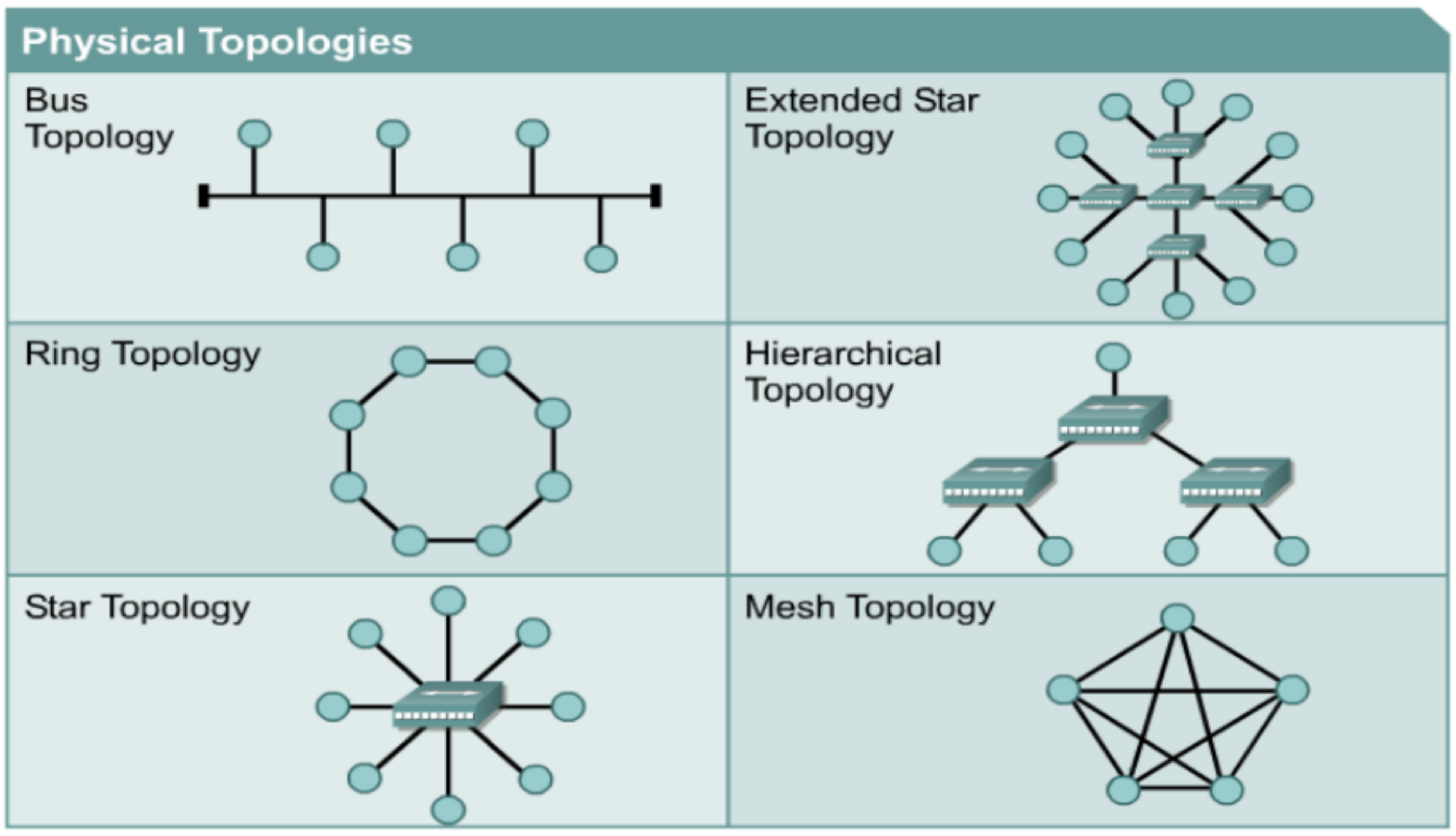
Client-Server vs. P2P

Client-Server	P2P
Needs dedicated server	No dedicated server
Single point of failure	Fault tolerance
Expensive to maintain	Easy to install and maintain
Will work with any applications	Good for file, printer, and resource sharing.
Limited scalability	Scalable
Handles shared database applications	Good for distributed database applications
More secure (dedicated server)	Less secure (server is workstation)

Network Topology



Network Devices

A **repeater** is a device that receives a signal, cleans it from the noise, regenerates it and retransmits it at a higher power level so that the signal can cover longer distances without degradation.

A network **bridge** connects multiple **network segments**

Network Devices

hub, switch work in layer 2

A network **hub** contains multiple ports. When a packet arrives at one port, it is copied ***unmodified*** to ***<u>all</u>*** ports of the hub for transmission

A network **switch** is a device that forwards and filters datagrams (chunk of data communication) between ports (connected cables) based on the MAC addresses in the packets

This is distinct from a hub in that switch only forwards the frames to ***the ports involved in the communication*** rather than all ports connected

Router → layer 3

Router

A **router** is a networking device that forwards packets between networks using information in protocol headers and forwarding tables (IP address) to determine the best next router for each packet

A **router** takes a chunk of information arriving on one of its incoming communication links and forwards that chunk of information on **one** of its outgoing communication links.

Network Throughput

Throughput refers to actual measured bandwidth, at a specific time of day, using specific Internet routes, and while a specific set of data is transmitted on the network

Throughput < Bandwidth

What is the Internet?

A type of computer networks

A public worldwide computer network

A network of networks that interconnect millions of computing devices throughout the world

Devices connected to the Internet are called hosts (end systems) including PCs, workstations, servers, PDAs, laptops, TVs, cell phones and even appliances

Hardware Components

Hosts (end systems): devices connected to the internet and use it to communicate

Communication links: media that connect hosts together (copper wires, coaxial cables, optical fibers, ...)

Routers: hosts are **not** connected together directly through one communication link. However, they are connected indirectly through routers

Route: the path that the packet takes from the sending host (source), through a series of communication links and routers, to the receiving host (destination).

Software Components

Internet Service Provider (ISP): allows hosts to access the Internet through 56kbps modems, DSL, high-speed LAN, wireless access

Packet: a chunk of information

Protocol: a set of rules that control the transmission of information within the Internet

Packet Switching

- each end-end data stream divided into packets
- user A, B packets share network resources (on demand)
- each packet uses full link bandwidth
- resources used as needed

~~Bandwidth division into "pieces"~~
~~Dedicated allocation~~
~~Resource reservation~~

- Reserved resources (circuit switching) versus on-demand resource allocation (packet-switching)

resource contention (competition):

- store and forward: packets move one hop at a time
  - Node receives complete packet before forwarding
- congestion: packets queue, wait for link use results in packet delay
- aggregate (collection) resource demand can exceed amount available results in packet loss

Packet switching vs. Circuit switching

	Packet switching	Circuit switching
Resource allocation	On demand: resources are not reserved; a session's messages use the resource on demand, and as a consequence, may have to wait (i.e., queue) for access to a communication link	Reserved: the resources needed along a path (buffers capacity, link bandwidth) to provide communication between the end systems are reserved (dedicated) for the duration of the session
Delay	Variable and unpredictable delays (store and forward & queuing)	Call set up delay: Smaller delays make it suitable for real time applications telephone calls and video conferences
Data Loss	Packet loss due to queuing	Smaller prob. for data loss
Cost	Less cost, simpler (no call setup required)	Relatively expensive and complex (call setup required)
Efficiency	More efficient, better utilization of BW	Less efficient, waste BW due to idle users
No. of users	more users	less users due to bw division
Usage	Used in computer networks	Used in telephone networks

Queuing delay

when characterizing queuing delay, one typically uses statistical measures, such as average queuing delay, variance of queuing delay and the probability that the queuing delay exceeds some specified value.

When is the queuing delay big and when is it insignificant?

Queuing delay depends mainly on:

- rate at which traffic arrives to the queue (a) --- arrival rate
- transmission rate of the link (R) --- departure rate
- nature of the arriving traffic (periodically, random)

Types of Delay

Delay type	Definition	Order	Comments
Processing delay	Time required to examine the packet's header and determine where to direct the packet	microseconds or less	After this nodal processing, the source router directs the packet to its queue that precedes the link to destination router
Queuing delay	Time for which a packet waits in the router's queue to be transmitted onto the outbound link	microseconds to milliseconds	depend on the number of earlier-arriving packets that are queued and network congestion; and can vary significantly from packet to packet.
Transmission (store-and-forward) delay	the amount of time required to push (transmit) all of the packet's bits into the outbound link	microseconds to milliseconds	=L/R where L: packet length R: transmission rate of the link, total=QL/R, Q is no. of links
Propagation delay	time required for a bit to propagate from the beginning of the link to end of the link	milliseconds	= d/s d: distance between two routers s: propagation speed which depends on type of physical media (fiber optics, twisted-pair, copper wire, …) $2*10^8$ m/s to $3*10^8$ m/s

Queuing delay

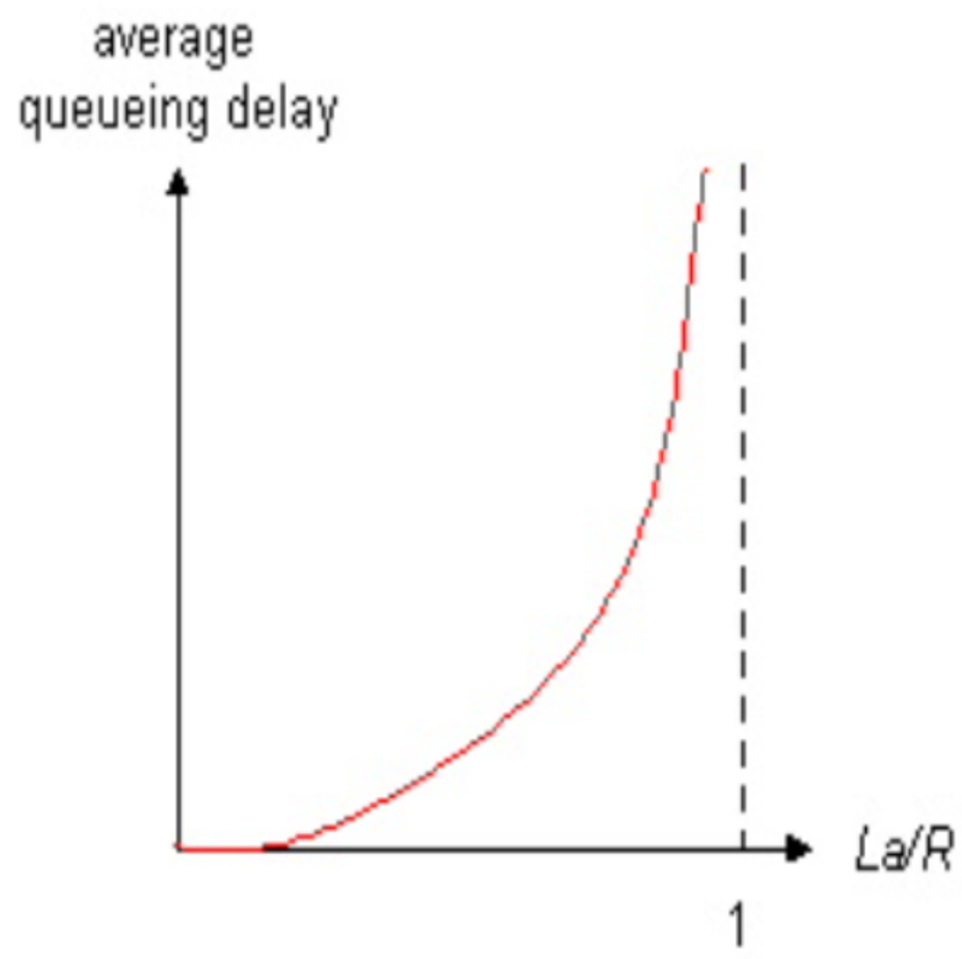
R=link bandwidth =transmission rate =departur

L=packet length (bits)

a=average packet arrival rate

traffic intensity = La/R

- La/R ~ 0: average queuing delay small
- La/R -> 1: delays become large
- La/R > 1: more "work" arriving than can be serviced, average delay infinite!



Why Network layering?

Modularization: dividing the complex system into smaller pieces (modules)
- Simplifies the complexity of network systems
- helps identify the functions and the relationships between these pieces
- Assists in protocol design, because protocols that operate at a specific layer have defined information that they act upon and a defined interface to the layers above and below.
- eases maintenance, updating of system
- change of implementation of layer's service doesn't affect the rest of system

Standardization: Provides a common language to describe networking functions and capabilities so products from different vendors can work together

Upgrade to Go ×

الملخص بالعربي:

تقسيم الشبكة إلى طبقات (Network Layering) بيخلي تصميم الشبكات أسهل من خلال **تقسيم النظام المعقد إلى أجزاء صغيرة (Modules)**. دا بيساعد في:

- تبسيط النظام وفهم وظائف كل جزء.
- تسهيل تصميم البروتوكولات وصيانتها وتحديثها.
- إمكانية تغيير طبقة معينة بدون ما تأثر على الباقي.

كمان **التقييس (Standardization)** بيوفر لغة مشتركة بين الشركات عشان أجهزتهم تشتغل مع بعض بسهولة.

الملخص بالإنجليزي:

Network layering simplifies the design of complex network systems by **dividing them into smaller modules**.

:This helps to

- .Simplify the system and clarify each function's role
- .Make protocol design, maintenance, and updates easier
- .Allow changes in one layer without affecting others

Also, **standardization** provides a common language that ensures devices and products from different .vendors can work together

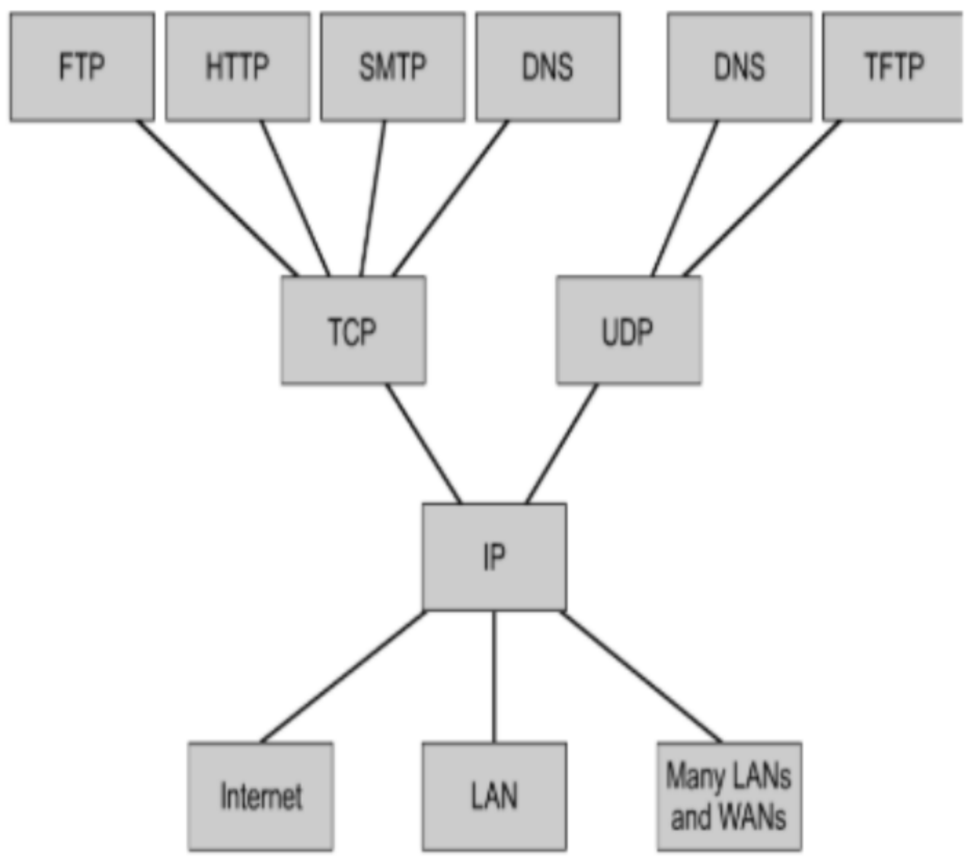
Internet protocols

Application layer protocols
- File Transfer Protocol (FTP)
- Hypertext Transfer Protocol (HTTP)
- Simple Mail Transfer Protocol (SMTP)
- Domain Name System (DNS)
- Trivial File Transfer Protocol (TFTP)

Transport layer protocols
- Transport Control Protocol (TCP)
- User Datagram Protocol (UDP)

Network layer protocol
- Internet Protocol (IP)

Link layer protocol:
- Ethernet

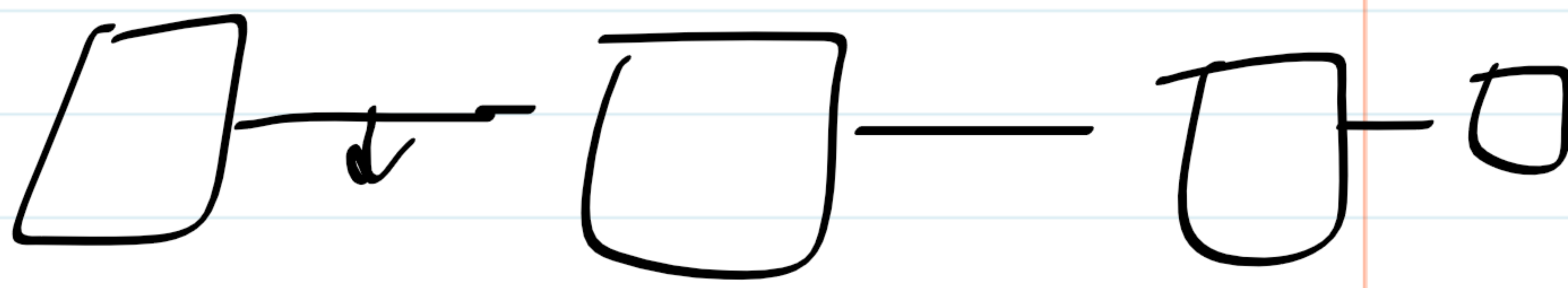


Question (1): [10 Marks]

$Q = 3$ / $L = 8.5\,Kb$

1. Data is transmitted from node A to node B on a route of three links with the following setup: Packet size= 8500bits, transmission rate of the links 1Mbps 2Mbps, 3Mbps respectively, link lengths are 1500, 2500 and 3500 Km, Signal speed = 270000 Km/s. Find its transmission delay, propagation delay and end-to-end delay.

$R = 1, 2, 3$



$V =$

$$T_{r_1} = \frac{8500}{1 \times 10^6} =$$

$$T_{P_1} = \left(\frac{270000}{1500}\right)^{-1} =$$

$$T_{r_2} = \frac{8500}{2M} =$$

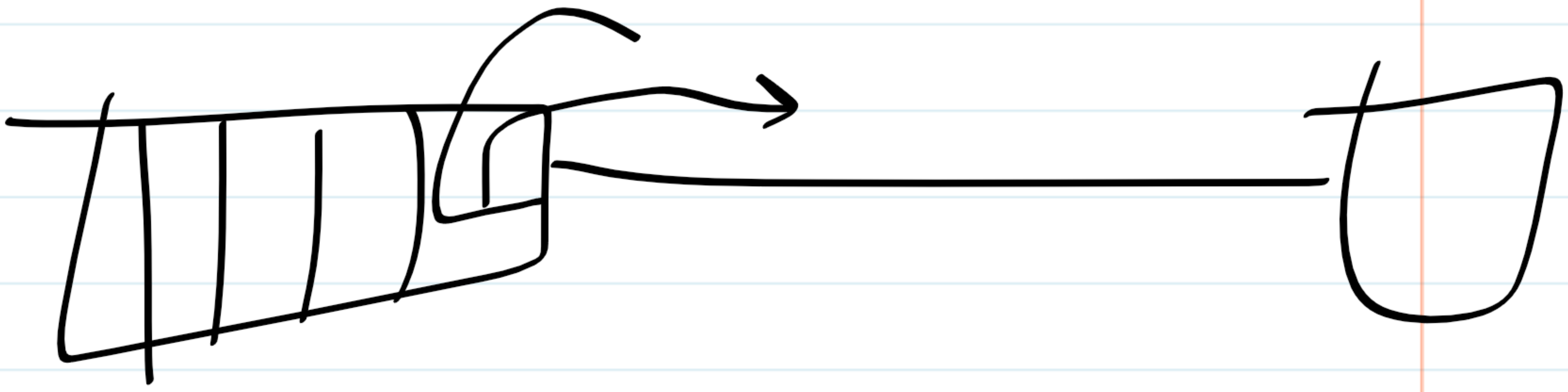
$$T_{P_2} = \left(\frac{V}{2500}\right)^{-1} =$$

$$T_{r_3} = \frac{8500}{3M} =$$

$$T_{P_3} = \left(\frac{V}{3500}\right)^{-1} =$$

$$d_{nodal} = \sum_{n=1}^{3} T_{r_n} + \sum_{n=1}^{3} T_{P_n}$$

$$= 0.04338$$



1. Circuit Switching Problem (6 Marks) L
   How long does it take to send a file of 2,400,000 bits from host A to host B over a circuit-switched network?

   - Total link bandwidth = 5 Mbps R n
   - Network uses TDM and divides bandwidth into 50 slots (circuits)
   - Circuit setup time = 100 ms
   - Find: Total time to send the file, including setup.

+

$$\frac{5M}{50} = 0.1\ M/S \qquad \frac{2,400,000}{0.1 \times 10^6}$$

$$= 24.1\ S$$

2. Packet Switching Delay Analysis (8 Marks)
   A packet of 1,000 bytes (8,000 bits) is sent over 2 links. Each link is 2,500 km long, and the transmission rate (R) for each link is 1 Mbps. Q
   - Propagation speed = 2.5×10^8 m/s
   - Processing and queuing delays are negligible.
   - a) Calculate the transmission delay for one link. (2 Marks)
   - b) Calculate the propagation delay for one link. (2 Marks)
   - c) Calculate the total end-to-end delay (from the first bit sent by the source to the last bit received by the destination). (4 Marks)

$L = 8K$

$D = 2500K,\ V = 2.5 \times 10^8$

$R = 1M$

$$T_r = \frac{L*}{R} = \frac{8K}{1M} = 8\ ms$$

$$T_p = P = \frac{X}{V} = \frac{2500 \times 10^3}{2.5 \times 10^8} = 10\ ms$$

$$= 36$$

3. Throughput Scenario (6 Marks)
A server with a 10 Gbps R_s link serves a client with a 1 Gbps R_c link. The data passes through an intermediate bottleneck link "X" with a capacity of 800 Mbps. This bottleneck link is shared by 3 other connections (for a total of 4 identical connections).
   - Find: The approximate average end-to-end throughput for this client. Justify your answer briefly.

$$\min\left(10G,\ 1G,\ \boxed{\frac{800}{4}}\right)$$