CS 421: COMPUTER NETWORKS **SPRING 2007**

FINAL
May 23, 2007
150 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) (6 pts) List one advantage and one disadvantage **each** of Cumulative ACKs, Selective ACKs and NAKs.

b) Assume that the bandwidth of a connection is 1 Mbps ($1x10^6$ bits/sec) and the round-trip propagation delay for the connection is 9 msec. Assume that each data packet is 125 Bytes long and the ACK packets have negligible lengths. **Separately answer the following questions for both Selective Repeat and Go-Back-N.**

   i. (5 pts) Assuming that no packets are lost, what should be the minimum window size (in packets) in order to achieve a bandwidth utilization of 80%?

   ii. (5 pts) What is the minimum number of bits necessary to represent the sequence numbers for proper operation using the window size that you calculated above?

   iii. (5 pts) Suppose that there are 20 packets to be sent and two packets with sequence numbers 4 and 12 are lost during transmission. Using the window size and the sequence number space that you calculated above, how many packets are retransmitted and what are their sequence numbers?

c) (6 pts) Give two possible scenarios under which a TCP segment is retransmitted although there are no data or acknowledgement packet losses at all.

d) (8 pts) You are the network engineer of the human colony on Titan, a moon of Saturn. You are given the task of establishing a connection with Earth using inter-planetary TCP. The one-way propagation delay from Earth to Titan is 10 seconds. The capacity of the connection is 1 Mbps, i.e., $1x10^6$ bits per second, and each packet has a length of 10,000 bits. TCP Reno is used to transmit a file of size $3x10^6$ bits from Earth to Titan. Assume that there is a timeout at the end of the 7^{th} round of transmission and a fast retransmission at the end of the 15^{th} round of transmission (each round is defined as a period of duration RTT as we have used in class in graphically describing Slow Start and Congestion Avoidance algorithms). How long does it take to transmit the entire file? What is the average bandwidth utilization of TCP Reno during the file transfer?

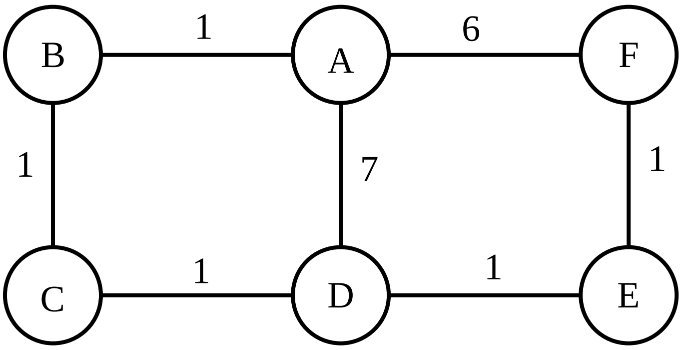
2)

a) (6 pts) Describe how CIDR introduces a tradeoff between the size of the routing tables and the number of wasted addresses in the address space as CIDR is compared with classful addressing and flat addressing (e.g, MAC addressing) schemes.

b) (6 pts) Consider a router with N input ports and N output ports that are connected by a bus that can transfer a packet in 1/N of the time it takes to transmit a packet on the input/output links. Is it possible that the input buffers of this router overflow? Is it possible that the output buffers of this router overflow? Justify your answers.

c) (6 pts) Answer the questions in part b) if the bus can transfer a packet in the same time it takes to transmit a packet on the input/output links. The bus can transfer up to N packets simultaneously, but at most N/4 packets can be forwarded to an output port concurrently. Justify your answers.

d) Consider the following network topology. Suppose that the routers are running the distance vector routing algorithm without poisoned reverse. Assume that time is slotted, i.e., t=0,1,2,3, ... and that a node sends its distance vector estimates to its neighbors at the beginning of each time slot starting at t=0. A distance vector estimate sent at the beginning of a slot arrives by the end of that slot. Distance estimates are computed using the most recently available estimates.



i. (4 pts) Fill in A's forwarding table at **t=0** (immediately after initialization):

Destination	Distance	Next hop
B		
C		
D		
E		
F		

ii. (4 pts) Fill in A's forwarding table at **t=2**:

Destination	Distance	Next hop
B		
C		
D		
E		
F		

iii. (4 pts) Fill in A's forwarding table at **t=4**:

Destination	Distance	Next hop
B		
C		
D		
E		
F		

3)

a) (8 pts) Suppose the data sequence 10011001 is transmitted using the generator sequence 100000111. Compute the CRC bits and the transmitted bit sequence. If the 1st,7th,8th and 9th bits starting from the highest order bit in the received sequence are errored, determine whether this error can be detected by the receiver.

b) Suppose that nodes A, B, C and D are connected to the same Ethernet. Assume all frames take one unit time to transmit. For simplicity, ignore the effect of the propagation delay.

   i. (5 pts) At t=0, node A starts to transmit a frame. At time t=0.5, nodes B, C and D each receive a new packet from the network layer for transmission. When will the first collision occur after t=0 on this Ethernet? Which nodes will be involved in this collision?

   ii. (7 pts) Assume that nodes A, B, C and D are involved in a collision, which is the 3rd collision for all four nodes. What is the probability that the next transmission after this collision will be a successful transmission?

c) (5 pts) Recall that wireless LAN (802.11) uses CSMA/CA. Is there a need to impose a minimum frame size requirement (similar to Ethernet) also in 802.11? Justify your answer.

d) Consider the wireless LAN topology shown below where there are 4 nodes: A, B, C and D. The large solid circles represent the transmission radius of nodes A and D, respectively, and the small dashed circles represent the transmission range of B and C, respectively. Assume that two nodes' transmissions interfere at a location if and only if they transmit at the same time and both of their transmission areas contain that location. Assume that losses only occur due to collisions. Assume that nodes A and C are saturated, i.e., they have infinite number of packets waiting to be transmitted to B and D, respectively (a new packet is passed to the link layer at both nodes immediately after a successful transmission).

   i. (5 pts) Assume that no MAC mechanism is used by the nodes, i.e., no carrier sensing and collision avoidance. What are the ratios of successful frame transmissions as a fraction of the channel transmission rate for A→B and C→D transmissions?

   ii. (5 pts) Now assume that each node uses CSMA/CA MAC mechanism. What are the ratios of successful frame transmissions as a fraction of the channel transmission rate for A→B and C→D transmissions?

   iii. (Bonus 5 pts) Now assume that each node uses RTS/CTS mechanism in conjunction with CSMA/CA. An RTS or CTS is sent if and only if no other RTS or CTS has been heard recently. Assume that RTS/CTS frames are small compared to data frames and have negligible overhead. What are the ratios of successful frame transmissions as a fraction of the channel transmission rate for A→B and C→D transmissions?