UNIVERSITY OF TORONTO

Faculty of Arts and Science

DECEMBER 2015 EXAMINATIONS

CSC458H1F – Computer Networks

Duration - 3 hours

Examination Aids:

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

Name: **Student ID:**

(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 in the space provided on this paper. If you need extra space you can use the reverse side of each page.

(iii) Make sure to write your name and student ID clearly 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	
Multiple Choice 1-6 (1 pt each total 6pts)	
Comparisons 7-10 (1 pt each total 4 pts)	
Longer Questions	
11 (6 pts)	
12 (2 pts)	
13 (2 pts)	
14 (4 pt)	
Total 24 points	

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Part I - Multiple Choice Questions [6 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.

1. Software-Defined Networking (SDN). Which of the following statements is true about software-defined networking?

(a) A software-defined network is the same as a traditional network, except all the hardware components have been replaced by software.
(b) In a software-defined network, the switches are responsible for choosing the shortest path to reach each destination.
(c) In a software-defined network, the controller can install new flow entries in switches.
(d) The controller uses iBGP to find shortest paths between different hosts in a software-defined network.

2. OpenFlow. Which one of the following is a true statement about OpenFlow?

(a) OpenFlow is a centralized SDN controller.
(b) OpenFlow is an abstraction that defines the interface between packet forwarding elements (switches) and the controller.
(c) OpenFlow is a protocol that describes how SDN controllers need to coordinate with each other.
(d) OpenFlow is the routing protocol in a software-defined network.

3. TCP. Which one of the following statements is true about TCP?

(a) TCP provides both congestion control, and flow control.
(b) TCP provides flow control but no congestion control.
(c) TCP provides congestion control, but no flow control.
(d) TCP provides no congestion control and no flow control.

4. Early Congestion Notification (ECN). Which of the following is true about ECN?

(a) ECN allows the router to notify the source about congestion without actually dropping the packet.
(b) ECN allows routers to notify the source about congestion by increasing the drop rate.
(c) ECN drops packets with probability 1 when the router's average queue length is greater than the maximum threshold value.
(d) ECN can entirely eliminate congestion in a network.

5. Middleboxes. Which of the following statements is true?

(a) A transparent web proxy can connect multiple web servers to each other.
(b) A firewall acts like a server and a client at the same time.
(c) We are running out of IPv4 addresses. A firewall can help with that problem.
(d) A web proxy can help reduce the time needed to download popular web content.

6. Distance Vector Routing. Which of the following statements is true about distance vector routing?

(a) In distance vector routing the routers keep track of the entire path towards each destination in the network.
(b) Distance vector routing relies on the exchange of information between neighboring routers to calculate the routes.
(c) Distance vector routing relies on flooding to notify routers about link up and down events.
(d) BGP is an example of distance vector routing protocols.

Part II – Comparisons [4 points]

Describe each of the following terms/concepts clearly and concisely (in at most 3-4 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 where possible.

7. Flow Control [1 point]

8. Distributed Denial of Service Attack [1 point]

9. Exterior Gateway Protocol (EGP) [1 point]

10. Nagle's Algorithm [1 point]

Part III - Longer Questions [16 points]

11. TCP [6 points]. Consider the behavior of a TCP slow start mechanism. At time 0, a TCP sender initiates a connection. As soon as the connection is established, the TCP sender will begin sending

data. The MSS is 1KB and RTT is 80ms.

(a) Describe the slow start phase, including its rationale, how it works, and what its start and stop conditions are.

(b) Why do connections often experience multiple packet losses during slow start?

(c) Assuming the connection does not lose any data or experience any timeouts, at what time will the sender's congestion window be 32KB?

(d) Right after the sender's congestion window has reached a size of 32KB, a timeout occurs. After the timeout is detected, the sender continues sending more data over the established connection. Assuming no additional packet loss or timeouts, how long (since the observed timeout) will it take for the congestion window to build to size 20KB?

(e) Describe fast retransmit, how it works, and its rationale.

(f) While its congestion window is at 20KB, the sender receives three acknowledgements for the same sequence number. How long after receiving the third acknowledgment will it take for the sender's congestion window to be at least 16KB again?

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12. Sequence Numbers [2 points]. TCP relies on a sequence number to identify which bytes have been sent and which ones are acknowledged.

(a) Explain why TCP connections use a random number for their initial sequence number instead of starting with 0 or 1?

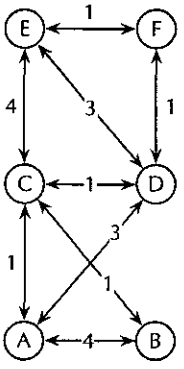
(b) Consider a 1-Gbps link. Assuming TCP could utilize the full bandwidth of the link continuously, what is the minimum and maximum amount of time it would take for the sequence number to wrap around?

13. Network Address Translation (NAT) [2 point]. NAT is a very common middelbox in today's Internet.

(a) When a packet is going from a local-area network onto the Internet, which header fields might be changed by a NAT device which is deployed on that path? Name two.

(b) Explain two reasons why we need to clean up defunct mappings in a NAT? (3-4 sentences max).

14. Routing Protocol [4 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 **A** to **D** has a cost of 3. All of the links are symmetric (i.e. the cost is the same in both directions).



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(a) (3 points) Using Dijkstra's algorithm, find the shortest-path spanning-tree for routing packets from router **A** to every router in the network. 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 router in the shortest path set, next-hop on the path to the new router, cost to reach the router). Note that here the next-hop is from router **A**'s perspective, i.e., if we have a packet sitting in router **A** and destined to the new router, which is the next-hop that packet has to take? Clearly, the next-hop for a packet sitting in **A** can be one of the two nodes **B**, or **C**.

Step	New entry in shortest path set (Router, Next-hop, Cost)	Shortest-path set **S**
1	(***A***, ***A***, 0)	**S** = {***A***}
2	(***C***, ***C***, 1)	**S** = {***A***, ***C***}
3		

(b) (1 point) What is the "count-to-infinity" problem? Can we have this problem in Dijkstra's algorithm? Explain why.

Total Marks = 24 points