Computer Network

Data-Link Layer

Lecture : 14

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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 : Stop N Wait, Goback N, Selective Repeat
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	

- **Transmission of Frame:** Time taken by system to transmit a frame to network.
- T(transmission) = frame size/data rate **= L bits / R bps**
- **Propagation delay:** Time taken by a single bit to propagate from one end to another end in network.
- T(Propagation) = Distance/Speed = **D meter/ V mps**

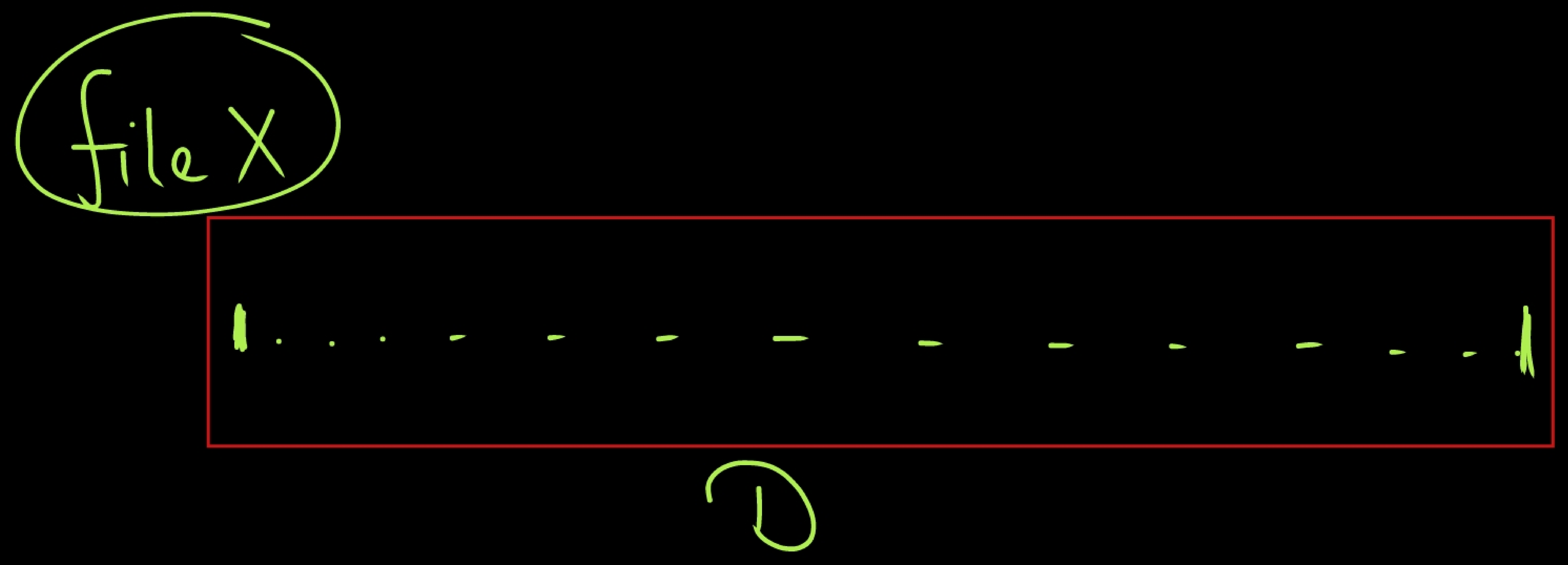
$$T_t = \frac{\text{Frame Size}}{\text{Band Width}}$$

$$T_p = \frac{\text{Distance}}{\text{Velocity}}$$

Q5. Which of the following **reduces transmission delay** but **does not affect propagation delay**?

A. Decreasing the packet size
B. Increasing bandwidth
C. Reducing link length
D. Using faster medium

$$T_p = \frac{\text{Distance}}{v}$$



- Utilization of Channel(U) = **Active time of sender/Cycle Time = η**
- **Efficiency Of Channel = Utilization of Channel**
- Throughput of Sender = Total Data / Total Time = **Frame Size / Cycle Time**
- **Throughput = Effective BW = BW utilization = η * BW**

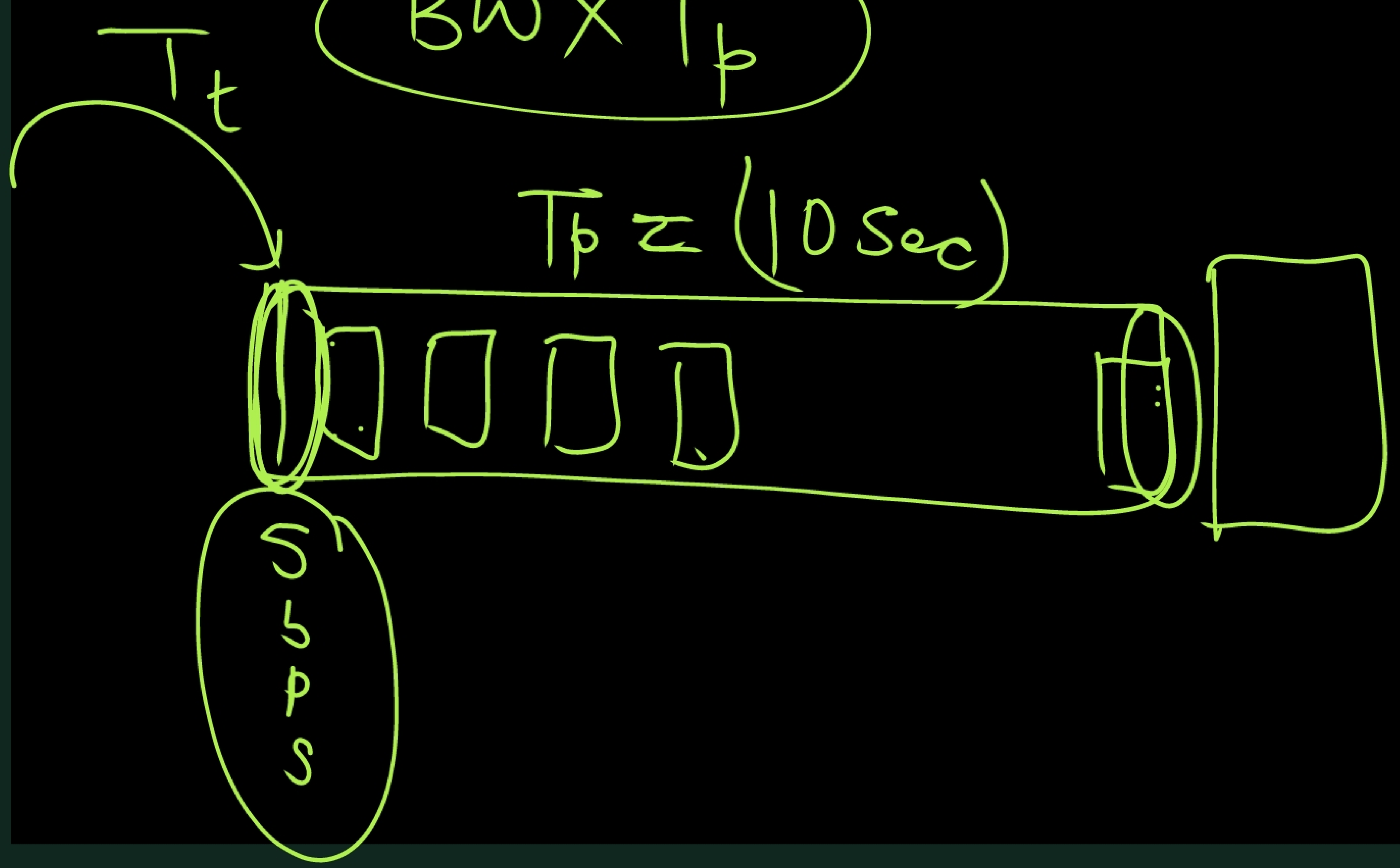
Delay Type	Where It Occurs?	Cause	Depends On?
Queuing Delay	Buffer (NIC, Router, Switch)	Frames waiting for transmission	Traffic load, buffer size
Processing Delay	Router, Switch, Receiver	Header inspection & error checking	CPU speed, processing power

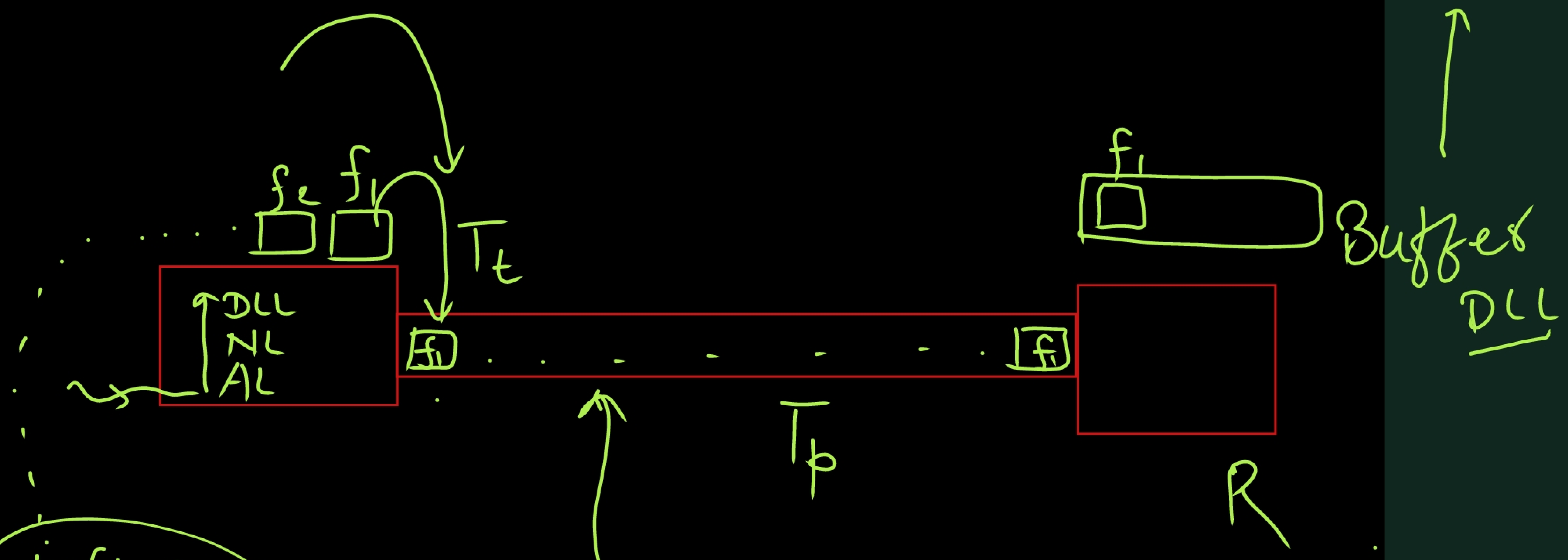
Flow Control

- Stop and wait
- GoBack-N
- Selective Repeat

Sliding window Algo

$BW \times T_p$

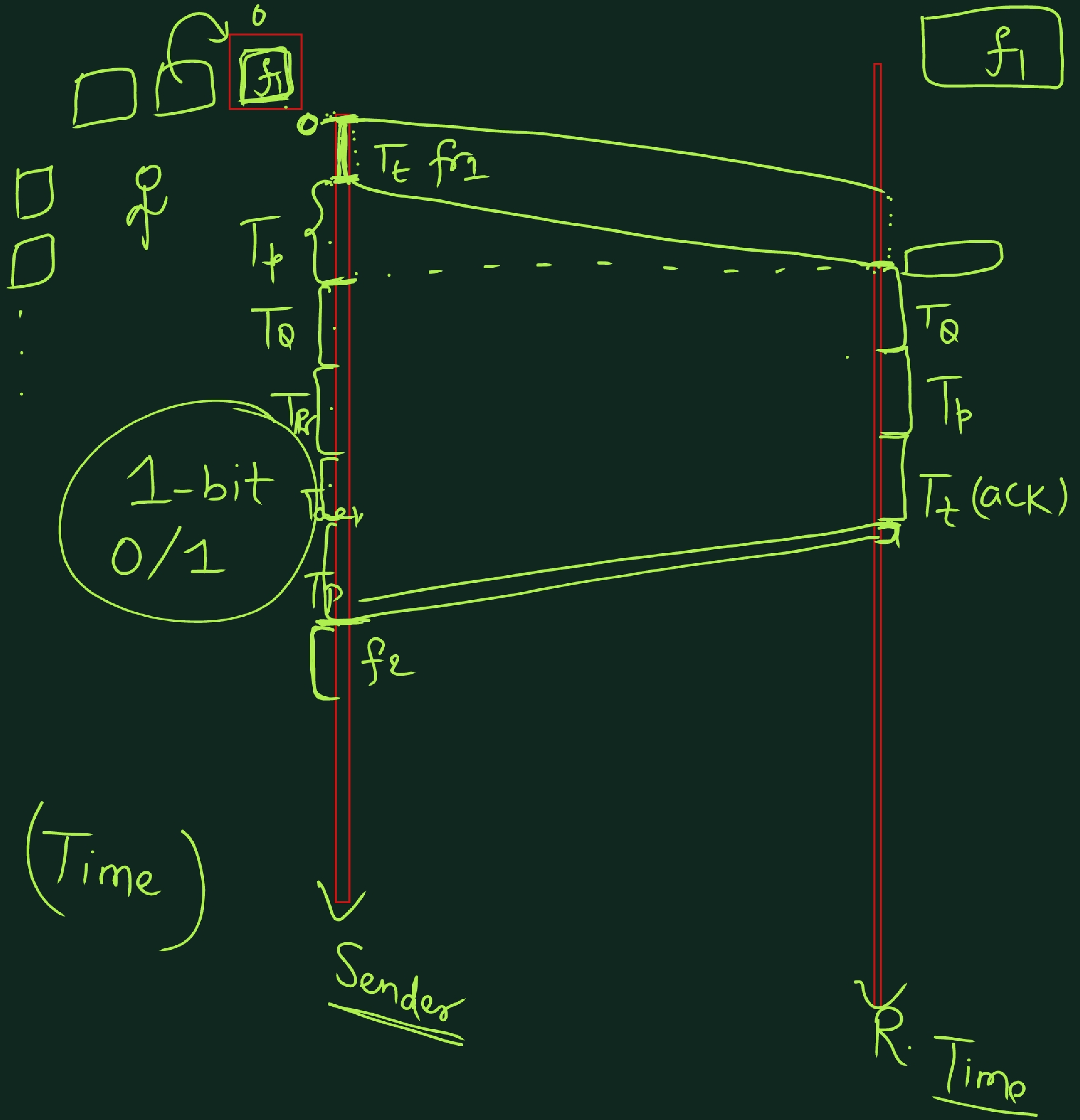




infinite

Channel Capacity

$= BW \times T_p$



$$\eta \,\{\text{Efficiency}\} = \frac{\text{Useful}\,\{\text{Trans}\}}{\text{Total Cycle time}}$$

$$= \frac{T_t}{T_{cycle}}$$

$$\{\text{Throughput} = \eta \times BW\}$$

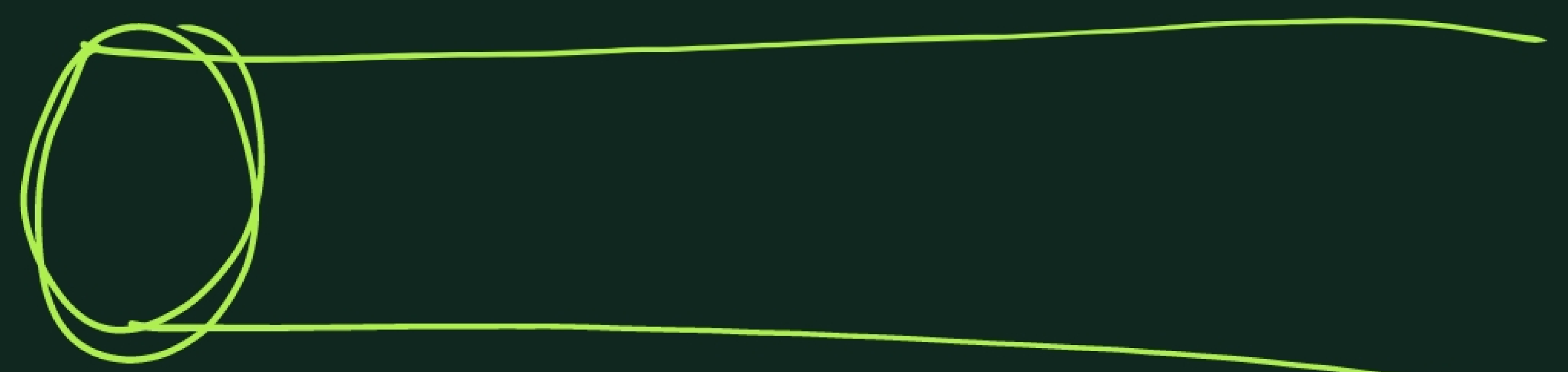
$$\{T_{cycle} : T_t(fr) + T_p + \cancel{T_Q} + \cancel{T_{pr}} + \cancel{T_t(ack)} + T_p$$

$$= \{T_t + 2\,T_p\}$$

$$T_t = 10 ms$$

$$T_{cycle} = 100 ms$$

$$\eta = \frac{10}{100} = \frac{1}{10}$$



$$BW = 10 mbps$$

$$\text{Throughput} = \frac{10 mbps}{10} = 1 mbps$$

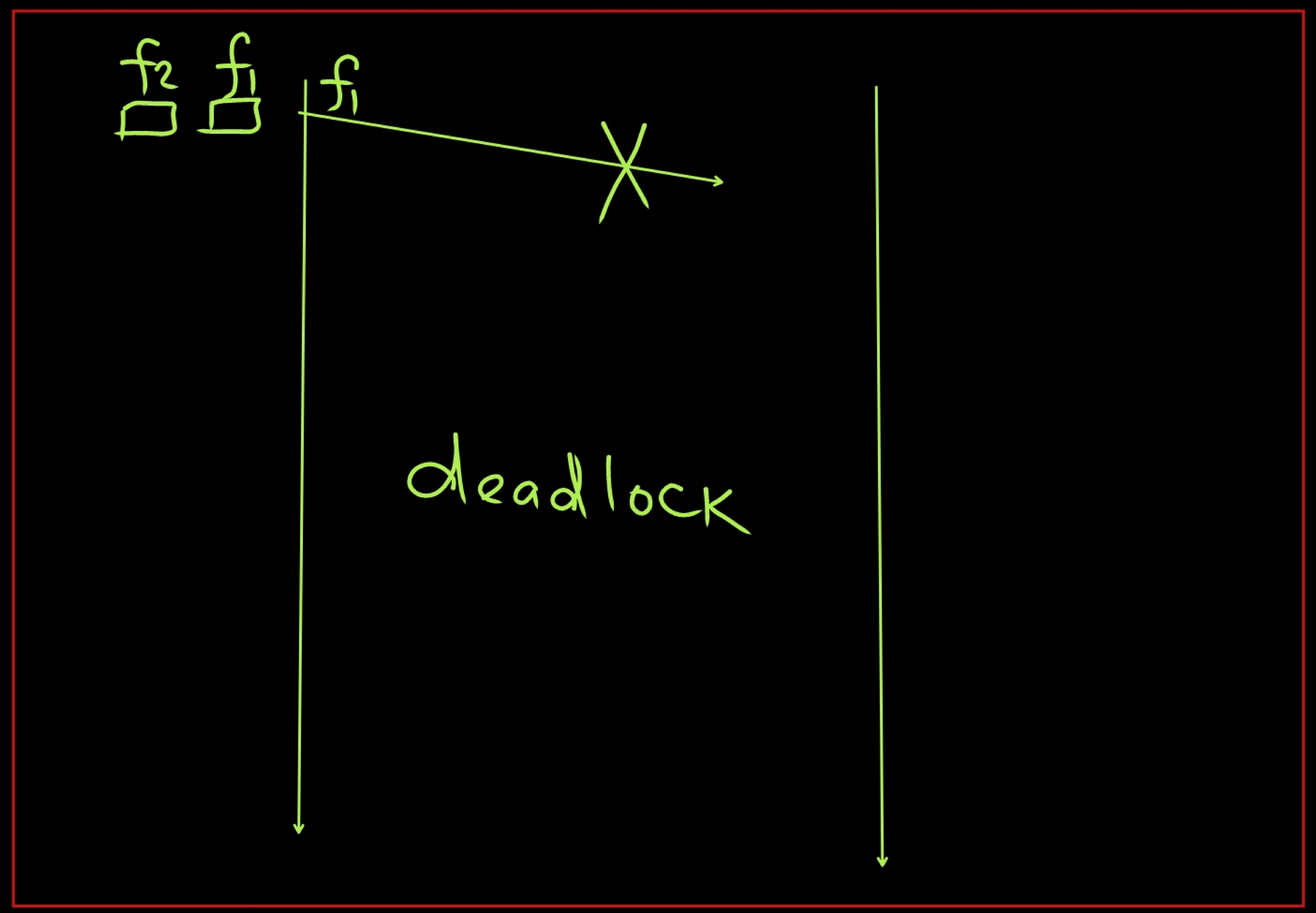
Stop and Wait ARQ(Automatic Repeat request)

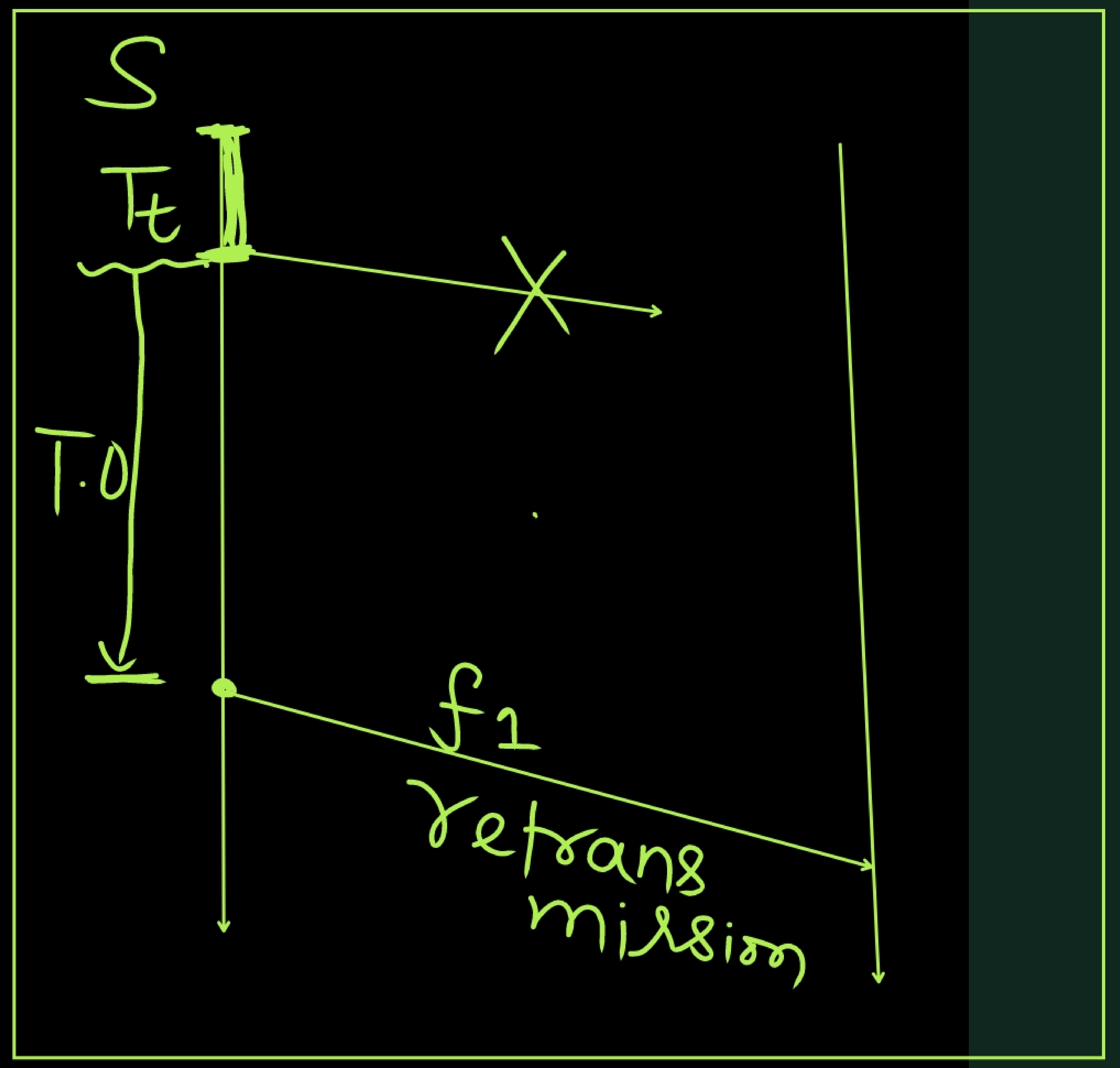
- Sender sends a frame → (Frame 0)
- Receiver receives the frame, checks for errors, and sends an ACK → (ACK 0)
- Sender receives ACK and sends the next frame → (Frame 1)
- If ACK is not received within a timeout period, the sender retransmits the same frame.

Case 1.

SNW + T.O

SNW ARQ

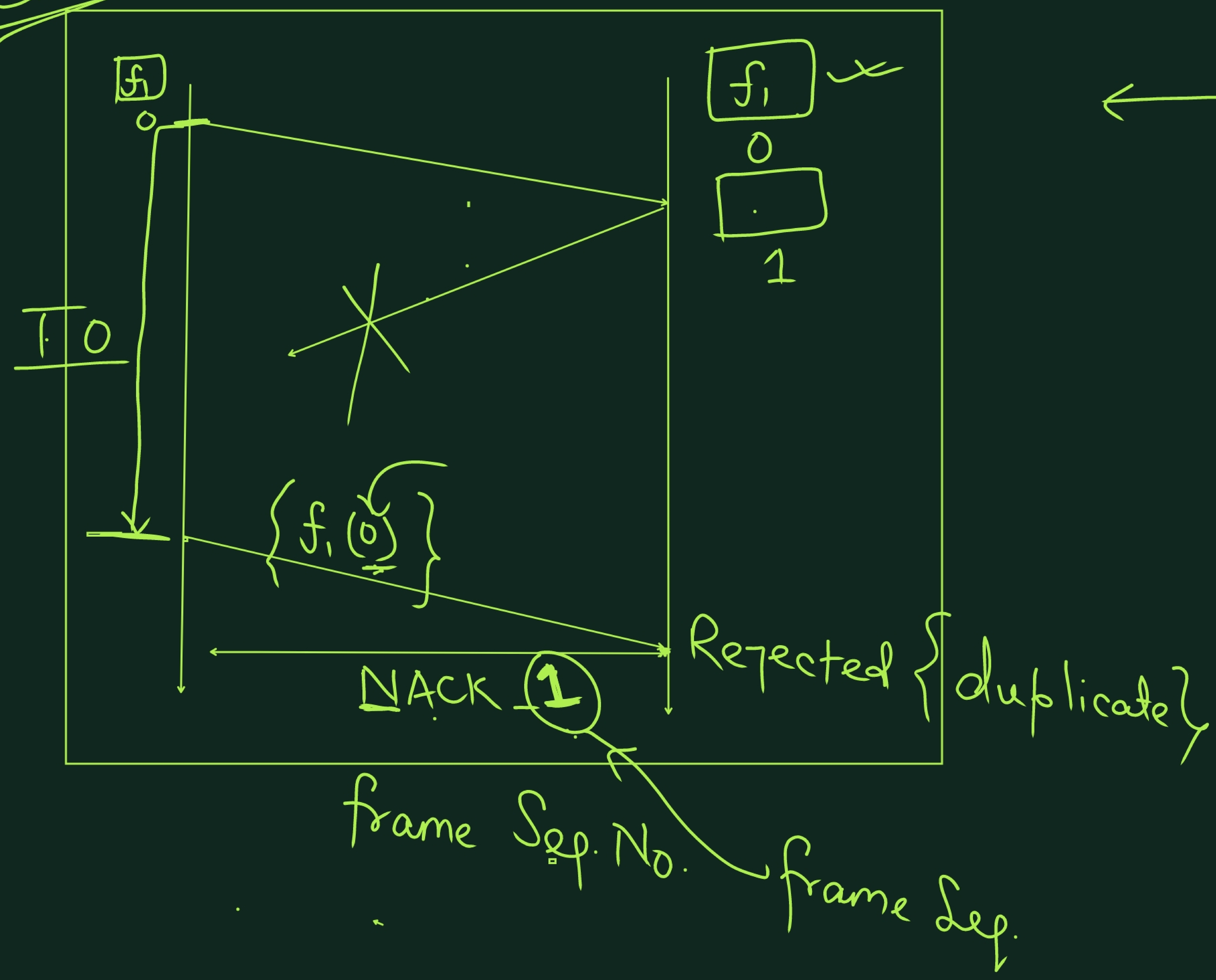


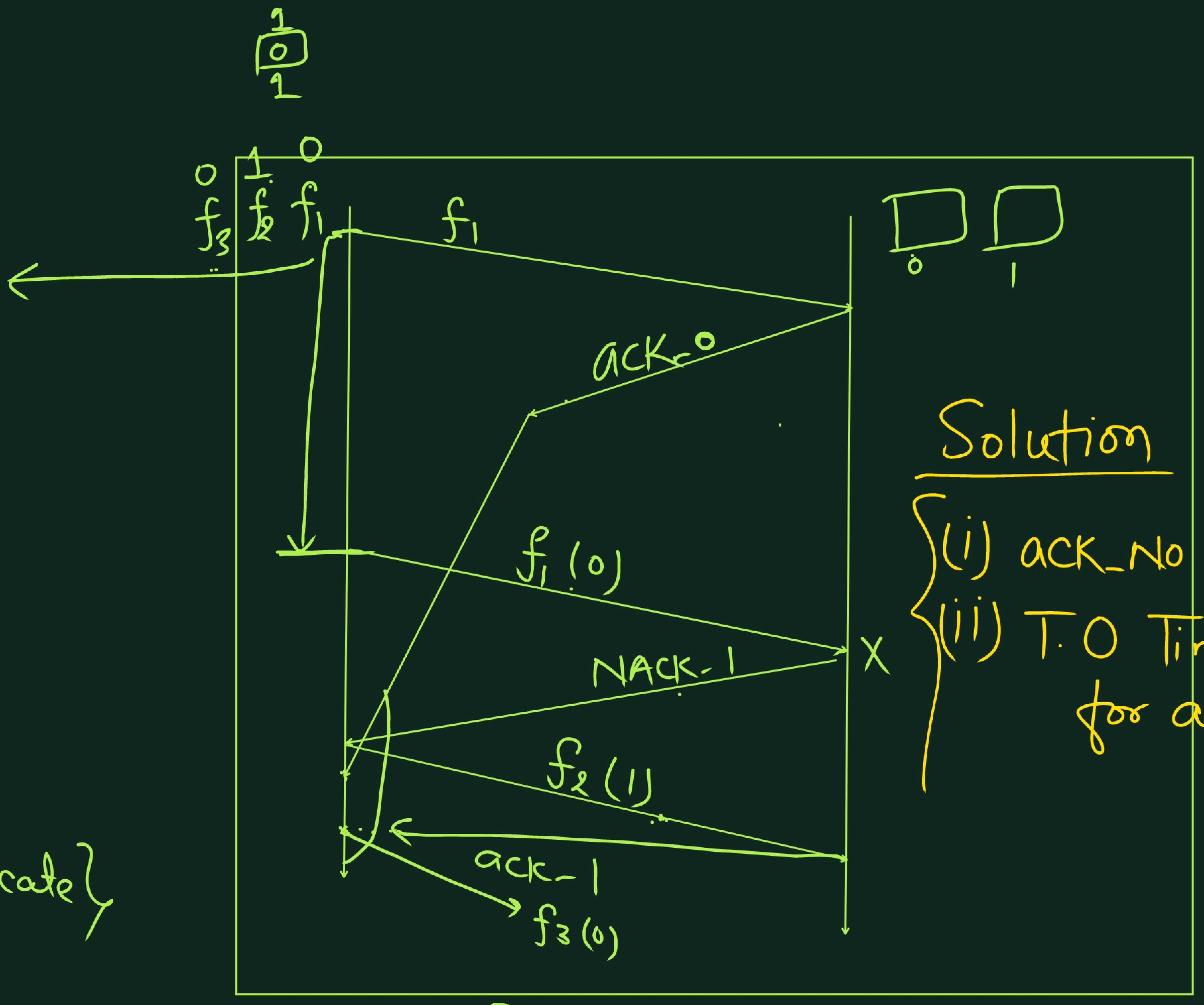


- Simple and reliable
- Ensures ordered delivery
- Inefficient for long-distance or high-speed networks (since the sender waits after each frame)

SNW ARQ

Case2





Solution

(i) ack_No

(ii) T.O Timer for ack

Delayed ACK

Stop and Wait ARQ(Automatic Repeat request)

Packet Loss: ACK and NACK and ARQ

Stop and Wait ARQ(Automatic Repeat request)

Stop and Wait ARQ(Automatic Repeat request)

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

T. Rate } BW

Transmission Time } BW

$$\eta = \frac{T_t = \frac{F.S}{\cancel{BW}}}{\frac{F.S}{\cancel{BW}} + 2 \cdot \frac{D}{V} \times BW}$$

A. Longer link length and lower transmission rate
B. Longer link length and higher transmission rate
C. Shorter link length and lower transmission rate
D. Shorter link length and higher transmission rate

$$= \frac{1}{1 + 2\left\{\frac{D \cdot BW}{V \cdot F.S}\right\}}$$

Yes

No

X >

4 <

X

2. Consider a **100 Mbps** link between an earth station (sender) and a satellite (receiver) at an altitude of **2100 km**. The signal propagates at a speed of **3×10⁸ m/s**. The time taken (in milliseconds, rounded off to two decimal places) for the receiver to completely receive a packet of **1000** bytes transmitted by the sender is

$$T_t = \frac{\text{Frame Size}}{BW}$$

$$= \frac{1000 \times 8 \text{ bits}}{100 \times 10^6 \text{ bits}} \times \text{Sec}$$

$$= \frac{80}{10^3} \text{ ms}$$

$$= 0.08 \text{ ms}$$

$$T_p = \frac{\text{Distance}}{v}$$

$$= \frac{\overset{7}{\cancel{21}}00 \times 1000 \text{ m}}{\cancel{3} \times 10^8 \text{ m}} \times \text{Se}$$

$$= 7 \text{ ms}$$

T. Time =

$$T_t + T_p$$

$$= 7.08 \text{ ms}$$

3. Consider two hosts X and Y, connected by a single direct link of rate **10^6 bits/sec** . The distance between the two hosts is **10,000 km** and the propagation speed along the link is **$2x10^8$ m/sec** . Host X sends a file of **50,000 bytes** as one large message to host Y continuously. Let the transmission and propagation delays be $\underbrace{\text{p milliseconds}}_{T_t}$ and $\underbrace{\text{q milliseconds}}_{T_p}$, respectively . Then the values of **p and q are**

A. p = 50 and q = 100
B. p = 50 and q = 400
C. p = 100 and q = 50
D. p = 400 and q = 50

$$T_t = \frac{5\cancel{0000} \times 8 \text{ bits}}{\cancel{10^6} \text{ bits}} \times \text{Sec}$$

$$10^2$$

$$= \frac{40}{10^2} \text{ Sec} = 400 \text{ ms}$$

4. A stop-and-wait ARQ protocol is used over a point-to-point link. The frame size is **1 KB (kilobyte)**, the link bandwidth is **100 Kbps**, and the one-way propagation delay is **50 ms**.

Assume:

- No transmission error
- No processing time at nodes
- 1 KB = 1024 × 8 bits
- 1 Kbps = 1000 bits/sec

Compute the **efficiency** of the Stop-and-Wait protocol.

$$\eta = \frac{T_t}{T_t + 2T_p} = \frac{81.92\text{ ms}}{81.92\text{ ms} + 2 \times 50\text{ ms}}$$

$$= \frac{81.92}{181.92}$$

$$T_t = \frac{1 \times 2^{10} \times 8\ b}{100 \times 10^3\ b} \times \text{sec}$$

$$= \frac{8 \times 1024}{100}\text{ ms}$$

$$= 81.92\text{ ms}$$

5. In a Stop-and-Wait ARQ system, the data frame size is **2048 bits**, the channel has a bandwidth of **1 Mbps**, and the one-way propagation delay is **10 ms**. There are **no errors**.

Calculate the throughput in Kbps.

BW: 1 Mbps

Ans: 92.8 Kbps

$$\begin{cases} \tau = \vec{r} \times \vec{F} \\ W = \vec{F} \cdot \vec{S} \end{cases}$$

Thank You