

**Name:**

**SID:**

Department of EECS - University of California at Berkeley  
EECS122 - Introduction to Communication Networks - Spring 2005  
Final: 5/20/2005

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**There are 10 questions in total. Please write your SID on each page.**

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**Question 1 (10 points)**

The statements are true/false (T/F); mark the appropriate choice.

1.  T –  F. Prefix-based addressing contributes to the scalability of the Internet.
2.  T –  F. Packet-switching supports widely different connection types and link rates.
3.  T –  F. The end-to-end principle is a set of rules for guaranteeing the quality of connections.
4.  T –  F. The address resolution protocol is needed when different hosts have the same IP address.
5.  T –  F. Generalized processor sharing is not used in routers because it is less efficient than weighted fair queuing.

**Question 2 (10 points)**

The following questions are multiple choice. Select the ONE answer that you think fits best.

1. Imagine ten packet flows, each controlled by a token bucket with size  $S$  bits and rate  $R$  bps. These flows go through one single router queue with bit rate  $C$ . The queue is initially empty. If  $C > 10R$ , then the maximum queuing delay cannot exceed
  - (a)  $S/(10R)$
  - (b)  $10S/C$
  - (c)  $S/R$
  - (d) None of the above.
2. Which one of the following is false?
  - (a) Ethernet does not use a NAV (network allocation vector) in the header.
  - (b) Wireless networks have higher propagation delay than wired ones.
  - (c) Wired networks such as Ethernet do not have the hidden node problem.
  - (d) Wired networks such as Ethernet do not have the exposed node problem.
3. Which of the following is a well-formed IP address?
  - (a) inst.eecs.berkeley.edu
  - (b) 00-E0-B8-49-52-67
  - (c) 216.67.5.003
  - (d) 264.112.34.9
4. To minimize the routing overhead in Ad-Hoc networks, following ideas are incorporated in the proposed routing protocols:
  - (a) Perform routing on-demand basis.
  - (b) Reduce the number of nodes involved in routing by delegating the networking routing function to only some of the neighborhood nodes.
  - (c) First attempt to perform pro-active routing updates only along the optimal paths determined previously.
  - (d) All of the above.
5. The RTS/CTS mechanism in **infrastructure** 802.11 Wireless LANs solves:
  - (a) Exposed node problem.
  - (b) Hidden node problem.
  - (c) Both exposed and hidden node problems.
  - (d) None of the above.

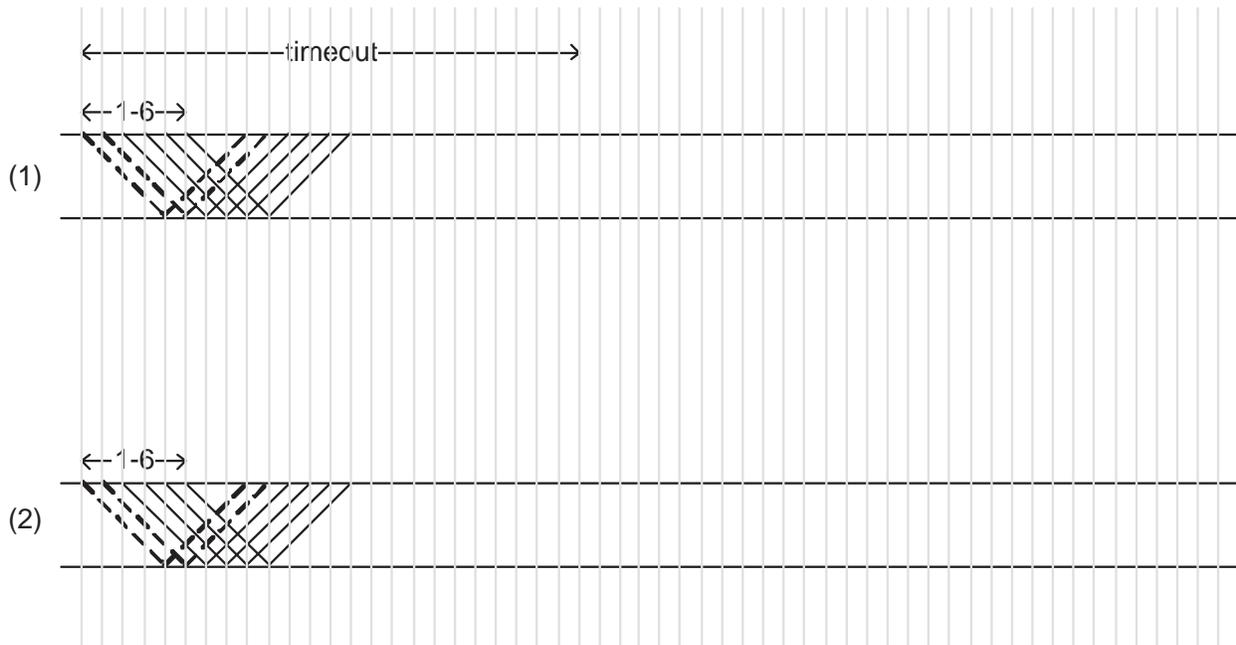


Figure 1: Diagrams for Question 3.

**Question 3 (12 points)**

Consider a TCP connection that, at time 0, is in the congestion avoidance phase with a window size equal to 6 MSS and then sends packets  $\{1, 2, \dots, 6\}$ . (The connection has sent packets before that were properly acknowledged.) All the packets have a length equal to one MSS. The round-trip time is very large compared to one packet transmission time. Packets 1 and 2 are lost. No other packet or ACK is lost.

To be specific, let  $RTT = 8$ , transmission time = 1, timeout = 24.

- (a) (6 points) Assume the sender does not implement fast retransmit nor fast recovery. After a timeout, it restarts in slow start. Draw a timing diagram that shows the transmission of the first eight packets by completing Figure 1 (1). Indicate the significant events, such as start of slow start (SS) or of congestion avoidance (CA) and the relevant congestion window sizes.
- (b) (6 points) Repeat the previous problem assuming that the host uses fast retransmit and fast recovery. Complete Figure 1 (2). Indicate the significant events, such as start of slow start (SS) or of congestion avoidance (CA) and the relevant congestion window sizes.

*Hint: When fast recovery begins, the window is set to  $CWND/2+3$ , and incremented by 1 with every subsequent duplicate ACK. When ACK for the retransmitted packet is received, the window is reset to half of the original CWND.*

**Question 4 (6 points)**

Alice wants to send a document  $P$  to Bob. She wants Bob to be certain that the document has been sent by her. Explain how they can achieve that objective using public key cryptography.

**Question 5 (15 points)** Consider a commercial 10 Mbps Ethernet configuration with one hub (i.e., all end stations are in a single collision domain).

(a) (4 points) Find Ethernet efficiency for transporting 512 byte packets (including Ethernet overhead) assuming that the propagation delay between the communicating end stations is always  $25.6 \mu s$ , and that there are many pairs of end stations trying to communicate.

(b) (3 points) Now consider an application making use of TCP/IP/Ethernet for the same scenarios as in (a). Assume that the overheads of TCP, IP, and Ethernet are 20, 20, and 26 bytes, respectively. How much total bandwidth is available at the application layer in this network?

(c) (4 points) Recall that the maximum efficiency of Slotted Aloha is  $1/e$ . Find the threshold for the frame size (including Ethernet overhead) such that Ethernet is more efficient than Slotted Aloha if the fixed frame size is larger than this threshold. Explain why Ethernet becomes less efficient as the frame size becomes smaller.

- (d) (4 points) Consider an 802.11b Wireless LAN (WLAN) operating at 10 Mbps and with fixed size frames. Assume we are operating without using RTS/CTS. Ignore the effect of propagation delay for the WLAN. Recall that each frame incurs the overhead of DIFS, Collision Window, ACK, and SIFS. Assume the combined overhead of DIFS, ACK, and SIFS to be  $200 \mu\text{s}$ . Further assume that the average Collision Window size is 1.5 times the transmission time of the frame. Give an expression for the WLAN efficiency. Find the range of fixed frame size where Ethernet is more efficient compared to WLAN.

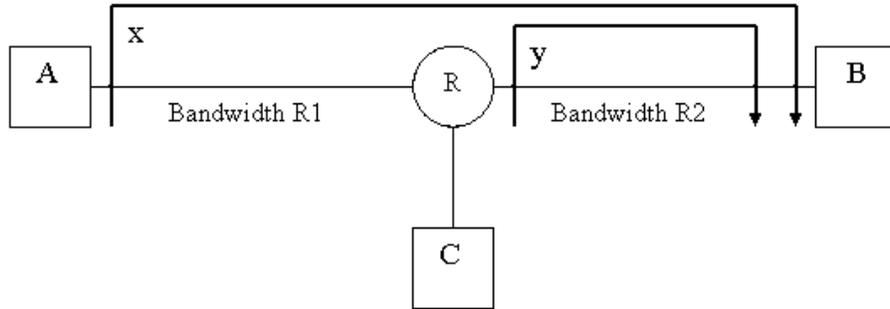


Figure 2: Diagram for Question 6.

**Question 6 (13 points)** Consider the configuration shown on Figure 2. Hosts A, B, and C are connected to each other via a router. The bandwidths of the links A-R and R-B are  $R_1$  and  $R_2$  respectively. The roundtrip time is the same between A-B, C-B and A-C.

(a) (8 points) Consider Figure 2. The rates for flows from A to B and C to B are  $x$  and  $y$  respectively. What are the values of  $x$  and  $y$  (as functions of  $R_1$  and  $R_2$ ) to which TCP converges? Figure 3 shows a diagram showing the sequence of rates (marked with solid lines) for specific values of  $R_1$  and  $R_2$ . Explain the rate changes occurring according to AIMD in Figure 3. You may assume that the transmission times are negligible.

(b) (5 points) Suppose another flow from A to C is also started (see Figure 4). Denote the rate of the additional flow as  $z$ . What are the values of  $x$ ,  $y$  and  $z$  (as functions of  $R_1$  and  $R_2$ ) to which TCP converges?

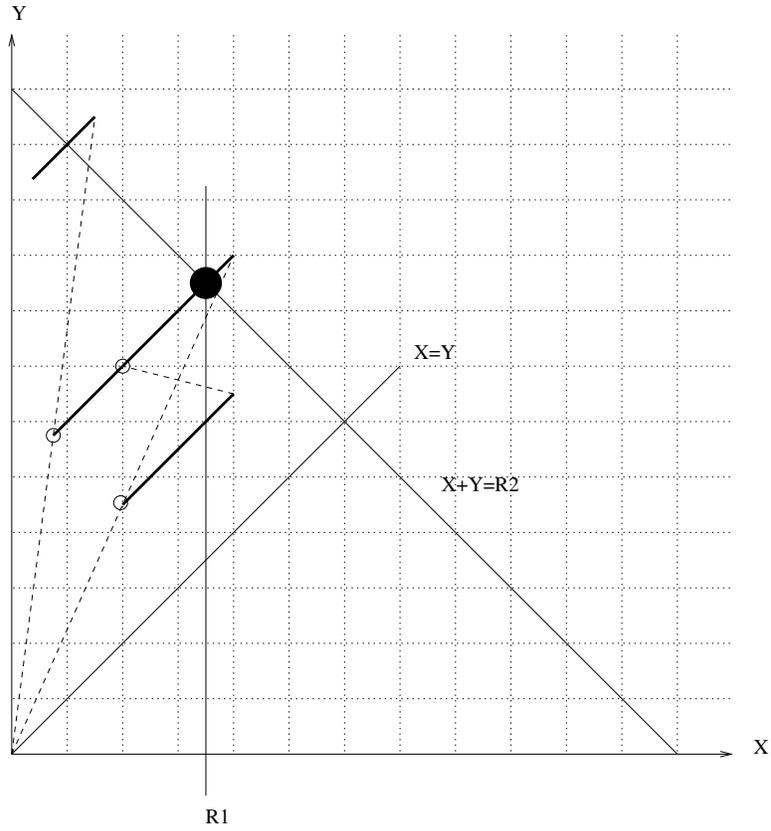


Figure 3: Diagram for Question 6(a). This shows the sequence of rates for specific values of  $R_1$  and  $R_2$ . The points on the solid lines are the rates ( $x$  and  $y$ ).

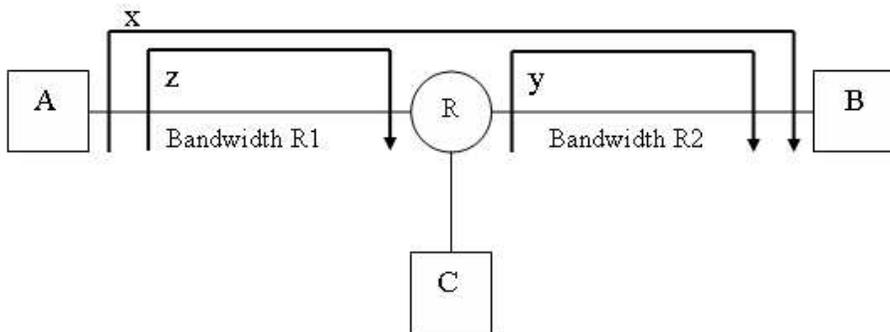


Figure 4: Diagram for Question 6(b).

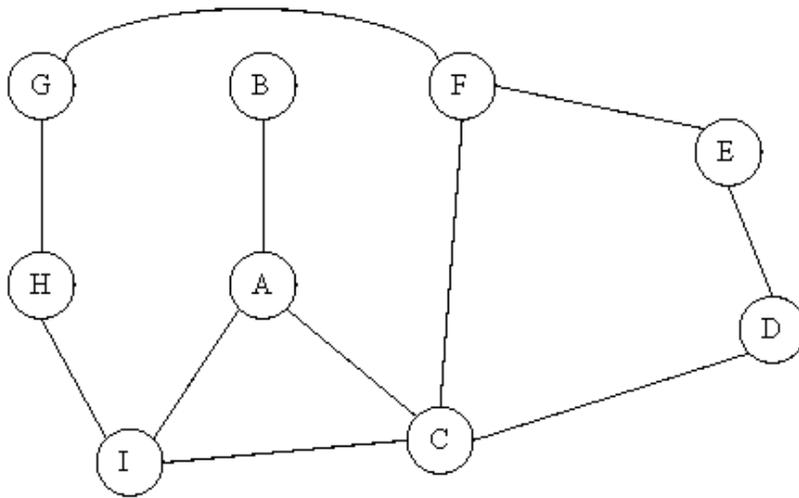


Figure 5: Diagram for Question 7.

**Question 7 (10 points)** Consider the network configuration shown in Figure 5. Assume that each link has the same cost.

- (a) (5 points) Run Bellman-Ford algorithm on this network to compute the routing table for the node A. Show A's distances to all other nodes at each step.
  
- (b) (5 points) Suppose the link A-B goes down. As a result, A advertises a distance of infinity to B. Describe in detail a scenario where C takes a long time to learn that B is unreachable.

**Question 8 (5 points)**

Your local telephone company is adding DSL service to its existing network, and they need your help! From their frequency spectrum they have allotted the frequency band from 200-800 kHz, allowing simultaneous voice communication at 300-3300hz. The signal to noise ratio is 30dB (to simplify your calculations, you can consider  $\log_2(1001)=10$ ).

(a) (3 points) What is the capacity of this link?

(b) (2 points) Should they advertise service with this link rate to their customers? Why or why not?

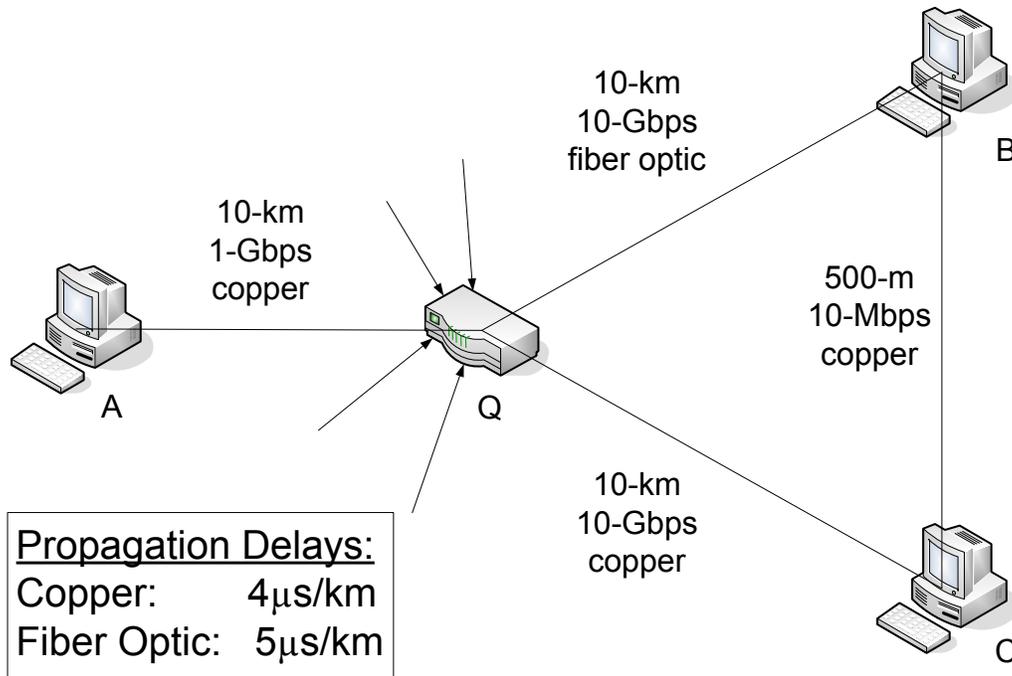


Figure 6: Diagram for Question 9.

**Question 9 (10 points)**

Consider the scenario shown in Figure 6. Host A is sending tiny packets to hosts B and C (neglect transmission time, just consider latency). Q is a store-and-forward switch with an average arrival rate of 10-Gbps and a buffer that contains 16 megabytes (base 10) of packets on average.

- (a) (2 points) What is the average delay that packets will incur going through the switch?

(b) (2 points) What is the latency between A and B?

(c) (2 points) What is the latency between A and C?

(d) (2 points) What is the latency between B and C?

(e) (2 points) Without changing the network, can you propose a solution to decrease the delay between A and B?

**Question 10 (9 points)**

Below is the DNS record for a fictitious corporation, OK Computer:

Name	Type	Value	TTL (seconds)
okcomputer.com	A	164.32.15.98	86400 (1 day)
okcomputer.com	NS	thom.yorke.net	86400
okcomputer.com	NS	karma.okcomputer.com	86400
okcomputer.com	MX	android.okcomputer.com	60
lucky.okcomputer.com	A	164.32.12.8	86400
www.okcomputer.com	CNAME	lucky.okcomputer.com	86400
android.okcomputer.com	A	164.32.15.99	86400

- (a) (3 points) If you type `http://www.okcomputer.com` into your web browser, to which IP address will your web browser connect?
- (b) (3 points) If you send an e-mail to `thom@okcomputer.com`, to which IP address will the message get delivered?
- (c) (3 points) The TTL field refers to the maximum amount of time a DNS server can cache the record. Give a rationale for why most of the TTLs were chosen to be 86400 seconds (1 day) instead of a shorter or a longer time, and why the MX record was chosen to have a 60-second TTL?