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Assignment -1

CS 433
Computer Networks

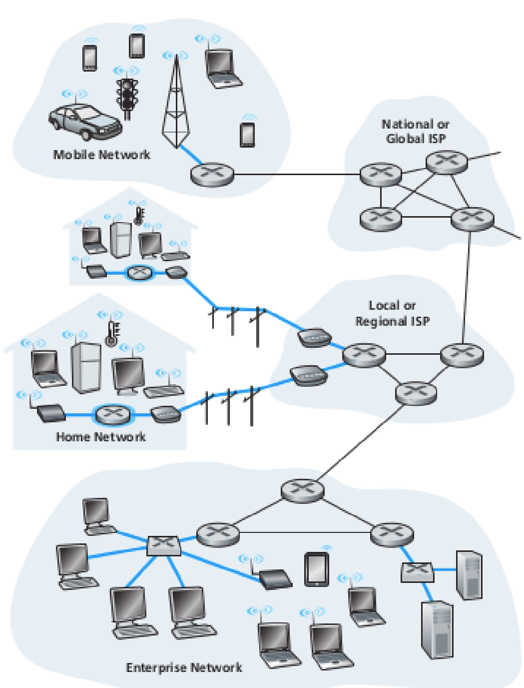
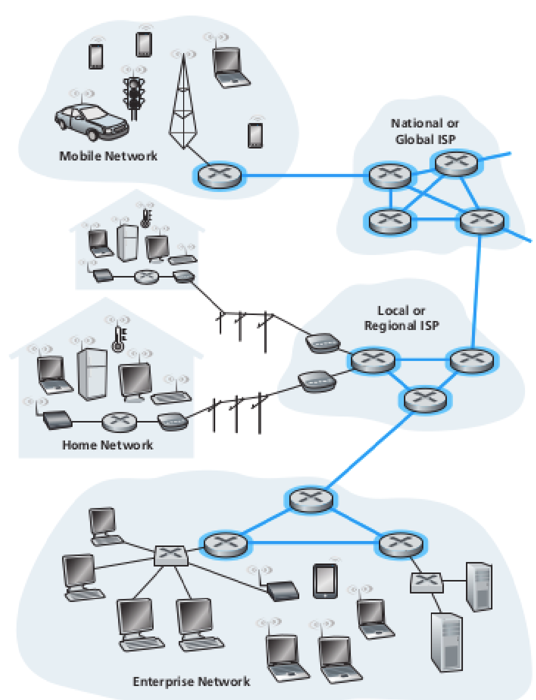
1. What is Internet? Distinguish between Internet and internet. (5 points)

The Internet is a computer network that interconnects billions of computing devices throughout the world.

Internet : The entire web or the biggest collection networks of networks.

internet: It refers to any groups of networks that are connected together. Example could be a network which connects one organization to another.

2. Distinguish the Access and Core networks. (5 points)

<table>
<tr><th>Access</th><th>Core Networks</th></tr>
<tr><td>1. The network that physically connects an end system to the first router on a path from an end system to any other end system.</td><td>1. The collection of packet switches (which include routers and link layer switches) and links that interconnect the Internet's end system is called Network Core.</td></tr>
<tr><td>2. Eg: Mobile Network through towers, DSL and FTTH cable lines in Home, Ethernet and Wifi,</td><td>2. Eg: routers and links connecting different ISPs.</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

3. Compare the ISO/OSI networking model with the TCP/IP model, and describe the pros and cons of layered architecture. (10 points)

<table>
<tr><th>ISO/OSI</th><th>TCP/IP</th></tr>
<tr><td>1. ISO/OSI Stack:

Application Layer
↓
Presentation Layer
↓
Session
↓
Transport Layer
↓
Network Layer
↓
Link Layer
↓
Physical Layer</td><td>2. TCP/ IP Architecture:

Application Layer
↓
Transport Layer
↓
Network Layer
↓
Link Layer
↓
Physical Layer</td></tr>
<tr><td>2. It has seven layers in its architecture.</td><td>3. It has five layers in its architecture.</td></tr>
<tr><td>3. Presentation Layer and session layer is present in addition to the other five layers present in TCP/IP stack.</td><td rowspan="2">4. Application Layer: A layer which interacts with the process and the transport layer. The layer where network applications and their application layer protocols reside. Important Application layer protocols include HTTP, SMPT, etc.

Transport Layer: It is responsible for the transport of messages from application layer at one end system to the other. TCP and UDP are two examples of transport layer protocols.

Network Layer: This is responsible for moving network layer packets known as datagrams from one host to another. IP protocol is an example of network protocol.

Link Layer: Link layer provides the service of moving a packet from one node (host or router) to the other.</td></tr>
<tr><td>4. Presentation Layer: Provide services that allow communicating applications to interpret the meaning of data exchanged. The services include data compression, data encryption and data description.

Session Layer: Provide services for delimiting and synchronization of data exchange. It includes the means to create a checkpoint and recovery scheme.</td></tr>
</table>

	Physical Layer: The job of the link layer is to move the entire frame from one network element to an adjacent network element. The job of the physical layer is to move the individual bits within the frame from one node to another.

Pros and Cons of Layered Architecture

Pros	Cons
1. Layering provides a structured way to discuss system components.	1. One layer may duplicate the functionality of the lower-layer.
2. Modularity makes it easier to design system components.	2. Functionality at one layer may need information that is present only in another layer. This violates the goal of separating layers (modularity).

4. Consider you have a 100MB file on your computer and you need to upload it to a server machine on a Campus network. You are connected through a WiFi that has a maximum of 54 Mbps bandwidth and has reliable transmission probability of 0.6. You are also connected on a wired network with a link bandwidth of 20Mbps. The core network connecting the server has a bandwidth of 50Mbps. Now answer the following (10 points)
a. Determine the total time needed to upload the file if you use the wired interface (2pt)
b. Determine the total time needed to upload the file using the WiFi (2pt)
c. Determine the total time needed to upload the file when you can use both the interfaces simultaneously to transmit data (3pt).
d. Suppose the bandwidth of the core network is doubled, what is the impact on total time to upload the file? (3pt)

Path of the file : Client → First router → Server
100MB = 100 x 8 = 800Mb

a. <u>Time taken to upload the file using wired interface:</u>

Time taken in the first segment (client to first router) = 800/20 = 40s.
Time taken in second segment (router to server) = 800/50 = 16s
Total time = 40 + 16 = 56s

b. Time taken to upload using WiFi:

   Time taken in the first segment = 800/(0.6 x 54) = 800/32.4 = 24.7s
   Time taken in the second segment = 800/50 = 16s
   Total time = 24.7 + 16 = 40.7s

c. Time taken to upload using both interface simultaneously:

   Total Bandwidth Available in the first segment = 20 + 54x0.6 = 20 + 32.4 = 52.4 Mbps
   Time taken in the first segment = 800/52.4 = 15.3s
   Time taken in the second segment = 800/50 = 16s
   Total time = 15.3 + 16 = 31.3s

d. The bandwidth of the core network is doubled
   New bandwidth of core = 50 x 2 = 100Mbps
   Time taken in the second segment = 800/100 = 8s
   Total time = time taken in the first segment + 8s
   Earlier it was "time taken in the first segment + 16s"
   There is a reduction of time taken by **8s.**

5. Discuss Circuit switching and packet switching networks. List the pros and cons of both the approaches (5 points)

Circuit Switching	Packet Switching
1. Resources needed along a path like buffers, link, transmission rate, etc to provide communication between the systems are reserved for the duration of communication between the systems.	1. Resources are not reserved. A session's messages use resource on demand. As a consequence may have to wait for access to a communication link.
2. Allocated resources remains unused when the link is not active.	2. The user can utilize all the resources. Since it is not reserved.
3. More expensive as more resources are needed.	3. Comparatively less expensive.
4. Eg: Traditional Phone Networks	3. Eg: Internet Telephony, Overseas call

Circuit Switching:

Pros	**Cons**
1. Sender can transfer the data to the receiver at the guaranteed transfer rate.	1. More Expensive. More bandwidth is required for setting up of dedicated channels.
2. In circuit switching there is no delay in data flow because of the dedicated transmission path.	2. Resources are not utilized during silent time.
3. Reliability and constant transfer rate is guaranteed which is not the case with packet switching.	3. It takes long time to establish a connection.
4. Best suitable for real time services.	4. Dedicated circuits are idle during inactive periods.

Packet Switching

Pros	**Cons**
1. Full utilization of resources. Allocates link on demand	1. Since resources are not reserved, when one of the links is congested then the packets may have to wait in the buffer at the sending side of the transmission link and can suffer a delay.
2. User can get higher transfer rate, when the traffic is low.	2. Users may get a lower transfer rate when the traffic is high.
3. Simpler, efficient and less cost to implement.	
4. It offers better sharing or transmission capacity than circuit switching	

6. Distinguish TDM and FDM. Present any two real-life use cases (one each for TDM and FDM) where you would apply TDM and FDM? (5points)

Frequency Division Multiplexing (FDM)	**Time Division Multiplexing (TDM)**
1. It is a technique by which the total bandwidth is divided into a series of non-overlapping frequency sub-bands,where each sub-band carry different signal.	1. Time-division multiplexing (TDM) is a method of transmitting and receiving independent signals over a common signal path by means of synchronized switches at each end of the transmission line.
2. Link dedicates a frequency band for each connection for the duration of the connection.	2. For a TDM link, Time is divided into frames of fixed duration and each frame is divided into fixed number of time slots.
3. Frequency spectrum of the link is divided among the connections.	3. When a network establishes a connection across a link, the network allots one slot in every frame to this particular connection.
4. Eg: FM radio, it uses frequency range between 88 MHz to 108 MHz. Each radio station is allocated particular frequency range.	4. These slots are dedicated for the sole use of that connection, with one time slot available for use (in every frame) to transmit the connection's data.
	5. Eg: Telephone conversation which is digitally transmitted over wire.

7. Consider a shared network link with capacity of 250Mbps and consider that each user requires 30Mbps to transmit data and are active only 20% of the time. Now answer the following questions: (10 points total)

(a) What is the maximum number of users that can be supported with circuit switching? (2pt)
(b) What is the maximum possible number of users that can be supported with packet switching mode (assume the link capacity is fully utilized and users share without contention)? (4pt).
(c) Assuming a total of 10 users, what is the probability that a given specific user is transmitting and rest of the users are idle? (4pt).

a. Maximum number of users = Link Capacity / user requirement

= 250/30 =8.33 or 8 users

b. Maximum number of users at a time = 8 users (from previous calculations)
Given that, each user is active only for 20% of the time. Assuming that each user appears only in their respective slot and number of users does not exceed 8 at a time.

Maximum number of users = 8*5 = 40 users (multiplied by 5 to make the time 100%)

c. Given number of users 10.
Active time = 0.2
The probability can be found out using binomial expansion.
The probability of one active user and rest idle user is $= 10C1 \times (0.8)^9 \times 0.2$
$= 0.2684354$

8. Suppose within your Web browser you click on a link to obtain a Web page. The IP address for the associated URL is not cached in your local host, so a DNS lookup is necessary to obtain the IP address. Suppose that your local DNS server has cached the TLD Name Server's address. Thus, a number N of DNS servers are visited (starting with your local DNS server which has the cached entry for the TLD DNS) before your host receives the IP address from DNS. What is the number N of DNS servers visited?

Assume the successive visits (including the local DNS) incur an RTT of RTT1, . . ., RTTN. Further suppose that the Web page associated with the link contains exactly one object, consisting of a small amount of HTML text. Let RTT0 denote the RTT between the local host and the server containing the object. Assuming zero transmission time of the object, how much time elapses from when the client clicks on the link until the client receives the object? Ignore all transport protocol effects. (10 points)

Solution:

<u>Path of Query from local dns:</u>

Local DNS server → TLD DNS server → Authoritative DNS server (gives the ip address of the requested website)

<u>Return Path:</u>

Authoritative DNS server → TLD DNS server → Local DNS server → Client

The number **N is 3**. The Local DNS server, TLD DNS server and Authoritative DNS server.

The path followed by the object:

Local Host → Local Cache (DNS lookup and obtain the IP address of the webpage) → server

Time for DNS lookup = RTT1 + RTT2
RTT for local host to establish TCP connection = RTT0
RTT for querying and receiving object = RTT0
Total Time = Time for DNS lookup + RTT for local host to establish TCP connection +RTT for querying and receiving the object

Therefore, total time = RTT0 + RTT0+ RTT1 + RTT2 = 2RTT0 + RTT1 + RTT2

9. Referring to Problem 8, suppose the HTML file references three (3) very small objects on the same server. Neglecting transmission times, how much time elapses with following modes: (10 points)

(a) Non-persistent HTTP (with no parallel TCP connections)? (5 points)

(b) Persistent HTTP (with no parallel TCP connections)? (5 points)

Solution:

a. Non-persistent
    - Separate TCP connection for each object
    - Total Time = 2RTT0 + RTT1 + RTT2 + 3x(2RTT0)
      = 8RTT0 + RTT1 + RTT2
    -
b. Persistent
    - A single TCP connection for all the three object
    - Total time = 2RTT0 + RTT1 + RTT2 + RTT0
      = 3RTT0 + RTT1 + RTT2

10. How does the “Last Modified” header line help in the HTTP protocol? (2 points)

The information about the last modified date and time is important for Web Cache or proxy servers. It helps to keep the cache updated with the origin server. If the last modified was not present, the cache would not be able to identify whether the origin server had updated and would supply the client with older versions of an item (website or objects) that have been saved earlier in the cached server.

11. Describe the use of the “If-Modified-Since” header in the HTTP protocol. (3 points)

The command helps in keeping the cache up to date with the origin server. It is used by the cache server. It is used in GET commands. The value of If-modified since is exactly the same as the Last-Modified response of the cached copy of the object. Cache server sends a GET request to the origin server, and using the If-modified-Since, if the original server is not modified, it will get a response from the origin server that the server is not modified and can proceed to show the cached version of the object. The response sent from the origin server is fast since there is no object entity attached to it.

12. What is the role of a HTTP proxy server in network? What does it do when it gets requests from a client browser and response from a server? What does it do when it gets a subsequent request from a different client? (5 points)

An HTTP proxy server it serves the request on behalf of origin Web server. The proxy server or Web Cache has its own disk storage and keeps copies of recently requested objects in this storage. It helps in reducing the response time for client request and it also helps in reducing traffic on access link used by the client connected to the Web Cache.

When Web Cache gets a request from a client browser. The browser would have established a TCP connection with the Web Cache.

1. It checks whether it has a local copy of it
    - If yes -> Then sent a GET request to origin Web Server with If-Modified-Since having values of the last modified line from the header of the local copy
        - If the response from the origin webserver is “Not Modified”, the proxy server returns the object within an HTTP response message to the client.
        - If it get a response as modified, it will direct the client to the origin Web Server and save a new copy of the object.
    - If No -> Proxy server opens a TCP connection to the origin Web server and sends an HTTP request for the object. After receiving this request, the origin server sends the object in an HTTP response message to the Web Cache. When the web cache receives the object, it stores a copy in its local storage and sends a copy to the client browser in an HTTP response message through the existing TCP connection.

When it receives a request from and sends response to a browser, it is a server.
When it sends a request to and receives a response from an origin server - it is a client.

When it gets a subsequent request from a different client. First it will check for modification by sending an HTTP request to the origin server. Since it had a recent copy, we assume it might have received a response of “Not modified”. Then, the proxy server returns the local copy of the object in an HTTP response message to the client.

13. Consider the campus network with 1000Mbps LAN and 200Mbps access link connecting to the public Internet with RTT of 1 second. Let us suppose the average request size and rate to be 100KB and 30 requests per second respectively. (10 points)

(a) What is the average LAN utilization and access link utilization? (2points)

100KB = 800kb = 0.8 Mb
LAN Intensity

Lan Intensity =Request Per Sec * Request Size/ Request Rate
= 30(req/sec)*(0.8Mb/1000Mbps)
= 0.024

Access intensity

Access Intensity = 30(req/sec)*(0.8Mb/200Mbps)
=0.12

(b) In the current setup would it be useful to deploy a Local web cache in the campus network and why? (2point)

Since access intensity is 0.12 and is very less compared to 1, the current network infrastructure is sufficient to serve the needs.

(c) Now let us consider the number of active users increases by 100 fold and accordingly the active requests per second increased by 100x. Now what is the LAN and Link utilization? (2 points)

LAN Intensity

Lan Intensity =Request Per Sec * Request Size/ Request Rate
= 3000(req/sec)*(0.8Mb/1000Mbps)
= 2.4

Access intensity

Access Intensity = 30*100(req/sec)*(0.8Mb/200Mbps)
=12

(d) If the local cache is deployed and it is observed to have a hit rate of 0.7. What is the impact on LAN and access link utilizations and what is the impact on total delay? (4 points)

Access intensity = 0.3*12 = 3.6
Lan intensity would be same

Assuming internet delay = 2s
Assume lan delay = 10ms = 0.01s

When Cache is not deployed:

Average Delay = 2+0.01 = 2.01s

When Cache is deployed

Average delay = 0.7 x 0.01s + 0.3 (2+0.01)= 0.613s

14. Consider the host IP address to be 10.0.0.1. Specify either the tcpdump or Wireshark filter rule that can enable to capture the following traffic cases.

(a) Capture only the outgoing ICMP Echo response messages (1pt)
(b) Capture only the incoming ICMP Echo request and corresponding outgoing Echo response messages (2pt)
(c) Capture the HTTP and HTTPS traffic (2pt)
(d) Assume the Google servers use the IP address in the 172. 18. X. X. Capture all the traffic exchanged with the Google. (4pt)
(e) Capture all the DNS traffic (1pt).

All the tasks are achieved using tcpdump

a. $tcpdump icmp[icmptype]==0
b. $tcpdump icmp[tcmptype]==8 && icmp[tcmp]==0
c. $tcpdump 'tcp port https' && 'tcp port http'

```
shamir@Shamir-HP:~$ sudo tcpdump 'tcp port https' && 'tcp port http'
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on wlo1, link-type EN10MB (Ethernet), capture size 262144 bytes
16:40:43.882572 IP kul01s09-in-f78.1e100.net.https > Shamir-HP.37952: Flags [.],
,TS val 3854391003 ecr 1941158879], length 1288
16:40:43.883846 IP Shamir-HP.37952 > kul01s09-in-f78.1e100.net.https: Flags [.],
3], length 0
16:40:43.883778 IP kul01s09-in-f78.1e100.net.https > Shamir-HP.37952: Flags [.],
```

d. Traffic from google
    1. Method one: Using the website address
       $tcpdump host google.in
       $tcpdump -vv host google.in //to see more details

```
shamir@Shamir-HP:~$ sudo tcpdump host google.in
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on wlo1, link-type EN10MB (Ethernet), capture size 262144 bytes
16:16:35.458214 IP Shamir-HP.57790 > bom07s18-in-f4.1e100.net.http: Flags [.], ack 4047758912, win 50
33], length 0
16:16:35.543586 IP bom07s18-in-f4.1e100.net.http > Shamir-HP.57790: Flags [.], ack 1, win 248, option
th 0
16:16:51.492764 IP Shamir-HP > bom07s18-in-f4.1e100.net: ICMP echo request, id 38, seq 1, length 64
16:16:51.571347 IP bom07s18-in-f4.1e100.net > Shamir-HP: ICMP echo reply, id 38, seq 1, length 64
16:16:52.494065 IP Shamir-HP > bom07s18-in-f4.1e100.net: ICMP echo request, id 38, seq 2, length 64
16:16:52.946016 IP bom07s18-in-f4.1e100.net > Shamir-HP: ICMP echo reply, id 38, seq 2, length 64
```

2. Method Two: Using IP address
   Find IP address of google using ping.

   IP Address of google.in is **172.217.166.36**

```
shamir@Shamir-HP:~$ ping google.in
PING google.in (172.217.166.36) 56(84) bytes of data.
64 bytes from bom07s18-in-f4.1e100.net (172.217.166.36): icmp_seq=1 ttl=115 time=73.1 ms
64 bytes from bom07s18-in-f4.1e100.net (172.217.166.36): icmp_seq=2 ttl=115 time=73.8 ms
64 bytes from bom07s18-in-f4.1e100.net (172.217.166.36): icmp_seq=3 ttl=115 time=77.8 ms
64 bytes from bom07s18-in-f4.1e100.net (172.217.166.36): icmp_seq=4 ttl=115 time=89.7 ms
```

$tcpdump host 172.217.166.36

```
shamir@Shamir-HP:~$ sudo tcpdump host 172.217.166.36
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on wlo1, link-type EN10MB (Ethernet), capture size 262144 bytes
16:19:42.613968 IP Shamir-HP > bom07s18-in-f4.1e100.net: ICMP echo request, id 39, seq 44, length 64
16:19:42.694249 IP bom07s18-in-f4.1e100.net > Shamir-HP: ICMP echo reply, id 39, seq 44, length 64
16:19:42.844954 IP Shamir-HP > bom07s18-in-f4.1e100.net: ICMP echo request, id 38, seq 172, length 64
16:19:42.910657 IP bom07s18-in-f4.1e100.net > Shamir-HP: ICMP echo reply, id 38, seq 172, length 64
16:19:43.615636 IP Shamir-HP > bom07s18-in-f4.1e100.net: ICMP echo request, id 39, seq 45, length 64
16:19:43.692741 IP bom07s18-in-f4.1e100.net > Shamir-HP: ICMP echo reply, id 39, seq 45, length 64
16:19:43.846285 IP Shamir-HP > bom07s18-in-f4.1e100.net: ICMP echo request, id 38, seq 173, length 64
16:19:44.617113 IP Shamir-HP > bom07s18-in-f4.1e100.net: ICMP echo request, id 39, seq 46, length 64
16:19:44.866318 IP Shamir-HP > bom07s18-in-f4.1e100.net: ICMP echo request, id 38, seq 174, length 64
```

e. $sudo tcpdump port 53

```
shamir@Shamir-HP:~$ sudo tcpdump port 53
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on wlo1, link-type EN10MB (Ethernet), capture size 262144 bytes
15:43:12.034191 IP Shamir-HP.59335 > _gateway.domain: 43554+ A? z-p42-instagram.c10r.facebook.com. (51)
15:43:12.034872 IP Shamir-HP.37293 > _gateway.domain: 20526+ PTR? 1.43.168.192.in-addr.arpa. (43)
15:43:12.040446 IP _gateway.domain > Shamir-HP.37293: 20526 NXDomain 0/0/0 (43)
15:43:12.041143 IP Shamir-HP.38255 > _gateway.domain: 18968+ PTR? 249.43.168.192.in-addr.arpa. (45)
15:43:12.042522 IP _gateway.domain > Shamir-HP.38255: 18968* 1/0/0 PTR Shamir-HP. (68)
15:43:12.082066 IP _gateway.domain > Shamir-HP.59335: 43554 1/0/0 A 157.240.192.174 (67)
15:43:13.117430 IP Shamir-HP.53312 > _gateway.domain: 37136+ A? fonts.googleapis.com. (38)
15:43:13.118068 IP Shamir-HP.42587 > _gateway.domain: 40214+ A? code.jquery.com. (33)
15:43:13.121912 IP Shamir-HP.48711 > _gateway.domain: 8562+ A? gstaticadssl.l.google.com. (43)
15:43:13.164174 IP _gateway.domain > Shamir-HP.53312: 37136 1/0/0 A 216.58.196.74 (54)
15:43:13.167437 IP _gateway.domain > Shamir-HP.42587: 40214 2/2/2 CNAME cds.s5x3j6q5.hwcdn.net., A 209.19
15:43:13.167531 IP _gateway.domain > Shamir-HP.48711: 8562 1/0/0 A 172.217.167.163 (59)
```

As port 53 is the port of DNS protocol.

15. Consider a packet switched network with bandwidth of 10MBps (all the links). Source needs to send a message of size 1000 bytes. Source will packetize the data and transmit to the receiver. Each packet that needs to be transmitted need to add an additional 100 bytes header per packet.
(1) Consider the propagation and processing delays are zero. Identify which of the below configurations would result in minimum time for delivering the message to the receiver. (5 points)

e. 1 Packet
f. 5 packets
g. 10 packets
h. 20 packets

The main idea here is, when the first packet reaches the first router and starts its journey to the second router, the second packet starts from the sender.

Data that is needed to be sent = 1000bytes

To calculate the time taken for the 5 packet configuration:

- The first packet will reach the receiver in 3x L/R time. (Since there are three links)
  Sender(4) → First Router(3) → Second Router(2) → Receiver (1)
- At that time, that time packet 4 would be at sender
- When packet 4 reaches the receiver, the fifth packet will be at the second router.
  Sender → First Router - Second Router(5) → Receiver (4)
- Total time = Time taken by the first packet + Time taken by the fourth packet + L/R (The fifth packet needs to cover only one link)
  Total time = 3x (L/R) + 3x(L/R) + L/R = 7 L/R

To calculate the time taken for the 10 packet configuration:

- At t = 3L/R
  Sender(4) → First Router(3) → Second Router(2) → Receiver (1)
- At = 6L/R
  Sender(7) → First Router(6) - Second Router(5) → Receiver (4)
- At t = 9L/R
  Sender(10) → First Router(9) - Second Router(8) → Receiver (7)
- At t = 12L/R
  Sender → First Router - Second Router → Receiver (10)

- Total time = 12L/R

To calculate the time taken for the 20 packet configuration:

- At t = 3L/R
  Sender(4) → First Router(3) → Second Router(2) → Receiver (1)

- At = 6L/R
  Sender(7) → First Router(6) - Second Router(5) → Receiver (4)
- At t = 9L/R
  Sender(10) → First Router(9) → Second Router(8) → Receiver (7)
- At t = 12L/R
  Sender(13) → First Router(12) → Second Router(11) → Receiver (10)
- At t= 15L/R,
  Sender(16) → First Router(15) → Second Router(14) → Receiver (13)
- At t = 18L/R
  Sender(19)→ First Router(18) → Second Router(17) → Receiver (16)
- At t =21 L/R
  Sender → First Router → Second Router(20) → Receiver (19)
- Total time = 21 L/R + L/R = 22 L/R

Number of Packets	Data in a single packet	Total Packet Size (+header size) L	Time taken for transmission through a link (L/R)	Total Time for all the packets to reach the receiver
1	1000	1100	0.11	3x 0.11 = 3
5	200	200+100 = 300	0.03	7 x 0.03 = 0.21
10	100	100+100 = 200	0.02	12x0.02 = 0.24
20	50	50+100=150	0.015	22x0.015=0.33

From the above calculation it is clear that the minimum time taken is when we use 5 packets.

16. Now consider the same topology. Assume the Queue at each intermediate device can only hold 2 packets and the sender/router has to wait when the queue is full. How would this affect the overall transmission delay? (5 points)

In our case, it won’t affect the overall delay. Since the sender sends the second packet only when the first router receives the first packet. There won’t arise an issue of queuing.

Reference:

1. James Kurose and Keith Ross, Computer Networking A Top-Down Approach 7th Edition, Pearson Publishers, 2017.