Computer Network

Data-Link Layer

Lecture : 13

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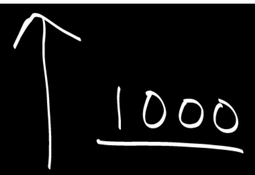
TCP/IP

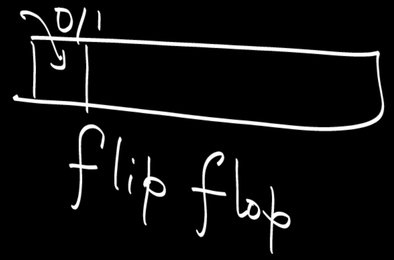
TCP/IP Layer	Hardware	Software/Protocols
Application	None	HTTP, FTP, SMTP, POP3, IMAP, DNS, SSH
Transport	None	TCP, UDP
Internet	Routers	IP (IPv4/v6), ICMP, IGMP, ARP, RARP Routing(DVR(RIP), LSR(OSPF), BGP)
Data Link	Switches, Bridges, NICs	Ethernet (MAC framing), Wi-Fi (802.11 MAC), PPP, Frame Relay, 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	



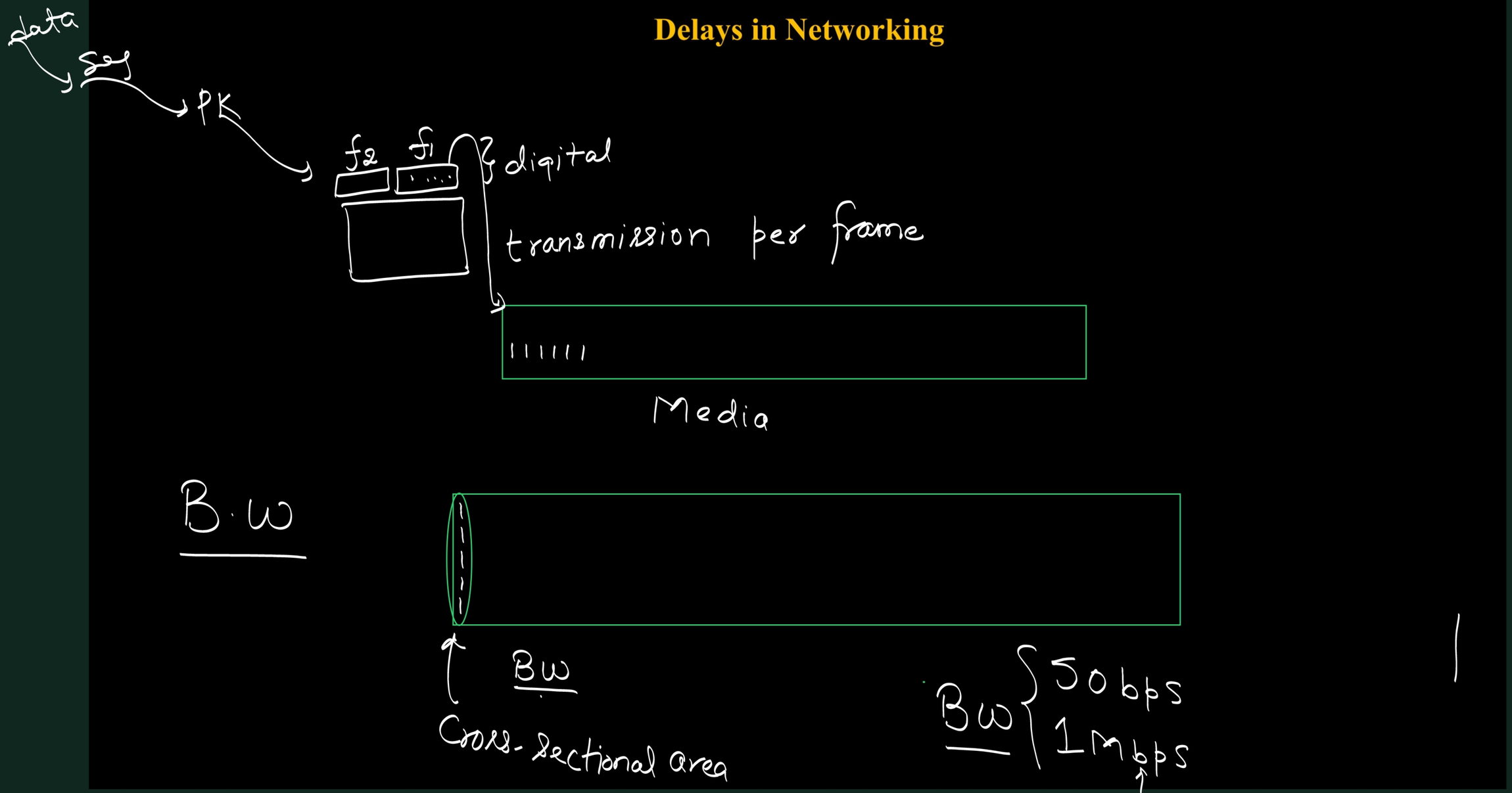


Transmission Delays and Bandwidth

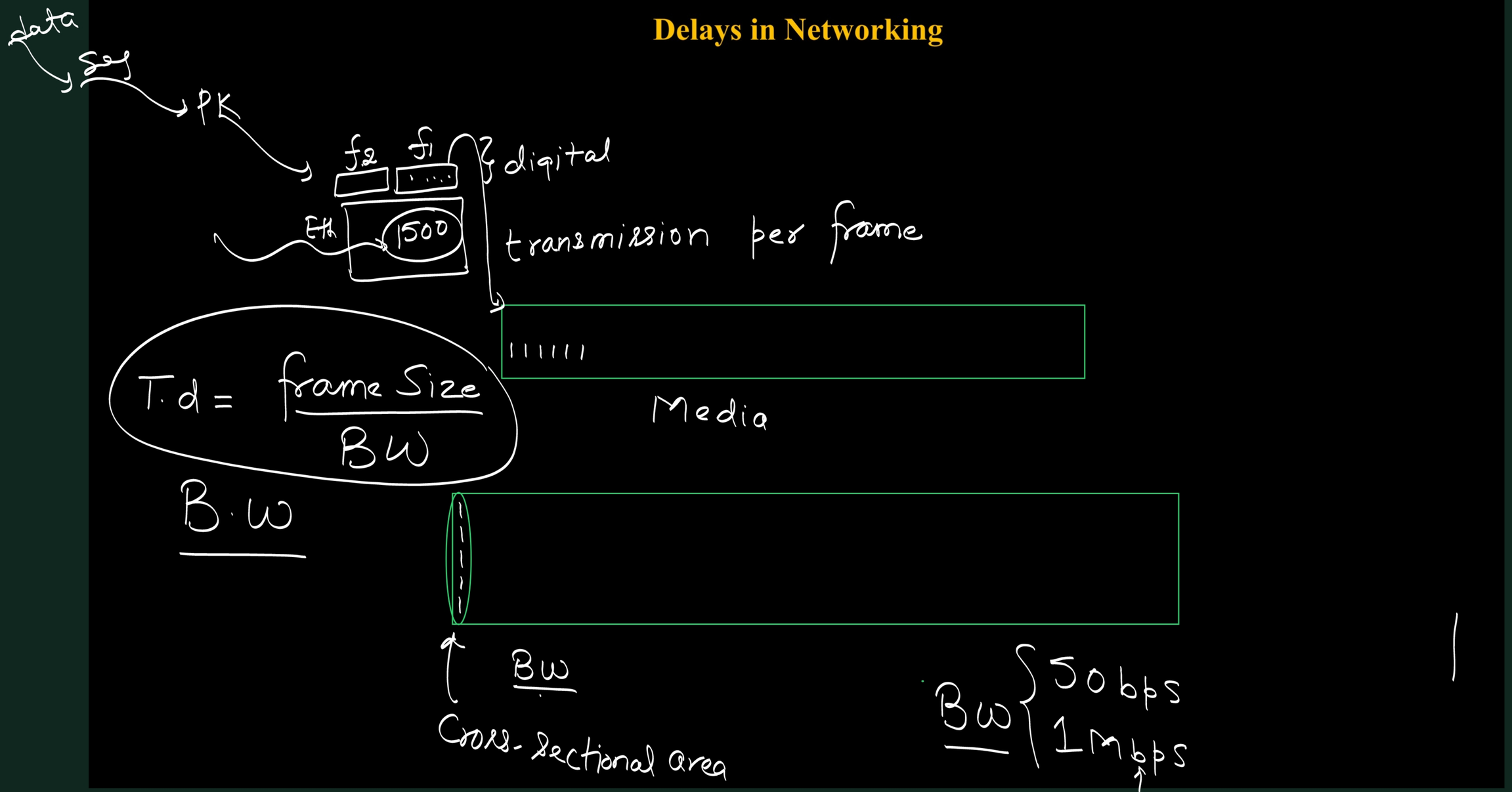
Ethernet Transmission (No Modulation)
Frame → Parallel to Serial → Encoding (Manchester) → Transmission Delay → Bits sent over Wire

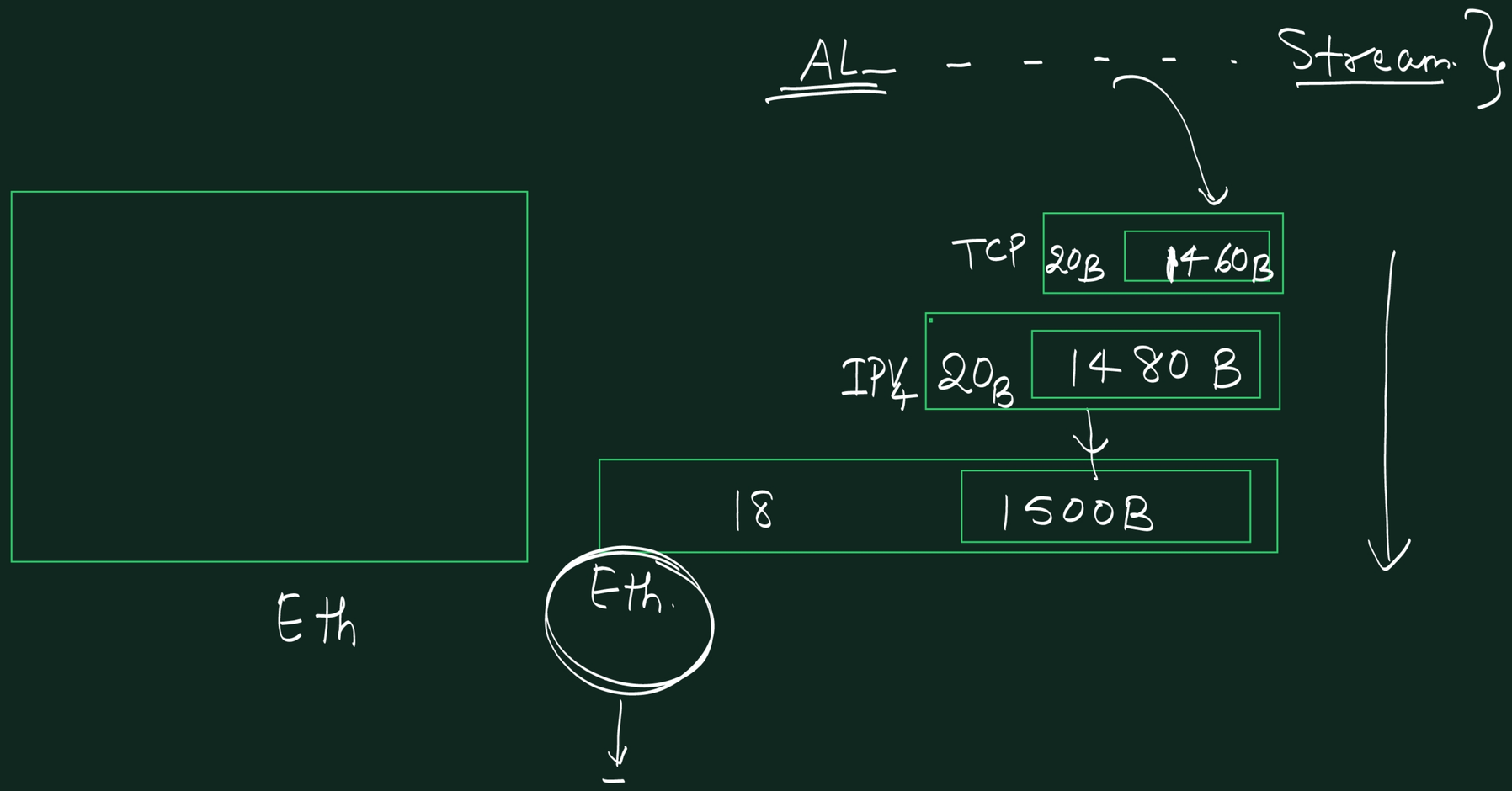
Wireless Transmission (Requires Modulation)
Frame → Parallel to Serial → Encoding → Modulation (Processing Delay) → Transmission Delay → Analog wave sent over Air

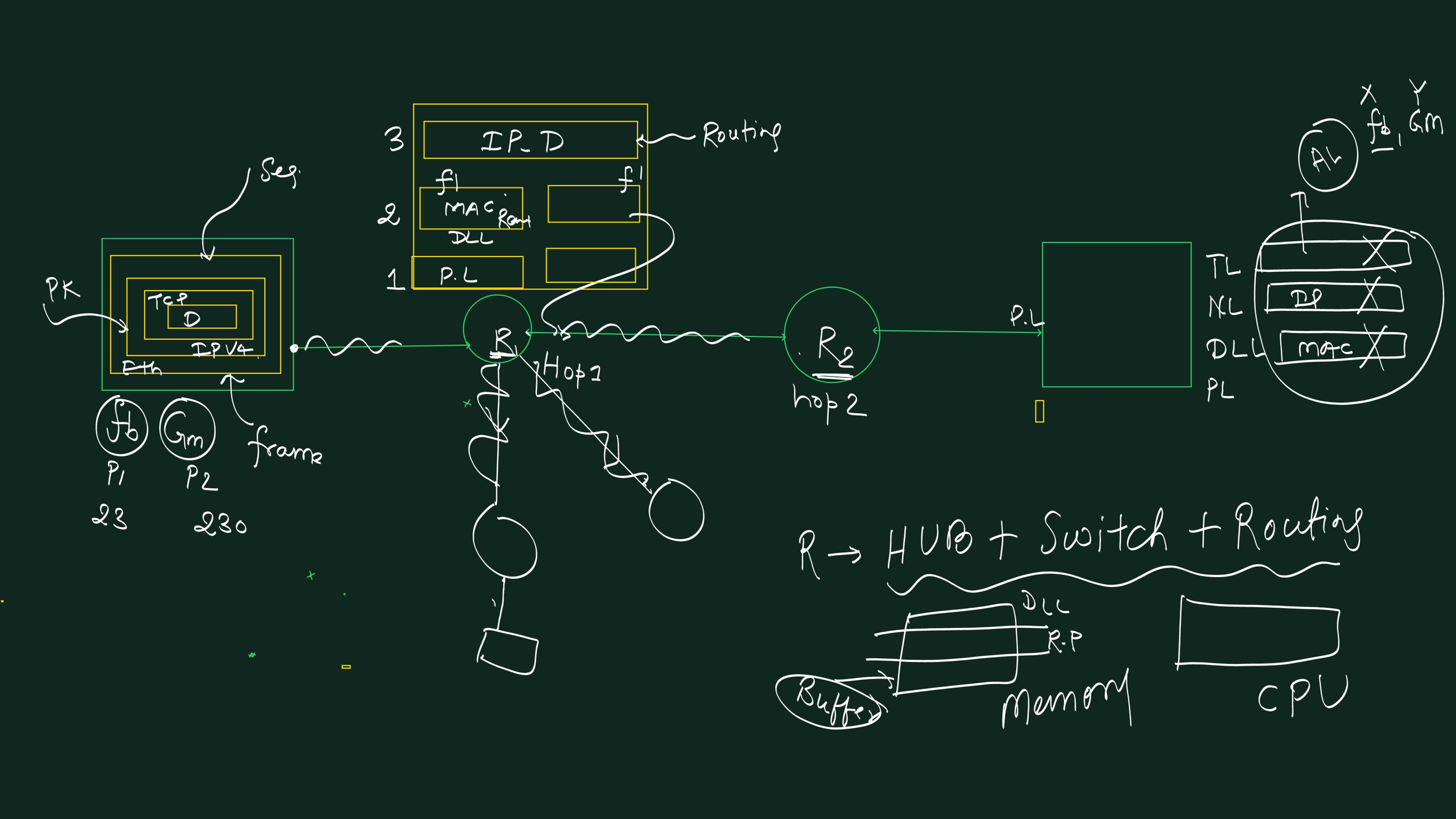
Delays in Networking

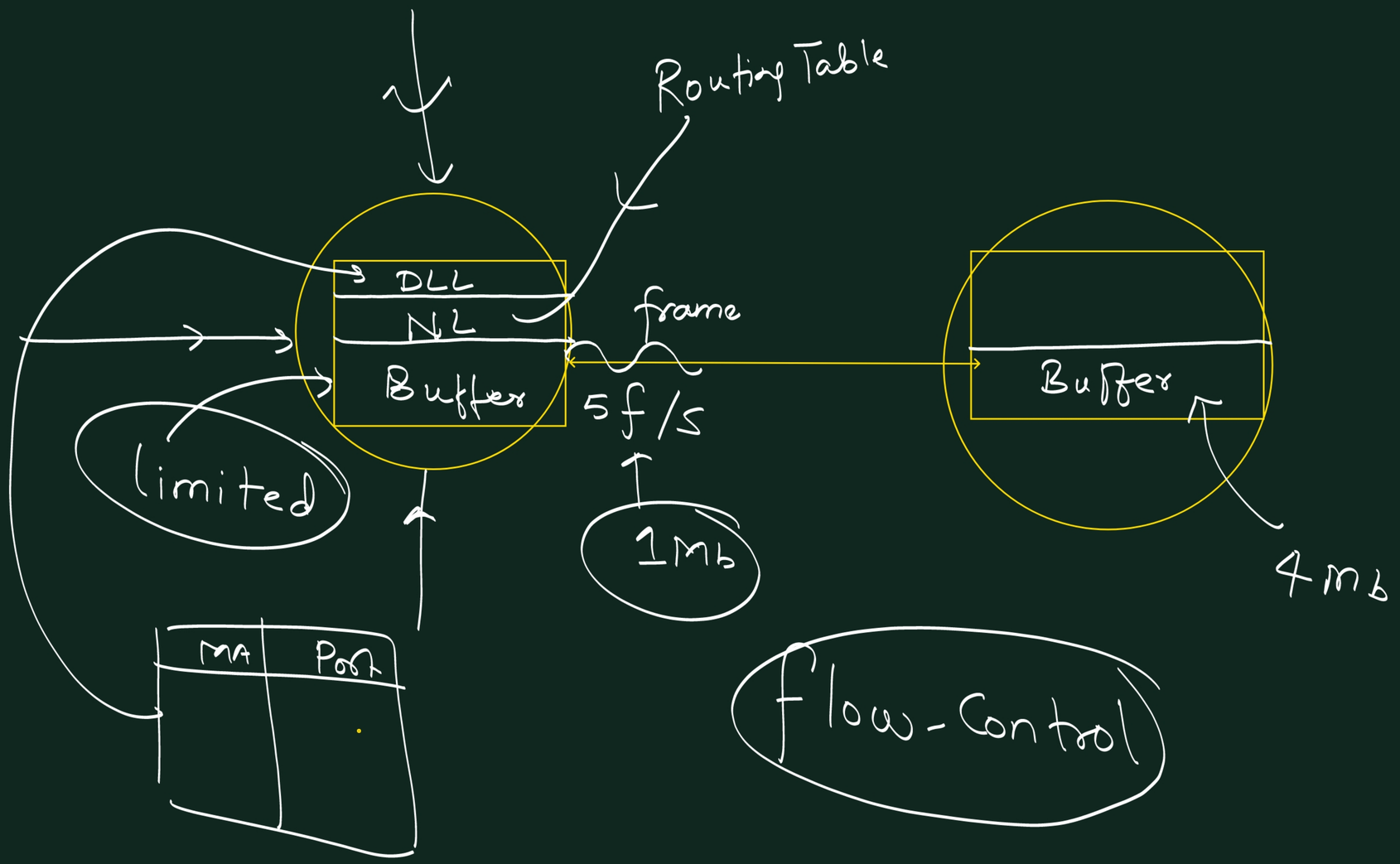


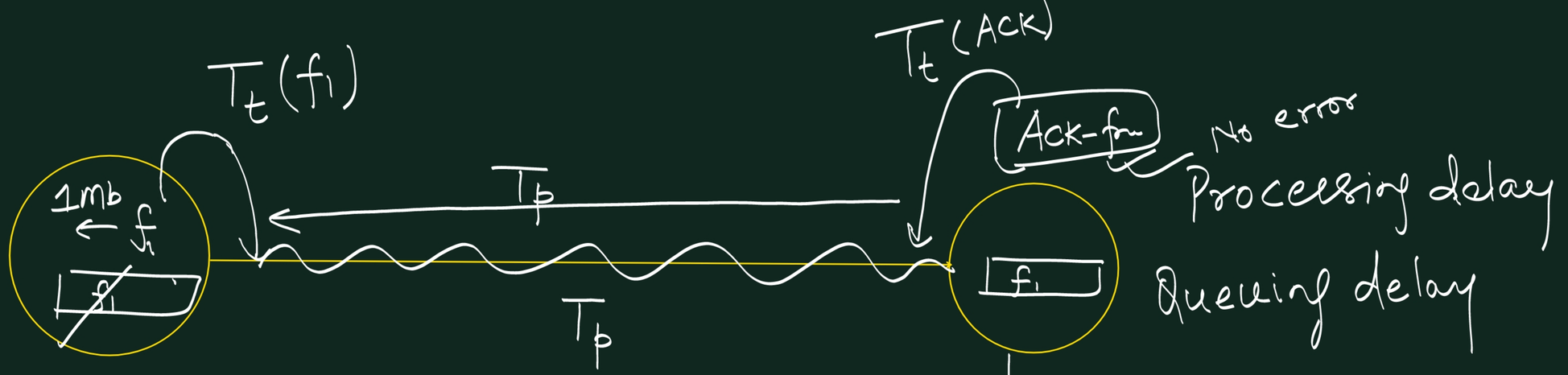
Delays in Networking




AL
Stream
TCP
20B
1460B
IPV4
20B
1480 B
18
1500B
Eth
Eth.


Seg
PK
TCP
D
IPV4
Eth
frame
P1
P2
23
230
3
IP_D
Routing
f1
f1
2
MAC
DLL
1
P.L
R1
Hop1
R2
hop 2
P.L
AL
X
Y
fb
Gm
TL
NL
DLL
PL
DP
MAC
R → HUB + Switch + Routing
DLL
R.P
Buffer
Memory
CPU


Routing Table
DLL
NL
Buffer
frame
5 f/s
1Mb
limited
Buffer
4Mb
MA
Port
flow-Control



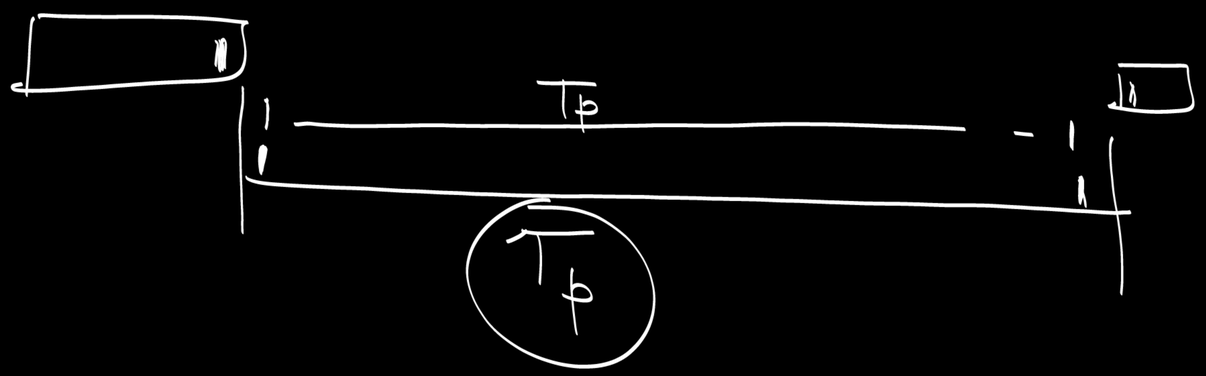
Total delay = $T_t(f_1) + T_p + T_q + T_{pr} + T_t(ack) + T_p$

$= (T_t + 2T_p)$

- **Transmission of Frame:** Time taken by system to transmit a frame to network.
- T(transmission) = frame size/data rate **= L bits / R bps**

BW

- **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**



1. A **1 KB (1024 bytes)** packet is sent over a **1 Mbps** link. What is the **transmission delay**?

A. 0.1024 ms
B. 8.192 ms
C. 1.024 ms
D. 0.8192 ms

$$T_t = \frac{\text{frame size}}{Bw}$$

$$= \frac{1024 \times 8 \text{ bits}}{10^6 \text{ b}} \times \text{Sec}$$

2. A signal travels over a **1200 km** link with a propagation speed of 2×10^8 m/s. Find the **propagation delay**.

A. 6 ms
B. 5 ms
C. 7 ms
D. 8 ms

3. A file of **500 KB** is sent over a **10 Mbps** link. What is the **transmission delay** in seconds?

A. 0.4096
B. 0.512
C. 0.4
D. 0.5

$$T_t = \frac{500 \times 1024 \times 8\ b}{10 \times 10^6\ b} \times 5$$

4. A **2 KB** packet is sent over a **10 Mbps** link which is **2000 km** long.
Propagation speed is 2×10^8 m/s.
What is the **total delay (Transmission + Propagation)** in ms?

A. 1.6
B. 0.816
C. 0.916
D. 11.63

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

- 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

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.

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

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.

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

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 $\mathbf{3\times10^8}$ **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

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 p milliseconds and q milliseconds, 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

Thank You