CSC 458/2209 (Section L0101): Computer Networks, Winter 2025

Department of Computer Science, University of Toronto

Midterm Exam – 100 Minutes **Date:** Monday, February 24th, 2025

(i) This test has 14 questions. Make sure to skim through all the questions before starting. This will help you pace yourself. This exam has 50 points in total, and you have 100 minutes (*i.e.,* 2 minutes per point).

(ii) This exam is closed book and closed notes. You can use a non-programmable calculator.

(iii) Write your answers on this questions paper. Make sure to put your name on this page.

(iv) Show your reasoning clearly. If your reasoning is correct, but your final answer is wrong, you will receive some credit. If you just show the answer without reasoning, and your answer is wrong, you may receive no points at all.

Part I - Multiple Choice Questions [10 points]

For each of the following questions, only one assertion is correct. Selecting the correct assertion earns you 2 points, while selecting an incorrect assertion deducts 1 point from your total score for this section. If you are unsure of the answer and do not select any assertion, you will neither gain nor lose points. Your total score for this section cannot go below 0, even if all your selected assertions are incorrect.

1. Link Layer. Which of the following is true about MAC addresses?

a) They are assigned by a DHCP server.
b) They are globally unique and assigned by the manufacturer.
c) They change when a device moves to a different network.
d) They are used for routing packets at the network layer.

2. Hamming Distance. In the context of error correction, what is the Hamming distance between codewords 11011011 and 11100111?

a) 2
b) 3
c) 4
d) 5

3. Longest Prefix Match. Why do IP routers implement a "Longest Prefix Match" rule when forwarding packets?

a) To ensure that a packet follows the most optimal physical route.
b) To allow subnetting and hierarchical IP addressing to work efficiently.
c) To prevent packet fragmentation at intermediate routers.
d) To reduce lookup times of IP addresses.

4. BGP. Why does BGP use path-vector routing instead of distance-vector or link-state?

a) To allow each AS to apply its own routing policies.
b) Because path-vector protocols have lower latency.
c) To prioritize shortest paths over policy-based paths.
d) Because it requires less memory than link-state protocols.

5. Sliding Window. Which of the following statements is/are true about the sliding window mechanism in reliable data transfer?

a) The sliding window protocol allows a sender to transmit multiple packets before requiring an acknowledgment for the first one.
b) Only the receiver needs to implement the sliding window protocol as only the receiver knows the amount of data it can receive without dropping packets.
c) A larger window size can improve throughput and reduces the risk of congestion.
d) The sliding window allows the sender to encrypt packets before sending them to the receiver.

Part II – Comparisons [8 points]

Compare the following pairs of terms/concepts very briefly (in at most 2-3 sentences). For each pair, explain the key differences – the context they are defined at, protocol(s) they are related to, when/where they are used, etc.

6. Single-Homing vs. Multi-Homing

7. Congestion Control vs. Flow Control

8. MAC Address vs. IP Address

9. Store-and-Forward vs. Cut-Through Switching

Part III - Longer Questions [30 points]

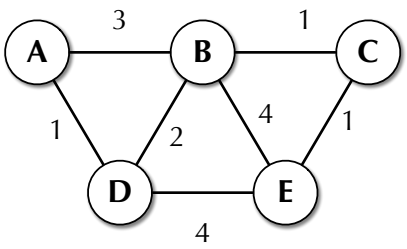
10. Fragmentation [6 points]. A sender transmits an IPv4 packet of 6000 bytes (including a 20-byte IP header) over a network with an MTU of 1200 bytes.

a) How many fragments will be created?

b) Determine the size and offset of each fragment. Here, the offset is assumed to be the sequence number of the first byte of the packet. You can assume the first packet has an offset of zero.

c) What is the ratio of bytes received by the receiver (including data and header bytes) when we have fragmentation compared to the time where we do not have any fragmentation.

11. Shortest Path Routing [6 points]. In the topology shown in this figure, the links are bidirectional (work in both directions) and the number next to each link shows the cost. Find the routing tables using the Bellman-Ford algorithm.



Step 1:

Table for A

Dest	Cost	Next Hop
A	0	A
B		
C		
D	1	D
E		

Table for B

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

Table for C

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

Table for D

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

Table for E

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

Step 2:

Table for A

Dest	Cost	Next Hop
A	0	A
B		
C		
D		
E		

Table for B

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

Table for C

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

Table for D

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

Table for E

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

Step 3:

Table for A

Dest	Cost	Next Hop
A	0	A
B		
C		
D		
E		

Table for B

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

Table for C

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

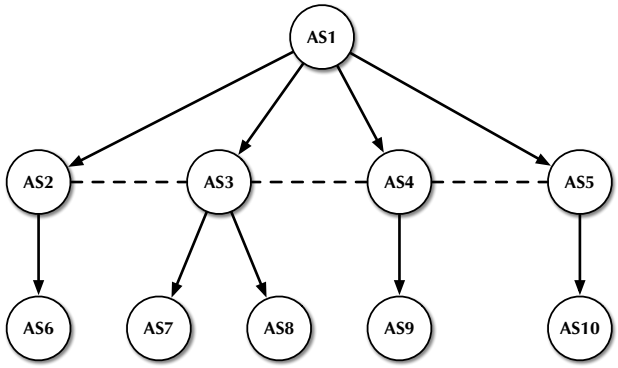
Table for D

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

Table for E

Dest	Cost	Next Hop
A		
B		
C		
D		
E		

12. Autonomous Systems [8 points]. Consider ten autonomous systems **AS1**, **AS2**, …, **AS10** shown in the figure below. Here, an arrow indicates a customer-provider relationship (i.e., **AS1→AS2** shows **AS1** is a provider for **AS2**), and a dashed line represents a peer-peer relationship between two autonomous systems (e.g., **AS2** and **AS3** have a peer-peer relationship).
Let us assume **H6**, **H7**, …, **H10** are hosts located inside **AS6**, **AS7**, …, **AS10** respectively.



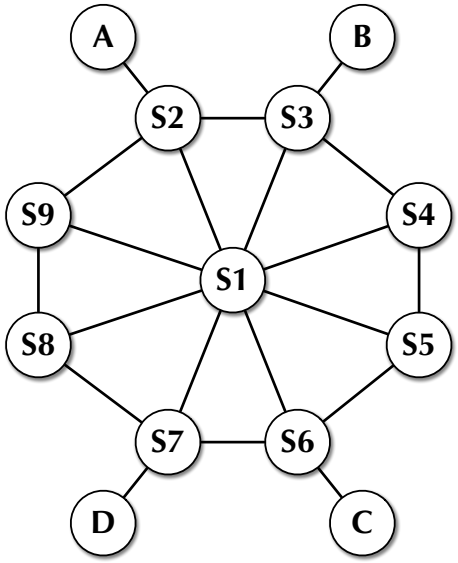
a) Let us assume **H6** sends a number of packets to **H7**. Show the path taken by these packets (i.e., list the autonomous systems that these packets follow to reach their destination).

b) Imagine **AS1** is completely down due to a power failure. Can host **H6** communicate with host **H8**? If the answer is yes, show the path. If not, briefly explain why.

c) Assuming **AS1** is down, can host **H8** communicate with host **H10**? If the answer is yes, show the path. If not, briefly explain why.

d) Now, let us assume **AS1** is back to normal operation, except that the link **AS1→AS3** is still down and not able to carry traffic. Can host **H10** communicate with **H8**? If the answer is yes, show the path. If not, briefly explain why.

13. Learning Switches [8 points]. Consider four hosts **A**, **B**, **C**, and **D** connected by a network of switches named **S1** to **S9** as shown in the figure below. Here, the IDs of switches **S1** to **S9** are **1** to **9** respectively.



a) Switches **S1** to **S9** run the spanning tree algorithm in order to make sure there are no loops in the network. Which switch is the root of the tree? Which links are discarded after running the spanning tree algorithm? (Here, if a node has to choose between two neighbors of the same cost, the tie is broken by selecting the neighbor with the smaller ID).

b) In the spanning tree you identified in part (a), what is the length of the path between **A** and **B**? (That is, how many links on the path)? What is the length of path between **C** and **D**?

c) Let us assume switch **S1** fails. The remaining switches will form a new spanning tree. Once again, if a node has to choose between two neighbors of the same cost, the neighbor with the

smaller ID will be selected. What is the root of this new spanning tree? Which links are discarded?

d) In the spanning tree you identified in part (c), what is the length of the path between **A** and **B**? (That is, how many links on the path)? What is the length of path between **C** and **D**?

14. IP Forwarding [4 points]. Consider the following routing table for a router:

Destination Network	Next Hop
10.0.0.0/8	Router A
10.0.1.0/24	Router B
10.0.1.64/26	Router C
10.0.1.64/27	Router D
*	Router E

The last row is the default entry that matches all packets that miss prior entries.

a) If a packet arrives for 10.0.1.70, which next hop is chosen and why? Explain your answer in 2-3 sentences.

b) If a packet arrives for 10.0.1.100, which next hop is chosen? Why? Explain your answer in 2-3 sentences.

[Use this page if you need more space for any of the problems.]