CS 421: Computer Networks **SPRING 2022**

MIDTERM
April 5, 2022
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.

Clearly state any assumptions that you make in your solution.

Q1	
Q2	
Q3	
TOT	

1) **Answer the following questions using only the space under each question.**

a) (5 pts) The maximum packet size used in the Internet is in the order of KBytes. Give two disadvantages of using much larger packet sizes, e.g., 1 MByte?

b) (5 pts) Suppose you want to transfer a large file from a host to a very large number of users running on different hosts. Would you prefer the client-server or the peer-to-peer application architecture?

c) (5 pts) Will you choose TCP as the transport layer protocol for an internet telecommunication application such as Skype which requires a minimum throughput from the network for proper operation? Why or why not?

d) (5 pts) Why does TCP wait for 3 dupACKs until fast retransmission instead of retransmitting after the first dupACK?

e) (5 pts) Will you use Go-Back-N or Selective Repeat for reliable communication over a connection where acknowledgement segments experience high rate of loss whereas data segments experience no losses? Why?

f) (5 pts) Assume that UDP traffic shares the same bottleneck link with a single TCP connection. Is the capacity of the bottleneck link equally split between UDP and TCP traffic? Why or why not?

1)

a) A 10 GBytes file will be transferred between two applications over a connection with a maximum transmission rate of 20 Mbps, i.e., 20×10^6 bps. The distance between the sender and receiver is 4000 km. Assume that the delay for the connection is dominated by the propagation delay and the speed of propagation is 2×10^5 km/s. The connection has MSS = 1000 Bytes including 40 Bytes header. Assume that no segments experience errors or losses and that the processing time at the receiver is negligible.

   i) (4 pts) What is the maximum possible average **net data throughput** that can be achieved between the two applications?

   ii) (4 pts) What is the minimum **window size in Bytes** that should be used for this connection so that the maximum average throughput that you computed in i) can be achieved?

   iii)(4 pts) If FTP is used for this file transfer, can we achieve the maximum throughput that you computed in i)? Justify your answer.

b) (8 pts) A version of Stop-and-Wait protocol is used for a data transfer where no sequence number is used and there are no lost segments. Errors can occur to both data and feedback segments. After each reception, receiver sends an ACK if received segment is correct or sends a NAK otherwise. Sender transmits a new segment only if it receives an error-free ACK message, otherwise it retransmits. Let p_1 be the probability that a data segment is received with errors, and p_2 be the probability that an ACK/NAK message is received with errors. Calculate the average number of times a data segment is transmitted until the sender receives an error-free ACK. *Hint:* $\sum_{n=1}^{\infty} n a^{n-1} = \frac{1}{(1-a)^2}$ for $a < 1$.

c) (10 pts) A file containing 12,000 Bytes will be transferred over a connection with a round-trip delay of 10 ms and transmission rate of 8 Mbps. Each segment has a maximum size of 1000 Bytes including a 40 Bytes header. The communication between the sender and receiver is full duplex, i.e., sender can send data segments while receiving an ACK segment. We use the **Selective Repeat** protocol for the file transfer with a window size of **N = 6** segments. The initial sequence number is 1. Assume that the **first transmissions** of the **ACK segments** with acknowledgment numbers **3, 7 and 10** are errored, whereas **all other data** and **ACK segments are received correctly**. The timeout for each data segment is set to **15 ms starting from the end of the transmission of the segment**. ACK transmission and processing times are negligible. How much time is required to complete the transfer of the whole file and receive the **final ACK** at the sender?

d) (10 pts) Calculate the transfer time for the file transfer in c) when **Go-Back-N** protocol is used with a window size of **N = 6** segments. Each window of the sender has a timeout of **15 msec starting from the time when the window is set by the sender**.

3)

a) (5 pts) A TCP connection measures RTT of 10 msec for 60% and 100 msec for 30% of segments, and remaining 10% of segments experience a loss event. EstimatedRTT and DevRTT are computed using exponential weighted moving average and they are equal to their true (ensemble) values. What fraction of segments will be assumed lost by TCP sender if TCP sets TimeOut = EstimatedRTT+4xDevRTT?

b) (7 pts) Suppose that a file composed of 20 segments, each with a size of 1250 Bytes, will be transferred over a TCP connection with a round-trip delay of 6 ms and transmission rate of 10 Mbps, i.e., 10×10^6 bps. Assume that 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 and assume that ACK messages have a negligibly small transmission time. After the TCP connection is established, how long does it take to transmit the entire file and receive the final ACK?

c) Four TCP connections are sharing a link with capacity of 100 Mbps. RTT for connections are 40 ms, 100 ms, 100 ms and 200 ms, respectively.

   i) (4 pts) Assume that the bandwidth bottleneck for all four connections is this shared link. Calculate the throughputs achieved by each connection.

   ii) (4 pts) Assume now that the first TCP connection (the one with 40 ms RTT) has another bottleneck link with capacity of 25 Mbps. Calculate the throughputs achieved by each connection.

d) (5 pts) At time t, a TCP connection has CongWin=4000 Bytes, ssthresh=4500, nextSequenceNumber=500 and there are no unacknowledged segments. The sender sends three more segments between t and s (s > t), each containing MSS=1000 Bytes. TCP sender receives two ACK segments between t and s with ACK numbers 1500 and 2500. Last ACK segment contains RcvWin=3500 Bytes. How many more bytes is the TCP sender allowed to send at time s?

e) (5 pts) A client is downloading a file from a server. TCP code at the client is modified such that when client receives a segment with a sequence number S which contains N Bytes, it sends 10 successive ACK messages with ACK numbers S+N/10, S+2N/10,…, S+N. Does client get any advantage from this modification in terms of download speed from server? If yes, describe how. If no, describe why not.