Computer Network

Data-Link Layer

Lecture : 15

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TCP/IP

TCP/IP Layer	Hardware	Software/Protocols
Application	None	HTTP, FTP, SMTP, POP3, IMAP, DNS, SSH
Transport	None	TCP, UDP
Internet	Routers	IP (IPv4/v6), ICMP, IGMP, ARP, RARP Routing(DVR(RIP), LSR(OSPF), BGP)
Data Link	Switches, Bridges, NICs	Ethernet (MAC framing), Wi-Fi (802.11 MAC), PPP, Frame Relay, HDLC
Physical	Cables (fiber, coaxial, twisted pair), Hubs, Repeaters, Connectors (RJ-45), Amplifier	ONLY physical standards (IEEE 802.3 for wiring, IEEE 802.11 PHY for Wi-Fi)

Data-Link Layer

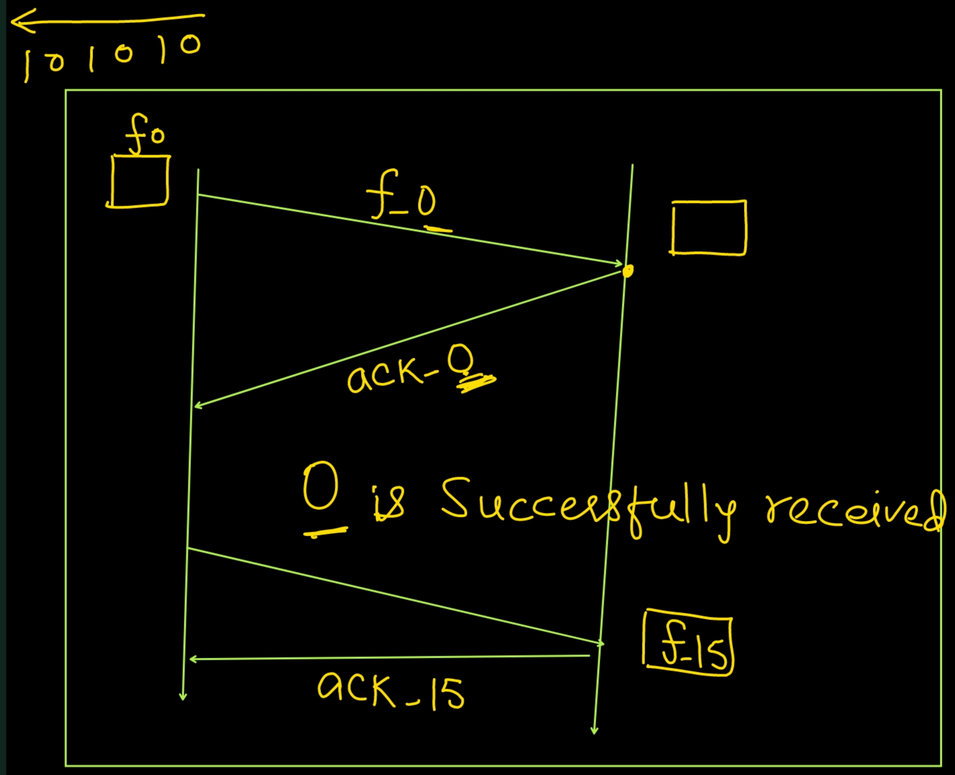
Responsibility
Framing
Error Detection
Error Recovery
Flow Control
Access Control
Addressing
Link Management
Framing and Encapsulation

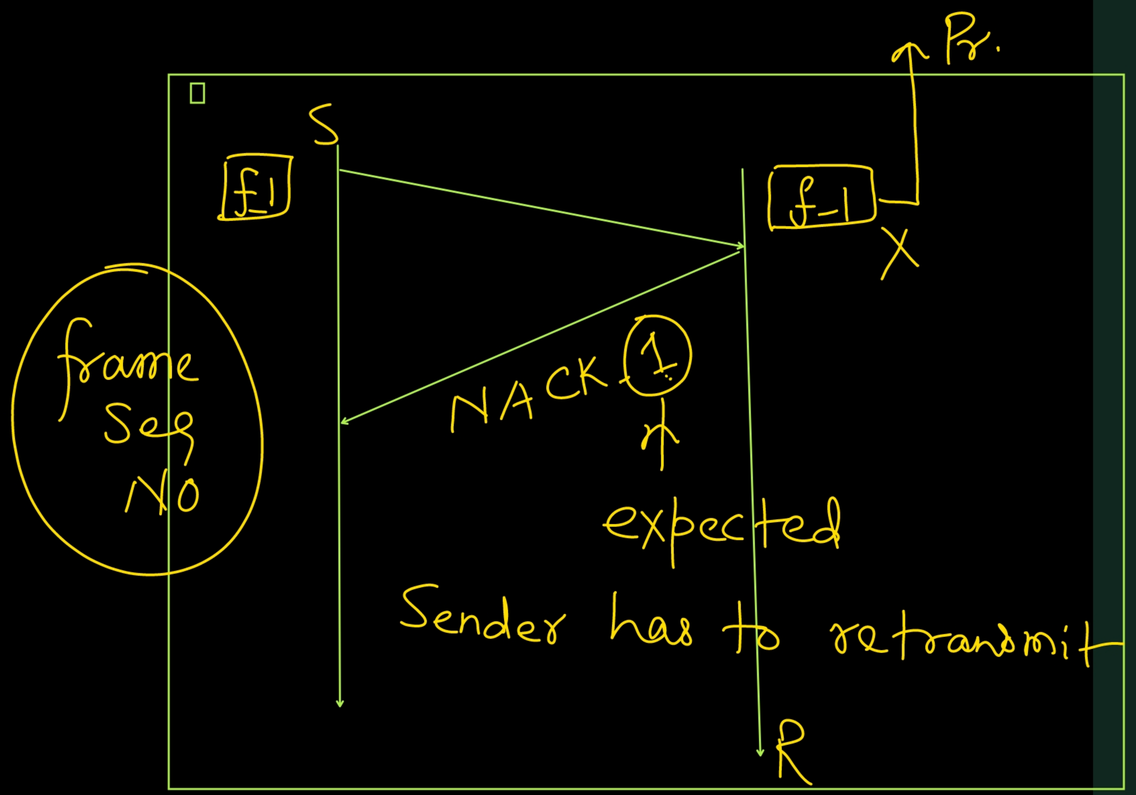
Unit	Name (Decimal)	Value (Decimal – Base 10)	Used In (Bandwidth)	Value (Binary – Base 2)	Used In (Memory Size)
1 kB	Kilobyte	1,000 bytes	Network speeds, file size	1,024 bytes	RAM, memory blocks
1 MB	Megabyte	1,000,000 bytes	Internet speed (MBps)	1,048,576 bytes (2^{20})	File size, RAM
1 GB	Gigabyte	1,000,000,000 bytes	HDD, bandwidth	1,073,741,824 bytes (2^{30})	RAM, ISO files, VMs
1 TB	Terabyte	1,000,000,000,000 bytes	Cloud storage	1,099,511,627,776 bytes (2^{40})	High-capacity storage
1 Mbps	Megabits/second	1,000,000 bits per second	Internet speed	—	—
1 MiB/s	Mebibytes/second	1,048,576 bytes per second	—	Used in OS, RAM transfers	

Stop and Wait ARQ(Automatic Repeat request)

Seq No: {0,1} & Window Size : 1

ACK and NACK





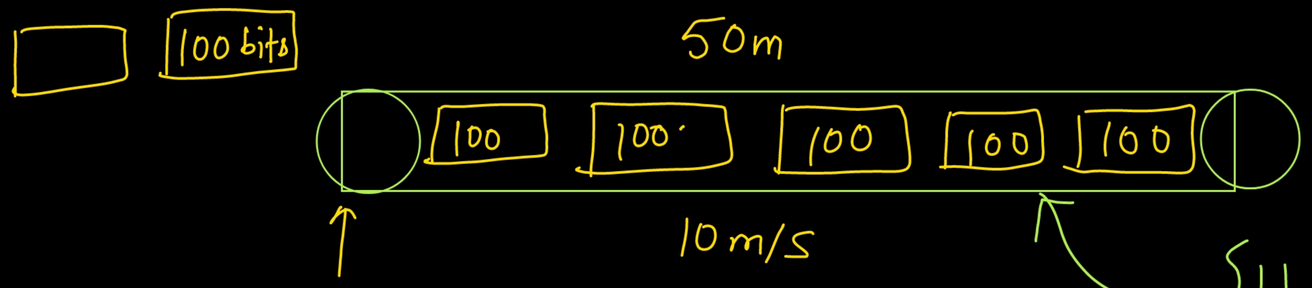
Stop and Wait ARQ(Automatic Repeat request)

Seq No: {0,1} & Window Size : 1

ACK and NACK

Step 1: Send Frame 0 •**Sender → Receiver: Frame with Sequence Number 0** •**Receiver → Sender: ACK 0 (means "I received frame 0 correctly")**	**Step 3: Retransmit Frame 1** •**Sender → Receiver: Frame 1 (again)** •**Receiver → Sender: ACK 1**
Step 2: Send Frame 1 •**Sender → Receiver**: Frame with **Sequence Number 1** •Frame 1 is **corrupted or lost** •**Receiver → Sender**: **NACK 1** (means "Frame 1 not received correctly")	**Step 4: Send Frame 2** •**Sender → Receiver**: Frame **2** •**Receiver → Sender**: **ACK 2**

Pipe and Pipelining



BW
100 bits/Sec

$T_t = 1$ Sec

$T_p = 5$ sec

{Half Duplex}

{Capacity : $\overbrace{BW}^{} * \overbrace{T_p}^{\text{delay}}$

$100 \times 5 = 500$ bits}

BDP {Bandwidth delay product}

[Full Duplex :: BDP {$2 \times BW \times T_p$}

1. A channel has a bandwidth of 5 Mbps and a one-way propagation delay of 100 ms. What is the **Bandwidth-Delay Product (BDP)** of the channel?

(A) 0.5 Mbits
(B) 1 Mbits
(C) 2.5 Mbits
(D) 5 Mbits

BW x Tp

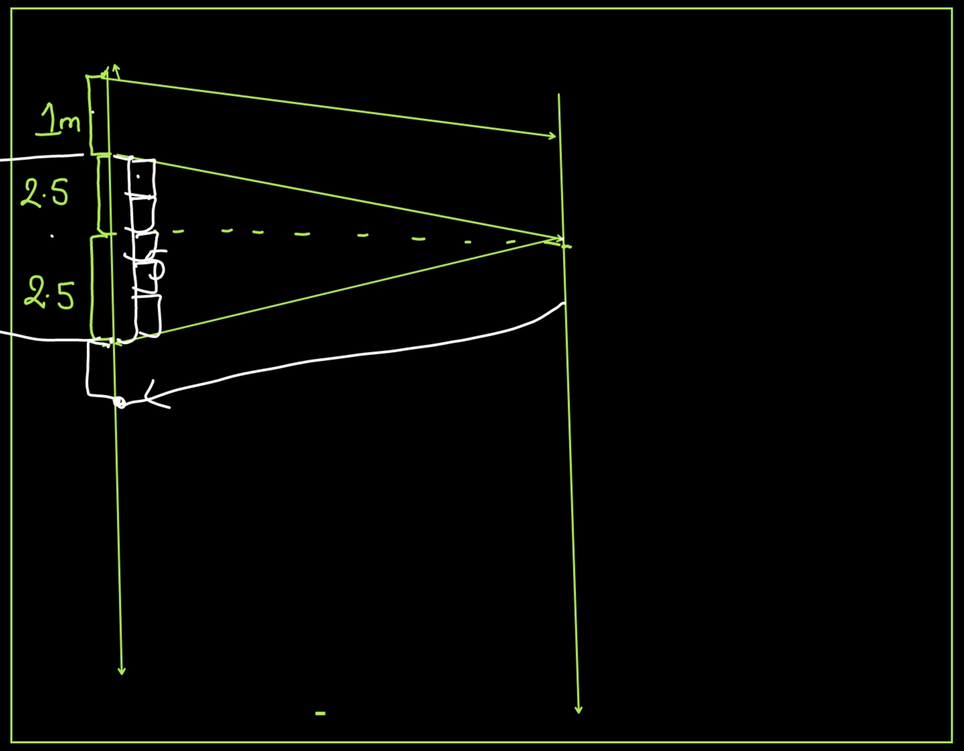
$5 \times 10^6 \text{ b/s} \times 100 \text{ ms}$

$= 5 \times 10^5 \text{ b}$

$= 0.5 \text{ Mbits}$

2. In pipelined protocols, which of the following best explains the advantage over Stop-and-Wait?

(A) Requires no acknowledgements
(B) Saves bandwidth by sending smaller packets
(C) Improves channel utilization
(D) Reduces processing overhead at receiver



$T_t = 1\,ms$

$T_p = 2.5\,ms$

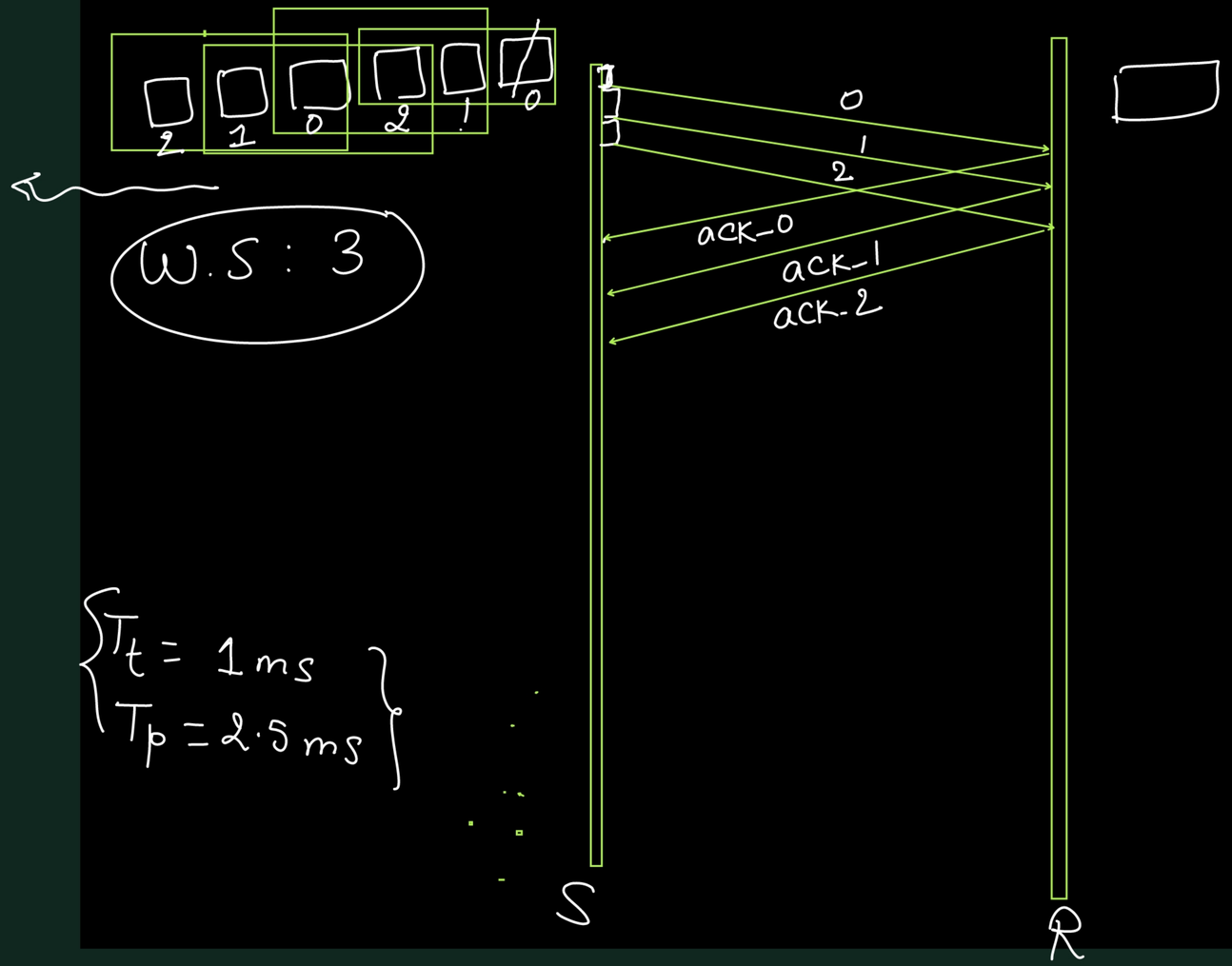
$$\eta = \frac{1}{1 + 2 \times 2.5}$$

$$= \frac{1}{6}$$

Sliding Window Protocol

Go back N

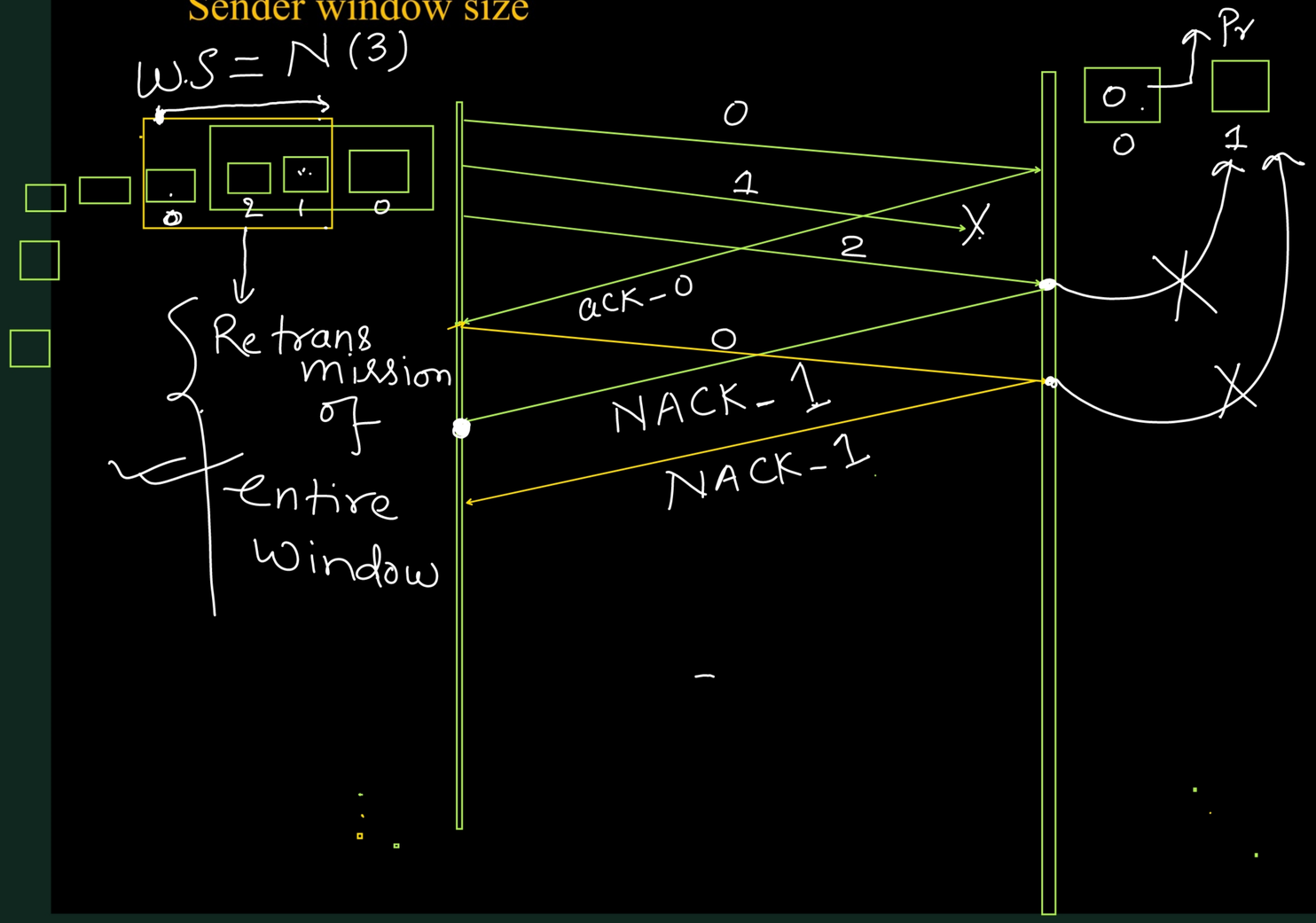
Selective Repeat



GoBack-N ARQ

Sender window size

W.S = N (3)



Receiver Window Size

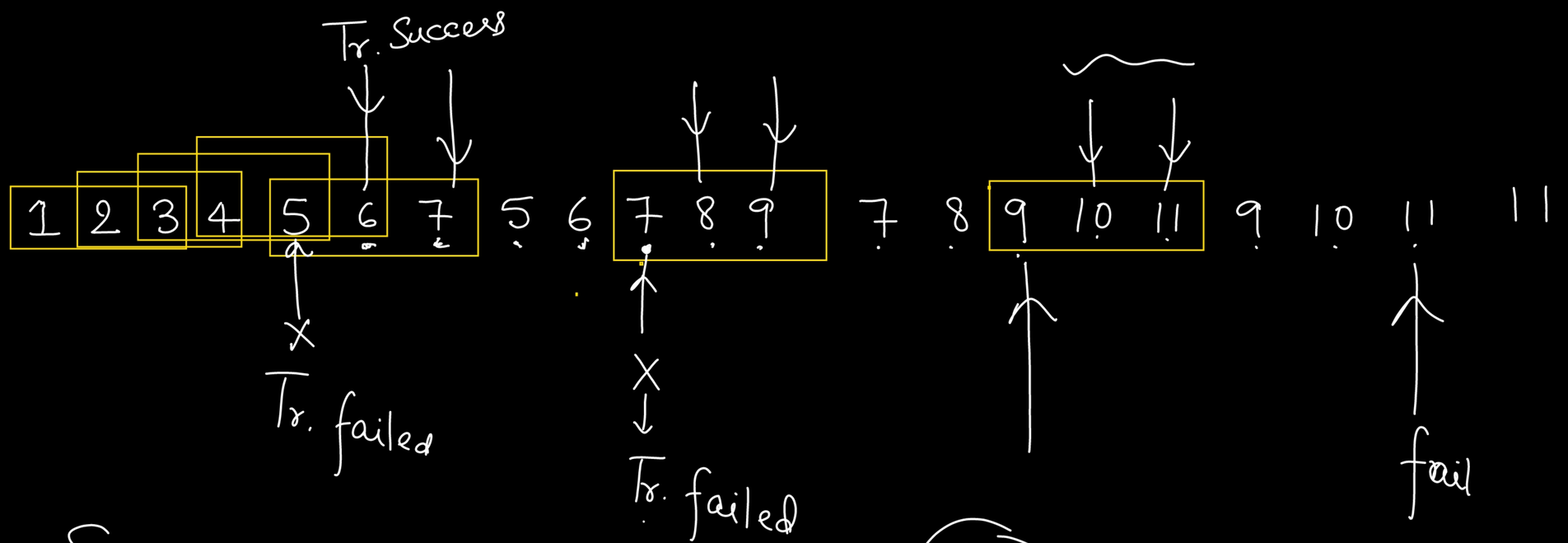
W.S = 1

[% In-order acceptance

GoBack-N ARQ

Independent ack, Cumulative ack {every frames ack or bundled based on ack timer}

A sender has to transmit 11 packets, and every 5th packet that is being transmitted is lost. What is the total number of transmissions required using Go-Back-N with a window size of 3 (GB3)?



Successful Transmission = 17

21

GoBack-N ARQ

Sequence number & sequence bits

Thank You