UNIVERSITY OF TORONTO

Faculty of Arts and Science

Sample Final Exam

CSC458 – Computer Networks

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Duration - 3 hours

Examination Aids:

Non-Programmable Calculators, 1 Double-Sided Page of Notes

(i) This exam is closed book and closed notes. However, you may refer to a sheet of 8.5”x11” paper (double-sided) of your own design. You can also use a non-programmable calculator.

(ii) Write your answers on the exam booklet only. You will not receive any points for any answer you write on the questions paper.

(iii) Make sure to write your name and student ID clearly on the exam booklet.

(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.

Part I - Multiple Choice Questions [4 points]

Instructions: In the following questions, check the assertion that appears to be correct. There is exactly one correct assertion per question. Checking the correct assertion will earn you one point. If you check an incorrect assertion, or if you check more than one assertion per question, you will not earn any points for that question. *Don’t forget to enter your answer on the exam booklet and NOT on this questions paper.*

1. TCP. Which one of the following is a true statement about TCP?

(a) TCP is a routing protocol used throughout the Internet.
(b) TCP establishes a connection between two end-hosts using a 2-way handshake scheme.
(c) TCP learns of congestion via packet loss or variations in delay.
(d) If the SYN packet sent by a TCP source is lost, the connection is closed.

2. Coding. Suppose a 10Mb/s adapter uses Manchester encoding to send an infinite stream of 1's into a link. How many transitions per second will the signal emerging from this adapter have?

(a) 5 million transitions per second.
(b) 10 million transitions per second.
(c) 20 million transitions per second.
(d) None of the above.

3. Random Early Detection (RED). Which of the following is true?

(a) RED is tolerant of bursts because when the average queue occupancy is close to the maximum threshold, there is still room in the queue to accept new bursts of packets.
(b) The probability of RED dropping a packet belonging to a flow is proportional to the number of the flow's packets queued at the router.
(c) RED drops packets with probability 1 when the router's queue length is greater than the maximum threshold value.
(d) If two flows, one TCP and one UDP, share a "RED" router, the RED algorithm will ensure that both flows receive an identical share of the outgoing link.

4. TCP. Which of the following statements is true about TCP?

(a) TCP segments can only be lost when router queues overflow.
(b) There is no performance benefit to having a window size larger than the receiver window size.
(c) The received sees duplicate ACKs (with the same sequence number) only when a packet is lost.
(d) A receiver reduces the advertised window size in response to congestion.

<u>Part II - Definitions [3 points]</u>

Describe each of the following terms/concepts clearly and concisely (in at most 4-5 sentences). For each of these terms, explain the context they are defined at – which protocol(s) they are related to, when/where they are used, etc. – and give examples if possible. Remember to use the exam booklet and not this paper for your answers.

1. Fast Retransmission

2. Nagle's Algorithms

3. Maximum Segment Size (MSS)

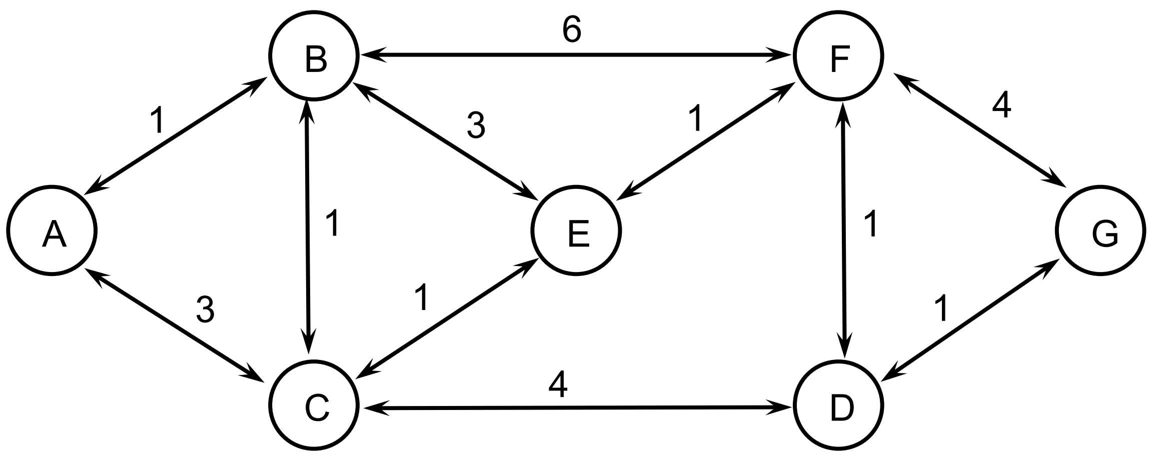
4. Stub Autonomous System (AS)

5. Interior Gateway Protocol (IGP)

6. Distance Vector

Part III - Longer Questions [18 points]

1. Routing Protocol [2 points]. Consider the network topology shown below. The topology consists of multiple routers interconnected by full-duplex links. Each link has a static cost associated with it, which represents the cost of sending data over that link. For example, the link from B to F has a cost of 6. All of the links are symmetric (i.e. the cost is the same in both directions, such as between B and F).



(a) If we use Bellman-Ford's distributed algorithm to find the shortest path between every pair of nodes, how many steps will it take for the algorithm to converge in this case? Explain.

(b) In general if we have a network with ***N*** nodes, what is the maximum number of steps for the Bellman-Ford algorithm to converge? Explain.

2. Spanning Trees [4 points]. Ethernet switches compute a spanning tree using the spanning-tree protocol.

2a) Explain briefly how the spanning tree protocol works. **(2 points)**

2b) Do the switches learn the network topology (connecting the switches), like routers do in a link-state protocol? Does each pair of switches communicate over a shortest path, like routers do in link-state protocols? **(2 point)**

3. TCP [6 points]. Consider a TCP flow over a 1-Gb/s link with a latency of 1 second that transfers a 10 MB file. The receiver advertises a window size of 1 MB, and the sender has no limitation on its congestion window (i.e., it can go beyond 64 KB).

(a) How many RTTs does it take until slow-start opens the send window to 1 MB?

(b) How many RTTs does it take to send the file?

(c) If the time to send the file is given by the number of required RTTs multiplied by the link latency, what is the effective throughput of the transfer?

(d) What percentage of the link bandwidth is utilized?

4. Power [6 points]. In class and the textbook, we used the somewhat arbitrary measure of "power" to characterize network performance. The usual definition of power, ***P***, is given by:

$$\boldsymbol{P} = \frac{\text{load}}{\text{average delay}}$$

(a) Explain why this definition of power is commonly used, and in what sense it is "arbitrary".

(b) A commonly used approximation to the relationship between normalized load (which can vary between 0 and 1 only) and average delay is $\boldsymbol{d} = \frac{1}{1-\boldsymbol{\lambda}}$; where $\boldsymbol{\lambda}$ is the normalized load offered to the network and ***d*** is the average delay of packets passing through the network. Find and sketch the value of power, ***P***, as a function of the offered load for this network. Be sure to show the minimum and maximum values of power and load, as well as the value of offered load that maximizes the power.

(c) Now suppose we modify the definition of power to give more emphasis to throughput than delay, i.e. let us have $\boldsymbol{P} = \frac{\boldsymbol{\lambda}^2}{\boldsymbol{d}}$. Sketch the new power function against the offered load, being careful to show the maximum and minimum values of both load and power, as well as the value of load that leads to maximum power. Comment on why the value of load that maximizes the power is larger than in the previous part of the question.

Total Marks = 25 points