Date
Page No.

Unit - II

#1) Data Link Layer

- Data link layer is the second layer of OSI Layered Model.
- This layer is one of the most complicated layer and has complex functionalities and liabilities.
- It hides the details of underlying hardware and represents itself to upper layer as the medium to communicate.
- It works between two hosts which are directly connected in some sense.
- It is responsible for converting data stream to signals bit by bit and to send that over the underlying hardware.

#) Responsibilities of Data link layer

→ Flow Control

A receiving node can receive the frames at a faster rate than it can process the frame. Without flow control, the receiver buffer can overflow and frames can get lost. To overcome this problem the data link layer uses the flow control to prevent the sending node on one side of the link from overwhelming the receiving node on another side of the link.

Scanned with CamScanner

Date
Page No. S.R

Error Control - The data link layer adds reliability to the Physical layer by adding mechanism to detect and retransmit damaged or lost frames. Data link layer controls the error from hop to hop / node to node. It can be done by cyclic Redundancy Check (DLL) & CheckSum (Transport layer) or parity bits

Access Control - The most important method used for access control is carrier shell multiple access/ collision detection. When two or more devices are connected to same link, data link layer protocol are necessary to determine which device has control over the link at any given time

Framing - Data link layer take packets from Network layer and encapsulates them into frames then, it sends each frame bit by bit on the hardware and assembles them into frames.

Synchronization - When data ~~transfers~~ frames are sent on the link, both machine must be synchronized in order to transfer to take place.

Node to Node delivery

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#) Framing

- Frames are unit of digital transmission, particularly in computer networks and telecommunications.
- Framing is a point to point connection between two computers or devices consisting of a wire in which data is transmitted as a stream of bits.
- It provides a way for sender to transmit a set of bits that are meaningful to the receiver.
- Framing is character oriented.

#) Methods of Framming

There are mainly 4 types of methods that are used for framing :-

- Character Count
- Character Stuffing
- Bit Stuffing
- Encoding Violations

1) Character Count -

This Method is rarely used and is generally required to count total number of characters present in frame. This is done by using field in header. Character Count method ensures data link layer at the

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receiver or destination about total number of character that follow and about where the frame ends.
There is disadvantages of using this method i.e. anyhow character count is disturbed or receiver might lose synchronization. The destination or receiver might also be not able to locate or identify beginning of next frame.

Character Stuffing -

Character stuffing is also known as byte stuffing or character oriented framing and is same as that of bit stuffing but byte stuffing actually operates on bytes whereas bit stuffing operates on bits. In byte stuffing, the special byte that is basically known as ESC (Escape character) that has predefined pattern is generally added to data section of the data stream or frame where there is message or character that has same pattern as that of flag byte.

But receiver removes this ESC and keep data apart that causes some problems or issues. In simple words, we can say that character stuffing is addition of 1 additional byte if there is presence of ESC or flag in text.

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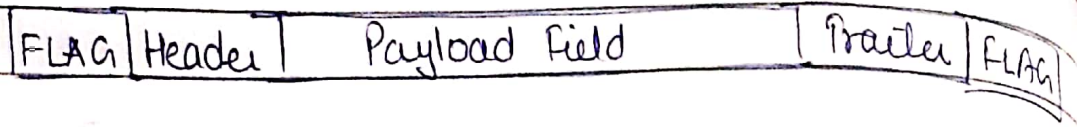
(A) 

(B)

original Character	After Stuffing
A FLAG B	A ESC FLAG B
A ESC B	A ESC ESC B
A ESC FLAG B	A ESC ESC ESC FLAG B
A ESC ESC B	A ESC ESC ESC ESC B

(A) A frame delimited by flag bytes
(B) Four Examples of byte Stuffing.

3) **Bit Stuffing**

Bit Stuffing is also known as bit oriented framing or bit oriented approach. In bit Stuffing, extra bits are being added by network protocol designers to data stream. It is Generally insertion or addition of extra bits into transmission unit or message to be transmitted as simple way to provide and give signaling information and data to receiver and to avoid or ignore appearance of unintended or unnecessary control sequences. It is a

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Date
Page No. S.R

Type of protocol management simply performed to break up bit pattern that results in transmission to go out of synchronization. Bit Stuffing is very essential part of transmission process in network and communication protocol. It is also required in USB.

Applications

1. Synchronize several channels before multiplexing
2. Rate match two separate single channel
3. Run length limited Coding → To limit the no. of consecutive bits of the same value in the data to be transmitted. A bit of opposite value is inserted after the max. allowed number of consecutive bits.

Disadvantages

1 → The code rate is unpredictable.
2 → It depends on the data being transmitted

Example

(Without bit Stuffing)

Bit Sequence → 1101011111010111110101111110

With Bit Stuffing → 11010111110010111110010111110110

After every five consecutive 1 bits, 0 bit is stuffed.

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Date
Page No.
S.R.

#) Flow Control

- Flow Control is a design issue at data link layer
- It is a technique that generally observe a proper flow of data from sender to Receiver
- It is a speed matching mechanism i.e. speed for sending the data by sender and for receiving the data by receiver should be same.
- Flow Control coordinates the amount of data that can be sent before receiving an acknowledgment.
- Flow Control is a set of procedures that tells the sender how much data pt can transmit before it must wait for an acknowledgement from receiver
- Receiver has a limited speed at which it can process incoming data and a limited amount of memory in which to store incoming data.
- Receiver Must Inform the sender before the limits are reached and request that the transmitter to send fewer frames or stop temporarily.

Scanned with CamScanner

Date
Page No. S.R

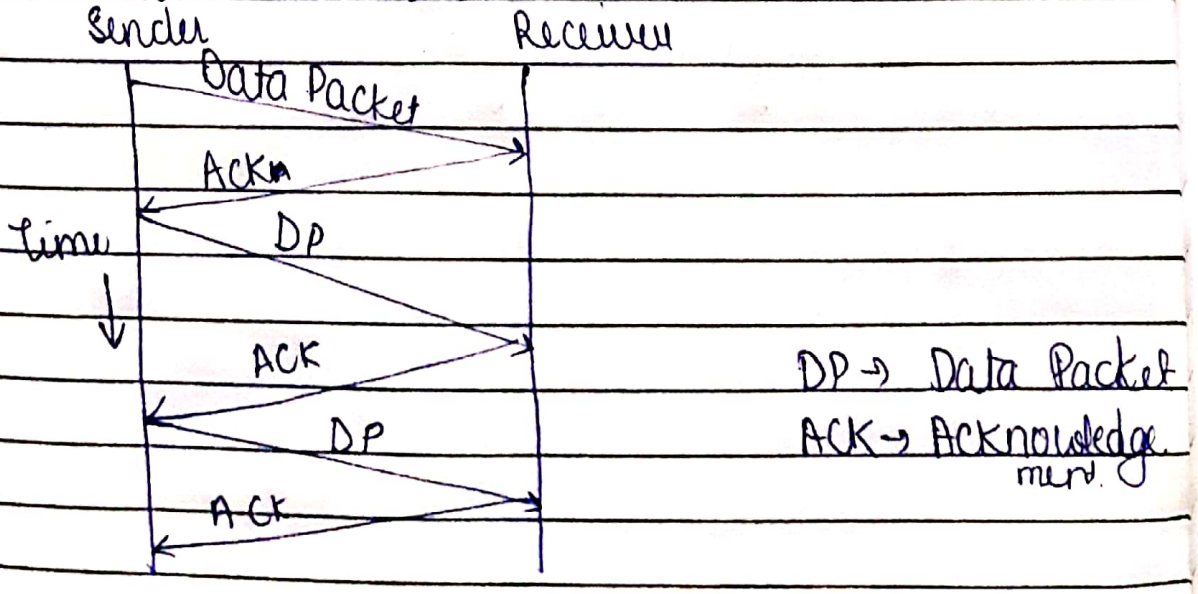
Flow Control Protocols

Flow Control

- Noiseless Channels
  - → Simplest
  - → Stop & Wait
- Noisy Channel
  - → Stop and Wait ARQ
  - → Go-Back-N-ARQ
  - → Selective Repeat ARQ

1) STOP-AND-WAIT PROTOCOL

It is simplest flow control method. In this, sender will send one frame at a time to the receiver. Until then, the sender will stop and wait for the acknowledgement from the receiver. When the sender gets the acknowledgement then it will send the next data packet to the server and wait for the acknowledgement again and this process will continue.



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- The idea of stop-and-wait protocol is straightforward.
- It provides unidirectional data transmission with flow control facilities but without error control facilities.
- It is data link layer Protocol for transmission of frames over noiseless channels.

Total time taken

Total time taken in sending one packet =
(Transmission delay)packet + 2x propagation delay.

Efficiency (η)

$$= \frac{(\text{Transmission delay})_{\text{packet}}}{(\text{Transmission delay})_{\text{packet}} + 2 \times \text{propagation delay}}$$

Propagation delay → Amount of time taken by a packet to make physical journey from one router to another router.

Propagation delay = $\frac{\text{distance B/w routers}}{\text{velocity of Propagation}}$

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Date
Page No. S.R

Primitives of Stop-and-Wait Protocol

Sender Side :-

Rule 1 :- Send one data packet at a time.

Rule 2 :- Send the next packet only after receiving ACK for the previous.

Receiver Side :-

Rule 1 :- Receive and consume data Packet

Rule 2 :- After consuming Packet, ACK need to be sent

Advantages

- It is very simple to implement
- The incoming Packet from receiver is always an ACK.

Disadvantages

- Data loss - If sender sends data and in case the data is lost due to some external source, the receiver doesn't receive it and keeps on waiting for a long time. It does not ACK & Sender will not send further data packets.
- Acknowledgement loss - After receiving the data from the sender, if ACK is lost due to some external source, the sender doesn't receive ACK

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and doesn't send further data Packets

- Time loss - Since it only receive & sent one data packet at a time, if there are a large no. of data Packets, it will take a lot of time to send & recieve data Packets that results in time loss.

#) STOP-AND-WAIT ARQ Protocol

- The Idea of Stop-and-wait ARQ protocol is straightforward.
- After transmitting one frame, the sender waits for an ACK before transmitting the next frame.
- If the ACK doesnot arrive after a certain period of time, the sender time outs and retransmits the original frame.
- Stop-and-wait ARQ = Stop-and-wait + timeout time + Sequence Numbers.
- If sender sending a frame and receiver receives that and sends an ACK. If ACK has not reached to sender, a time will run on sender Side.
- Once the timer expires, the sender will retransmits the frame again. This retransmission is automatic; we call it as Stop And Wait ARQ (Automatic Repeat Request) protocol.

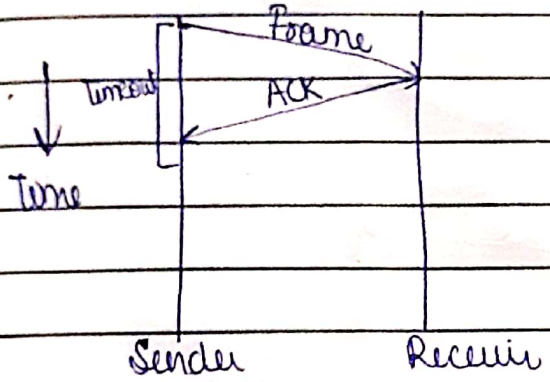
Scanned with CamScanner

Date
Page No. S.R

Scenarios of Stop & Wait ARQ Protocol

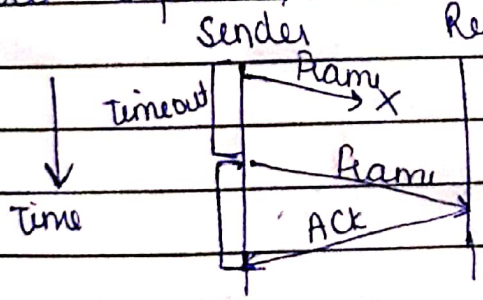
- The acknowledgement is received before the time expires :-

The timeline diag. shows that the sender has sent the frame and receiver sent the ACK before timeout. So this is perfect stop-&-wait ARQ Protocol



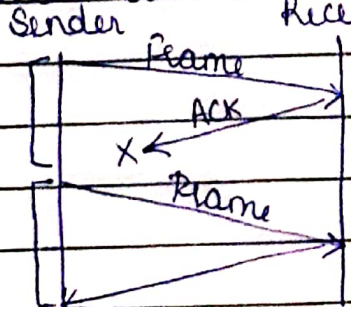
- The original frame is lost :-

Here the sender sends the frame and frame is lost. So if sender doesn't receive any ACK before timeout expires, sender will again retransmit.



- The Ack is lost :

Here receiver sent the ACK, but ACK is lost. Sender will wait until timeout expires and retransmit



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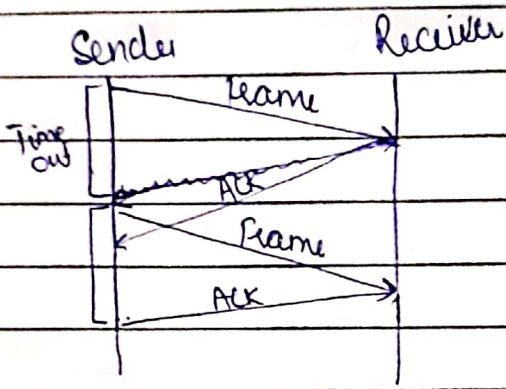
- The timeout fires so soon :-
Here, Sender sent frame & receive sent an ACK. But due to some delay in network, ACK is received after the timeout expires. So once the sender find out the timeout expired, it retransmits the frame again to get the ACK.



Advantages
- The main advantage of this protocol is precision
- No time loss

Disadvantages
- Less efficiency
- Poor Performance
- Poor utilization of Bandwidth

#) Sliding window Protocol

- Sliding window is a method of sending multiple frames at once
- It manages data packets between two devices ensuring delivery of data frames reliably and gradually
- It also found in TCP
- No. of frames to be sent is based on window size.

Scanned with CamScanner

Date
Page No. S.R

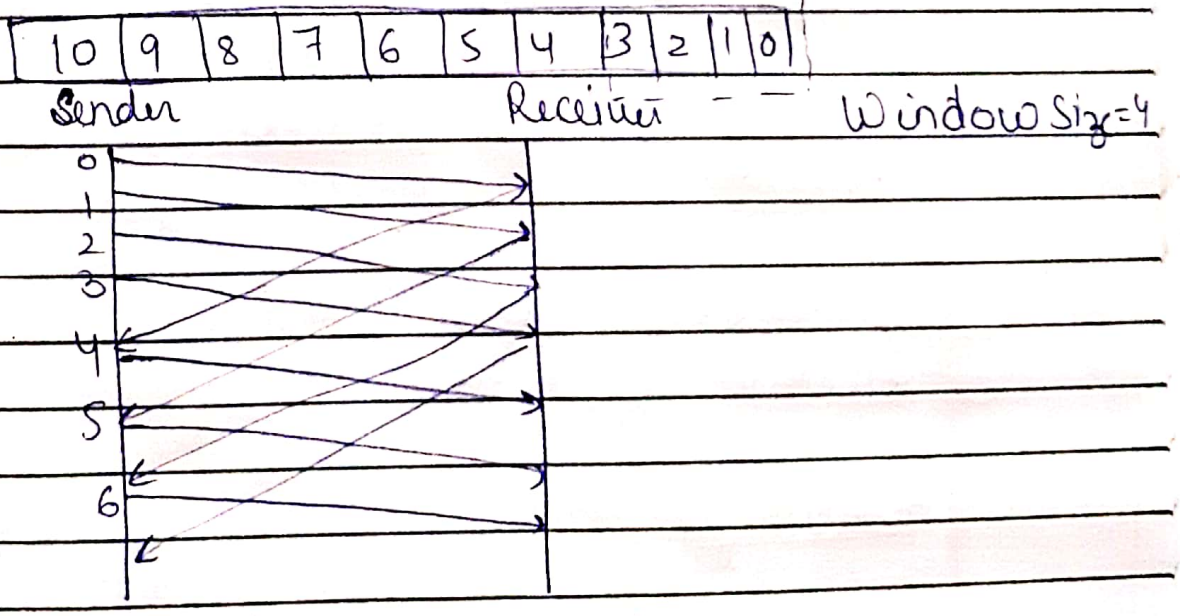
- Each framed is numbered → Sequence Number
- The sequence number find use in receiving end to locate missing data and to avoid duplicate data

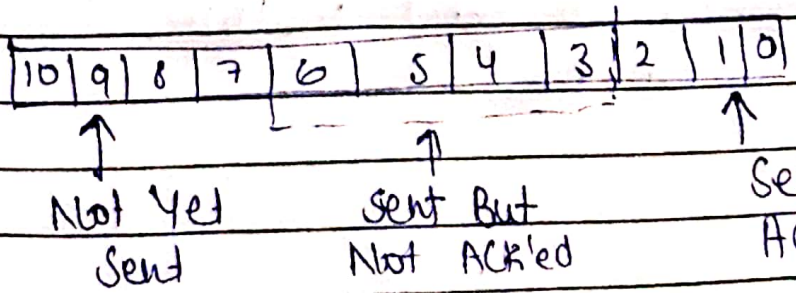
Working

The sender has a buffer called sending window and receiver has a buffer called receiving window.

The size of sending window determines the sequence number of the outbound frames. The size of sending window is $2^n - 1$

The size of receiving window is the max. no. of frames that the receiver can accept at a time. It determines the max. no. of frames that the sender can send before receiving ACK.





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Sender Side

- The Sequence No. of frame occupies a field in the frame. So, the Sequence No. should be kept in mini.
- Sender window can only be $2k-1$ in size.
- Sender Buffer will be of same size as sliding window.

Receiver Side

- Size of window is always 1.
- The receiver window can hold 2, 3, 4 frame but Ack frame will be held until 4th arrives. Ack of these will be done one at a time.
- Receiver Requires a Buffer size of one.

Sliding window Protocol can be divided into :-

1. Go-Back-N ARQ
2. Selective Repeat ARQ.

Advantages

1. It is Possible to send multiple Packets without receiving an Ack.

Scanned with CamScanner

Date
Page No. S.R

② Piggybacking with full duplex lines is Possible

Disadvantages

① This Protocol does not impose any restrictions on sequence Number.
② There may be waste of Bandwidth.

Go-Back-N ARQ Protocol

Sender Window size

- The Go-Back-N Automatic Repeat Request protocol is known as Go-Back-N-ARQ Protocol.
- It is a sliding window method find in this data link layer Protocol.
- In the event of corruption or loss of frames, all subsequent frames must be sent again.
- In this protocol, the sender window size is N.
- The size of receiver window is 1.
- It uses the Concept of protocol pipelining i.e. the sender can send multiple frames before receiving the acknowledgment for the first frame.
- There are finite number of frames and the frames are numbered in a sequential manner
- The no. of frames that can be sent depends

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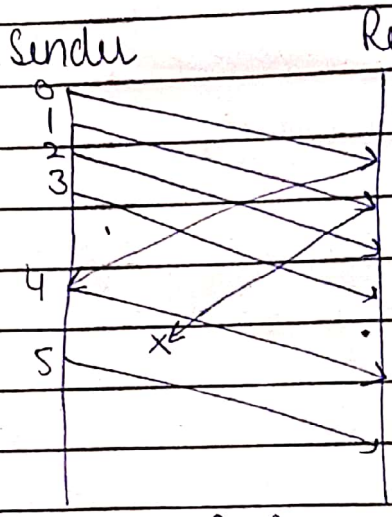
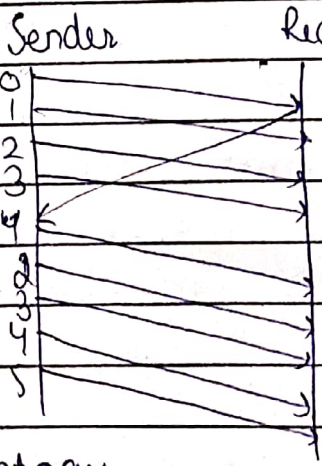
on the window size of the sender.
- If the acknowledgement of a frame is not received within an agreed upon time period, all frames in the current windows are transmitted.
- The size of the sending window determines the sequence number of the outbound frames.





10	9	8	7	6	5	4	3

window size=4

Advantages

- The efficiency of this protocol is more
- The waiting time is pretty much less in this protocol.

Scanned with CamScanner

Date
Page No. S.R

- With this, the timer can be sent for many frames
- Also, sender can send many frames at a time
- Only one ACK frame can acknowledge more than one frame

Disadvantages

- Timeout timer runs at the receiver side only
- The transmitter needs to store the last N packets.
- The retransmission of many error-free packets on erroneous packet

Example

Station A need to send a message consisting of 9 packets to station B using a sliding window (window size 3) and Go back error control strategy. All packets are ready and immediately available for transmission. If every 5th packet that A transmits get lost (but no ACK from B ever get lost), then what is number of packets that A will transmit for sending the message to B

a) 12
b) 14
c) 16
d) 18

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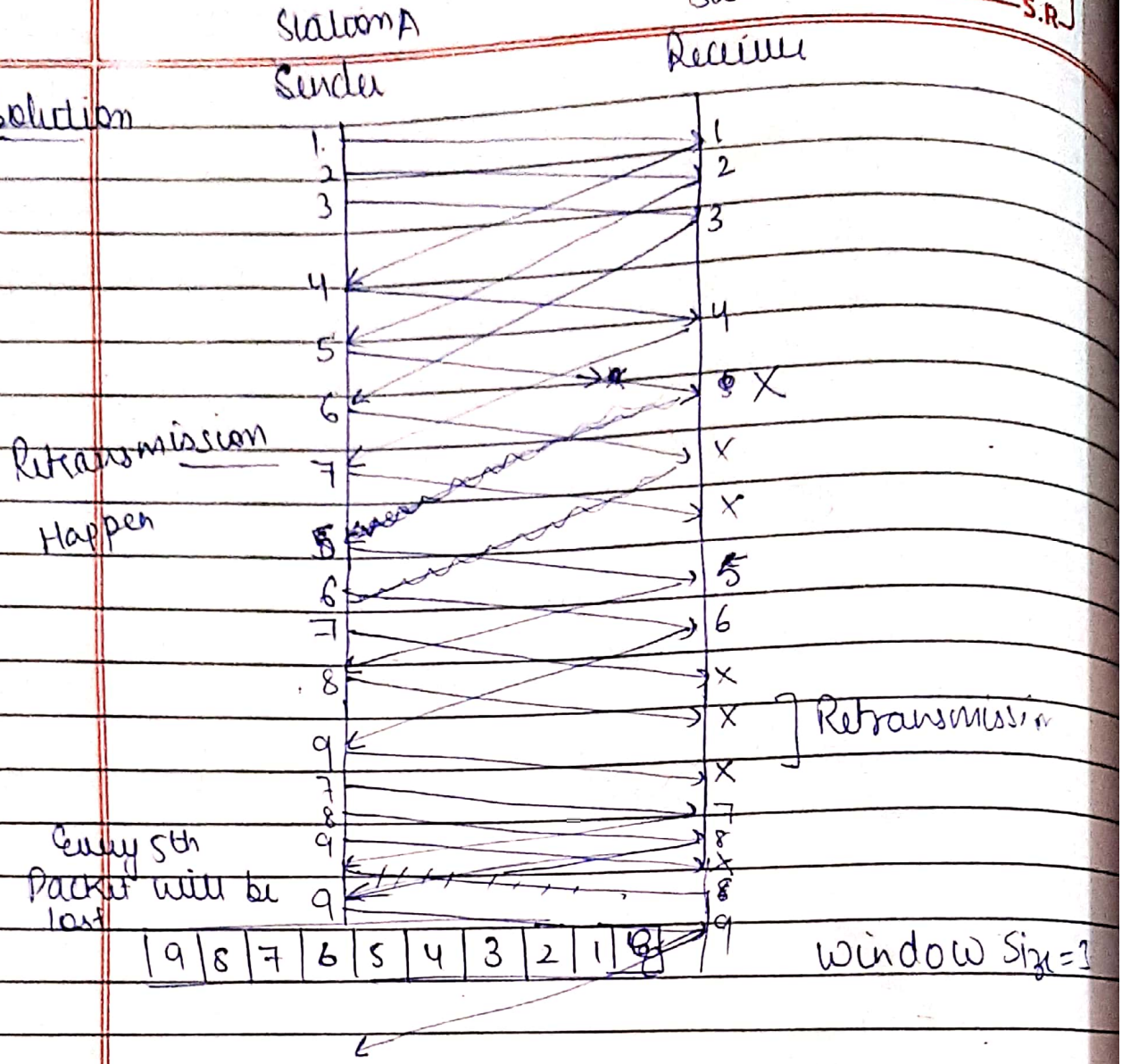
Solution



Sender Sends 16 packets.

#) Selective Repeat ARQ

Selective Repeat Protocol, also known as Selective Repeat Automatic Repeat Request (ARQ) is a data link layer protocol that uses the sliding window technique for reliable data frame delivery.

Scanned with CamScanner

Date
Page No. S.R

Selective Repeat ARQ is used in the data link layer for error detection & control. The sender sends several frames specified by a window size in the selective Repeat without waiting for individual acknowledgement from the receiver as in Go-Back-N-ARQ

Working of Selective Repeat ARQ

- In Selective Repeat ARQ, only the erroneous or lost frames are retransmitted, while correct frames are received and buffered
- While keeping track of Sequence Numbers, the receiver buffers the frame in memory and send NACK (Negative ACK) for only the Missing or damaged frame.
- The Sender will send or retransmit the packet for which Negative ACK is received

Efficiency = $N(1+2a)$

a = Propagation delay / Transmission delay

Buffers = $N+N$

Sequence Number = N (sender side) + N (receive side)

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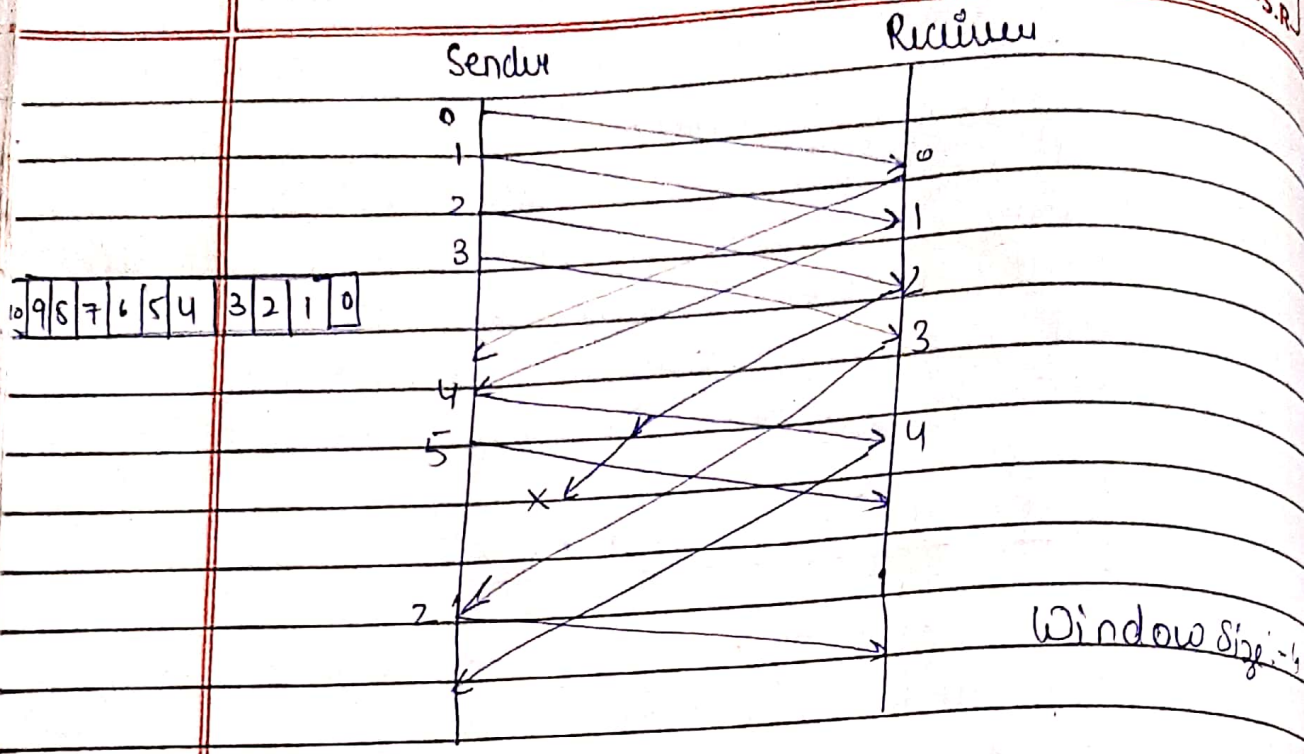

As shown, for 2, NACK is received and it will retransmit frames only.

- Selective Repeat works better at times when the network line is mostly unreliable.
- In this, we can avoid unnecessary transmission by sending only the damaged or Missing frames.

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