Name: ____

Department of Electrical Engineering and Computer Science

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

6.829 Computer Networks: Spring 2013

Quiz I

There are 19 questions and 10 pages in this quiz booklet. Answer each question according to the instructions given. You have **100 minutes** to answer the questions. The maximum score is also 100 (that might help with time management).

Please explain your answers in the space provided below each question; in many cases, even if your answer is incorrect, your explanation may help you earn partial credit. If you find a question ambiguous, be sure to write down any assumptions you make.

Be neat and legible. If we can't understand your answer, we can't give you credit!

Use the empty sides of this booklet if you need scratch space. You may also use them for answers, although you shouldn't need to. *If you use the blank sides for answers, please say so clearly!*

PLEASE WRITE YOUR NAME IN THE SPACE ABOVE AND SIGN THE STATEMENT BELOW.

4 crib sheets allowed; no other supporting materials.
MAKE SURE YOU'VE READ ALL THE INSTRUCTIONS ABOVE!

Honor code: I certify that I will not receive aid from any unauthorized materials or persons, nor give aid to anyone else, on this quiz. I will not exceed the time allotted for this quiz.

Signed: ____

Do not write in the boxes below

1-2 (x/9)	3-4 (x/10)	5 (x/10)	6-7 (x/13)	8-10 (x/9)

11-12 (x/12)	13-15 (x/12)	16 (x/12)	17-19 (x/13)	Total (x/100)

I TCP Congestion Control

1. [3 points]: Consider a long-running TCP connection running additive-increase/multiplicative-decrease (AIMD), experiencing a packet loss rate of ℓ and round-trip time of R seconds, using packets of size s bytes.

We saw in lecture that such a connection's throughput in bytes/s is proportional to $\frac{s^a}{\ell^b R^c}$, where

$a =$ ____________________

$b =$ ____________________,

$c =$ ____________________.

2. [6 points]: Suppose the current TCP window size is 28000 bytes and the maximum segment (packet) size is 1400 bytes. The congestion window is maintained in bytes. In slow start, each incoming new ACK increments the congestion window by the maximum segment size.

Suppose the sender previously received cumulative ACK 135801 (i.e., the receiver says it got all bytes sent to it, up to and including, sequence number 135800). The sender next receives cumulative ACK 140001.

Assuming the sender is in slow start and has enough data in its transmit socket buffer, calculate the number of bytes it now sends.

Number of bytes = ____.

II Router-Assisted Congestion Control

3. [6 points]: Consider a RED router with $\max_p = 0.04$, $\min_{th} = 8$ packets and $\max_{th} = 32$ packets. Each packet is 10000 bits long and the link rate is 10 Megabits/s (Mega = 1 million). On this router, Alyssa observes that the average time spent by a packet in the queue is 16 milliseconds. Using these observations, calculate the RED router's packet drop probability.

RED packet drop probability = ________________________

4. [4 points]: Circle **True** or **False** for each statement below about XCP.

A. True / False XCP can achieve fair throughput allocations amongst multiple XCP connections without maintaining any per-flow state in the routers.

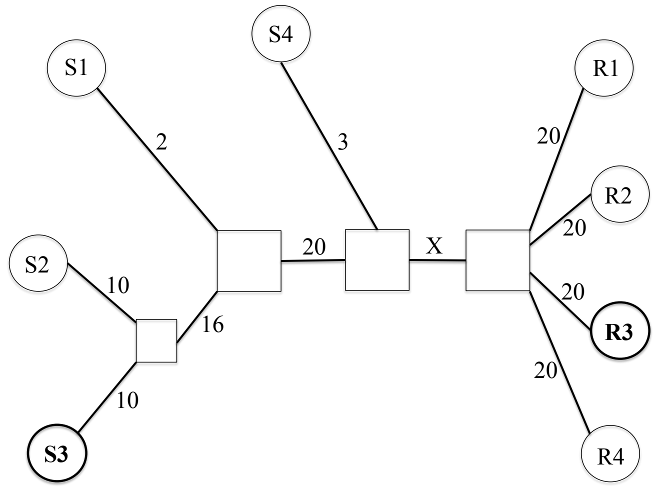
B. True / False To achieve its goals, XCP requires queue management to be done using RED.

C. True / False To compute its feedback, an XCP router needs to know the rate of the link on which the packet is being sent.

D. True / False An XCP router's feedback has a term proportional to $-Q$, where Q is the instantaneous queue length.

III Fair Queueing

5. [10 points]: Each router (a rectangularly-shaped node) in the figure below runs **per-flow fair queueing with equal weights**. The senders and receivers are shown as circles. Four concurrent backlogged flows are active: S1 to R1, S2 to R2, S3 to R3, and S4 to R4. The number next to each link is the link's rate in Megabits/s.



In the following questions, we are interested in the **throughput of the S3-to-R3 flow**.

A. The throughput when X = 30 is ____________________.

B. The throughput when X = 7 is ____________________.

C. Sketch the graph of the throughput as a function of X, the link rate of one of the links in the picture above. Label the values on the x and y axes where the curve changes direction or slope.

IV Router Design

6. [5 points]: Circle **True** or **False** for each of the following statements about switch scheduling.

A. True / False Parallel Iterative Matching (PIM) uses randomization; iSLIP does not.

B. True / False iSLIP improves on round-robin scheduling

C. True / False PIM, round-robin scheduling, and iSLIP always produce maximal matchings within 3 iterations.

D. True / False iSLIP requires a speedup > 1 to achieve 100% switch utilization.

E. True / False To perform well, iSLIP requires some mechanism to avoid head-of-line blocking, such as virtual output queueing.

7. [6+2=8 points]: This question is about router buffering. Consider an AIMD congestion control scheme where the window size increases by 1 packet every RTT without congestion, and the window size decreases from W to βW when the sender detects congestion.

A. Suppose we have just one connection with RTT R running over the bottleneck link whose rate is C. Then, the smallest amount of router buffering required for this scheme to achieve 100% utilization is ____. **Explain below.**

B. Suppose there are N unsynchronized connections with the same RTT sharing the bottleneck link. Let the answer to Part **A** be Q. Then, with high probability, what is the smallest amount of buffering needed to achieve 100% utilization?

A. Q/N **B.** $Q/\sqrt{N}$ **C.** Q/N^{β} **D.** Q

V Mobility

8. [1 points]: Fill in the blank: the home agent in Mobile IP intercepts packets destined for the mobile host and encapsulates them by setting the destination address to the

____.

9. [6 points]: Circle **True** or **False** for each of the statements below.

A. True / False If all connections are initiated from the mobile host, then there is no reason for a correspondent (fixed) host using Mobile IP to use the mobile host's permanent home address in order to achieve correct routing of packets to the mobile host.

B. True / False In Mobile IP, when a mobile host moves, information about its new location must be sent to the corresponding (fixed) host.

C. True / False Let M be a mobile host in a foreign network and F be a fixed host. Suppose F and M are able to communicate successfully using Mobile IP. Then, the unicast Internet path between F and M's care-of address (in the foreign network) is guaranteed to be a working path.

D. True / False Mosh allows an interactive terminal session to be resumed after many hours of disconnection, while SSH running over Mobile IP may not.

E. True / False With Mosh, a mobile client will be able to resume a session by sending exactly one packet to the server (assuming that packet isn't lost).

F. True / False SSH running over a Mobile IP supports both ends being simultaneously mobile, whereas Mosh does not.

10. [2 points]: Mosh uses the State Synchronization Protocol (SSP), which ensures which of the following properties?

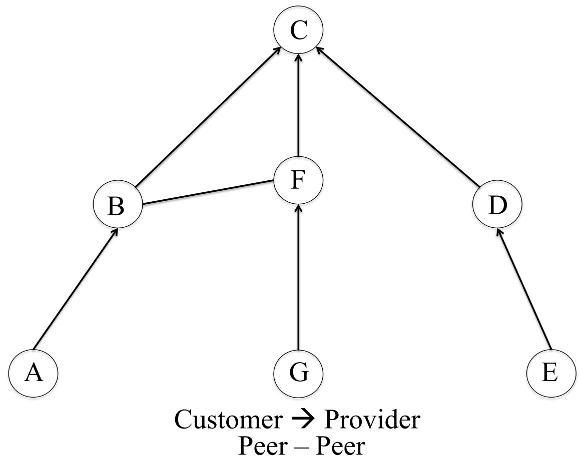
(Circle **True** or **False** for each choice.)

A. True / False States are delivered in exactly the order in which they were traversed by the sender.

B. True / False All states traversed by the sender are delivered reliably.

VI BGP

In the interdomain topology shown below, each node is an autonomous system (AS). Denote the set of IP addresses inside an AS X by IP_X. Assume standard customer-peer-provider route filtering and ranking rules as discussed in class. There are no other autonomous systems of interest in the following questions.



Consider AS F. From each of its neighboring autonomous systems, F receives some set of routes using BGP.

11. [6 points]: From each AS given below, for which **IP addresses** (in IP_X notation) does F receive advertisements?

Neighbor AS	IP addresses
From G:	
From B:	
From C:	

12. [6 points]: After F processes BGP advertisements received from each neighbor, F routing table entries whose next-hops are routers in a neighboring AS. For each neighboring AS given below, list the **IP addresses** (in IP_X notation) for which that AS's router is F's next-hop.

Next-hop	IP addresses
G:	
B:	
C:	

VII Zigzag and Spinal Codes

13. [1+2+1=4 points]: Circle **True** or **False** for each statement below about Zigzag decoding.

A. True / False It detects that a collision has occurred by seeing if the packet's CRC or checksum fails.

B. True / False It can successfully decode at least one packet if the first collision involves packets P_1 and P_2 and the second collision involves packets P_1 and P_3, as long as all packets are sent by the same two nodes.

C. True / False It requires all packets to have a known preamble.

14. [5 points]: Ben Bitdiddle implements spinal codes in his system. He uses the puncturing schedule described in the Perry et al. paper, where in each punctured pass every 8th symbol is transmitted. He uses $k = 5$ (i.e., 5 message bits are passed to the hash function on each invocation). On average, he finds over a certain channel that a message gets decoded successfully after 30 punctured passes. Calculate the average rate (in bits per symbol) achieved by the code over this channel. Assume there are no tail symbols. Explain your answer below.

Average rate = ____________________________.

15. [3 points]: Ben Bitdiddle wishes to improve the rate achieved by his spinal code implementation. Based on the results in the Perry et al. paper, which of the following methods is almost always likely to achieve his goal?

(Circle **True** or **False** for each choice.)

A. True / False Increase the beam width of the decoder from 16 to 32.

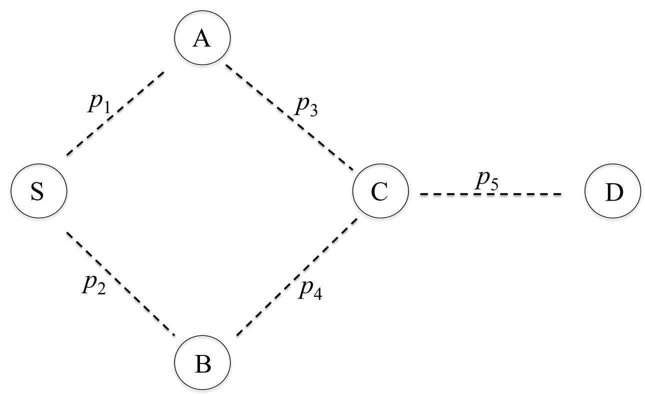
B. True / False Decrease the value of k from 5 to 2.

C. True / False Increase the number of tail symbols from 0 to 1.

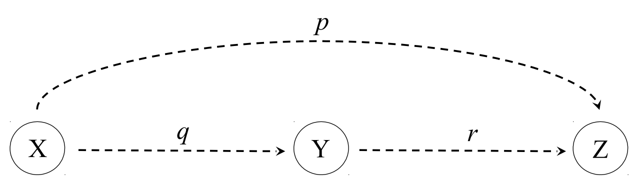
VIII Wireless Mesh Networks

16. [4+4+4=12 points]: In the questions below, the packet success probability is shown near each wireless link. Assume that link-layer ACKs are delivered with probability 1.

A. The wireless network shown below performs routing using the ETX metric. What is the expected number of transmissions to send a packet successfully from S to D?



B. The network below uses MORE to send data from X to Z. Under what constraints on p, q, r will MORE use node Y to relay packets to Z?



C. The network from Part **B** uses a batch size of K packets. Assume that Y is involved in relaying packets. Circle **True** or **False** for each statement below.

(a) **True / False** Node X transmits randomly coded packets from the batch.

(b) **True / False** Node Y forwards the packets it receives without re-coding them.

(c) **True / False** Once Z has received K packets, it is always able to decode the original message.

(d) **True / False** Once Z has received K linearly-independent packets, it is always able to decode the original message.

IX DHTs and Data-Centric Networks

17. [8 points]: Ben Bitdiddle implements a variant of Chord, called Bhord, without any data replication. In Bhord, when a node joins, it

1. finds the successor of its ID,
2. correctly sets the successor and predecessor pointers of itself as well as its closest neighbors (the successor and the successor's old predecessor),
3. moves the keys it is responsible for from the successor, and
4. updates finger table entries and periodically runs the Chord stabilization protocol.

Note that steps 2 and 3 are swapped from Chord. Circle **True** or **False** for each statement about Bhord below. Assume no packets are lost.

A. True / False A query issued by some other node for a key that the new node is responsible for may fail even though the key existed before the new node joined.

B. True / False Assume key k_1 has value 5, then some node issues *put*(k_1, *6*), then another node issues *get*(k_1). Bhord will always return 6.

Explain your answers in the space below.

18. [2 points]: For a peer-to-peer network, you are considering using either *Chord* or *Full Mesh*. In Full Mesh each node maintains a connection to all other nodes and search requests are flooded to all neighbors in parallel. Assume all round-trip times are large (RTT = 100 ms), links are fast ($> 10^7$ packets/sec), and there are 100 nodes in the network.

(Circle **True** or **False** for each choice.)

A. True / False Chord has lower search latency than Full Mesh.

B. True / False Chord consumes less bandwidth than Full Mesh for searches.

19. [3 points]: Circle **True** or **False** for each statement below about the CCN system.

A. True / False An Interest request in CCN is routed toward the source(s) of matching data, but may be served by any node en route that has the relevant data stored.

B. True / False An Interest request is flooded along all faces in a router, with a node terminating its flooding if there is a match in its storage or pending interest table.

C. True / False CCN uses a routing protocol to populate each node's FIB with entries of the form "name:face".