CSC458/2209: Computer Networks, Fall 2019

Department of Computer Science, University of Toronto

Midterm Exam – 100 Minutes **Date:** Tuesday, October 22th, 2019

Name: **Student ID:**

(i) This test has 9 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.

(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 every page.

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

Question	**Score**
Comparisons 1-2 (4 pts)	
Short Questions 3-6 (21 pts)	
Longer Questions (25 pts)	
7 (13 pts)	
8 (6 pts)	
9 (6 pt)	
Total 50 points	

Name:

Part I – Comparisons [4 points]

Compare the following pairs of terms/concepts in at most 4-6 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.

1. Flow Control vs. Congestion Control

Flow control: control packet tranmissions at the host in order to make sure that the buffer at the receiver does not overflow (drop packet).

Congestion control: control of packet tranmissions in order to make sure that the buffers at the routers in the network do not overflow (get congested)

2. Routing vs. Forwarding

Routing: Determine packet path from source (host) to destination (host). The outcome of routing is used to popluated the forwarding tables at the routers.

Forwarding: Determining for each packet at a given router to which next hop (router interface) the packet should be forwarded/on which interface the packet should be sent out.

Name:

Part II - Short Questions [21 points]

3. Stop-and-Wait ARQ [4 points]. Consider the situation where a sender **A** and a receiver **B** communicate with each other using stop-and-wait ARQ. Suppose that **A** uses as the initial sequence number (ISN) 200, i.e. we have that ISN=200. Furthermore suppose that the first packet that **A** sends to **B** consists of 100 bytes.

(a) What is the SN number that A puts into the packet header (such as for example a TCP packet header)

200 (or 201)

(b) If **B** receives the first 100 bytes packet from **A** without an error, what is the ACK number that **B** uses in the packet that is sends to **A** in response to the packet it received?

300 (or 301)

(c) If **B** detects an error in the first 100 bytes packet that it receives from **A**, what is the ACK number that **B** uses in the packet that is sends to **A** in response to the packet it received?

200 (or 201)

4. MAC and IP addresses [9 points]. In this question we explore properties of IP and MAC addresses.

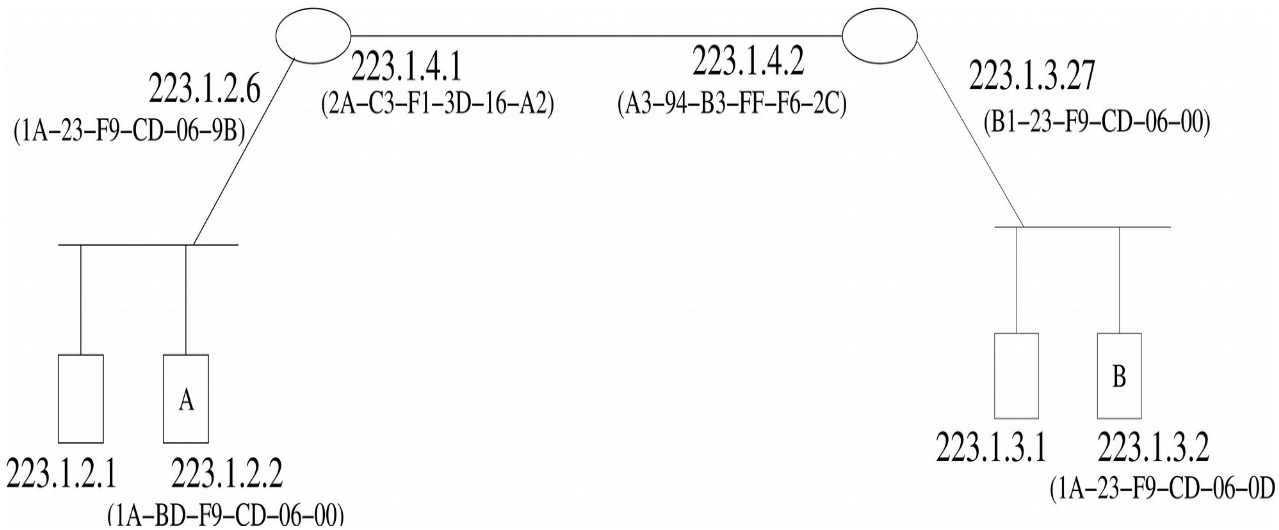
(a) Let the following be addresses of (destination) IP networks:
- Network 1: 131.21.0.0/16
- Network 2: 131.22.0.0/16
- Network 3: 133.22.12.0/24

And consider the following hosts with IP addresses:
- Host A: 131.21.12.19
- Host B: 133.21.12.19
- Host C: 133.22.11.19
- Host D: 131.21.21.21
- Host E: 133.22.21.21

To which (destination) network do the different hosts belong? Are there any hosts that do not belong to any of the above networks?

- Host A: Network 1
- Host B: no match
- Host C: no match
- Host D: Network 1
- Host E: no match

(b) The figure below gives a network topology of hosts and routers, and the corresponding MAC and IP addresses.



Assume that host **A** sends a message/packet to host **B (**using the route that is indicated in the above figure). For each hop over which the message/packet travels, indicate the source and destination MAC and IP addresses that are used in link layer, and network layer, packets.

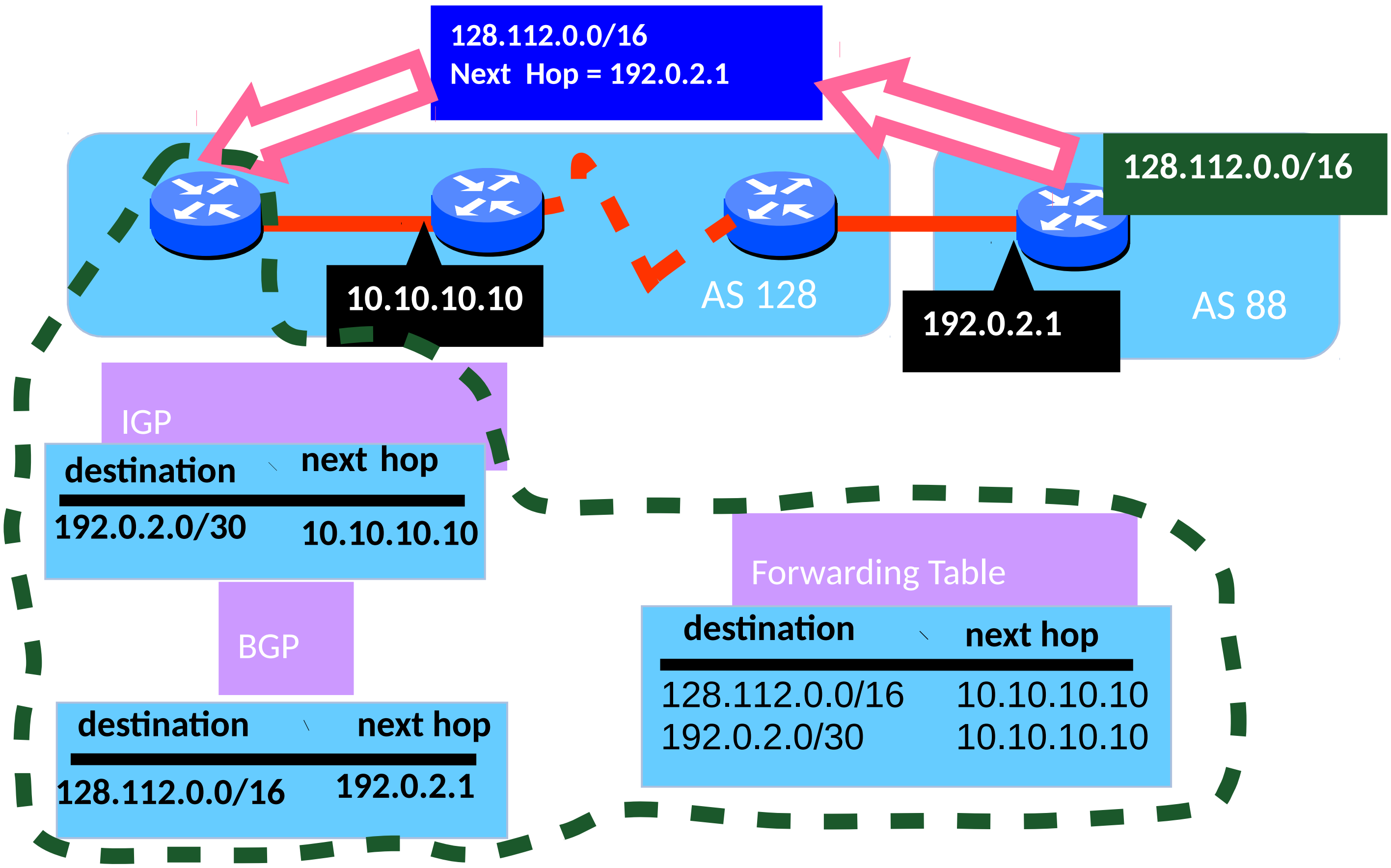
Packet 1: source IP: 223.1.2.2 destination IP: 223.1.3.2
source MAC: 1A-BD-CD-06-00 destination MAC: 1A-23-F9-CD-06-9B

Packet 2: source IP: 223.1.2.2 destination IP: 223.1.3.2
source MAC: 2A-C3-F1-3D-A2 destination MAC: A3-94-B3-FF-F6-2C

Packet 1: source IP: 223.1.2.2 destination IP: 223.1.3.2
source MAC: B1-23-F9-CD-00 destination MAC: 1A-23-F9-CD-06-0D

Name:

5. Forwarding Tables [4 points]. In the figure below, indicate how information from the IGP and BGP routing protocols are combined to populate the forwarding table, i.e. fill out the forwarding table based on the information obtained from the BGP and IGP protocol.



Name:

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6. Error-Correcting Codes [4 points]. Consider the 2D parity-check code given in the figure below. Explain in details how, and why, the code can correct 1 error.

0101001	1
1101001	0
1011110	1
0001110	1
0110100	1
1011111	0
1111011	0

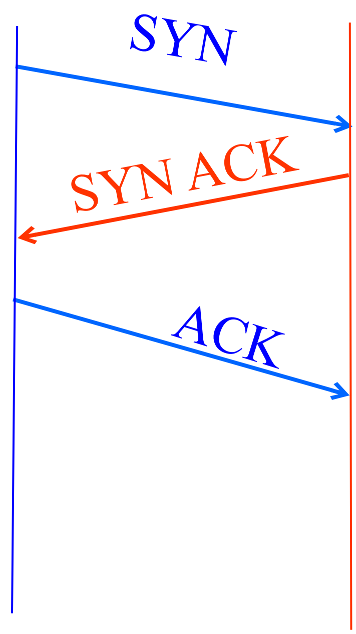
One error produces a parity mismatch in one row and one column. Suppose that the mismatch occurs in row n and column m. Combining this information it follows that the bit at entry (n,m) is wrong, and we can correct the error.

Name:

Part III - Longer Questions [25 points]

7. TCP Connections [13 points]. Consider a TCP connection between two applications running on two end-hosts **A** and **B**.

(a) In the diagram below show the sequence of packets exchanged between **A** and **B** required to initiate (setup) the connection.



(b) For each packet in a), indicate which flags are set, and which information is provided, in the TCP packet header.

SYN: A’s port, B’s port, A’s initial sequence number ISNA, SYN flag

SYN ACK: A’s port, B’s port, A’s initial sequence number ack ISNA+1, B’s initial sequency number ISNB, SYN flag, ACK flag

ACK: A’s port, B’s port, B’s initial sequency number ack ISNB+1, ACK flag

(c) Provide an explanation of the purpose of each packet.

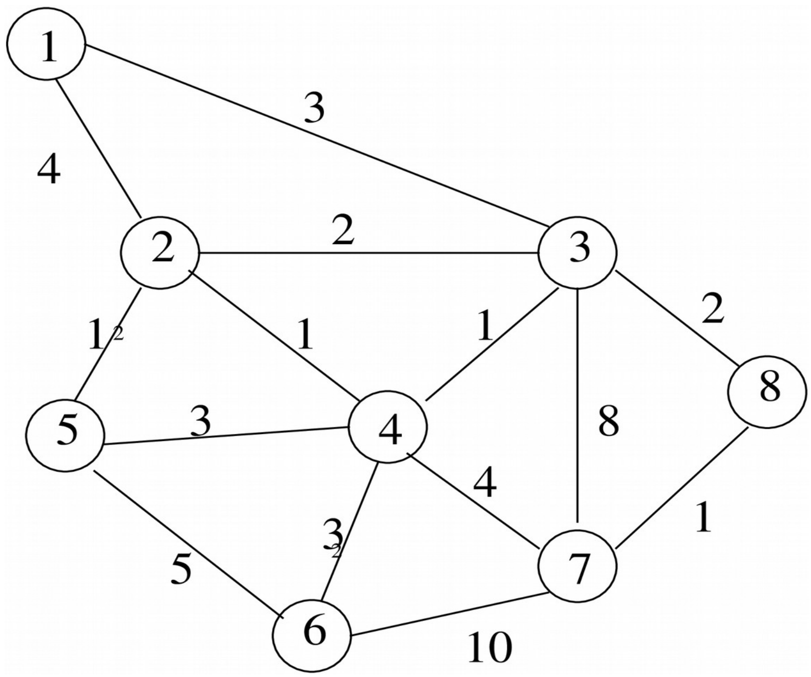
SYN: A tells B that it wants to open a new TCP connection and indicates initial sequence number at A for the connection.

SYN ACK: B acknowledges the connection set up request and the initial sequence number at A for the connection, and indicates the initial sequence number at B for the connection.

ACK: A acknowledges the initial sequence number at B for the connection.

Name:

8. Routing Algorithm [6 points]. Consider the weighted graph given below. Using Dijkstra's algorithm, find the shortest-path spanning-tree for routing packets from node 1 to every other node in the graph. Clearly show each step of the algorithm, including the evolution of the shortest-path set, S. Write your answer in the table below. Each entry in the second column should be a triple: (New node in the shortest path set, Next-node from node 1 to reach the new node, cost to reach the node).



Step	**(Destination node, next node, cost)**, **S**
1	(1,1,0), **S** = {1}
2	(3,3,3), **S** = {1,3}
3	(2,2,4), **S** = {1,3,2}
4	(4,3,4), **S** = {1,3,2,4}
5	(5,2,5), **S** = {1,3,2,4,5}
6	(8,3,5), **S** = {1,3,2,4,5,8}
7	(7,3,6), **S** = {1,3,2,4,5,8,7}
8	(6,3,7), **S** = {1,3,2,4,5,8,7}

9. End-to-end latency [6 points]. A message of size 10,000 bits (*not bytes*) is sent from a source node **A** to a destination node **B** passing through two routers **R1** and **R2**. All three links on the path have a delay of 20 ms. Node **A** has a transmission rate of 100 bits/sec, **R1** and **R2** have a transmission rate of 1000 bits/sec. We assume this is a store and forward system, there is no queueing delay, and we ignore all header overheads for simplicity.

(a) Find the end-to-end latency of the message when it is sent as a whole.

Propagation delay per link: 0.02 sec
transmission delay at A: 100 sec
transmission delay at router R1and R2: 10 sec

total delay over 3 links: 100.02 sec + 2x10.02 sec = 120.06 sec

(b) Find the end-to-end latency of the message when it is broken into 10 packets each of size 1000 bits and then transmitted to the destination.

Note that message transmission delay at A is larger than at R1 and R2. As a result, there are “gaps” between the packet transmissions at R1

Propagation delay per link: 0.02 sec
message transmission delay at A: 100 sec
packet transmission delay at router R1and R2: 1 sec

total delay over 3 links: 100.02 sec + 1.02 sec + 1.02 sec = 102.06 sec