Student ID: ____________________

CS457: Computer Networking
Date: 3/21/2008
Name: ________________________

Instructions:

1. Be sure that you have 8 questions
2. Be sure your answers are legible.
3. Write your Student ID at the top of every page
4. This is a closed book exam
5. Answer each question clearly and to the point. Show all work and assumptions, but do not define or describe concepts unless asked to do so; assume that the graders are familiar with the concepts.

Question	***Points***	***Score***
1	10	
2	15	
3	15	
4	15	
5	10	
6	10	
7	10	
8	15	
total	**100**	

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1. Answer the following True/False questions by circling either **T** or **F.**

    1. When the timer expires at the sender in TCP, the threshold is halved T F
       Question from Section 3.7; out of scope for this exam. Free point.

    2. In terms of file transfer, SMTP is a pull-based protocol T F

    3. A web cache is both a server and client T F

    4. The sequence number range must be at least twice the send window for GBN T F

    5. UDP uses both the source and destination ports to dispatch a segment at the receiver
       T F

    6. HTTP 1.0 will require 12 RTTs to transfer 1 web page with 5 objects T F

    7. TCP's "fast retransmission" will be effective with a pipeline of size 2 T F

    8. Congestion control reduces the transmission rate at the sender when the receiver is overloaded
       T F

    9. A server can open 2^{64} TCP sockets T F

    10. UDP are TCP are the same for applications that send one packet at a time T F

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2. Pipelining

a. Assuming no packet loss, how long does it take to send a 30Kb file on a 10Mbps link using 1.5 Kb packets, a pipeline of 10 packets, and a RTT of 3 milliseconds?

20 packets will be sent, and the transmission time t_trans is L/R = 0.150msec/packet.

The first set of 10 packets are sent, and the first Ack arrives after RTT + t_trans = 3.15 millseconds. The next 10 packets are sent in 10* t_trans = 1.5 millseconds, so the last packet is sent after a total of 4.65 milliseconds.

Also acceptable: the Ack for the last packet arrives 2*(RTT + t_trans) = 6.3.

b. What if the pipeline were increased to 20 packets? 30 packets?

If the pipeline were increased to 20 packets, all 20 packets would be sent at once, so the last packet is sent after a total of 20* t_trans = 3msec.

Also acceptable: the last Ack arrives at 3msec + RTT = 6msec.

Increasing the pipeline to 30 packets doesn't change anything, because there are only 20 packets.

c. What if the pipeline were 10 packets but the link were 1 Gbps?

t_trans = L/R = .0015msec.

Plugging into the same formulas from (a), the first packet is sent after RTT + t_trans*11 = 3.0165msec.

Also acceptable: The first Ack arrives after 2*(RTT + t_trans) = 6.003msec.

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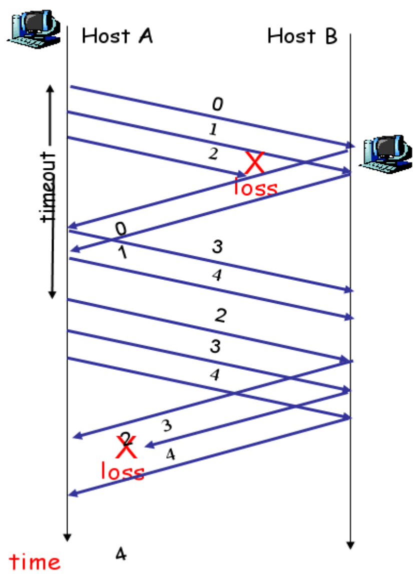
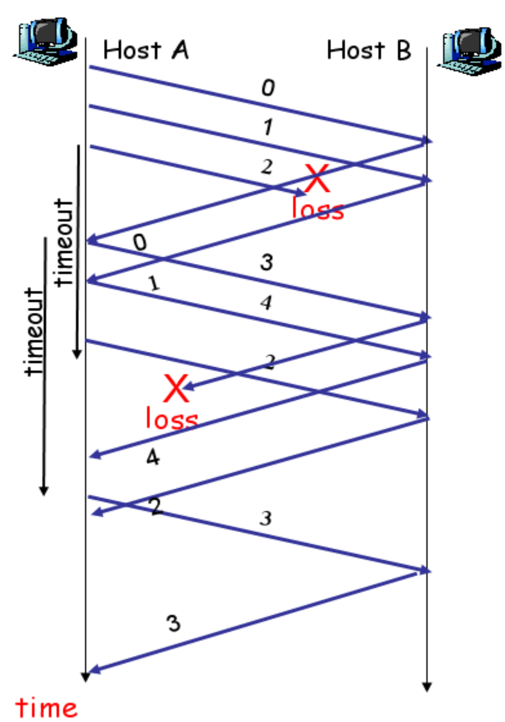
3. Reliable Transport

a. Draw a diagram with all messages and acknowledgments when sending 5 packets using the Go-Back-N protocol with a sending window (ie. a pipeline) of size 3. Label each message and acknowledgment with a sequence number between 0-4. Assume that the packet with sequence number 2 is lost the first time it is sent, and that the acknowledgment with sequence number 3 is lost the first time it is sent.



b. Repeat for the SR protocol.



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4. TCP

a. A node on a 19.2Kbps link sends five 10Kb packets using TCP with a pipeline of size 4 and a RTT of 3 seconds. Assuming all messages are received, how many acknowledgments will the receiver generate, in total? (It may be helpful to calculate the time that each packet is received.)

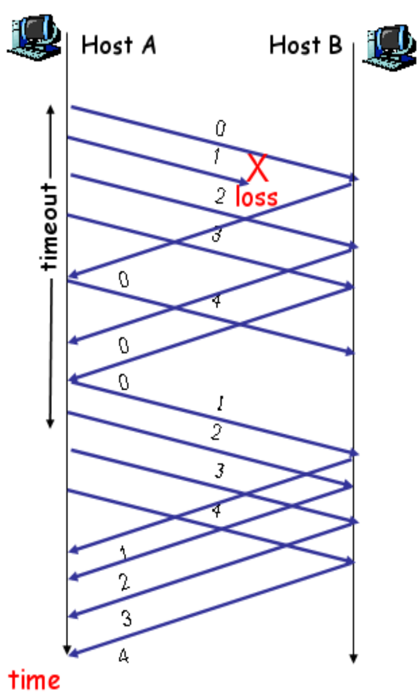
There will be 5 Acks. t_trans = L/R = 520msec. Therefore, the packets will not be received within 500msec of each other, and TCP's "delayed Ack" will not come into effect, so each packet will receive an individual Ack.

b. How many acknowledgments would be generated if the packets were only 5Kb?

There would only be 3 acks. Since t_trans = L/R = 260msec, TCPs "delayed ack" would come into effect and only the second and fourth packets would trigger an Ack. The fifth packet would also receive an Ack after the 500msec timeout.

c. Still assuming 5Kb packets, draw a diagram with all messages and acknowledgments, each with sequence numbers 0-4, in the scenario where the second message (ie. the message with sequence number 1) is lost. How many acknowledgments are sent in total? Assume the timeout value is set to RTT*2.

7 acks are sent.



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5. HTTP

A web page contains 4 images, 1 applet, and 3 images embedded within the applet. How many RTTs does it take to download all objects in the web page:

Due to ambiguity of the question about whether or not to download the web page itself, either the left answers or right answers will be accepted (although combinations of the two will not be accepted).

a. using non-persistent HTTP

9 * 2 = 18 || 8 * 2 = 16 (2 RTTs per object)

b. using persistent HTTP without pipelining

9 + 1 = 10 || 8 +1 = 9 (1 RTT to open the connection, and 1 for each object)

c. using persistent HTTP with pipelining.

1+1+1+1+1 = 5 || 1+1+1+1 = 4 (1 to open connect, and 1 for each group of objects)

d. In terms of the sender window, what is the difference between pipelining in HTTP and pipelining at the transport layer, such as in GBN or SR?

There is no sender window with HTTP. It is not necessary because HTTP is a pull-based protocol.

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6. Link Utilization and Web Caches

Suppose on a certain network there are 750 web requests per second. Each request has an average size of 1 Kb. Suppose the link to the Internet is a 1.5 Mbps link.

a. What is the utilization/traffic intensity of this link?

utilization = 750Kbps / 1.5Mbps = .5 = 50%

b. Suppose the network administrator was worried about queuing delays at the router and wanted to bring the utilization of the link down to 30%. If she decided to upgrade the link, what size link would they have to upgrade to?

2.5Mbps

c. If she decided to use a web cache, what would be the required hit rate to achieve the desired result?

40 percent hit rate

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7. Sockets

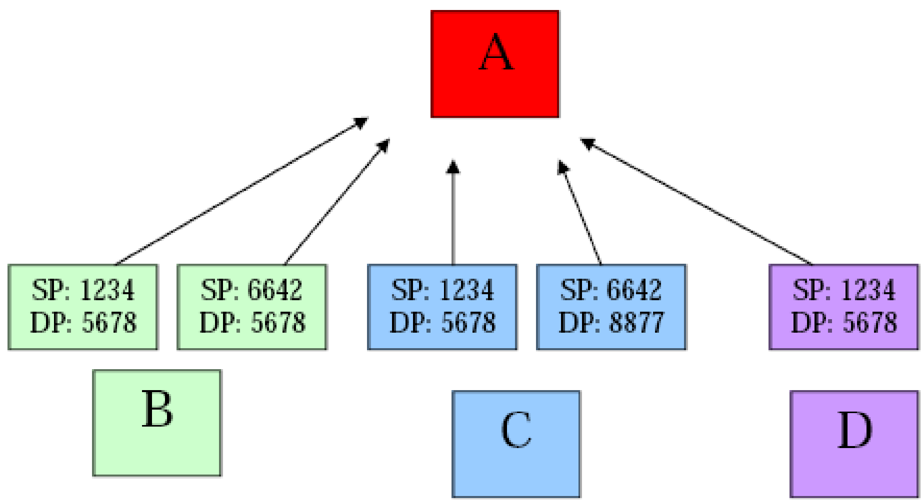
In the diagram below, nodes B, C, and D are sending messages to A with the indicated Source Port and Destination Port addresses. From this diagram, infer how many sockets A has opened:

a. if all nodes are using UDP

2 sockets, since all messages have one of only two destination port address: 5678 or 8877.

b. if all nodes are using TCP

5 sockets, since all messages have different combinations of SP, DP, and IP addresses.



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8. Delay

One-hundred 1Kb messages are sent from host A to host B across a network of 5 switches that are separated by 1.5 Mbps links that are 100m long. Assume no acknowledgments, and that the speed of light is 300 meters per microsecond.

a. What is the total transmission delay?

t_trans = L/R = .66msec, so for 100 packets the total transmission delay is 66msec

b. What is the total propagation delay?

t_prop = distance / speed = 6*100m /300 (m/microsec) = 2 microseconds

c. What is the total queuing delay?

0 msec. Since there is only one source, all packets are sent one at a time and never queue up.

d. What is the total store and forward delay?

#hops * t_trans = 5 * .66msec = 3.3msec (Each switch must transmit the packet, incurring another transmission time.)

f. What is the total delay from the time host A begins to send the first packet until host B finishes receiving the last packet?

66 + 2 + 0 + 3.3 = 71.3msec

g. Which of these delays would change if the same 100 messages were simultaneously sent from 100 different nodes. Would the total delay change?

If 100 nodes simultaneously send a packet to the first switch, that switch will queue up 11 packets. Thus, the queing delay would change.

The first switch will send all packets one at a time. Thus, the queing delay at the first switch in scenario 2 will be exactly equal to the transmission delay of the source in scenario 1. The transmission delay of each source in scenario 2 will be exactly equal to the transmission delay at the first switch in scenario 1. Therefore, these factors cancel out and the total delay will remain exactly the same.

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Honor Code

Signature ______________________________