

Carnegie Mellon  
Computer Science Department.  
**15-744 Fall 2009 Midterm 1**

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**INSTRUCTIONS:**

There are 11 pages (numbered at the bottom). Make sure you have all of them.

Please write your name on this cover and put your initials at the top of each page in this booklet **except the last**.

If you find a question ambiguous, be sure to write down any assumptions you make.

It is better to partially answer a question than to not attempt it at all.

Be clear and concise. Limit your answers to the space provided.

Question	A	B	C	D	E
Points	/ 30	/ 20	/ 20	/ 25	/ 5

## A True/False

Mark ALL answers that apply

1. Which of the following is true about modern high-speed routers?
  - A. A typical crossbar-based router uses input queueing so that it can implement sophisticated Quality-of-Service (QoS) processing.
  - B. The iSlip crossbar scheduling algorithm (a round-robin Parallel Input Matching algorithm) is efficient, but in practice does not fairly allocate time slots.
  - C. High-performance routers can not change the IP packets they forward at all
  - D. High-performance routers use a bus-based achitecture to achieve very high packet forwarding rates.
  - E. In a high-performance router, copies of the forwarding table are kept in the output ports.
  - F. In a high-performance router, copies of the forwarding table are kept in the input ports.

**Solution:** Only (f) is correct.

2. Which of the following is/are true about different unicast routing protocols:
  - A. The BGP routing protocol makes use of an area hierarchy.
  - B. Each iteration of a distance vector protocol (neighbor exchange) and each iteration of a link state protocol (LSP flood) creates the same number of total messages across the entire network.
  - C. The use of split-horizon and poison-reverse in a distance-vector protocol like RIP always prevents the count-to-infinity problem when a network partition occurs.
  - D. BGP always uses the shortest path (in terms of router hops) between two nodes.
  - E. Link-state protocols do not suffer from the count-to-infinity problem.

**Solution:** Total: 5 pts

- (A)(3 pts) and (E)(2 pts ) are correct answers
- (B)(-3 pts LSP flood requires node \* edges, DV requires 2 \* edges
- (B)(-2 pts) Split horizon and poison reverse fix single hop loops, but multiple hop loops can still remain.
- (E)(-2 pts) BGP uses the shortest number of AS path hops, not router hops.

3. Why is it not necessary to perform admission control on a network in which there are only elastic applications?

**Solution:** adding applications (and reducing everyone's bandwidth proportionally) actually increases the total utility of the network

4. Which of the following is true about different wireless networks?
- A. In a white space network, participating nodes may not be able to use the same set of wireless network channels.
  - B. Since channels are used one at a time, the set of available channels in a white space network will be contiguous.
  - C. In a pair of “cells” that are far from each other, all clients in both cells will correctly prefer to have both cells have concurrent (i.e. simultaneous) transmission.
  - D. In a pair of “cells” that are close to each other, all clients in both cells will correctly prefer to have both cells have concurrent (i.e. simultaneous) transmission.

**Solution:** a and c are true

5. In a pair of “cells” in which the nodes do not agree that concurrency or multiplexing is the correct choice, what prevents throughput from dropping significantly?

**Solution:**  
rate adaptation makes the penalty of being forced into the non-optimal choice minimal

## B TCP, RED, and Fair Queueing

6. Recall that TCP's throughput depends on the RTT, the packet size (MSS), and the loss rate ( $p$ ). Two connections experience the same loss rate and use the same packet size. Connection A has RTT 5ms, and connection B has RTT 10ms. Express the throughput of connection B ( $tput_B$ ) in terms of the throughput achieved by connection A ( $tput_A$ ), or indicate if there is no relationship between the two.

**Solution:**  $tput_B = \frac{tput_A}{2}$

7. You remember from an earlier lecture that Random Early Detection gateways (RED) compute a loss probability  $p$  and drop packets randomly based upon this probability. Suppose that two TCP connections A and B traverse a network consisting only of RED gateways. They both traverse the same congested gateway, and do not traverse any other congested gateways. Assume that the flows have the same RTT and packet size.

- (a) Express the throughput of connection B ( $tput_B$ ) in terms of the throughput achieved by connection A ( $tput_A$ ), or indicate if there is no relationship between the two. Give a one-sentence explanation of your answer.

**Solution:**  $tput_B = tput_A$ . The two flows experience the same loss rate, and have the same RTT.

- (b) List two advantages that RED provides over drop-tail queueing.

**Solution:**

- Prevents burst losses
- Prevents lock-out / shares b/w more fairly
- Prevents full queue problems / shorter queueing delays

8. A third network uses routers with fair queueing. This is *not* weighted — all weights are the same.

- (a) Two connections share the same congested gateway and have no other congested gateways. Connection A has RTT 5ms, connection B has RTT 10ms. Express the throughput of connection B ( $tput_B$ ) in terms of the throughput achieved by connection A ( $tput_A$ ), or indicate if there is no relationship between the two.

**Solution:**  $tput_B = tput_A$

- (b) Two connections traverse the same congested gateway, but *also* traverse some other unshared congested gateways. Express the throughput of connection B ( $tput_B$ ) in terms of the throughput achieved by connection A ( $tput_A$ ), or indicate if there is no relationship between the two.

**Solution:** Without knowing the other flows in the network, you cannot find a relationship between the two.

## C Phase Plots

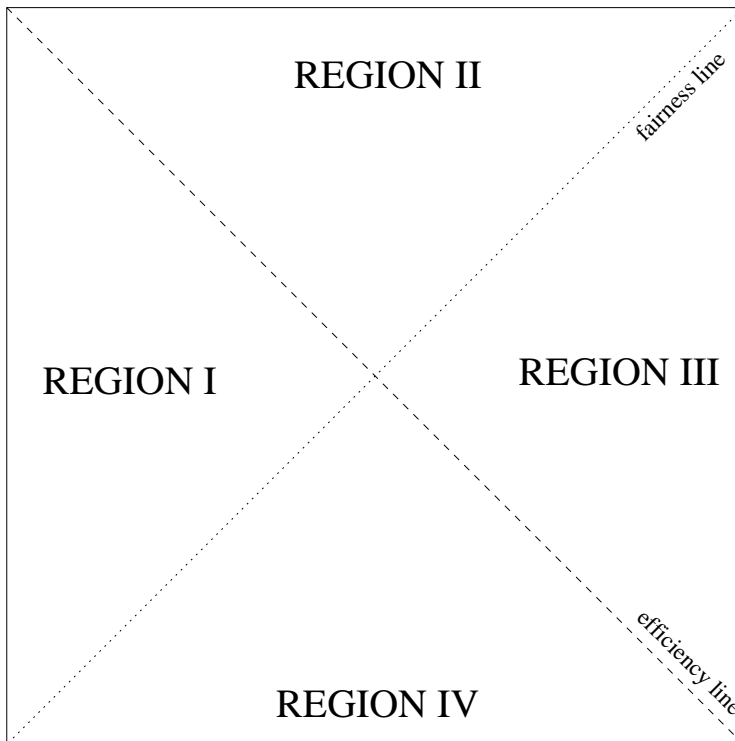
Harry Bovik is building a new type of router. The router uses three explicit feedback messages - DECREASE, STAY and INCREASE - to communicate with sources in the network. It uses these messages in the following ways:

- If the network is underutilized, the router sends an INCREASE message to all sources.
- If the network is overutilized, the router sends a DECREASE to the sources with the high-est allocation and STAY messages to all other sources.
- If the network is perfectly utilized, the router sends a DECREASE to sources with the highest allocations.

We will assume that the number of streams using the router is always fixed, feedback messages are never lost, and the round-trip times for all connections are the same.

Despite having learned from the Chiu and Jain paper that additive-increase/multiplicative decrease (AIMD) is the “only good scheme”, Harry decides that sources in this network should use additive increase/*additive decrease* (AIAD). In this scheme, each source will increase its sending rate additively by a small amount in response to a INCREASE message, decrease additively by a small amount on a DECREASE message, and not adjust its sending rate on a STAY message. Harry claims that the system should still converge to fairness and efficiency.

9. Harry decides to use phase-plots to check his intuition for the two-user case. The figure belows shows a simple phase plot. In the graph, the state of the system is represented by a point  $(x_1, x_2)$ , where  $x_1$  is stream 1’s current rate and  $x_2$  is stream 2’s current rate. The total capacity of the link is  $C$  bits/s. On the figure, for each of the labelled regions, I, II, III, and IV, draw vectors indicating the direction in which the system will move after feedback from the router.



10. In each of the following regions, does the response to the router messages increase, reduce or keep fairness the same?

Region I:

**Solution:** Increase (AI)

Region II:

**Solution:** Increase (AD for max flows only)

Region III:

**Solution:** Increase (AD for max flows only)

Region IV:

**Solution:** Increase

On the 45-degree line through the origin:

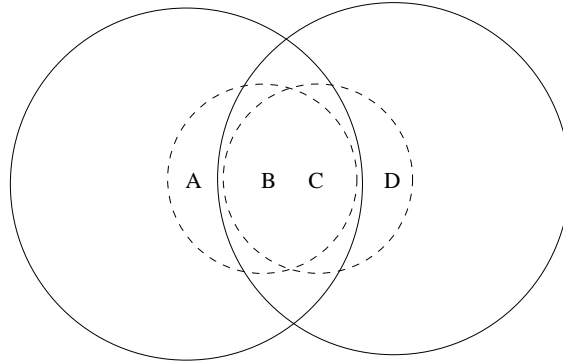
**Solution:** Constant

11. Does Harry's scheme converge to a fair allocation? Explain your answer.

**Solution:** Yes, increase or constant fairness in all regions.

## D Exposed & Hidden Terminals

Wireless radios that transmit with higher power will have a larger range. Consider the wireless topology below:



The solid circles represent the transmission radius of nodes A and D, respectively, and the dashed circles represent the transmission range of B and C, respectively. Assume that if the transmissions of two nodes' will interfere at a location if and only if they transmit at the same time and their transmission areas overlap. In these problems, assume that losses only occur due to collisions.

12. When node **A** transmits to node **B**, list the potential hidden terminals (in either direction - those who might clobber A's transmission or those who A's transmission might clobber) and exposed terminals.

**Hidden terminals:**

**Solution:**

C and D are both hidden terminals. If they were transmitting, A would not see them and would clobber reception by either B or C. Similarly, if A was transmitting, D would not see the transmission, and might clobber reception at B.

**Exposed terminals:**

**Solution:** C. When A is transmitting to B, C could (in the absence of ACKs) transmit to D.

What about when node **B** transmits to node **C**?

**Hidden terminals:**

**Solution:** D is a hidden terminal. It might broadcast, not hearing B's transmission, and clobber reception at C.

**Exposed terminals:**

**Solution:** None



13. Suppose A is sending data to B and C is sending data to D, both at a constant bit rate equal to the physical capacity (“as fast as they can”).

- (a) Assume that no mechanism is used to detect or avoid collisions. What is the throughput of each transfer as a fraction of its send rate?

**Solution:**  $A \rightarrow B \approx 0$ ,  $C \rightarrow D = 1$ . All of A’s transmissions to B will collide with C’s transmissions.

- (b) Now suppose that each node uses CSMA/CA. Again, express the throughput of each transfer as a fraction of its send rate.

**Solution:**  $A \rightarrow B = 1$ ,  $C \rightarrow D \approx 0$ . A’s transmissions will clobber C’s because C will always backoff. A can not hear C so it will never back off.

- (c) Now assume that we also use an RTS/CTS scheme like that in MACAW. An RTS is sent if and only if no other RTS or CTS has been heard recently; ditto for a CTS. Assume that RTS/CTS exchanges are small compared to data packets and have negligible overhead. Again, express the throughput of each transfer as a fraction of its send rate.

**Solution:**  $A \rightarrow B \approx 1/2$ ,  $C \rightarrow D \approx 1/2$ . The first node-pair to get an RTS and CTS through will obtain the channel. The node pairs are symmetric, so about 1/2 the time, each pair will obtain the channel.

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The End – Phew!

**E Free Points for Tearing Off Page: Anonymous Feedback**

List one thing you liked about the *class* and would like to see more of or see continued (any topic - lectures, homework, projects, discussion site, topics covered or not covered, etc., etc.):

List one thing you would like to have changed or have improved about the class: