Solution.

Computer Networks (CS3001)   ## Final Exam

Date: December 22nd 2025

Total Time: 3 Hours

Course Instructor(s)

Total Marks: 70

Dr. Arshad Ali, Dr. Abdul Qadeer,

Total Questions: 8

Dr. Ahmad Raza, Ms. Umm-e-Ammarah,

Ms. Sarah Khaleel, Mr. Nauman Moazzam Hayat,

Mr. Umar Bin Farooq

Roll No	Section	Student Signature

Instruction/Notes:
- Attempt all questions on the provided separate answer sheet, except **Question 2, 4, 5 & 8** which are to be answered on the **Question Paper,** to be attached with the answer sheet.
- Clearly write corresponding question number and part number at the top center of the answer sheet with a thick pen / marker before starting a new question / answer.
- In case you have used rough sheets, they should **NOT** be attached to the answer sheet.

CLO 1 (Question 1): **Describe** utilization of network protocol concepts vis-a-vis OSI and TCP/IP stack.

Q1: Three Application Layer messages i.e. Message A (size = 200 bytes), Message B (Size = 800 bytes) & Message C (Size = 1400 bytes) are sent. **Headers per message per layer** are as follows: Transport = 20 bytes, Network = 20 bytes, Link header/trailer = 18 + 4 = 22 bytes.   **[3 + 1 +1 = 5 Marks]**

(a) Compute the frame size for each message.   A) 200 + 62 → 262 B) 800+62 = 862 C) 1400+62 = 1462

(b) Total overhead for sending all 3 messages. 62×3 = 186 bytes

(c) Average overhead percentage across the three transmissions.

Total data = 200 + 800 + 1400 = 2400 ; Total sent: 262 + 862 + 1462 = 2586

CLO 2 (Questions # 2, 3, & 4): Demonstrate **the basics of network concepts using state-of-the-art network tools/techniques.**

overhead % = (2586 − 2400)/2586 × 100 ⇒ 186/2586 × 100 ⇒ 7.19%

Q2: (**To be answered on the Question Paper.**) Alice logged into her email account, after logging in successfully to **www.mail-service.com**, Alice composes an email to **bob@gmail.com** and clicks **Send**. For login and session management of Alice, **HTTP cookies** are used, with Cookie ID numbered as 6001. Fill in the following blanks on the question paper: **[1 * 5 = 5 Marks]**

i) Identify the **exact HTTP response header line** the server sends to establish Alice's login session. Set - cookie : 6001

ii) Identify the **exact HTTP request header line** sent by Alice's browser on subsequent authenticated requests. cookie : 6001

iii) Which application-layer protocol is used between: Alice's browser and mail-service.com? HTTP

iv) Which application-layer protocol is used between: mail-service.com and gmail.com? SMTP

v) Is the protocol in part (iv) above **Push or Pull**? Push

(handwritten top-left)

$$1100100000011010$$
$$+000011011100001$$
$$11010101$$
$$001101011$$
$$0010101000100100 \leftarrow Ans$$

0

Q3: Answer both parts below: **[3 + 4 = 7 Marks]**

    (a) Suppose you have the following three 16-bit words 0101001101100110 , 0111010010110100 , 0000110111000001. Compute the Internet Checksum for this and show all your work.
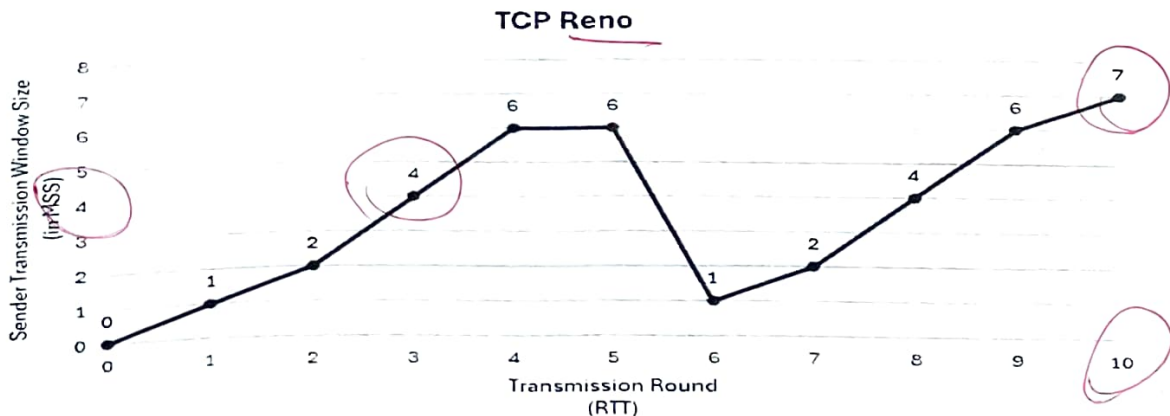
    (b) Now suppose the receiver receives 0101001101100110 , 0111010000110100 , 0000110111000001 in addition to the checksum calculated in part "a." How will the receiver detect the error (if any)? Show all your work.

(handwritten work near Q3)

0111010010110100
0101001101100110
+0101001101100110
1100100000011010
1100100000011010

0111010000110100
+0101001101100110
11001110011010
+0000110111000001
1101010101011011

1111111110111111   } = all ones (error)

Q4: (**Both parts to be answered on the Question Paper**) Consider a TCP Reno connection as illustrated by the diagram below. Please also note the points below: **[0.5 * 30 + 2 = 17 Marks]**

- 1 MSS = 100 bytes
- At RTT = 0, TCP connection has been established but no segment has been sent by the sender yet. Initial (default) values of different parameters at RTT = 0 are given in the TCP sender table below.
- The sender starts its transmission i.e. sends the first segment with sequence number = 0, at RTT = 1
- 14th segment sent by the sender is lost
- Out of sequence received segments are not buffered but discarded
- SS is short for Slow Start, CA for Congestion Avoidance, FR for Fast Recovery & N/A for Not Applicable.

    (a) For the TCP Sender table given below (**Table No: 4**) for this connection, some entries in the table are pre-filled. Please fill in all the remaining missing entries for this table in the question paper (& attach it with the answer sheet.)

    (b) What is the sequence number of the segment which was lost? _____1300_____

TCP Reno — Sender Transmission Window Size (in MSS) vs Transmission Round (RTT)

(handwritten notes at bottom)

SS:

ssthres = cwnd / 2
cwnd = ssthres + 3

← in case of 3-dup ACK

→ new ACK arrives:
   cwnd = ssthresh
Enter CA (linear increase)

National University of Computer and Emerging Sciences
Lahore Campus

Table No: 4

TXN Round (RTT)	Receive Window (rwnd in MSS)	Congestion Window (cwnd in MSS)	Slow Start Threshold (ssthresh in MSS)	Received ACK Number	Sequence Number(s) of Transmitted Segment(s)	Timer (Timeout in ms)	No Loss Or Timeout Or 3dupAck	TCP Sender Congestion Mode (SS or CA or FR)
0	6	0	12	N/A	N/A	600	No Loss	N/A
1	6	1	12	N/A	0	600	No Loss	SS
2	6	2	12	100	100, 200	600	No Loss	SS
4	6	6	12	700	700, 800, 900, 1000, 1100, 1200	600	No Loss	SS
5	6	12	12	1300	1300, 1400, 1500, 1600, 1700, 1800	600	No Loss	CA
6	20	1	6	1300	1300	1300	Timeout	SS
190	20	7	6	2600	2600, 2700, 2800, 2900, 3000, 3100, 3200	1200	No Loss	CA

cwnd = ssthresh +3

CLO 3 (Question # 5, 6, 7 & 8): **Demonstrate** various classical routing and switching protocols via simulations.

Q5 (a) (All parts to be answered on the Question Paper): An IPv4 packet arrives at an Internet router interface. This packet's header contains the following details: **[3 Marks]**
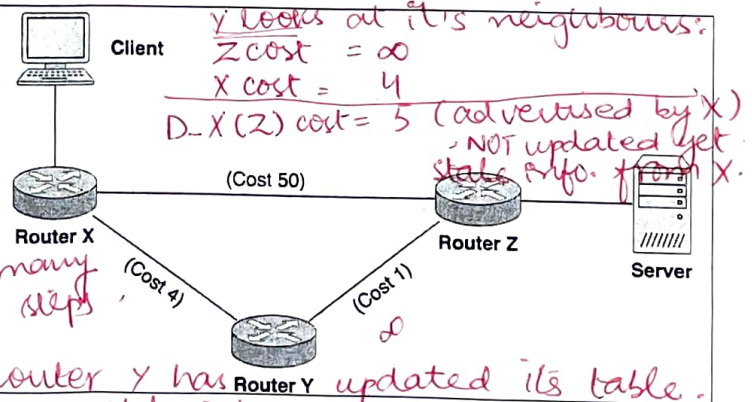
Source IP: 128.119.40.18	Destination IP: 200.23.18.7

(handwritten): 1100 1000 . 0001 0111 . 0001 0010 . 0000 0111

The router consults its forwarding table (shown below) to determine where to send the packet. Circle **(on this question paper)** which **Interface ID** the router will select to forward this packet.

Entry no.	Destination Prefix (Binary)	Interface ID
1	11001000 00010111 0001000	0
2	11001000 00010111 00010010	1
3	11001000 00010111 0000	2
4	11001000 00010111 00010010 1	3
5	11001000 0000	4
6	11001000 00010111 00010010 00001	5
7	11001000 00010111 00010010 0000	6
8	11001000 00010111 00010010 000000	7
9	10000000 01110111 00101000	8
10	* (Default)	9

(b) Consider a network topology of a small ISP (with three routers) as shown on the right. Routers use plain distance vector algorithm to find the lowest cost paths. The administrator has configured the update interval to 30 seconds to disseminate any routing changes to other routers. *(handwritten: 54 after many steps)* For a client, router X is the default gateway, and a server is connected to an interface of the router Z.

(handwritten annotations on diagram):
- Y looks at it's neighbours:
- Z cost = ∞
- X cost = 4
- $D\_X(Z)$ cost = 5 (advertised by X) — NOT updated yet. stale info. from X.
- Only router Y has updated its table.
- Routers X and Z still have old info.

(diagram labels): Client; (Cost 50); Router X; Router Z; Server; (Cost 4); (Cost 1); ∞; Router Y

At time t = 0, the network routing is stable and already converged. Router X is currently forwarding traffic to Z via Y (Cost 5). Suddenly, the link between Y and Z fails completely (i.e. cost becomes infinity). Router Y detects this failure first and needs to update its routing vector: (Assume **Poison Reverse** option is **not** available). **[1 + 5 + 1 = 7 Marks]**

(handwritten): → to avoid routing loops

i) Router Y executes the Bellman-Ford algorithm to find a new path to Z. Based on the above scenario, what is the new cost to Z that Router Y installs in its routing table?

New Cost: _____9_____

(handwritten): $D\_y(Z) = \min(\text{infinity}, \text{Cost}(Y,X) + D\_X(Z)) = (\infty, 4+5) \Rightarrow 9$

ii) Immediately after the Router Y installs new cost in its own routing table, a network engineer at the client (connected to X) runs a *traceroute* command to the Server connected to Z. Fill in the output that the engineer sees for the first 5 lines of traceroute output.

Note: If the packet reaches the destination or stops before line 5, leave the remaining lines blank.

client to:

1st Router Name: _____X_____

2nd Router or Host Name: _____Y_____

3rd Router or Host Name: _____X_____

4th Router or Host Name: _____Y_____

5th Router or Host Name: _____X_____

x will thinks best path to z is via y

(y now thinks best path to z is via x)

(Packet start looping b/w x and y).

iii) Immediately after the Router Y installs new cost in its own routing table (part (i) if an IPv4 packet leaves the client with TTL value of 64 and is destined to the server, how lower this TTL value will go during the lifetime of this specific IPv4 packet if no further routing information is shared between the routers? *Each hop reduce TTL by 1. Packet never reaches z and is dropped when TTL reaches 0!*

Final TTL Value: _____1_____ or 0 *(decremented to '0' when datagram reaches router).*

Q6: Suppose Autonomous Systems, i.e. AS X & AS Z are not directly connected but are instead connected by AS Y. Further suppose that X has a peering agreement with Y, and that Y has a peering agreement with Z. Finally, suppose that Z wants to transit all of Y's traffic but does not want to transit X's traffic. **[2 + 4 = 6 Marks]**

a) Does BGP allow Z to implement this policy? (Yes or No) *Yes* *can.*

b) If No, why not? If Yes, how? (Give at least two reasons for either case.) *(i) Y will not advertise X's route to Z (peer to peer rule). (ii) Z can enforce import filters to drop X-origin routes via AS Path Attribute Filtering. by configuring filter to reject BGP updates from Y that have AS X in AS PATH.* *Z reject routes to X, by*

Q7: Suppose four active nodes—nodes A, B, C and D—are competing for access to a channel using slotted ALOHA. Assume each node has an infinite number of packets to send. Each node attempts to transmit in each slot with probability 0.2. The first slot is numbered slot 1, the second slot is numbered slot 2, and so on.

a. What is the probability that node A succeeds in slot 1?

b. What is the probability that node A succeeds for the first time in slot 4? **[2 * 5 = 10 Marks]**

Q8: (**All parts to be answered on the Question Paper**): Consider the diagram below of a network which is composed of three LAN switches (S1, S2 & S3), one router (R1), and several hosts. Different entities are assigned IP and MAC addresses as follows: **[2 * 5 = 10 Marks]**
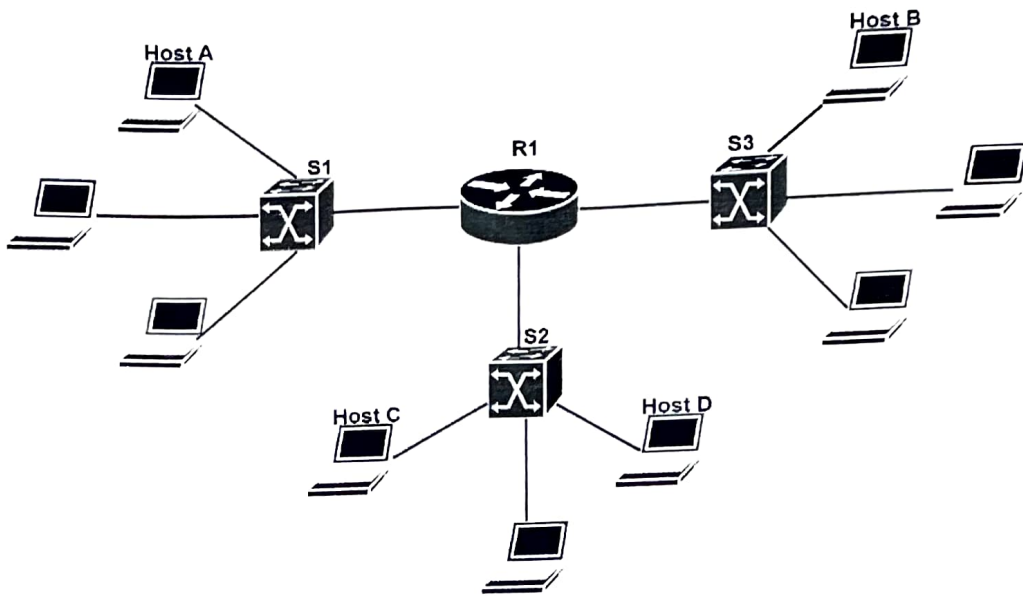
Interface	IP Address	MAC Address
Host A	192.168.1.7	AA:AA:AA:AA:AA:AA
Host B	10.125.125.7	BB:BB:BB:BB:BB:BB
Host C	172.16.1.7	CC:CC:CC:CC:CC:CC
Host D	172.16.1.8	DD:DD:DD:DD:DD:DD
Interface of R1 connected with S1	192.168.1.5	11:11:11:11:11:11
Interface of R1 connected with S2	172.16.1.5	22:22:22:22:22:22
Interface of R1 connected with S3	10.125.125.5	33:33:33:33:33:33

Q7: (a) Prob. that node A transmits in slot 1 = 0.2

" " other nodes don't " " " " = $(1-0.2)^3$

" " node A succeeds in slot 1 = $[0.2(1-0.2)]^3$ ⟹ 0.1024

(b) Prob. that node A remains unsuccessful in 1st 3 slots = $(1-0.1024)^3$

" " " " succeeds 1st time in slot 4 = $0.1024(1-0.1024)^3$

= 0.074

i) If Host A needs to send an IP datagram to Host B, answer the following:

   a. Which MAC addresses Host A would need to know, and which protocol will be used to get those addresses?

Answer: S1 ,   11:11:11:11:11:11 , through ARP query.

   b. What are the source and destination MAC addresses in the link-layer frame originated by Host A?   → AA:AA|AA:AA:AA:AA

Answer: 11:11:11:11:11:11

   c. What are the source and destination MAC addresses in the link-layer frame received by Host B?

Answer: 33:33:33:33:33:33

                                BB:BB:BB:BB:BB:BB

ii) If Host C needs to send an IP datagram to Host D, which MAC addresses Host C would need to know?

Answer: DD:DD:DD:DD:DD:DD

iii) Assume that router R1 receives a broadcast frame, over the interface connected with switch S2, having destination MAC address equals to FF:FF:FF:FF:FF:FF. Does R1 forward this frame to any other switches, yes or no?

Answer: No, router does'nt forward broadcast frame to oth interfaces.