CS 421: Computer Networks **FALL 2009**

MIDTERM
November 18, 2009
120 minutes

Name: ________________________________

Student No: ____________________________

Show all your work very clearly. Partial credits will only be given if you carefully state your answer with a reasonable justification.

Q1	
Q2	
Q3	
TOT	

1)

a) (5 pts) Suppose that a web server is supporting *n* simultaneous connections at a particular moment, each from a different client host. How many sockets are used by the server at this moment? Justify your answer.

b) (5 pts) Suppose that an HTTP client wants to retrieve a Web document at a known URL. The IP address of the HTTP server is initially unknown to the client. What **transport** and **application** layer protocols will be used in this scenario until the desired Web document is retrieved?

c) (5 pts) If DNS local name servers cache host name-IP address mappings for a long time, e.g., 1 week, will there be a problem in providing correct DNS replies in response to DNS queries?

d) (5 pts) Assume that the network layer does not deliver any out-of-order packets. Assume further that the number of bits used to represent the sequence number is sufficiently large. Is it possible for the sending transport layer to receive an ACK for a segment that falls outside of the current sender's window when the selective repeat protocol is used? Why or why not? Justify your answer.

e) (5 pts) TCP uses cumulative acknowledgements. Give one advantage of using cumulative acknowledgements instead of selective acknowledgements.

f) (5 pts) Suppose that the TCP fast retransmission algorithm is modified such that a segment is retransmitted once **one** duplicate ACK for that segment is received (instead of **three** duplicate ACKs as in the original TCP). What would be a possible negative effect of this modification?

g) (5 pts) A TCP connection between two applications A and B is observed. A segment arrives at A with sequence number 5000, and some time later you observe that a segment belonging to the same TCP connection arrives at A which has a sequence number 8000. Is it possible to compute the number of bytes sent from B to A between these two observation instances? Justify your answer.

2)

a) Consider a 1 Mbits/sec connection with a 12 msec one-way propagation delay, i.e., 24 msec roundtrip propagation delay. We want to transfer a file of size 6000 Bytes. Each segment has a total size of 625 Bytes including the 25 Bytes header. When there is data to be transmitted, each segment contains the maximum number of bytes. Assume that ACK segments are negligibly small and there is a processing delay of 1 msec after a segment is fully received at the receiver until the transmission of the corresponding ACK is started. Assume that the processing delay at the sender after an ACK is received is negligible. **Selective Repeat** protocol is used with a window size of N = 5 segments. Assume that every 4^{th} segment crossing the forward channel is lost while ACKs are not lost or corrupted, and the timeout for each segment is set to 30 msec starting from the end of the transmission of the segment.

   i. (9 pts) How much time is required to complete the transfer of the whole file and receive the final ACK at the sender?

   ii. (3 pts) What is the average rate of data transfer for this file?

b) A TCP sender is transmitting 1000 Byte segments over a 100 Mbps (100×10^6 bits/sec) connection which has a 5 msec one-way delay. Assume further that a very large amount of data is transferred and no packets are lost or errored. The sender utilization (U_{sender}) is defined as the percentage of time the sender is busy transmitting bits (same as defined in your textbook). Remember that the receive window field in the TCP header is 2 Bytes long.

   i. (6 pts) Assume that window scaling is not used for this connection. What is the maximum value of U_{sender} possible for this connection?

   ii. (6 pts) Now suppose that this TCP connection uses a window scaling factor of 4. What is the maximum value of U_{sender} possible for this connection?

c) Assume that the SendBase for a TCP sender is currently 4000. Four TCP segments have been sent with sequence numbers 4000, 4500, 5500, 7000. The sender then receives a segment with an acknowledgement number 7500 and a receive window 6000. The congestion window, CongWin, is set to 10000 after this ACK is processed. Answer the questions i-iii assuming that this ACK is processed and no further ACKs are received:

   i. (3 pts) What is the value of SendBase?

   ii. (3 pts) How many bytes in total are sent in the four TCP segments?

   iii. (3 pts) What is the last byte (number) that the TCP sender can send with certainty that the receiver's buffer will not overflow?

   Now assume that three more TCP segments are received by the sender, where all three segments have TCP acknowledgement number 7500. Answer the questions iv-v assuming that all three ACKs are processed and no further ACKs are received:

   iv. (3 pts) What is the sequence number of the next segment that will be sent?

   v. (3 pts) What is the final value of CongWin?

3)

a) (8 pts) Suppose a TCP connection experiences round-trip times (RTT) of 20 msec for 40% of its packets, 40 msec for 20% of its packets, 100 msec for 40% of its packets and no packets are lost. Assume that the timeout is equal to the estimated mean (estimatedRTT) plus the estimated deviation (devRTT), i.e., TimeOut = estimatedRTT+devRTT. TCP connection calculates the estimated RTT and deviation such that they are equal to their true (ensemble) averages, i.e., EstimatedRTT = E[SampleRTT] and devRTT = E[|SampleRTT-EstimatedRTT|]. What fraction of the packets will be assumed lost by the TCP sender?

b) (10 pts) You are the network engineer of the human colony on Rhea, a moon of Saturn. You are given the task of establishing a connection with Earth using inter-planetary TCP. The round-trip propagation delay from Earth to Rhea is 10 seconds. The bandwidth of the connection is 1 Mbps, i.e., $1x10^6$ bits per second. Each TCP segment has a total length of 1000 Bytes and the file can be transferred using 1024 TCP segments. Assume that the TCP connection uses window scaling that allows receive windows of up to 1 MBytes and no loss event occurs during the entire file transfer. Further assume that the slow start threshold (ssthresh) at the beginning of the TCP connection is infinitely large. Ignore all processing and queueing delays. How long does it take to transmit the entire file and receive the final ACK?

c) (8 pts) Assume a congestion feedback model for a system composed of two flows sharing a bottleneck link with bandwidth R bits/sec where both connections have the same RTT. Each flow gets binary synchronous feedback in discrete time steps of one RTT. If the aggregate consumption of the two flows is above the bottleneck bandwidth, both senders receive a congestion notification signal (**CN**), otherwise they receive no CN. The flows use a simple congestion control scheme: When no CN is received in a time step, each sender increases its window by one segment. On the other hand, for each congested time step, i.e., when both senders receive CN, each sender decreases its window by one segment. So, we can call this algorithm as *Additive Increase-Additive Decrease* (**AIAD**). **Prove or disprove** that AIAD achieves a fair allocation of bandwidth between the flows, i.e., each flow getting R/2, by using graphical arguments similar to the one we made in class in showing that TCP's AIMD algorithm is fair. Assume that the initial throughputs achieved by the two connections correspond to "A".