SOLUTION

0014

National University of Computer and Emerging Sciences, Lahore Campus

Course Name:	Computer Networks	Course Code:	CS3001
Degree Program:	BCS, BSE	Semester:	Spring 2023
Exam Duration:	180 Minutes	Total Marks:	80
Paper Date:	31-May-2023	Weight	45%
Section:	ALL	Page(s):	11 + 1(Rough Page)
Exam Type:	Final		

Name:________________________ Roll No.________________ Section:__________

Instruction/Notes:
- Attempt all questions on the provided space in the question paper.
- Space for rough work is provided at the end of the paper.
- Even if you do use rough sheets, they should NOT be attached with final paper.
- If you find any ambiguity in a question, you can make your own assumption and answer the question accordingly by stating your assumption.

Question #	1	2	3	4	5	6	7
Total Marks	10	10	10	10	15	10	15
Obtained Marks							
CLO #	1	1	2	3	3	3	3

Question 1: Answer the following multiple-choice questions by **filling the following table**. Cutting and overwriting is not allowed. Any answer outside the table will be awarded **zero marks**. [1+1+1+1+1+1+1+1+1+1 = 10 Marks] (CLO 1)

Any answers outside the table will NOT be marked.

1	B
2	C
3	A
4	D
5	A
6	A
7	C
8	B
9	C
10	B

1.1. Which of the following statement(s) is true
- A. Clients are part of the network edge, while Servers and Routers are part of the network core
- B. Clients and Servers are part of the network edge, while Routers are part of the network core
- C. Clients, Servers and Routers are all part of the network core
- D. Clients, Servers and Routers are all part of the network edge

1.2. Following is/are the similarity/similarities between Routers & Switches
- A. Both are Layer 3 devices
- B. Both are transparent to the end systems
- C. Both are store & forward and have forwarding tables
- D. They have no similarities

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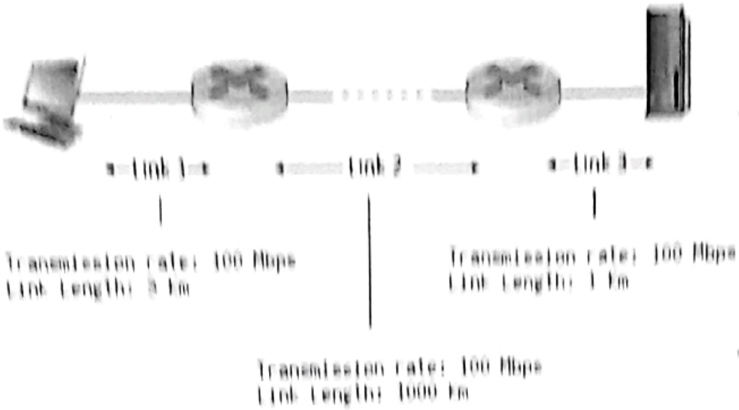
Question 2: Consider the figure below, with three links, each with the specified transmission rate and link length

[10 Marks] (CLO 1)



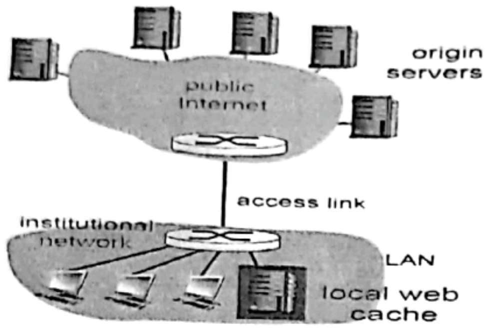
Assume the length of a packet is 8000 bits. The speed of light propagation delay on each link is 3×10^8 m/sec.

Calculate the following Delays:

	Link 1	Link 2	Link 3
Transmission Delay	$L/R = 8000\text{ bits}/100\text{ Mbps}$ $= 8.00\times10^{-5}$ seconds	$= 8000/100$ $= 8\times10^{-5}$ seconds	$= 8000/100$ $= 8\times10^{-5}$ seconds
Propagation Delay	$d/s = \frac{(3\text{ km})*1000\text{ m}}{3*10^8\text{ s}}$ $= 1\times10^{-5}$ seconds	$= \frac{1000*1000}{3*10^8}$ $= 0.0033$ seconds	$= \frac{1*1000}{3\times10^8}$ $= 3.33\times10^{-6}$ sec
Total Delay	$= 8\times10^{-5} + 1\times10^{-5} = 9\times10^{-5}$	$8\times10^{-5} + 0.0033$ $= 0.0034$	$= 8\times10^{-5} + 3.33\times10^{-6}$ $= 8.33\times10^{-5}$

Total Delay of the path = $9\times10^{-5} + 0.0034 + 8.33\times10^{-5} = 0.0036$ seconds

Question 3: Refer to the figure below, a web cache (proxy server) can significantly reduce the overall average delay to the internet (in the case of a cache hit), but there may be an increase in this total average delay (in the case of a cache miss.) Following are the total delays on average (totals including both directions). Let the total LAN delay be 15 ms, the total access link delay be 55 ms, the total internet delay be 300 ms and the total cache penalty delay be 25 ms (where cache penalty delay is the time required to check the cache in both the scenarios, i.e. either a cache hit or a cache miss.) Ignore all other delays. **[1 + 2 + 2 + 5 = 10 Marks] (CLO 2)**



(a) Find the total delay in the scenario where no cache is used? [1]

Total Delay = LAN Delay + Access Link Delay + Internet Delay = 15ms + 55ms + 300ms
= 370ms

(b) Find the total delay when a cache is used with a hit ratio of 90%? [2]

= 90% * (LAN Delay + Cache Penalty) + 10% (LAN Delay + Cache Penalty + Access Link Delay + Internet Delay)

$= 0.9 * (15+25) + 0.1 * (15+25+55+300) = 36 + 39.5 = 75.5$ ms

(c) Find the total delay when a cache is used with a hit ratio of 10%? [2]

= 10% * (LAN Delay + Cache Penalty) + 90% (LAN Delay + Cache Penalty + Access link Delay + Internet Delay)

$= 0.1 * (15+25) + 0.9 * (15+25+55+300) = 4 + 355.5 = 359.5$ ms

(d) Find the hit ratio above which the use of cache is justified? [5]

Let y = hit ratio, cache's use is justified when total delay including cache penalty is less than the total delay with using cache. i.e less than 370 ms.

y * (Lan Delay + Cache Penalty) + (1-y) * LAN Delay + Cache Penalty + Access Delay + internet delay) < 370ms.

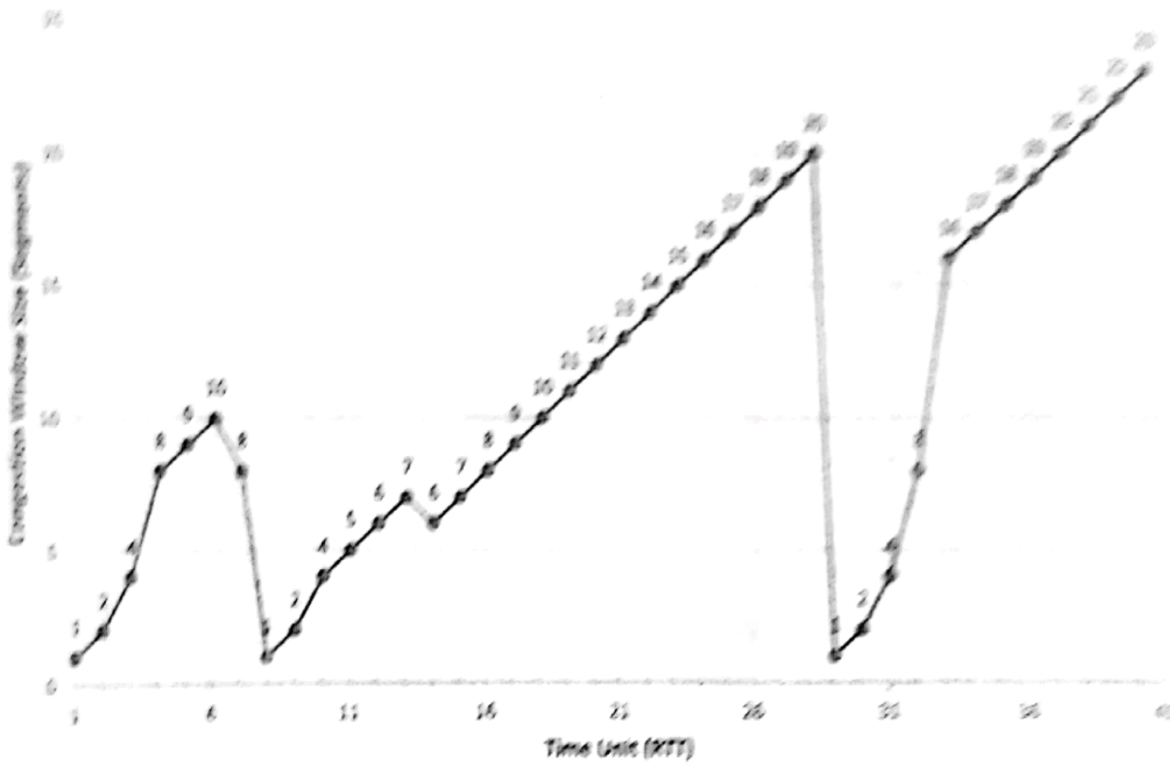
$\Rightarrow y * (15+25) + (1-y) * (15+25+55+300) < 370$

Solving for y gives

$y > 0.0704$

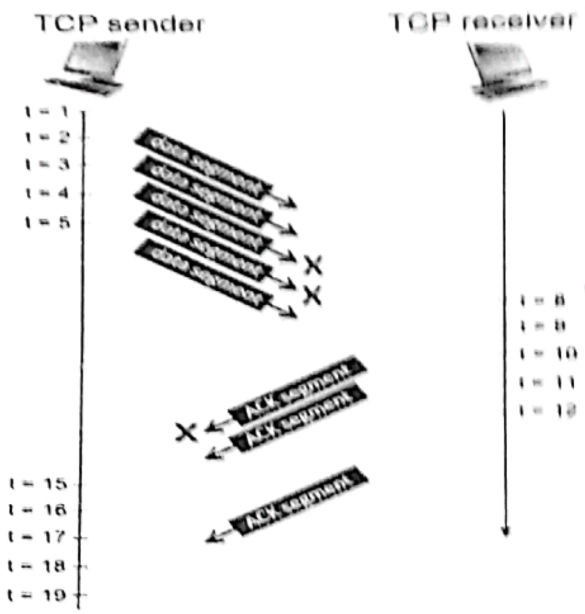
$\boxed{\text{or } 7.04\%}$

Question 4 (a). Consider the figure below, which plots the evolution of TCP's congestion window at the beginning of each time unit (where the unit of time is equal to the RTT). In the abstract model for this problem, TCP sends a "flight" of packets of size cwnd at the beginning of each time unit. The result of sending that flight of packets is that either (i) all packets are ACKed at the end of the time unit, (ii) there is a timeout for the first packet, or (iii) there is a triple duplicate ACK for the first packet. In this problem, you are asked to reconstruct the sequence of events (ACKs, losses) that resulted in the evolution of TCP's cwnd shown below. The initial value of cwnd is 1 and the initial value of ssthresh is 8. (values of x-axis, i.e. RTT, starts from 1) [illegible]



Mention the RTT intervals during which TCP is in slow start phase	1-4, 8-10, 29-33
The times at which congestion avoidance phase started.	4, 10, 14, 33
The times at which packets are lost via timeout.	7, 28
The times at which the value of ssthresh changes.	7, 8, 14, 29
The times at which packets are lost via triple ACK.	6, 13

(b): Consider the figure below in which a TCP sender and receiver communicate over a connection in which the segments can be lost. The TCP sender wants to send a total of 10 segments to the receiver and sends an initial window of 5 segments at t = 1, 2, 3, 4, and 5, respectively. Suppose the initial value of the sequence number is 187 and every segment sent to the receiver each contains 550 bytes. The delay between the sender and receiver is 7 time units, and so the first segment arrives at the receiver at t = 8, and an ACK for this segment arrives at t = 15. As shown in the figure, 2 of the 5 segments is lost between the sender and the receiver, but one of the ACKs is lost. Assume there are no timeouts and any out of order segments received are thrown out.



If there is no segment to send at a given time, write None.

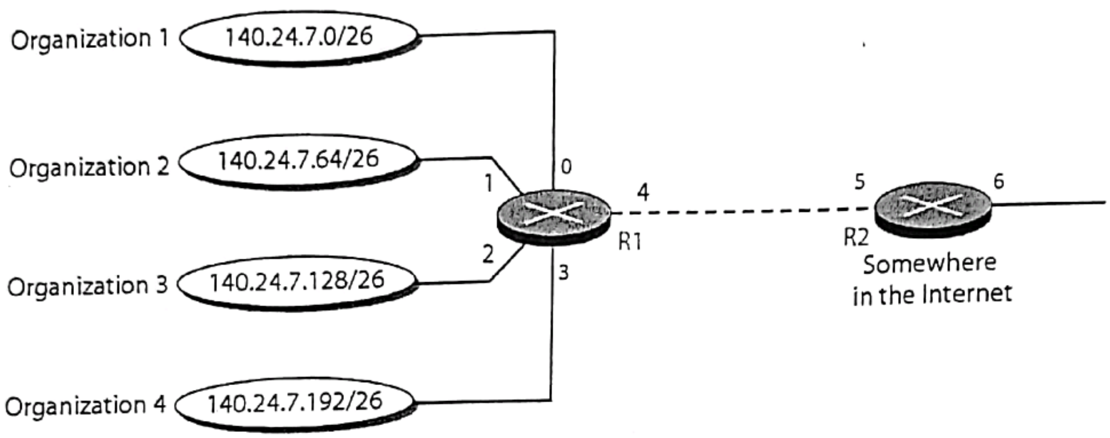
Sequence numbers for segments at Time:	
2	187+550 - 737
3	737 +550 =1287
5	1287+550 = 1837
16	1837+55 =2387
18	None

Acknowledgment Number of segments at time:	
8	737
9	1287
10	None
11	None
12	1287

Question 5: Answer both parts (a) and (b): [6 + 9 = 15 Marks] (CLO 3)

(a) Refer to the network scenario in figure 1 below, Routers R1 & R2 with interfaces 0,1,2,3,4 and 5,6 respectively employ IP Address Aggregation (Route Summarization). Please fill in the entries of the tables for both the routers R1 & R2 accordingly. (First entries, i.e. default entries have been pre-filled.) [6]

Figure 1

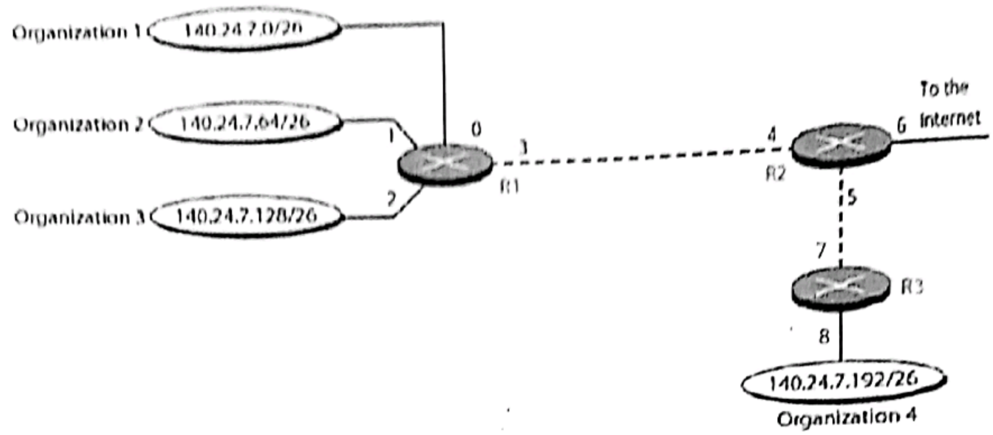


Routing Table for R1	
Network (IP) Address Range with Prefix	Interface
0.0.0.0/0 (Default)	4
140.24.7.0/26	0
140.24.7.64/26	1
140.24.7.128/26	2
140.24.7.192/26	3

Routing Table for R2	
Network (IP) Address Range with Prefix	Interface
0.0.0.0/0 (Default)	6
140.24.7.0/24	5

(b) Now refer to network scenario in figure 2 below, Routers R1, R2 and R3 with their respective interfaces 0,1,2,3........ etc. employ IP Address Aggregation as well as Longest Prefix matching. Please fill in the entries of the tables for the routers R1, R2 & R3 accordingly. (First entries, i.e. default entries have been pre-filled.) [9]

Figure 2



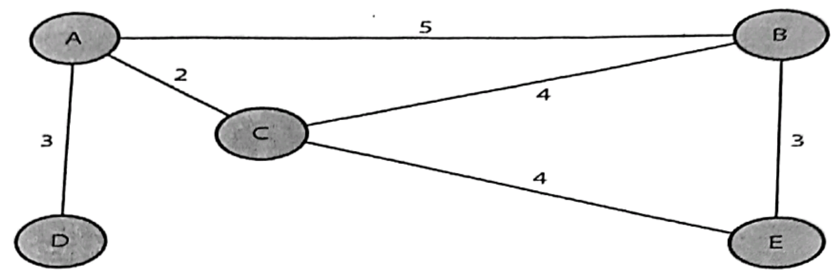
Routing Table for R1	
Network (IP) Address Range with Prefix	Interface
0.0.0.0/0 (Default)	3
140.24.7.0/26	0
140.24.7.64/26	1
140.24.7.128/26	2

Routing Table for R2	
Network (IP) Address Range with Prefix	Interface
0.0.0.0/0 (Default)	6
140.24.7.0/26	5
140.24.7.0/24	4

Routing Table for R3	
Network (IP) Address Range with Prefix	Network (IP) Address Range with Prefix
0.0.0.0/0 (Default)	7
140.24.7.192/26	8
140.24.7.0/24	7

Question 6: Answer both parts **(a)** and **(b)**: [6 + 4 = 10 Marks](CLO 3)

(a) Refer to the autonomous system in the figure below, OSPF is running in all the routers of this AS. Please compute the shortest path from Router A to all the other Routers B, C, D & E. [6]



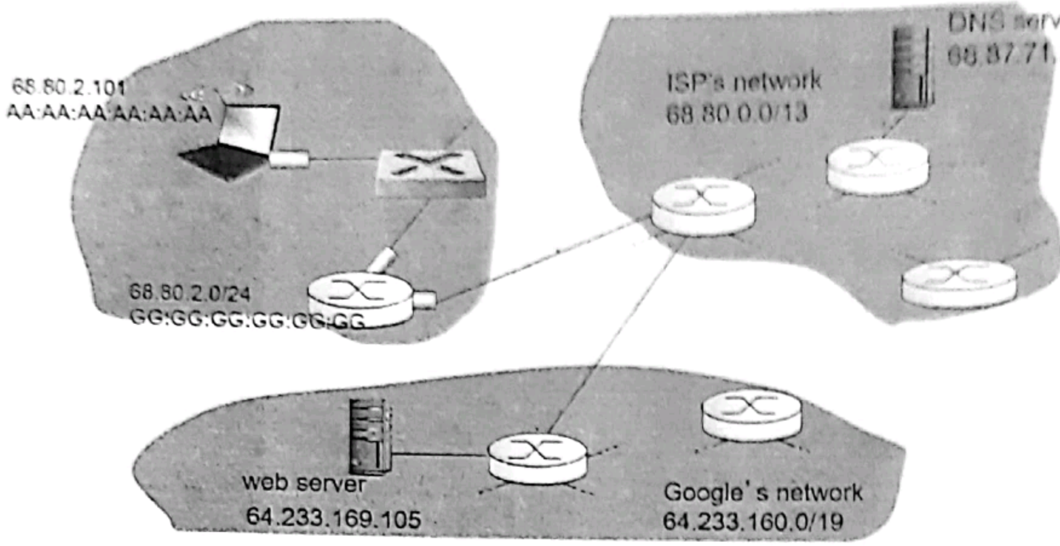
Step	N'	D(B) p(B)	D(C) p(C)	D(D) p(D)	D(E) p(E)
0	A	5,A	2,A	3,A	∞
1	AC	5,A		3,A	6,C
2	ACD	5,A			6,C
3	ACDB				6,C
4	ACDBE				

(b) Consider an AS with routers A, B, C, D & E with the topology **A—B—C—D—E** where hop-count is the metric. A goes down. B does not receive the vector update from A so it concludes that its route of cost 1 to A is no longer available. C doesn't know yet that A is down and tells B that A is 2 hops away from it. Thus the wrong info propagates until it reaches infinity. Briefly give the solution to this problem? **[4]**

Answer:

Poison Reverse. i.e. C advertise to B, the route to A with a cost of infinity, so that B does not route to A via C.

Question 7: Suppose you walk into an organization, connect your laptop to Ethernet, and want to download a Web page. What are all the protocol steps that take place, starting from powering on your PC to getting the Web page? Assume there is nothing in our DNS or browser caches when you power on your PC. [15 Marks] (CLO 3)



First Type of Packet Sent from your host is	DHCP request message	
	Source	Destination
Port Number	68	67
IP Address	0.0.0.0	255.255.255.255
MAC Address	AA.AA.AA.A.A.AA.AA	FF.FF.FF.FF.FF.FF
Application Layer Protocol	DHCP	
Transport Layer Protocol	UDP	

First Packet Received on your host is: DHCP ACK message

It contains: (Fill in the missing items in either of the columns in the table below.)

1) Alloted IP address for your host	68.80.2.101
2) IP address of DNS server	68.87.71.226
3) IP address of gateway router	68.80.0.2
4) Subnet Mask	/24

How many messages/packets are exchanged in getting IP address for your host? 4.

Next ARP query message will be generated to get Mac Address of gateway router

ARP Query	Source	Destination
IP Address	68.80.2.101	68.80.2.0
MAC Address	AA:AA:AA:AA:AA:AA	FF:FF:FF:FF:FF:FF

ARP response message will contain:

	Source	Destination
IP Address	68.80.2.0	68.80.2.101
MAC Address	GG:GG:GG:GG:GG:GG	AA:AA:AA:AA:AA:AA

After getting IP address, and ARP response next packet sent from your host is		DNS Query Message
	Source	Destination
Port Number		53
IP Address	68.80.2.101	68.87.71.226
MAC Address	AA:AA:AA:AA:AA:AA	GG:GG:GG:GG:GG:GG
Application Layer Protocol	DNS Protocol	
Transport Layer Protocol	UDP	

As a response of the above query your host will get: DNS reply message (host name to IP mapping of web server)

Now is the time to contact webserver for your required webpage which uses HTTP.
How many packets will be exchanged between your host and server before sending actual data and why?

2, HTTP uses TCP which uses 3-way handshake for establishing connection, before sending actual data as payload in 3rd packet.