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Student ID Number: __________________________  

Date of Exam: Feb 23, 2015  
Time Period: 6pm-7:20pm  
Number of Exam Pages: 7  
(including this cover sheet)  
Exam Type: open book/notes  

Marking Scheme:  

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1. Internet Design (10 pts)

(a) (5 pts) Important goals for the DARPA Internet protocols include support for multiple
types of communication service and the ability to accommodate a variety of networks.
List at least two types of communication services and two types of networks used in
today’s Internet.

(b) (5 pts) In the figure below, each link provides perfect reliability and perfect security. In
other words, the link will never drop or re-order any packets and packets on the wire
cannot be observed or modified. Node A wants to establish a reliable and secure com-
munication channel with node E. Describe how the link properties of perfect reliability
and perfect security will (or will not) help in establishing a reliable and secure channel
between A and E.
2. BGP puzzles (10 pts). In class we learned that BGP convergence may take an extremely long time! Even worse, in theory, a path vector protocol like BGP may never converge. In the topology shown in Figure 2a, each circle represents an AS. The path preference of each AS to reach AS 0 is specified in the figure. Each AS prefers the path announced by the next AS clockwise, regardless of the path length. The next preferred path is the direct path, and the least preferred path is the one announced by the next AS counter-clockwise.

(a) (5 pts) Describe a stable path assignment for AS 1,2,3 to reach AS 0 such that no AS will change its path choice, i.e., no AS has a more preferable path that does not contain a loop. Describe the path assignment using words such as AS 1 selects path 1 0. (Hint: there are at least three such assignments.)

(b) (5 pts) Consider an initial path state such that AS 1 selects path 1 0, and AS 2 selects path 2 0, and AS 3 selects path 3 1 0. BGP in this topology may never converge with this initial state. Explain why using the sequence of BGP messages each AS would announce.
3. (10 pts) BGP slow convergence. Suppose in Figure 2, all ASes select the shortest AS path to reach the destination AS D. AS A has \( n \) neighbors, each of which is on a path of length \( i \) \((i=1,\ldots,n)\) path to reach AS B as shown in the figure. The nodes B and D have a directed link and a path of length \( x+2 \) (i.e., \( BQ_1Q_2\ldots Q_x D \)) connecting them. Each AS’s Minimum Route Advertisement Interval (MRAI) timer is set to 30 seconds. Answer the following questions.

(a) (2 pts) Before the link between ASes B and D fails, what is A’s BGP path to D?

(b) (4 pts) After the link between B and D fails, how long will it take for A to converge to the new path?

(c) (4 pts) Can you come up with a proposal to speed up BGP convergence in this topology? Please explain your answer.
4. (10 pts) TCP unfairness. Suppose TCP flows $H_a$ to $H_b$ and $H_c$ and $H_d$ share a bottleneck link as shown in Figure 3. Router $R_1$ uses a RED queue. Answer the following questions. Each TCP flow sends packets of size 1000 bytes.

(a) (5 pts) To keep the bottleneck link between $R_1$ and $R_2$ fully utilized, what should be the average packet loss rate at $R_1$? Explain how you obtain the results.

(b) (5 pts) Does TCP+RED achieve a max-min fair allocation between flows competing for the same bottleneck link? If not, explain why.
5. (10 pts) After learning how to design and analyze congestion avoidance protocols, Ben Bit-Diddle have a new idea and proposes a new three-phase congestion avoidance protocol similar to VCP. This protocol works as follows. When a link’s utilization is less than 80%, all flows multiplicatively increase their rates; and when the utilization is between [80%, 100%], flows additively increase their rates; and after the link is congested, flows multiplicatively decrease their rates. Use the phase plot shown below to explain whether this protocol will converge to a fair and efficient allocation. Assume all flows have the same RTTs.
6. (10 pts) Among all the papers we have studied so far, which one do you like the most, and which one do you dislike the most? Explain why. Please be concise.