CS 421: COMPUTER NETWORKS **FALL 2009**

FINAL
December 29, 2009
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.

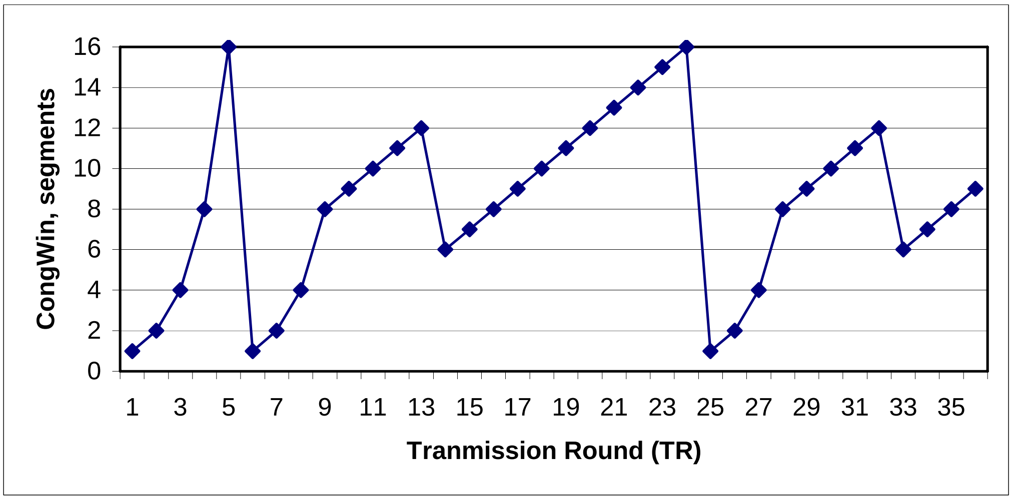
Q1	
Q2	
Q3	
TOT	

1)

a) (7 pts) The Trivial File Transfer Protocol (TFTP) is an application layer protocol that uses the Stop-and-Wait protocol (rdt3.0 in your textbook). The server breaks the file into packets each containing 512 Bytes of data and sends these packets to the client using the Stop-and-Wait mechanism. Find the sender's utilization, U_{sender} , (defined as the fraction of time the sender is busy sending **data bits** into the channel) in transmitting a file over a 100 Mbits/sec Ethernet LAN where the distance between the server and the client is 300 meters and the propagation speed is $2x10^8$ m/s. Assume that there are no transmission errors and that each data packet contains a 40 Bytes header. The ACK packets have a total length of 40 bytes.

b) (7 pts) Assume that the bandwidth of a connection is 10 Mbits/sec ($10x10^6$ bits/sec) and the round-trip propagation delay for the connection is 10 msec. Assume that each data packet is 1000 Bytes long including the header and the ACK packets are 40 Bytes long. Assuming that no packets are lost, what should be the **minimum window size in Bytes** in order to achieve full bandwidth utilization when TCP is used as the transport layer protocol?

c) (7 pts) The following figure shows the evolution of the Congestion Window for a TCP connection as a function of time. The x-axis denotes the Transmission Round (TR), where each tick corresponds to one round-trip-time (RTT) (assume that all packets have negligible transmission times). The y-axis is the Congestion Window in segments at the beginning of each TR. Use the table below in order to identify the time intervals during which Congestion Control algorithm is in a certain phase, i.e., Slow Start (SS) or Congestion Avoidance (CA), the value of the Slow Start threshold (ssthresh) parameter during that time interval and the reason for the phase/parameter change which ends that time interval for TR = 1,…,36.



Time Interval [starting TR,ending TR]	Phase (SS or CA)	ssthresh (in segments)	Event causing phase or parameter change
[1 ,]			
[,]			
[,]			
[,]			
[,]			
[,]			
[, 36]			

d) (5 pts) The timeout in the original TCP was computed as

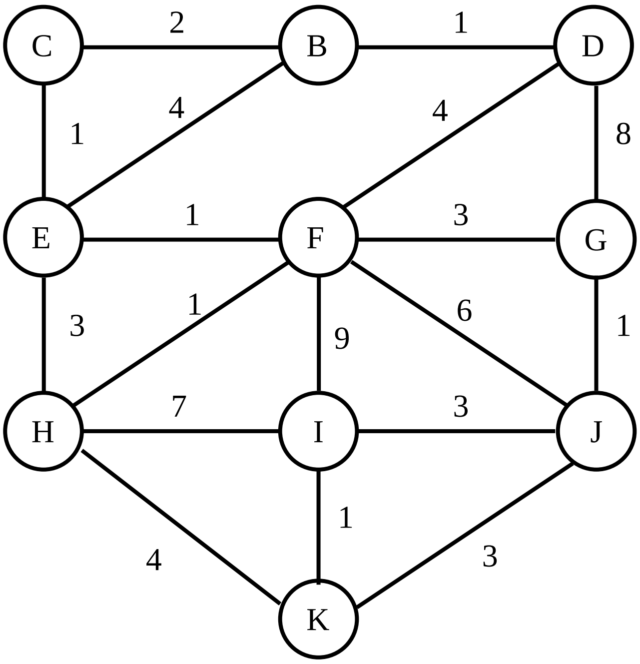
$$\text{TimeOut}=2 \times \text{EstimatedRTT}$$

What was the main problem with this computation of the timeout? How is this problem fixed in the currently used versions of TCP?

e) (5 pts) Explain how the window scaling factor in TCP options is used. For what type of connections is it beneficial to use the window scaling factor?

2)

a) (10 pts) Execute the Dijkstra algorithm **at node B** for the network shown below by filling in the following table. In the table, you need to give both the distance *D(v)* and the previous node *p(v)*.



iter.	*N*	*D(C), p(C)*	*D(D), p(D)*	*D(E), p(E)*	*D(F), p(F)*	*D(G), p(G)*	*D(H), p(H)*	*D(I), p(I)*	*D(J), p(J)*	*D(K), p(K)*

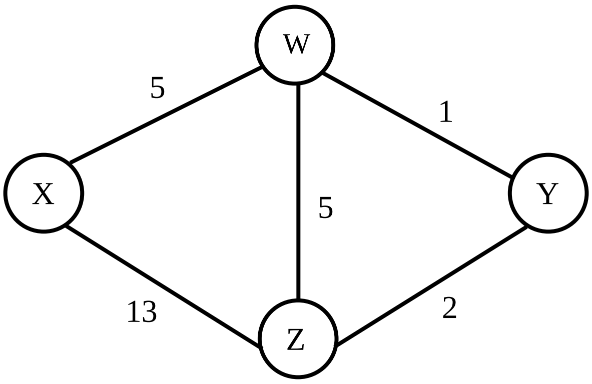
b) The network below uses the distance-vector routing algorithm **without poisoned reverse**. Assume the following:

- Links have the same cost in both directions.
- Nodes exchange their routing info once every second, in perfect synchrony and with negligible transmission delays. Specifically, at every t = k, k = 0, 1, 2, 3,..., each node sends and receives routing info instantaneously, and updates its routing table; the update is completed by time t=k+0.1.
- At time t = 0, the link costs are as shown below and the routing tables have been stabilized. At time t = 0.5, the link (W,X) becomes 30. There are no further changes in the link costs.
- Route advertisements are **only exchanged periodically**, i.e., there are no immediate route advertisements after a link cost change. Hence the first route advertisement after the link cost

change at t = 0.5 occurs at t = 1.0. *Note:* However, whenever a link cost change occurs, two nodes at the endpoints of this link immediately make corresponding changes in their distance tables.

i. (10 pts) Give the evolution of the distance tables with respect to destination X. Specifically, give the distance table entries for destination X at nodes W,Y, Z, for t = 0.1, 0.5, 1.1, 2.1, ..., **until** all distance vectors stabilize. Present your final answer in the table given below where $D^i(j)$ is the distance vector denoting the distance from *i* to *j* .

ii. (3 pts) Suppose you have a packet generated by node Y at t = 4 sec which is destined for node X. Determine the path traversed by this packet.



Time, t	$D^W(X)$ via			$D^Y(X)$ via		$D^Z(X)$ via		
	X	Y	Z	W	Z	W	X	Y
0.1								
0.5								
1.1								
2.1								
3.1								
4.1								
5.1								
6.1								
7.1								
8.1								
9.1								
10.1								
11.1								

c) (6 pts) You are given the assignment of setting subnet addresses for 4 buildings at Bilkent. The number of Internet connected PCs in each building is given in the following table. Assume that the 139.179.192.0/18 address block is given to you for this purpose. Use the following table to show the addresses of the four subnets that you created. In your address assignment, make sure that each assigned CIDR block contains **just sufficient number of addresses**.

Building	**# of PCs**	**Subnet address (CIDR format)**
1	3500	
2	2300	
3	2000	
4	300	

d) (5 pts) The forwarding table at router R is given below.

Destination Network	**Next Hop**
139.179.39.0 / 25	A
139.179.39.128 / 25	B
139.179.72.0 / 26	C
196.101.153.64 / 26	D
139.179.0.0 / 16	E
196.0.0.0 / 8	F

Suppose packets with the following destination IP addresses arrive at router R. Determine to what next hop each of these packets will be delivered according to the longest prefix match algorithm.

i. 139.179.39.136
ii. 139.179.72.136
iii. 196.101.153.136
iv. 139.179.39.125
v. 196.101.153.125

3)

a) (10 pts) Given the following 8-bit pattern data 1101001 and the generator sequence 110000011, compute the CRC bits and give the transmitted bit sequence. If the **least significant three** bits in the received sequence contain bit errors, determine whether this error can be detected by the receiver.

b) In this problem we will investigate an event known as the **Ethernet capture effect.** Consider a pair of nodes A and B, each with an **infinite number** of frames to transmit on an Ethernet LAN. A's frames are numbered as A_1,A_2, and so on, and B's similarly as B_1,B_2,…. Let T = 51.2μs be the exponential backoff base unit. Assume that the network is initially quiet. Suppose A and B simultaneously tried to transmit frames A_1 and B_1, respectively. They experienced a collision. Each detected the collision, aborted transmission, sent a jam signal, and calculated a backoff time. Suppose A chose 0 x T, and B chose 1 x T. Then, A transmits A_1 while B waits. At the end of the transmission, B will try to retransmit B_1 while A will try to transmit its next (new) frame A_2. So there will be another collision.

i. (6 pts) What is the probability that A and B select backoff times such that A will transmit A_2 before B_1 in the first retransmission attempt after the first collision involving A_2 and B_1?

ii. (6 pts) Assume now that A and B chose backoff times in (i) such that A transmitted A_2 before B tried to retransmit B_1, and we go through this again, i.e., after the transmission of A_2 there will be another collision involving A_3 and B_1. What is the probability that A and B select backoff times so that A will transmit A_3 before B_1 in the first retransmission attempt after the first collision involving A_3 and B_1?

iii. (3 pts) From the results you obtained above, briefly describe the Ethernet capture effect.

c) (5 pts) Consider an Ethernet LAN using CSMA/CD running at 100 Mbits/sec. The propagation speed for the signal over the cable is $2x10^8$ m/sec and the maximum distance between any two adapters in the Ethernet LAN is 500 m. Compute the minimum Ethernet frame size such that the CSMA/CD algorithm will work properly.

d) (5 pts) Suppose that we have a large switched network where a large number of networks (each with a large number of hosts) are interconnected using Ethernet switches. What will be the effect of having such a large switched network on the sizes of ARP tables at the nodes? Justify your answer.