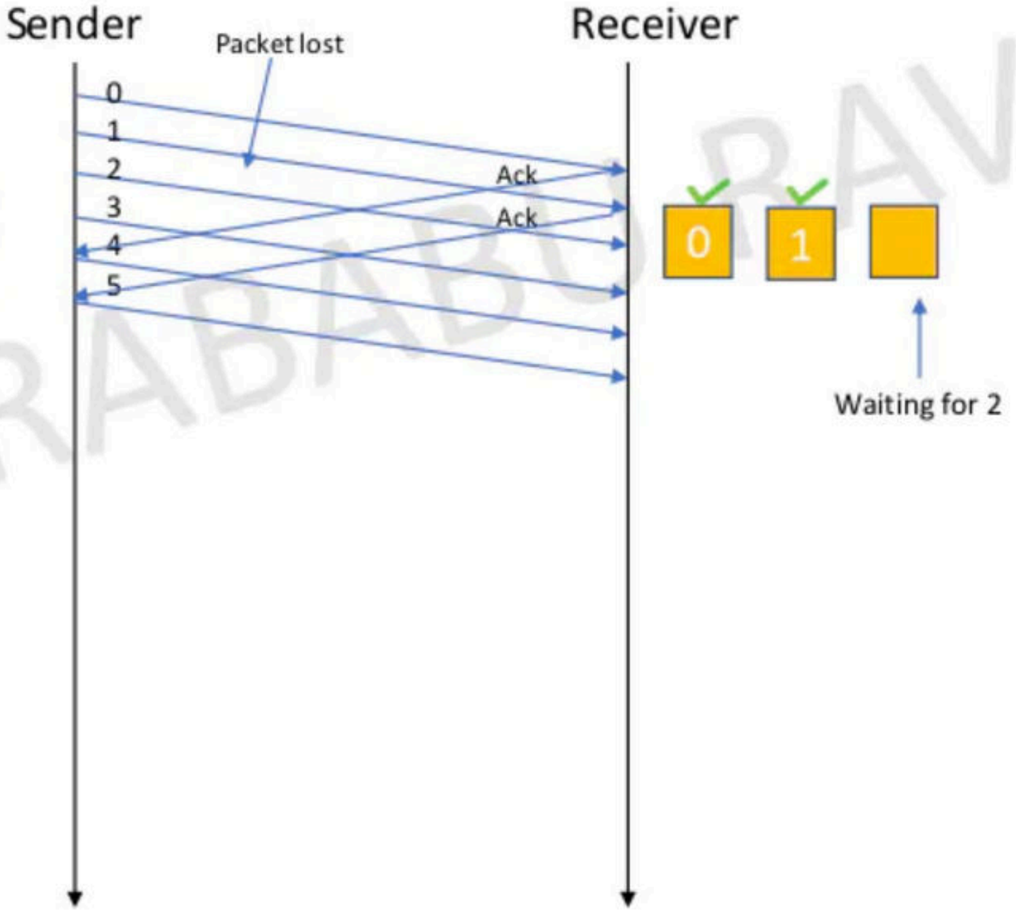
$$\text{Throughput} = \eta * BW = \frac{10}{100} * 40 = 4\ \text{Mbps}$$

Go Back N

Point 2 : Receiver Window Size is 1

Example of GB4 →
Ws=4 and Wr=1





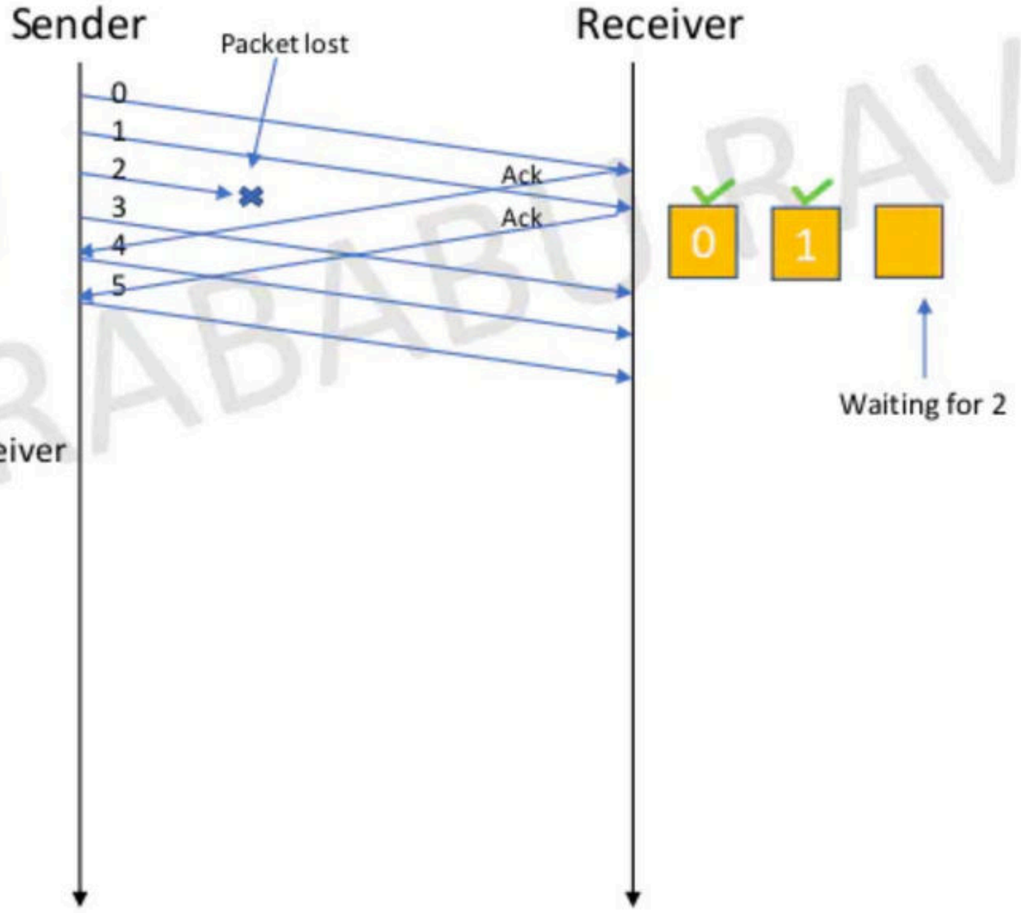
Go Back N

Point 2 : Receiver Window Size is 1

Suppose packet 2 is lost

Example of GB4 →
Ws=4 and Wr=1

Since this packet was lost
3 4 5 are discarded by the receiver



Go Back N

Point 2 : Receiver Window Size is 1

Example of GB4 →
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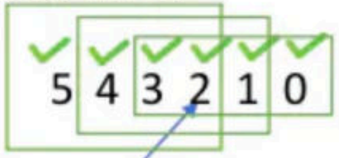
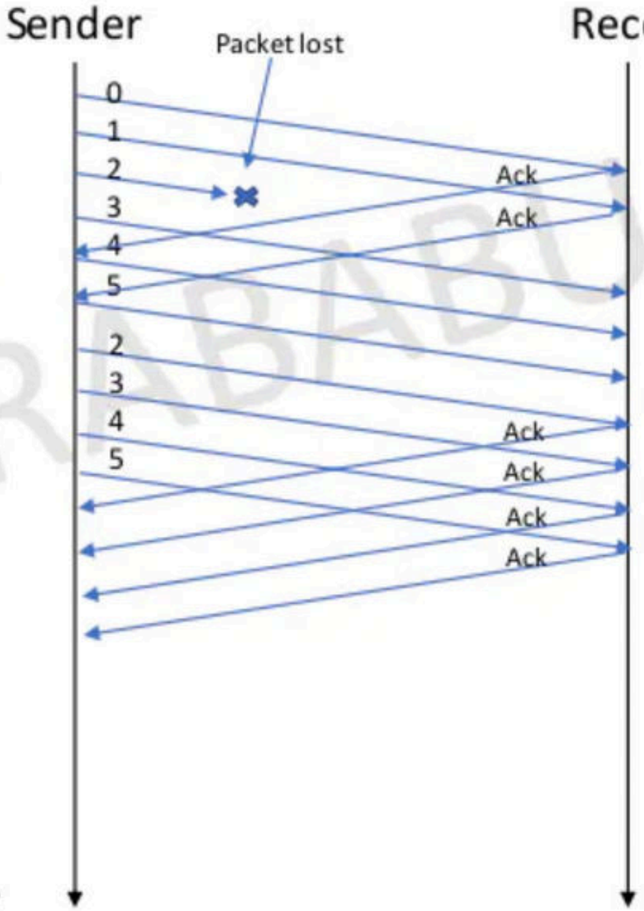


Since this packet was lost
2 3 4 5 were resent



Note:
Go back N is not going back from the lost
It is going back N from the last
From the example,

Note: The acknowledgement sent
By the receiver is not as shown,
it is just for the sake of understanding
this point, We will see the actual Ack point later

Example: In GB4, from the 10 packets to be transmitted if every 6th packet is lost. How many transmissions are required?

Solution:

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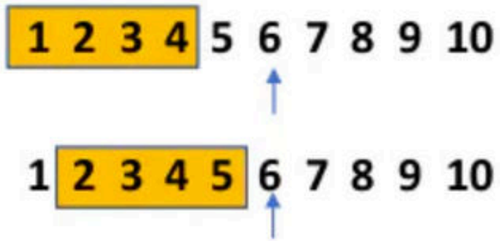

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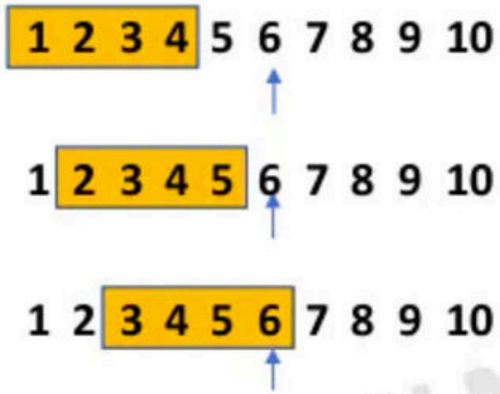

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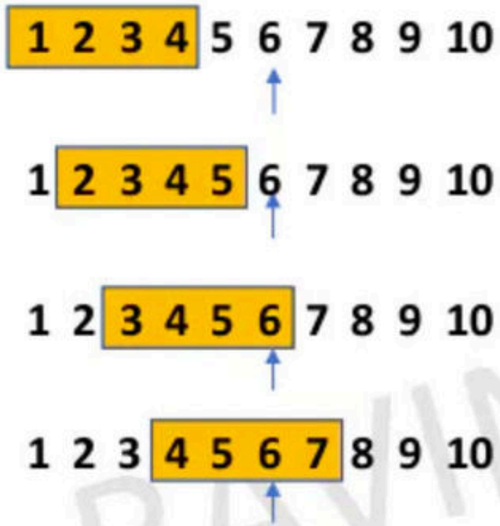

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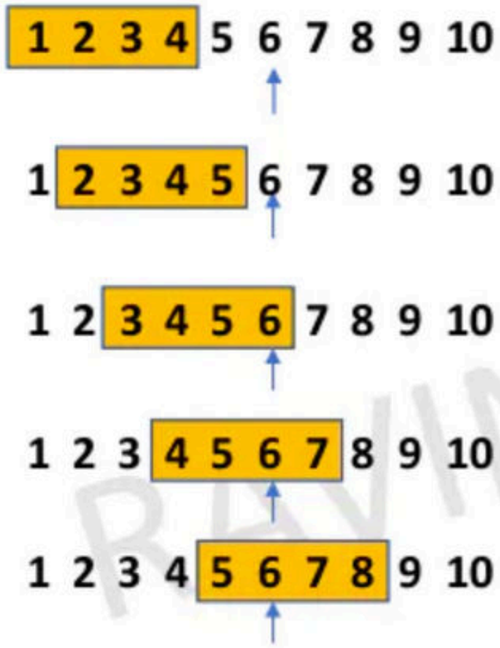

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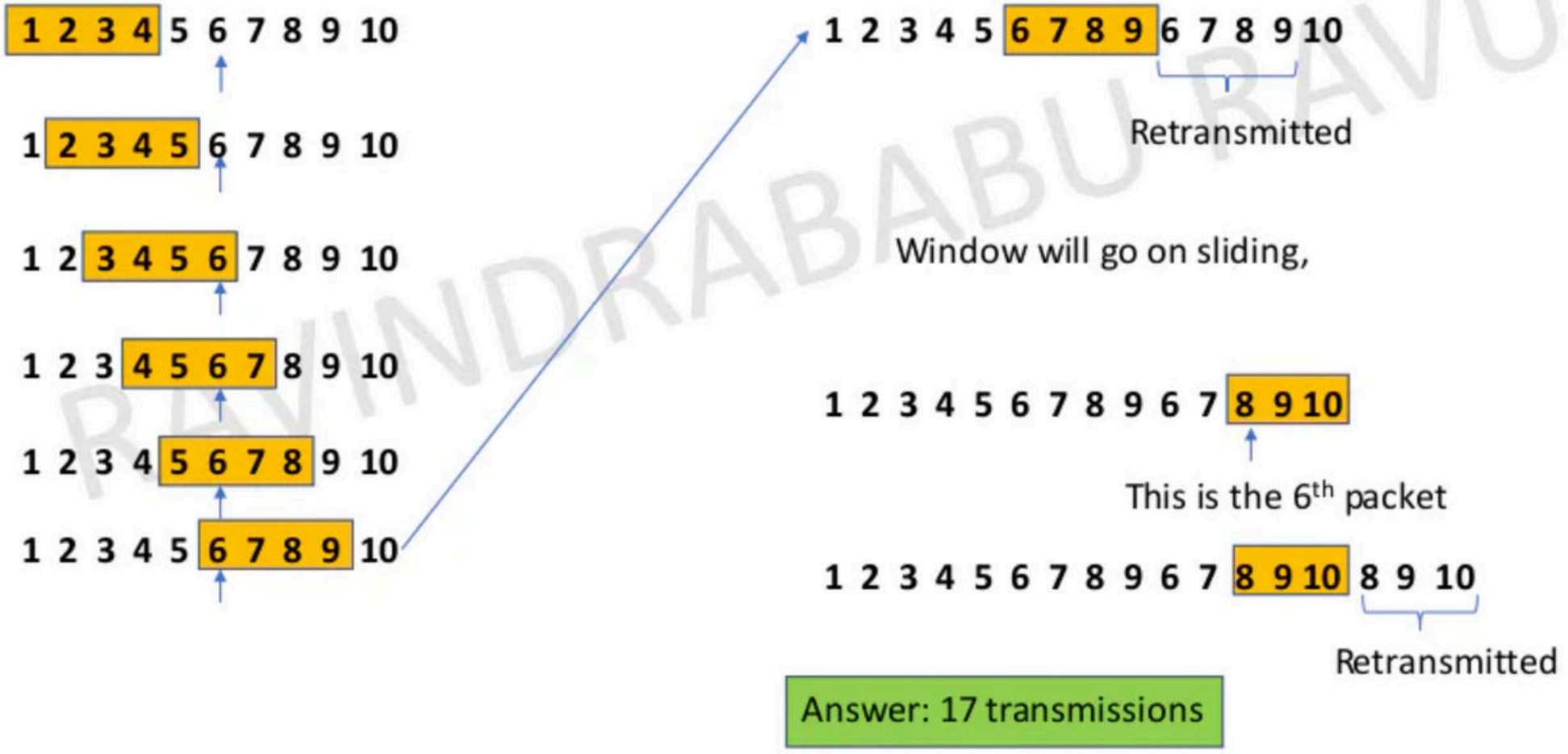
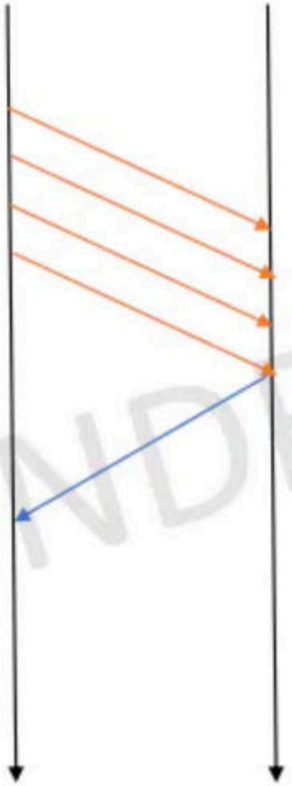


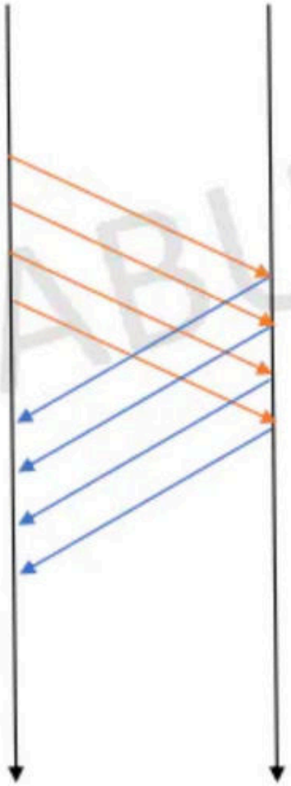
Types of Acknowledgement:

Cumulative



Advantage:
Less Traffic
Disadvantage:
Less Reliable

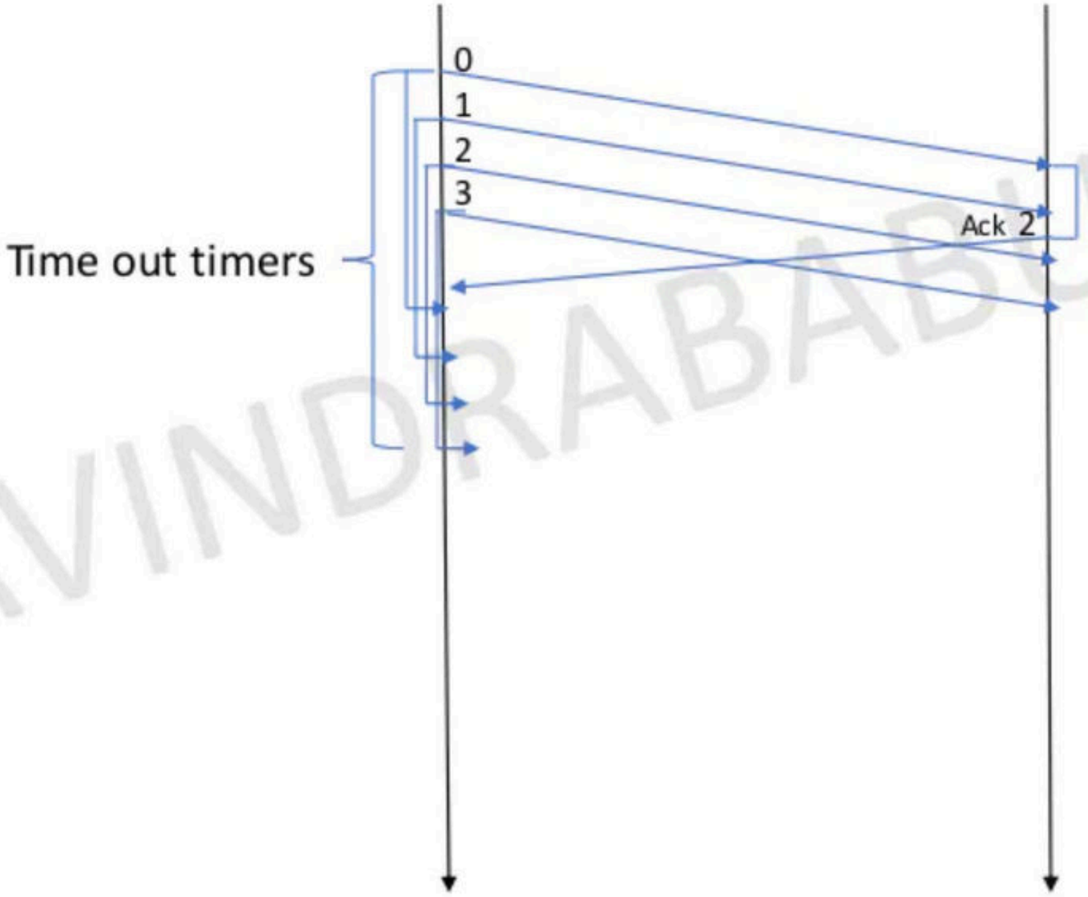
Independent



Advantage:
High Reliable
Disadvantage:
High Traffic

Go Back N

Point 3 : Cumulative Acknowledgement in GBN



ACK timer

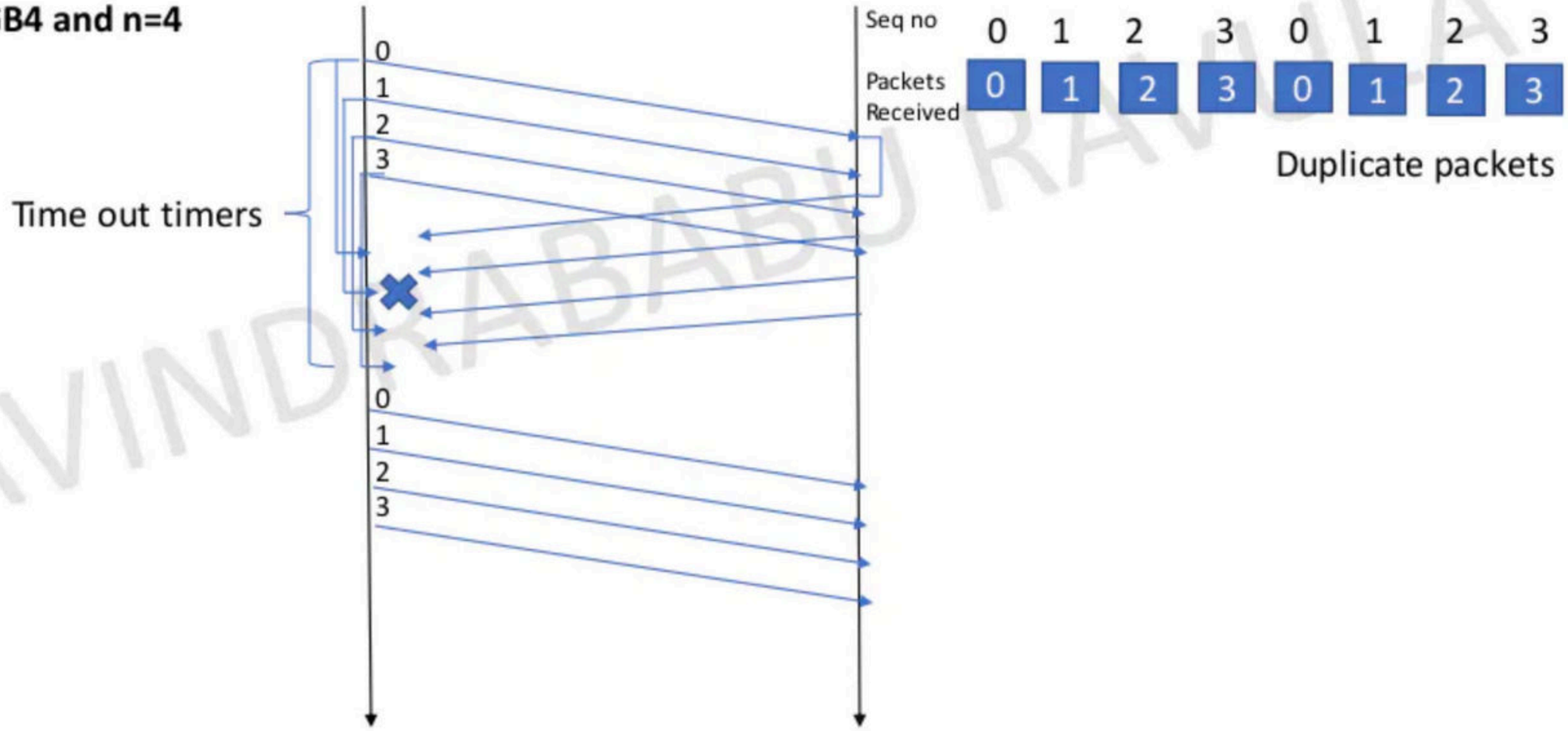
ACK = The no packets received till ack timer +1

Time out timer > Ack timer

Relation between Window Size and Sequence Nos

Let us consider few scenarios

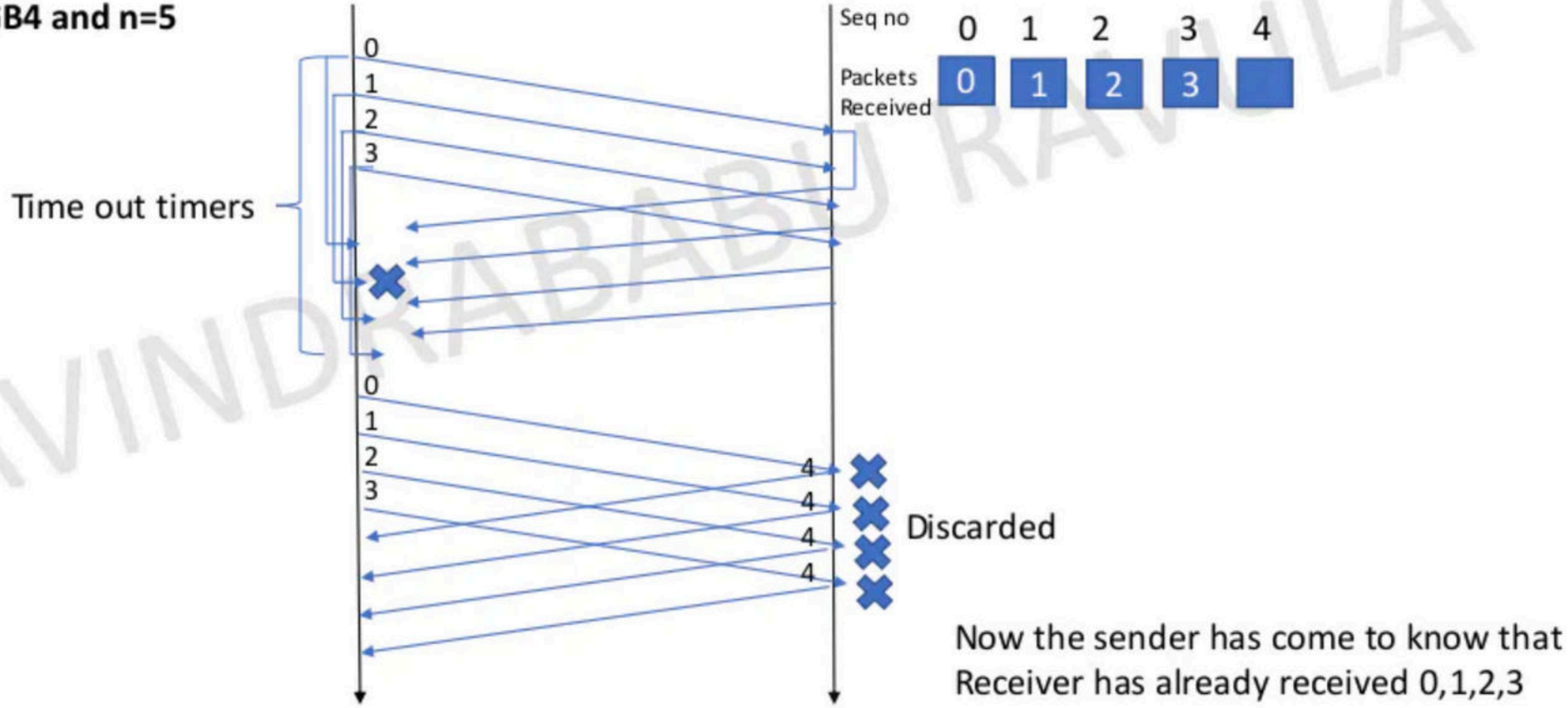
1.) GB4 and n=4



Relation between Window Size and Sequence Nos

Let us consider few scenarios

2.) GB4 and n=5

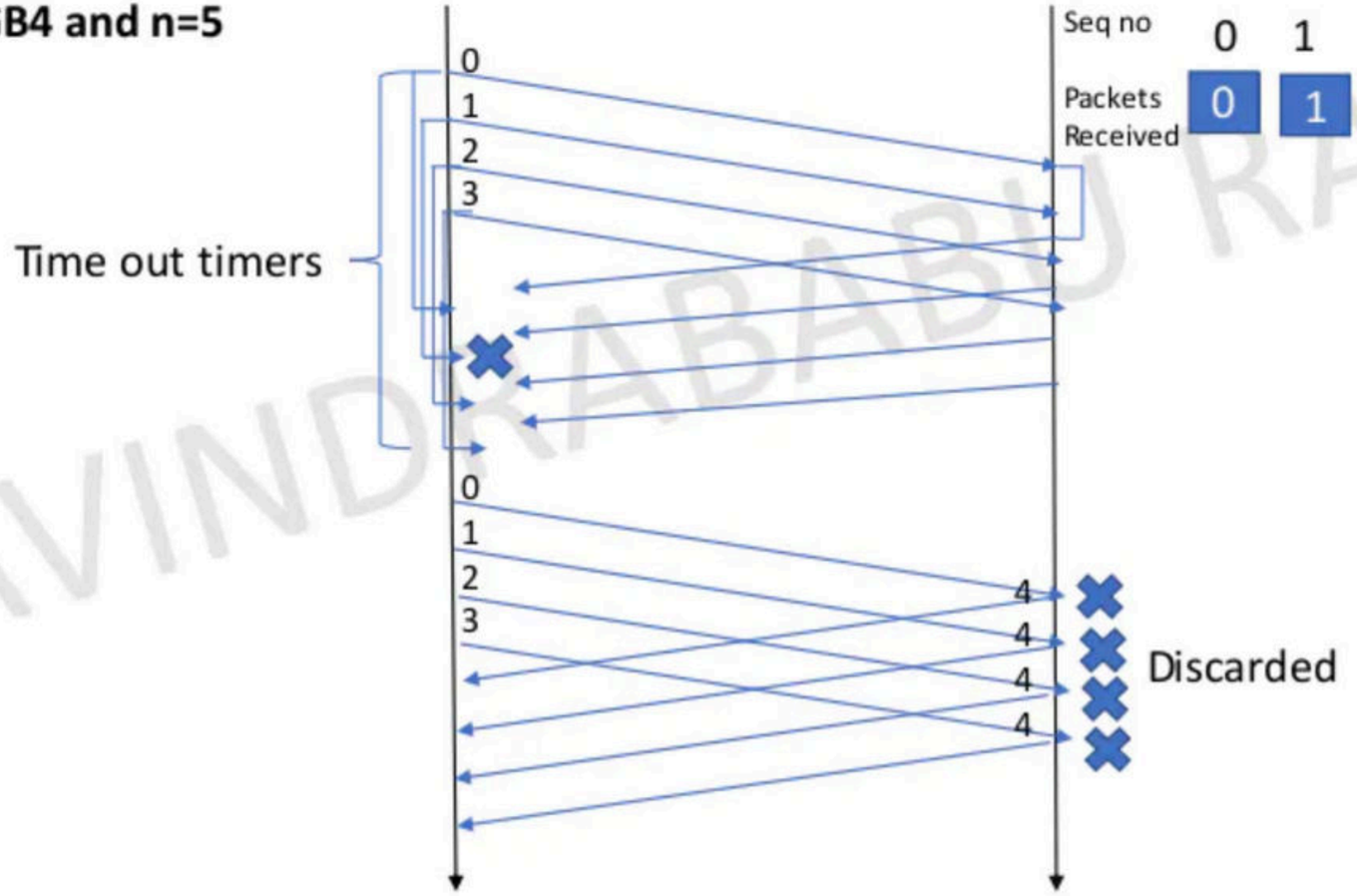


Now the sender has come to know that Receiver has already received 0,1,2,3

Relation between Window Size and Sequence Nos

Let us consider few scenarios

2.) GB4 and n=5



From the 2 examples, we can say that,

Available seq nos. >= Sender window size + Receiver window size

Number of bits required in the sequence no field = $\lceil \log_2 (N+1) \rceil$

We can say that, If

1.)Ws= N Wr=1 | Sequence no= N+1 Bits = $\lceil \log_2 (N+1) \rceil$

2.)Sequence no=N | Ws = N-1 Wr=1

3.)Bits required in seq no field = k | Seq no = 2^k Ws = 2^k -1 Wr=1

Computer Networks

Sliding Window protocol – Selective Repeat, Comparisons of Flow Control Protocols

Selective Repeat

Point 1:Ws>1

Example – Tt =1ms Tp=49.5ms Ws=50 BW= 4Mbps. What is the efficiency(η) in case of SR ad also calculate throughput?

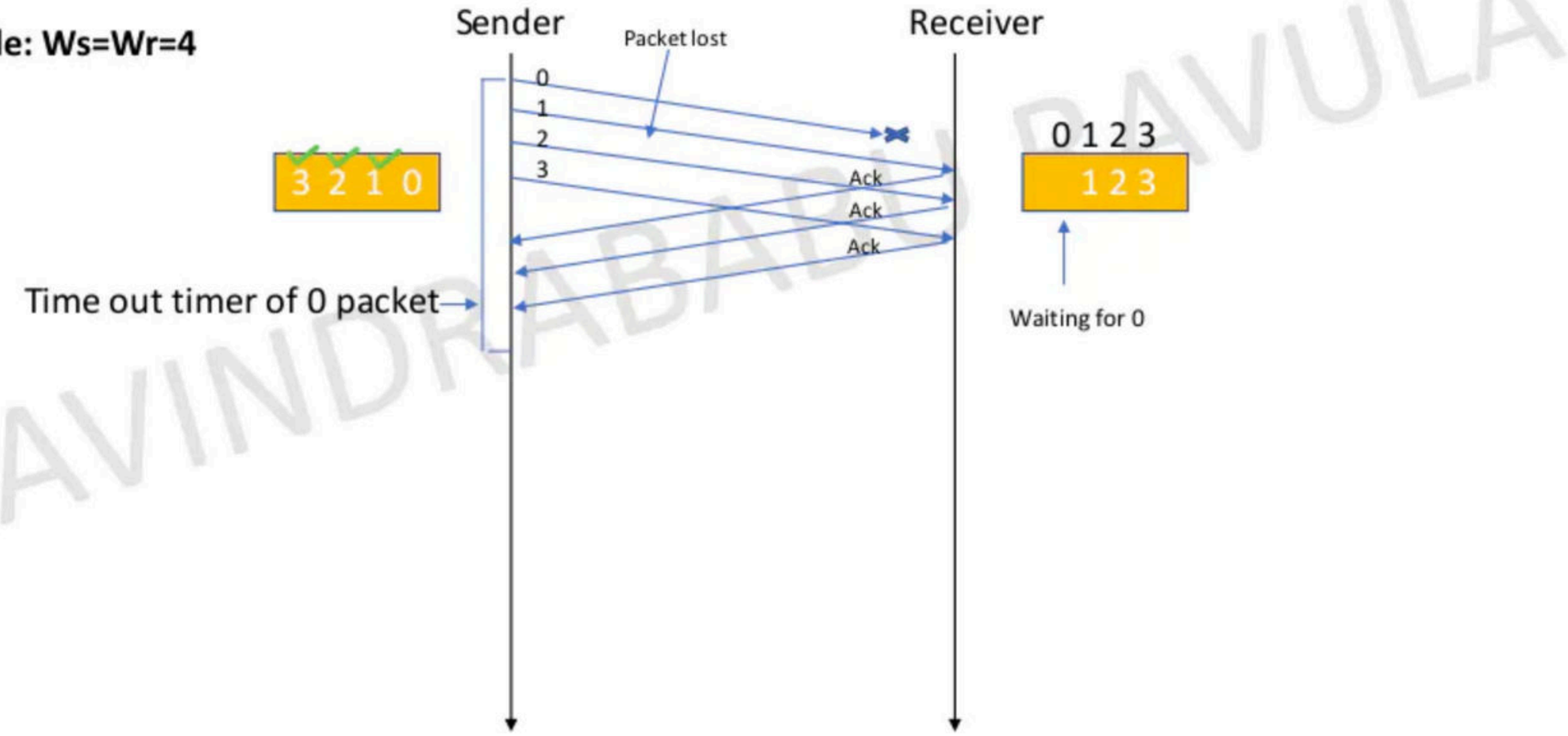
$$\eta = \frac{\text{sender window size}}{1+2a} = \frac{50}{100} = 50\ \%$$

$$\text{Throughput} = \eta * BW = \frac{50}{100} * 4 = 2\ \text{Mbps}$$

Selective Repeat

Point 2: Ws = Wr

Example: Ws=Wr=4



Selective Repeat

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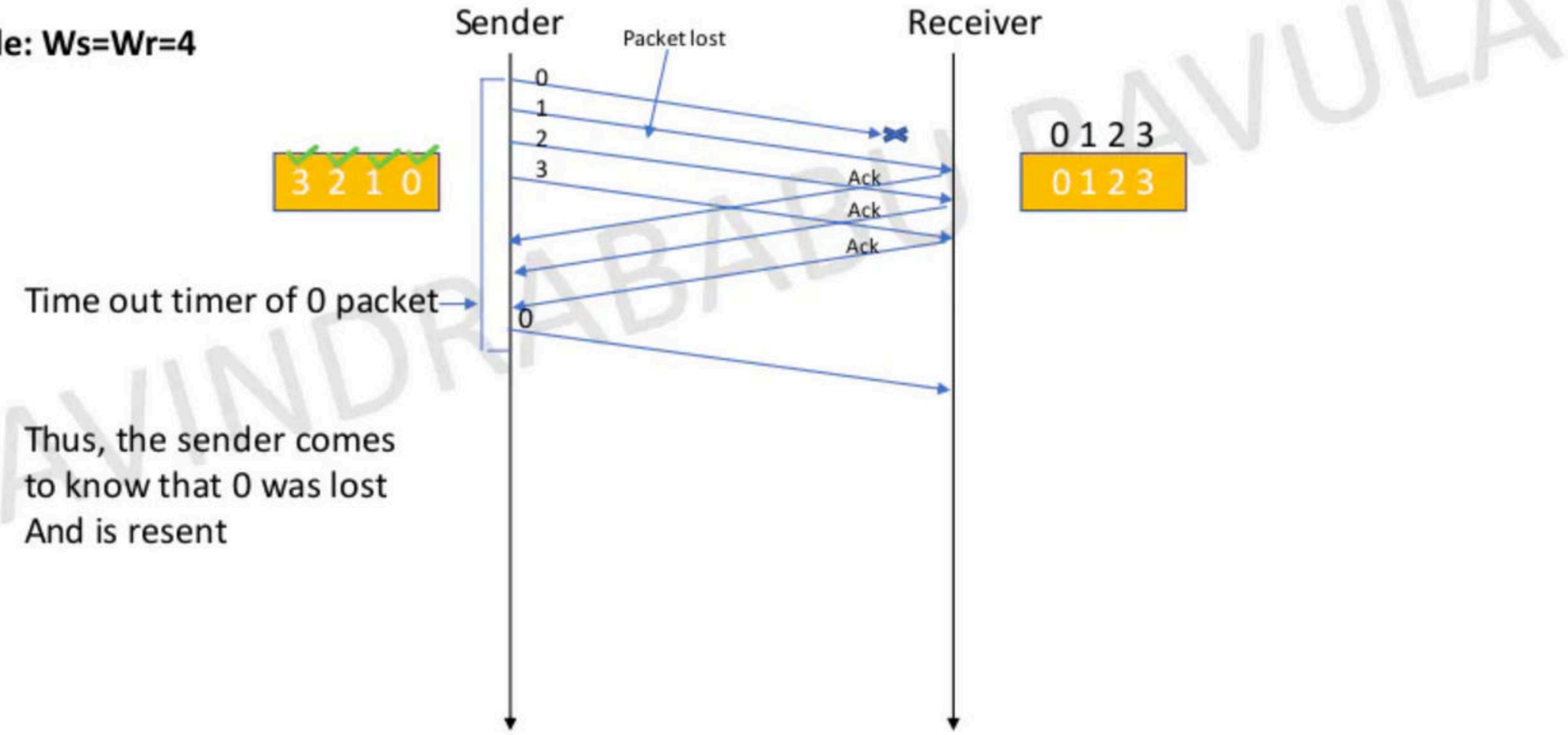
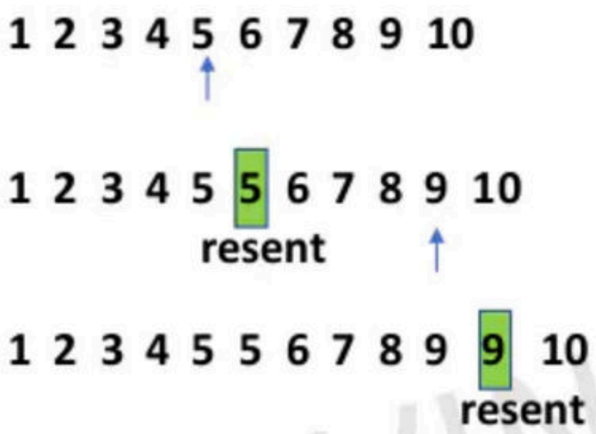


Example: In SR, from the 10 packets to be transmitted if every 5^{th} packet is lost.
How many transmissions are required?

Solution:



Therefore, 12 transmissions are required

Selective Repeat

Point 3: About Acknowledgement

In GBN,

The ack was cumulative and the receiver silently discards the out of order packets
Also in case of the corrupted packet, the receiver silently discards the packet without notifying the sender about it.
In both the cases, the sender waits for time out timer and then resends the entire window of packets.

In SR, The ack is **independent**.
If the Receiver does not receive any packet,
The sender sends that packet after time out timer.

If the receiver receives a corrupted packet then Receiver sends a **Negative Acknowledgement** to the sender of that packet

	Stop and Wait ARQ	Go back N	Selective Repeat	Remarks
Efficiency	1 / (1+2a)	N / (1+2a)	N / (1+2a)	Go back N and Selective Repeat gives better efficiency than Stop and Wait ARQ.
Window Size	Sender Window Size = 1 Receiver Window Size = 1	Sender Window Size = N Receiver Window Size = 1	Sender Window Size = N Receiver Window Size = N	Buffer requirement in Selective Repeat is very large. If the system does not have lots of memory, then it is better to choose Go back N.
Minimum number of sequence numbers required	2	N+1	2 x N	Selective Repeat requires large number of bits in sequence number field.
Retransmissions required if a packet is lost	Only the lost packet is retransmitted	The entire window is retransmitted	Only the lost packet is retransmitted	Selective Repeat is far better than Go back N in terms of retransmissions required.
Bandwidth Requirement	Bandwidth requirement is Low	Bandwidth requirement is high because even if a single packet is lost, entire window has to be retransmitted. Thus, if error rate is high, it wastes a lot of bandwidth.	Bandwidth requirement is moderate	Selective Repeat is better than Go back N in terms of bandwidth requirement.
CPU usage	Low	Moderate	High due to searching and sorting required at sender and receiver side	Go back N is better than Selective Repeat in terms of CPU usage.
Acknowledgements	Uses independent acknowledgement for each packet	Uses cumulative acknowledgements (but may use independent acknowledgements as well)	Uses independent acknowledgement for each packet	Sending cumulative acknowledgements reduces the traffic in the network but if it is lost, then the ACKs for all the corresponding packets are lost.